Renewable Energy Development In China

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Abstract

Along with rapid economic increase during the past 20 years, there is increasing pressure on Chinese energy industry from limited mineral energy resources and regulations for environmental protection.

China owns abundant renewable energy resources. Renewable energy as environmentally sound fuel source has the potential to provide energy services with zero or almost zero pollutant. Besides, renewable energy just uses indigenous resources, and theoretically it can supply energy ceaselessly. With these advantages, currently the development and utilization of renewable energy in China is becoming one important option to realize sustainable development of the energy system.

This report addresses existing statements and prospects of China's renewable energy and tries to identify the challenges and potential for the development of China's renewable energy in order to make a better way to effectively speed up China's renewable energy procedure.

Preface

This report is written as a result the 10th semester project of the Master program in Environmental Management at Aalborg University. The report is conducted under the theme "Environmental management in an institutional and societal perspective". And I chose to work with the topic "Renewable Energy Development in China"

The reference method used in this report is the Harvard method. All sources can be found in reference list in alphabetic order. Figure and table numbers follow the number of the chapter in which the figure or table is stated. For instance figure 3.1 refers to the first figure in chapter 3 and table 3.1 refers to the first table in chapter 3.

Acronyms are shown on the third pages. These will used throughout the report

I am thankful for the people from Aalborg University, which had contributed me with good suggestions, recommendation and useful information. Special thanks for my supervisor Jens Müller

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Acronyms

The following table provides the full form of the various acronyms used throughout this report.

Btu.....British thermal unit
CDM……Clean Development Mechanism
CREIA…… the Chinese Renewable Energy Industrial Association
GDP……Gross Domestic Product
ERI…… the Energy Research Institute
GHG.....Green House Gas
GEF…… Global Environment Facility
KTR&DP……Key Technologies R&D Program
MMS.....Mandated Market Share
MoEP…….Ministry of Electric Power
MoA……...Ministry of Agriculture
MoST…….Ministry of Science and Technology
MoWR……Ministry of Water Resourse
NGO…….. Non-Government Organization
NAoF……..National Administration of Forestry
NFFO.....Non Fossil Fuel Obligation
NPC…….National People Congress
NDRC……... the National Development and Reform Commission
PV……. Photovoltaic
RE…….. Renewable Energy
R&D…….. Research and Development
REPA……. the Renewable Energy Promotion Act
REC..... .Renewable Energy Certificate
SC…… State Council
SHS..... Solar Home System
SPC…….. the State Planning Commission
SSTC…… the State Science and Technology Commission
SETC…… the State Economic and Trade Commission
UNDP……. United Nations Development Program
VAT…… Value Added Tax
WTO..... the World Trade Organization

Contents:

Chapter 1: Introduction

1.1 Background

In the recent years China's economy is keeping rapid growth. In 2003 the Gross Domestic Product (GDP) in China grew 9.1 percent over the previous year, reaching 11.6694 trillion Yuan (1.4 trillion US dollars). According to the National Bureau of Statistics, the growth rate was the highest since 1997. Some studies forecast that China's GDP will grow by about 8% per year through 2005, and 7% annually thereafter through 2015{EIA, 2004} *see figure 1.1* below

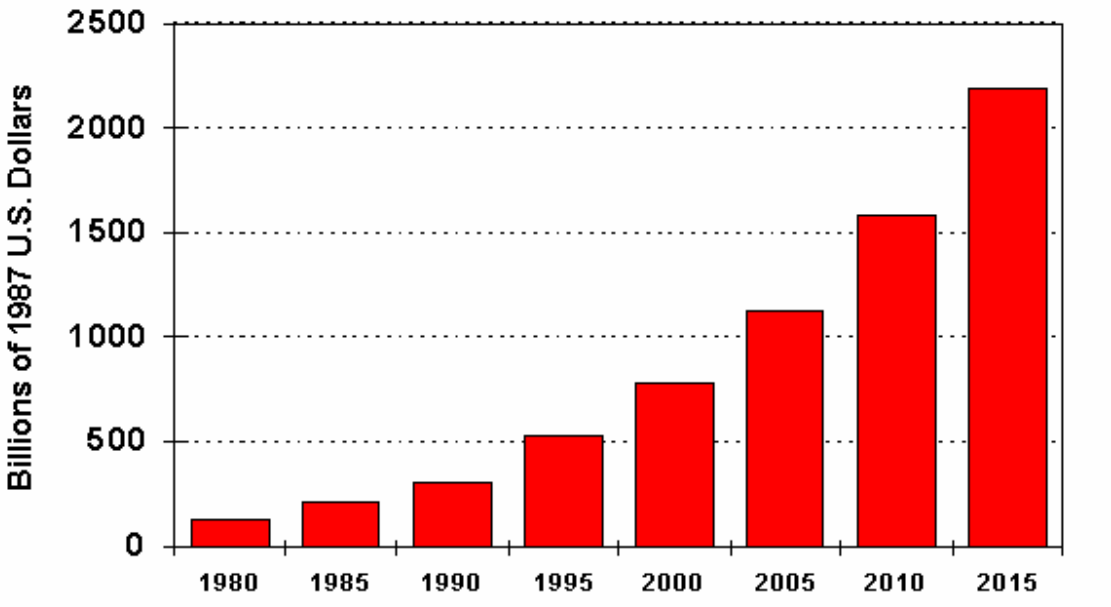


Figure 1.1 China's GDP forecast. Source from {EIA, 2004}

The rapid growth of China's economy indicates that the economic reform in China has obtained great successes. However it also inevitably causes some negative impacts. As we have known, the economy and environment are closely linked through the materials balance principle. Economic activities can be viewed as a process of transforming materials and energy into commodities. Environment supplies resources (renewable and non-renewable) and assimilates waste generated by the economic system. In China the rapid growth of economy

has lead to a large amount of energy consumption and severe environmental pollution. If China's economy still keeps current developing tendency in the coming years as it has been forecasted, the energy supply and environmental pollution will definitely become unavoidable problems, which have to be overcome, in order to ensure sustainable society development.

According to statistics the total energy consumption of China increased more than double in the two decades after 1980 from 400 millions tons of oil equivalent to over 900 millions. The energy consumption per person almost doubles in the same period {citysicence, 2003}. *See figure 1.2* below. This increasing energy consumption will not go down if the economy growth still lasts. Some experts forecast that every year's energy consumption will still reach 2600 million tons of coal equivalents after 2020; even if the economized and high-efficiency energy consumption measures have been adopted in that time. {Economy, 2005}

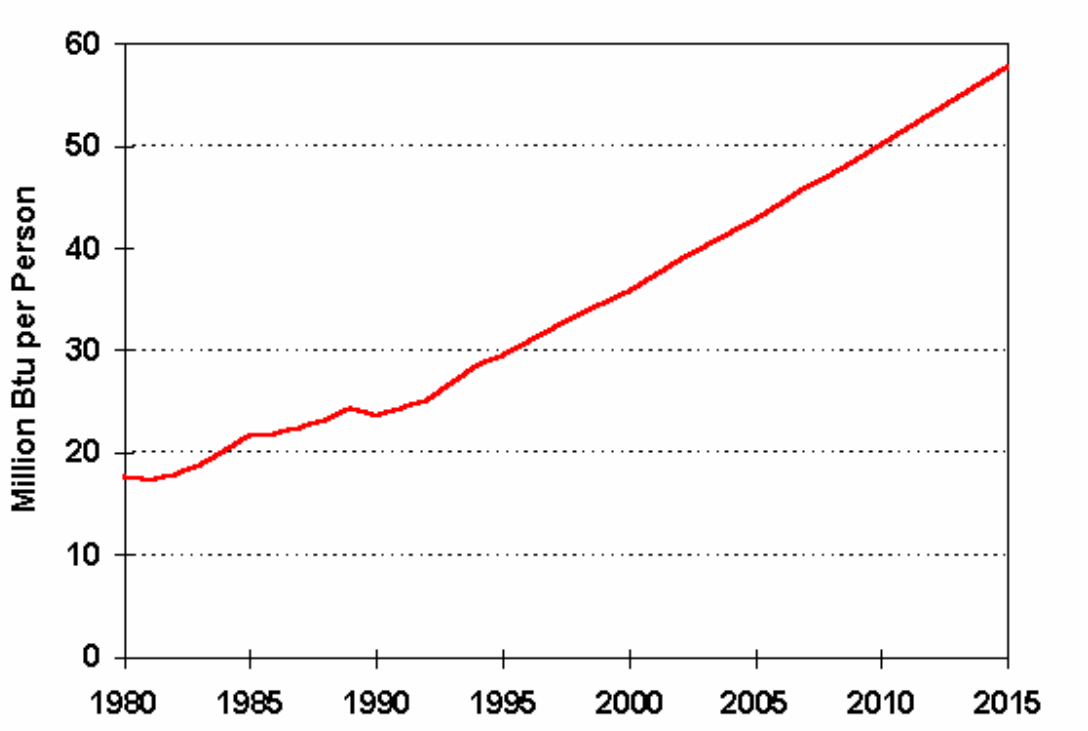


Figure1.2 energy consumption per capita. Source from {Eia, 2004}

Comparatively, Chinese existing energy resource becomes relatively scarce. Currently, the energy consumption in China still heavily depends on coal, for instance, in 2002 the coal occupied almost 70% of energy consumption and production, and this energy utilization

situation will still last a very long period. However, the exploitable coal storage is relatively limited. So far, the known coal storage is 90000 million tons of coal equivalents. It probably is only enough for sixty-year usage according to current consumption speed. {Economy, 2005} Petroleum as another Chief energy resource is also facing an embarrassing situation. The existing exploitable petroleum storage is 230 million tons of coal equivalents in China and only enough for fourteen-year exploitation if no more petroleum is discovered. {Economy, 2005} To moderate the tight situation of oil supply, China has become a net oil importing country since 1993. And with rapid growth of energy consumption the dependency on imported oil is quickly increasing. *See table 1.1 comparisons of energy production and consumption* below. Unfortunately, the unstable political situation in oil producing areas of the world and drastically rising oil price in recent years has shaped huge threats to China' energy importation strategy.

unit: EJ	Production					Consumption				
Year	Coal	Oil	Natural Gas	Hydro-electricity	Total	Coal	Oil	Natural Gas	Hydro-electricity	Total
1980	13.0	4.4	0.6	0.7	18.7	12.8	3.7	0.5	0.7	17.7
1981	13.0	4.2	0.5	0.8	18.5	12.7	3.5	0.5	0.8	17.4
1982	14.0	4.3	0.5	0.9	19.6	13.4	3.4	0.5	0.9	18.2
1983	15.0	4.4	0.5	1.0	20.9	14.4	3.5	0.5	1.0	19.4
1984	16.5	4.8	0.5	1.0	22.8	15.7	3.6	0.5	1.0	20.8
1985	18.3	5.2	0.5	1.1	25.1	17.0	3.8	0.5	1.1	22.5
1986	18.7	5.5	0.5	1.1	25.8	18.0	4.1	0.5	1.1	23.7
1987	19.4	5.6	0.5	1.2	26.8	19.3	4.3	0.5	1.2	25.4
1988	20.5	5.7	0.6	1.3	28.1	20.8	4.6	0.6	1.3	27.3
1989	22.1	5.8	0.6	1.4	29.8	21.6	4.9	0.6	1.4	28.4
1990	22.6	5.8	0.6	1.5	30.5	22.0	4.8	0.6	1.5	28.9
1991	22.8	5.9	0.6	1.4	30.7	23.1	5.2	0.6	1.5	30.4
1992	23.4	6.0	0.6	1.5	31.4	24.2	5.6	0.6	1.6	32.0
1993	24.1	6.1	0.7	1.7	32.6	25.4	6.2	0.6	1.8	34.0
1994	26.0	6.1	0.7	1.9	34.8	27.0	6.3	0.7	2.1	36.0
1995	28.5	6.3	0.7	2.1	37.8	28.7	6.7	0.7	2.3	38.4
1996	29.2	6.6	0.8	2.3	38.9	30.4	7.3	0.7	2.2	40.7
1997	28.8	6.7	0.8	2.5	38.8	29.0	8.3	0.7	2.5	40.5
1998	26.2	6.7	0.9	2.6	36.4	27.0	8.3	0.9	2.6	38.8
1999	21.8	6.7	1.0	2.4	32.0	25.9	8.8	0.8	2.5	38.1
2000	20.9	6.8	1.1	2.6	31.4	25.2	9.4	1.0	2.6	38.2
2001	24.3	6.9	1.2	3.1	35.4	25.8	9.6	1.1	3.0	39.5
2002	28.8	7.0	1.3	3.6	40.7	28.7	10.2	1.2	3.4	43.4

Table 1.1 comparison of energy production and consumption based on the National Bureau of Statistics {NBS, 2003} *(exajoule (EJ) a metric unit of energy. One exajoule equals 947.817 (U.S.) trillion Btu, 277.7778 petawatt hours, or about 9480 megatherms. The unit is often used in discussing global energy production, which is measured in hundreds of exajoules per year.)*

Furthermore, the current lower energy efficiency is also worsening the energy supply situation as its comprehensive energy efficiency stands at 33 percent, 10 percentage points lower than

that of developed countries, and China's energy consumption for per-unit output value is twice as much as that of developed countries {Demand, 2003}. Although China has started to extend the high efficiency energy technology for several years, the comprehensive and penetrative application still need longer time to attain prominent effect.

Despite of the increasing energy crisis, the large amount of energy consumption also causes serious environmental problems. In China coal occupies major part of the country's energy consumption. It produces a large amount of pollutant. For instance, China discharged 19.27 million tons of sulfur dioxide in 2002, 90 percent of which came from burning coal, and 200 million tons of ash and solid waste. The country's environmental watchdog said the amount of sulphur dioxide resulted in acid rain pollution in one third of the country, causing billions of dollars economic losses.{Demand, 2003}

Under the serious economic losses caused by environmental pollution and the huge pressure from international society, as China accounts for about 14% of world carbon emissions, ranking second behind the United States, *See figure 1.3 co2 emissions from fossil fuel burning by countries/regions* China's government has adopted further actions to mitigate the current pollutions including co_2 emission. On September 3, 2002 the former Chinese Premier Zhu Rongji announced at the World Summit on Sustainable Development that China has approved the Kyoto Protocol to the United Nations Framework Convention on Climate Change. Under this Protocol, China is slowly but surely pushing forward with a framework for Clean Development Mechanism (CDM) cooperation with other countries. {CDM, 2003}

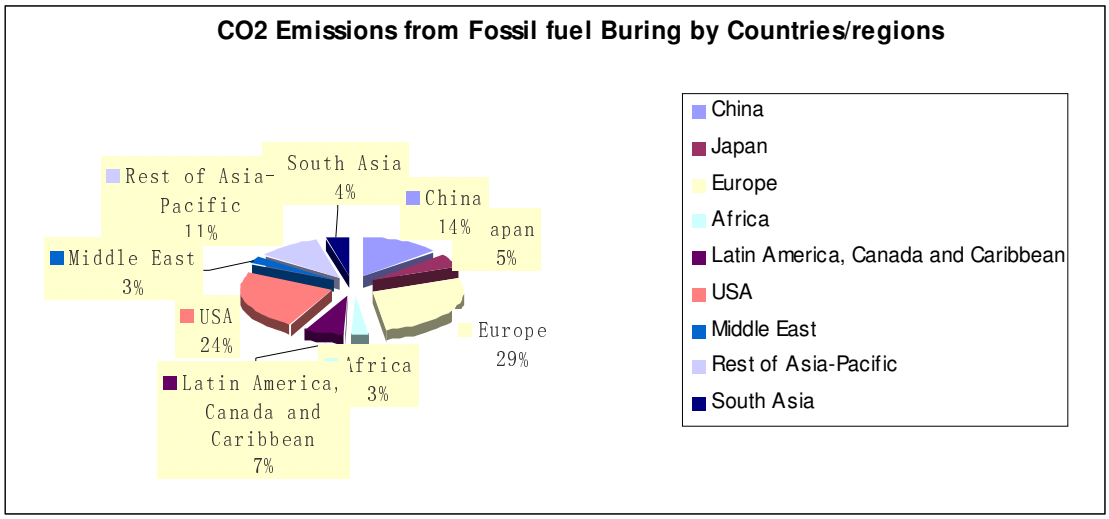


Figure 1.3 co2 emissions from fossil fuel burning by countries/regions, in 1997. The data based on the {Kingpins of Carbon, 1999}.

Apparently, all of those phenomena have indicated that current China's energy production and consumption structure can not ensure long-term demand of rapid growing economy. The feasible adjustment measures must be implemented immediately to make significant change, not only for handling the current problems of energy crisis and environment pollution, but also for sustainable society development in the future.

1.2 The problem formulation

To meet the constant growth of energy need and protect the environment, China has been adopting active actions in energy sector. Since late 1990s China's energy policy has shifted to the structural adjustment that emphasizes clean energy, technological upgrading of the energy industries and energy efficiency. Currently the basic content of China's energy policy is: efforts should be made to develop oil and gas on a full scale, with electric power at centre and coal as the basis; and develop nuclear power and renewable energy source to guarantee a secure energy supply.{China's energy strategy, 2003}

Renewable energy as environmentally sound fuel source has the potential to provide energy services with zero or almost zero pollutant. It will effectively cut off growth in pollution from coal-fired generation if renewable energy can be widely used on a large enough scale since the existing energy structure of China relies heavily on coal. Besides, renewable energy just uses indigenous resources, and theoretically it can supply energy ceaselessly. It gives renewable energy great significance in the energy security aspect. Effective utilization of renewable energy resources will helpfully reduce China's growing dependency on imported oil and provide a strong support for sustainable economy growth. On another side, there is still some remote rural population living without electricity and under the level of poverty condition in China. Local renewable energy utilization can be an effective means to moderate this situation. Therefore, development of new and renewable energy is not only an important measure for sustainable development; it also is an important way to shake off poverty for remote rural residents.

In recent years China's government has paid increasing attentions to renewable energy development. In 1995, the previous State Planning Commission, the State Science and

Technology Commission and the State Economic and Trade Commission (current the National Development and Reform Commission) have jointly formulated an outline on new and renewable energy development in China (1996-2010). Since then, many strategies and policies related to renewable energy development have been established and put in actions. {Nrel, 2001} The issue has also attracted the attentions of multi-lateral development institutes such as the World Bank and the Asia Development Bank. A study organised by World Bank and Chinese government in 1996 has identified priorities for power related renewable energy development in China and has assessed their economic viability {World Bank, 1996}. Thereafter, China's Tenth Five-Year Plan(2001-2005) also highlights new and renewable energies in the power industry's development strategy: "New energy development should be a long-term strategy in energy industry implementation," the plans says, emphasizing that in the areas with abundant resources and combined-grid conditions, large grid-connected wind, solar, thermal, and PV power should be exploited. Finally, the Tenth Five-Year Plan emphasizes the commercialization of PV and wind technologies, diesel and battery systems, bioelectricity, geothermal energy, and fuel forests in rural areas. The plan states that small hydropower, wind, and solar energy projects should be dispersed in these areas. {NREL.2001}

Although many policy related renewable energy development have been made and implemented, the effect seems slight. Currently renewable energy still occupies little proportion in energy industry structure. Renewable energy resources used for power in China mainly consist of small-scale hydropower. It accounts for about 5 percent of the total electricity generated in 1998. Small-scale hydropower has been developed to commercial levels for decentralized rural use and totals about 18 GW. The total installed capacity of solar photovoltaic (PV) energy is about 30MW, with the government targeting the installation of additional 15MW over the next five years. Geothermal energy, with an installed generating capacity of 28MW, plays a minor role in energy supply. To maintain this share of renewable energy in the power supply mix over the next ten years, about 18GW of installed capacity would need to be added according to present energy consumption tendency. {ADB, 2000}

Wind energy is the most promising renewable resource to face the challenge in China. Because China owns the world class wind resource. Especially in recent years the cost per unit of wind-powered electricity has already reduced dramatically as manufacturing and other costs have fallen. Those advantages provide the big potential for extensive wind energy utilization. Even wind energy utilization in China is still limited today, but Chinese government has start making efforts on large scale wind power development and expects the wind power will be able to play

a relatively important role in the Chinese energy structure in the near future. Furthermore, wind energy also is a kind of typical renewable energy that owns the many common characters of renewable energy. Therefore, the successful wind energy exploitation and utilization will be not only moderate current energy and pollution problems, but also will be a very good paradigm that can provide valuable experiences for the other kind of renewable energy development. In this report many cases about wind power have been studied in order to make significant enlightenment for future renewable energy development.

China has developed renewable energy for many years. And as we have mentioned before, many policies, projects and international cooperation related renewable energy have been implemented. However, the comprehensive progress of renewable energy development is still going slow. Commercialization as the symbol of successful technology application, for most renewable energies, is still in the infant phase. Apparently, to further increase the proportion of renewable energy in Chinese energy structure and moderate existing energy crisis and environmental degradation, there is the necessity to explore the reasons behind the slow development.

This report addresses existing statements and prospects of China's renewable energy and tries to identify the challenges and potential for the development of China's renewable energy in order to make a better way to effectively speed up China's renewable energy procedure.

The report tries to do some researches in this subject from two aspects below

1 to identify the positive and negative actors that affect application and development of renewable energy technology

2 to make recommendations on strategy and policy to support renewable energy technology application and development

1.3 Project structure

The report will be presented by two phases. *See figure 1.4* project structure. The phase one is descriptive part. Normally the descriptive researches are used to describe the characteristics of an existing phenomenon {research1, 2003}. Author uses descriptive research to deduce research question, collect data and analyse information. The phase two is qualitative part.

Qualitative research is used to examine human behaviours in social, culture, and political context which it occurs {research1, 2003}. As a typical qualitative method, case study usually is used to complete an in-depth study of one type of phenomenon {research2, 2003}. Here the author uses case study in second phase to do deeper researches. The case study mainly focuses on grid-connected wind power. Because the grid-connected wind power has been expected to play a more important role in the Chinese energy structure in the near future and have significant paradigm effect for the other kinds of renewable energy development.

There are seven chapters in the report. They are separated into three parts. The part one includes first chapter and second chapter. The main purpose of the part is the formulation of the problem and display of research methodology. As we have seen, the first chapter is introduction. In this chapter it states clearly the relationship between sustainable economic growth and energy consumption, highlights the current energy and pollution problems being faced by China government, and briefly outlines the existing statement of China's renewable energy. Thereafter it gives out the research question and project structure of this report. In the second chapter Research methodology will be presented.

The part two includes the third chapter, the fourth chapter and fifth chapter: its purpose is the collection and analysis of information. In this part it mainly introduce present situation of renewable energy technology and discuss the challenges and potential that China's renewable energy is facing and generalize the existing solution (include regulation, incentives, and actions and so on). The third chapter is to discuss market circumstance and commercialization of renewable energy. The fourth chapter bases on third chapter to discuss the transformation of renewable energy technologies as well as the possibilities of wide international technology cooperation The fifth chapter will present how the existing policy-making affect the development and application of renewable energy technologies.

The part three is the sixth chapter. In the sixth chapter the case study about wind energy development will be explored.

The part four is the seventh chapter "recommendations and conclusion" *See the figure 1.4*

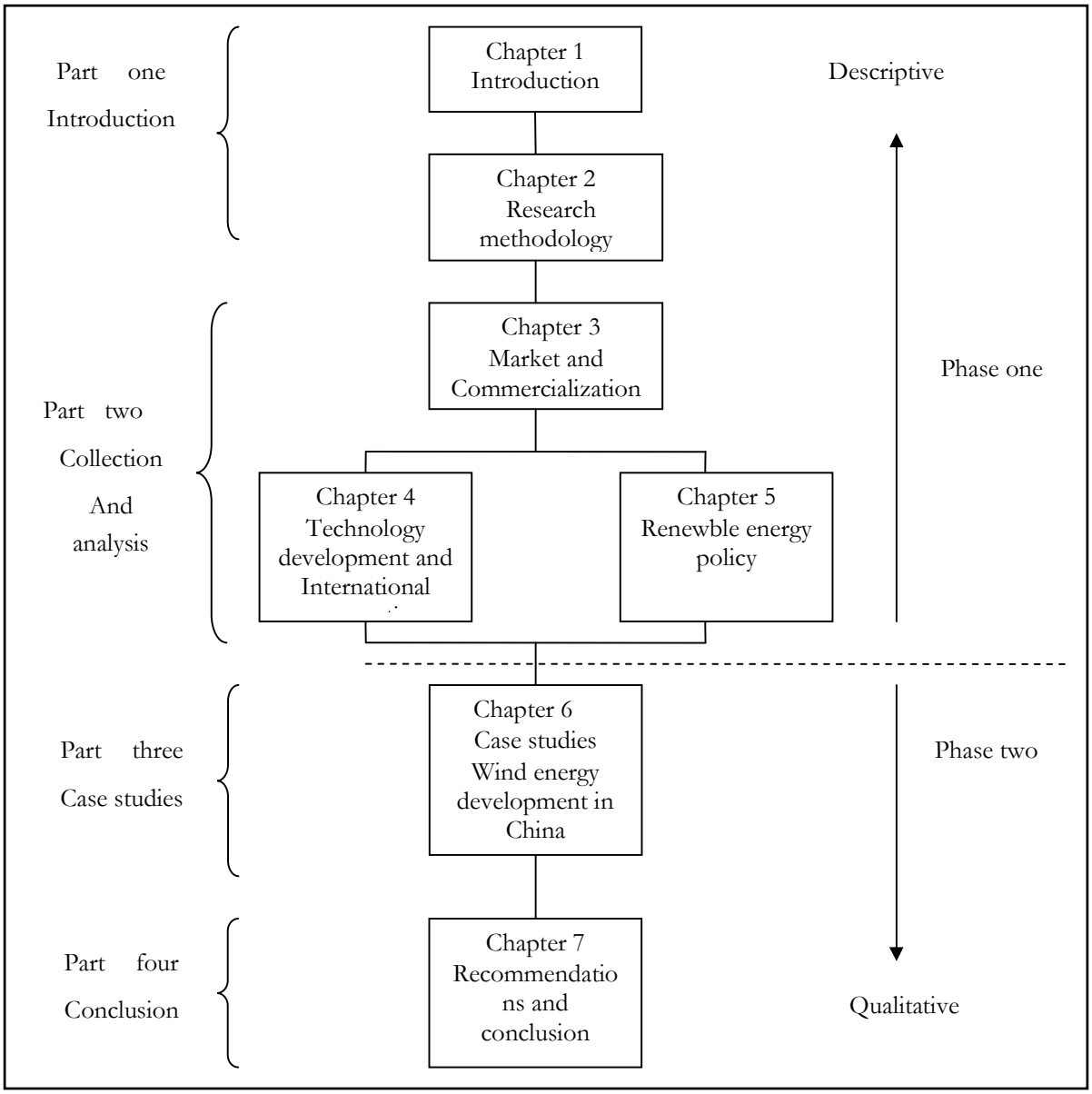


Figure1.4 the project structure

Chapter 2: Research methodology

2.1 Research methodology and project structure

In order to achieve our objectives, the following methods will be used in the report

- **Literature review**

All of the basic information and data incorporated in the report are collected from the literature review. We use these information and data to support our own viewpoint. The most of literatures are from the secondary source.

- **Comparisons approach**

In this report many comparisons have been made between China's renewable energy development and foreign renewable energy developing history, in particular about wind energy development. As many counties have developed the renewable energy for a quite long time and the prominent achievements have been made, the plenty of cumulative experiences and lessons will be valuable references for Chinese renewable energy development. By the comparisons, we can clearly show out the existing advantage and disadvantage, therefore, find out the best way to accelerate the Chinese renewable energy industries.

- **Case study**

The case study usually is used to complete an in-depth study of one type of phenomenon. Here we make in-depth study on wind energy sector in order to obtain some embodied experiences from the current policy implementation and problems disposal, therefore, obtain significant enlightenments for other kinds of renewable energy development.

- **Conceptual framework for technology transformation analysis**

There are many technology concepts. However, they may differ between different disciplines, languages, cultures and application purposes. Here we use technology definition first forwarded by Müller in 1973 as conceptual framework for renewable technology analysis. The reason why we choose this concept is that this technology concept in principle is valid at all

levels of aggregation. It is convenient for us to make analysis on renewable energy development in enterprise and industrial level, as well as the local and national level.

The definition has been defined: {Müller, 2001}

Technology is one of the means by which mankind reproduces and expands its living conditions. Technology embraces a combination of four constituents: Technique, Knowledge, Organisation and Product.

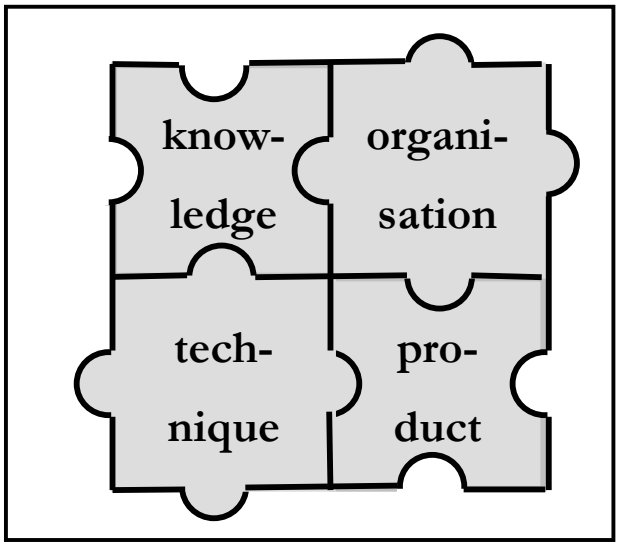


Figure 2.1: The technology concept

The definition of technology is symbolically illustrated in Figure 2.1. All four components are depicted as pieces of a jigsaw puzzle, arguing the following thesis:

> **A qualitative change in any one of the components will eventually result in supplementary, compensatory and/or retaliatory change in the others.**

The definition of technology devises how to describe a given technology through its four constituting components. By such a description we derive the structure of any particular technology. To this comes a process perspective. In fact a technology can be conceived as consisting of several simultaneous and often contrasting processes.

The main structural contents, and the concomitant process features, of each of the four areas of technology analysis are as follows:

Technology as technique: The structure of technique is made up of all the physical means of production or implements, hard-ware, involved in the technical process in question. To this comes the raw materials, components and energy inputs that are transformed or consumed in the same process; in this sense the process is a transformation and consumption process.

These processes are set in motion by physical labour; we thus have to do with a labour process as well.

Technology as knowledge: The knowledge component or soft-ware is structured according to the empirically acquired skills, tacit knowledge and intuition of the direct producers and the scientific insight and creativity of the technology designers. An increasing portion of the soft-ware is being built into the hard-ware as embodied knowledge. The processes involved are psychical labour processes and searching-learning processes, which include all kinds of information input processing.

Technology as organisation: The internal division of labour and pattern of specialisation are central to the structure of the organisation component of technology. Sometimes this component is implied in the soft-ware concept. However, for argument sake, we call this component the "org-ware". The counterpart to the division of labour is co-operation. This requires management and co-ordination and involves all kinds of communication processes which can also be embodied in the hard-ware and/or soft-ware, or disembodied, i.e. person bound.

A useful structural distinction is between what is termed horizontal as opposed to vertical division of labour. The former is characterised by numerous, largely unconnected, similar production processes of final products. The latter implies backward and forward linkages between production processes of components that eventually end up as finished products for consumption.

Finally we distinguish between what we call technically determined and socially determined division of labour. The former implies that the knowledge and even the organisation components of technology are embodied the technique to such an extent that the division of labour so to speak is pre-determined, leaving very little room for alternative management arrangements and differing organisational cultures. To the contrary, where the division of labour primarily is socially determined, the room of manoeuvre for alternative arrangements is much broader.

Technology as product. The product component of technology stands for the immediate result of the combination of all the above mentioned processes. The structure of the product takes indefinitely different kinds of shapes. Here we shall just mention a distinction between material objects and immaterial services.

Chapter 3: Market and commercialization

3.1 background

The renewable energy resources are rich and widely distributed in China. During the last two decades China has achieved some progresses in renewable energy development, with a wide variety of institutes, agencies and enterprises involved in many different programs. However, most of renewable energy development has not moved into the commercialization stage yet since present higher cost of renewable energies cause them less competitive capacity with conventional fossil fuels. Although many studies and experiences have proved that mass production can greatly reduce cost, unfortunately as long as relatively few units are produced, prices will remain high. This leads to low demand and therefore low production volumes. This chicken-and-egg problem is especially difficult with those renewable technologies, which have higher up-front capital cost and cheaper operation and maintenance cost. For example, suppose a wind turbine installed today looks more expensive than a natural gas plant for the first five years, but is projected to be less expensive than the gas plant as fuel prices rise over the 20 to 30-year life of the wind turbine. In this case, a developer might select the gas plant, which is cheap in the short-run, and wait for the less expensive wind turbines to emerge later. But if all developers wait, the production volumes would not be achieved and the wind costs would never come down.

China has developed the renewable energy for many years. However, the renewable energy has only a negligible portion of less than 2% in the total energy consumption of the country until 2000. {RED, 2001}See *figure 3.1 energy consumption scales*

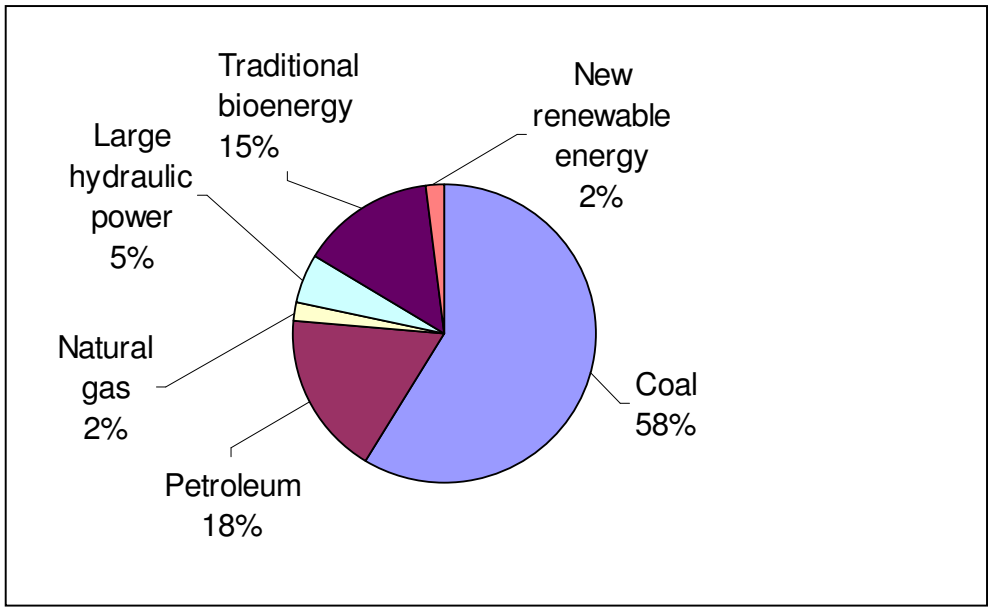


Figure 3.1 energy consumption scales from energy information administration {RED, 2001}

There are many factors, from different aspect including policy, economy, market mechanism, energy industry structure, and so on, causing current situation of development of renewable energy. One of the major reasons is that, when we look back of developing procedure of renewable energy, renewable energy was regarded more or less as an auxiliary tool to release people from poverty, but not industry. There are fewer considerations on environmental interest and strategy significance of renewable energy. However, this kind of situation has gradually changed with the constant progress of economy reform in China. Especially, in recent several years the frequently happening electricity shortage and drastically fluctuant oil market urges China government to make corresponding actions addressing the existing problems in energy industry. This would be a great challenge and opportunity to promote the commercialization of renewable energy.

In addition, China plans to enact a renewable energy bill in early 2005 and enforce it in 2006 to boost the development of renewable energies. According to the designer of the Renewable Energy Promotion Act (REPA), renewable energy is expected to increase to 10% within the next 15 years. {Law, 2004}

3.2 market environment

Renewable energy as a kind of commodity goes through the procedure of R&D, production, marketing, application, then finally realizes its use value and obtain profit. With this idea, maybe we can say the market performances of renewable energy mark the success or failure of the whole development procedure.

There are many factors determining renewable energy market performance.Here the author only illustrate some of the factors that could have bigger impacts on the performances of renewable energies under Chinese market circumstance. See figure 3.2: *key drivers and barriers for RE*. The factors derive from both national and local level accordingly. China has very broad area including 23 provinces, 5 autonomous regions, and 4 municipalities. In most places the renewable energy markets have different situation since local renewable energy resource，local living level，local policy and culture could be different to the other places . Therefore, not all the factors apply to every situation. In some cases some factors will take precedence whilst other will be less important. Some will give more direct impacts than others. For example, some factors (energy security and energy shortage) force government to make energy diversification policies including relevant incentives for renewable energy implementation. Whereas, rich local coal storage also could form big barrier for renewable energy development.

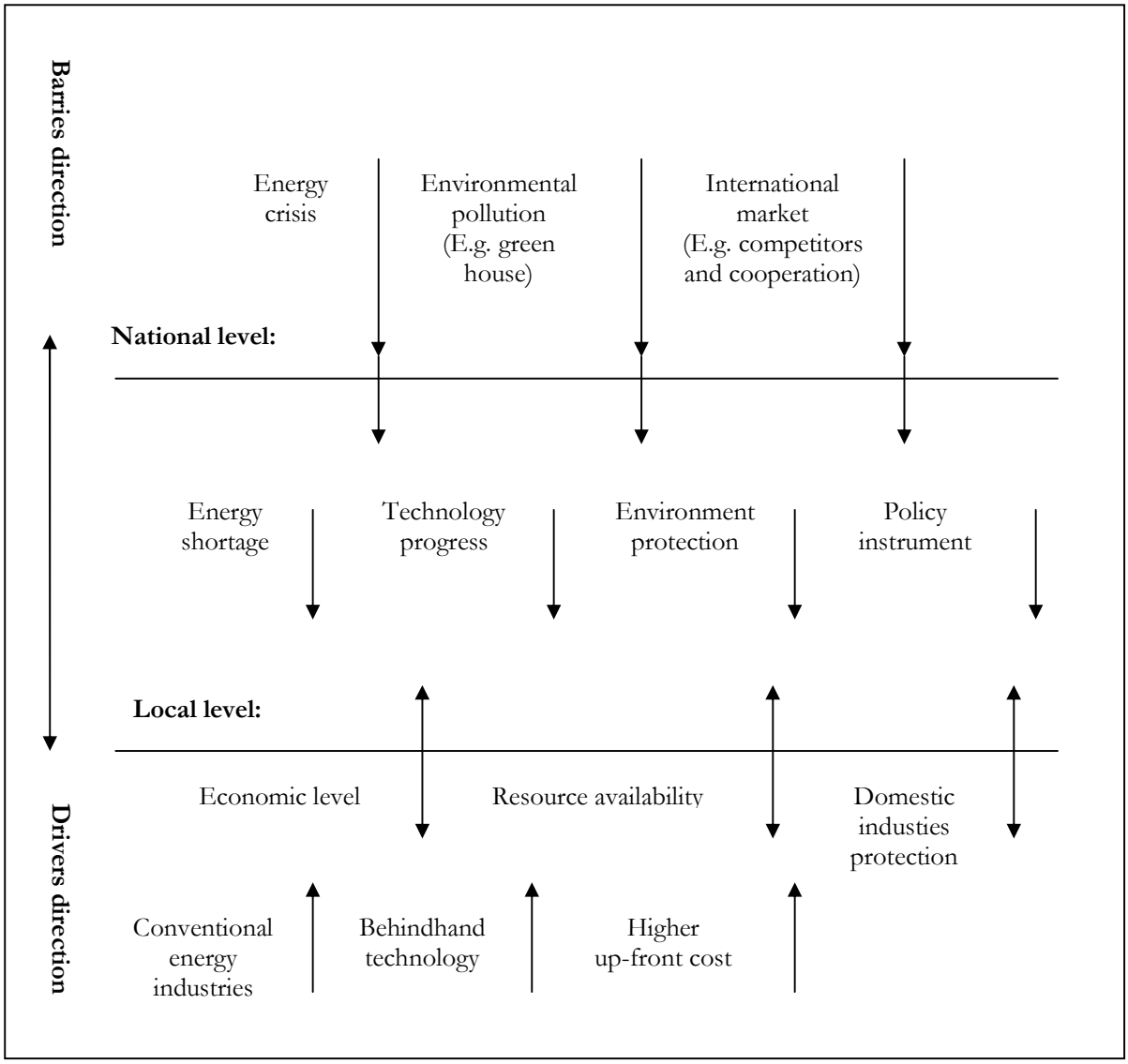


Figure 3.2key drivers and barriers for RE

All the factors are constructing China own renewable energy commercial circumstance from different aspects. Here the factors are put into different category so that they can be clearly studied respectively. See *table 3.1 commercial circumstance factors of RE*

	Barriers	Drives
Legal environment	• Policy instrument	• Policy instrument
Competitive environment	• Higher up-front cost • Conventional energy industries • Domestic RE industries protection	• Energy shortage • Domestic RE industries protection
Economic environment	• consumption ability • energy price • financial capacity	
Technological environment	• Behindhand technology of RE	• Technology progress
Geographic environment	• Resource availability	• Resource availability
International environment	• International competitor	• International cooperation
Social-cultural environment	• Environmental protection awareness	• Environmental protection awareness

Table 3.1 commercial circumstance factors of RE

Legal environment:

- Policy instrument: suitable policy instrument can create favourable market circumstance, attract investors to participate into renewable energy industry, and motivate manufactures to reduce cost. This has been proven in many developed countries, e.g. England. Whereas, unpractical economic policies will become barriers and impede renewable energy industry development. Currently China is trying to make some new polices in order to create favourable market circumstance for further development of renewable energies. We will discuss this issue in the chapter five.

Competitive environment:

- High up-front cost: renewable energy technologies have relatively high up-front capital costs; despite it has very low running costs. This has a strong negative influence on their performance in the market. Especially in China many users prefer to choose foreign

equipment in order to pursue high quality insurance since native renewable manufacturing industries currently have weaker capacity of technology in general e.g. wind industry. Expensive imported equipment and technology will lead to much higher up-front capital cost. This will seriously discourage the investments in renewable energy industry.

- Conventional energy industries: conventional energy industries in Chins own great price advantage. E.g. coal electricity. Because conventional energy industries have had mature technology, well-found infrastructure, huge occupied market, and therefore mass production and lower price. In addition the external costs of the pollution produced by conventional power generation are not usually considered. In contrast, the renewable energies typically offer more environmentally sound functions to society and their users than simply an energy service, but unfortunately renewable energy technologies in China currently have relatively high up-front capital costs, behindhand technology, undeveloped infrastructure and lack of economies scale, therefore relatively high price.
- Domestic RE industry protection: most of China's RE industries are still in infant period. It is good to have time growing up in the beginning without competition abroad under protection of government policy. However, it also could make them form over-dependency and lack capacity of competence.
- Energy shortage: currently rapid growth of economy leads to regional energy shortage, especially in well-developed industry areas. It is a great opportunity for renewable energy development with

Economic environment:

- Consumption ability: energy consumption ability per capita in China is relatively low. It leads to lower demands of variable energy. It is big barrier for renewable energy application. It is a long term issue. In addition the economics level distribution in China is not even between areas since China government implements different degree of intensity reformation in different part of China. According to statistic, the average GDP per capita in eastern area is 2.08 times and 2.63 times respectively than middle and western area in China. {SGC. 2004}
- Energy price: the higher renewable energies prices than conventional energies prices is the main barriers for commercialization of renewable energies. It does not only happen in China, but also in developed countries. It is common matter of developments that renewable energies are facing. The gap between renewable energy price and conventional energy price will gradually be shortened with constant technology enhancement and commercialization expansion.

- Financial capacity: lack of money is a main problem for large-scale renewable energy development. In addition, it also is difficult for renewable energy enterprises to obtain bank loan because of the higher risk from immature market. The financial supports from government for the research and development of renewable energy are not sufficient compared present demand.

Technological environment:

- Behindhand technology of RE: currently most of RE technology still are backward; despite few of them have achieved advanced international level. Backward technology leads to shorter lifetime of equipment, incredible quality, and high risk of investment, consequently, less competitive capacity.
- Technology progress: Present domestic R&D of renewable energy technology is relatively going slow compared with developed countries as less money is invested in this area. Currently RE technology progresses in China heavily depend on imported technology. And the outcome of technology can not be effectively turned into practical product.
- Advanced resources survey technology is needed to make sure accurate data and information for energy plan-making and investments. E.g. wind resource data.

Geographic environment:

- Resource availability: geography and weather feature predominately decide resource situation.

International environment:

- International competitors: own strong competitive capacity because of their obvious advantage of technology and rich experience.
- International cooperation: many international co operations, from World Bank, Union Nation, government, NGO, enterprises, and so on, have happened. All of the actives greatly impetus China's technology progress and development capacity in renewable energy industry.

Social-cultural environment:

- Environmental protection awareness: The environmental protection awareness factor is a long term educational issue. From history perspective, when time goes, it will penetrate

into anywhere of the society gradually and has bigger and bigger impacts to the people behaviors. Currently the renewable energy significances and concept still do not be well-known by the common people in China. The renewable energy knowledge's wide penetration will be strong supports to renewable energy development, especially in governmental department, financial institute, bank and so on.

3.3 commercial potentials for renewable energy

3.3.1 Market potential

Currently China houses nearly 1.3 billion populations, approximate 768 million of which living in rural areas. {Statistics, 2003} More than one fifth of world population are living in limited area of China. Big amount of energy is been consuming daily. With the rapid growth of economy and enhancement of living quality in recent years the energy consumption speed become much faster. The energy shortage has often happened in some well-developed industrial areas.

Despite this, the Primary Energy Consumption per Capita in China is still far lower than the developed countries. See figure 2.4 *Primary Energy Consumption per Capita in 2000.* Apparently if China wants to reach developed countries living level, there is a large gap of energy demand needs to be meet.

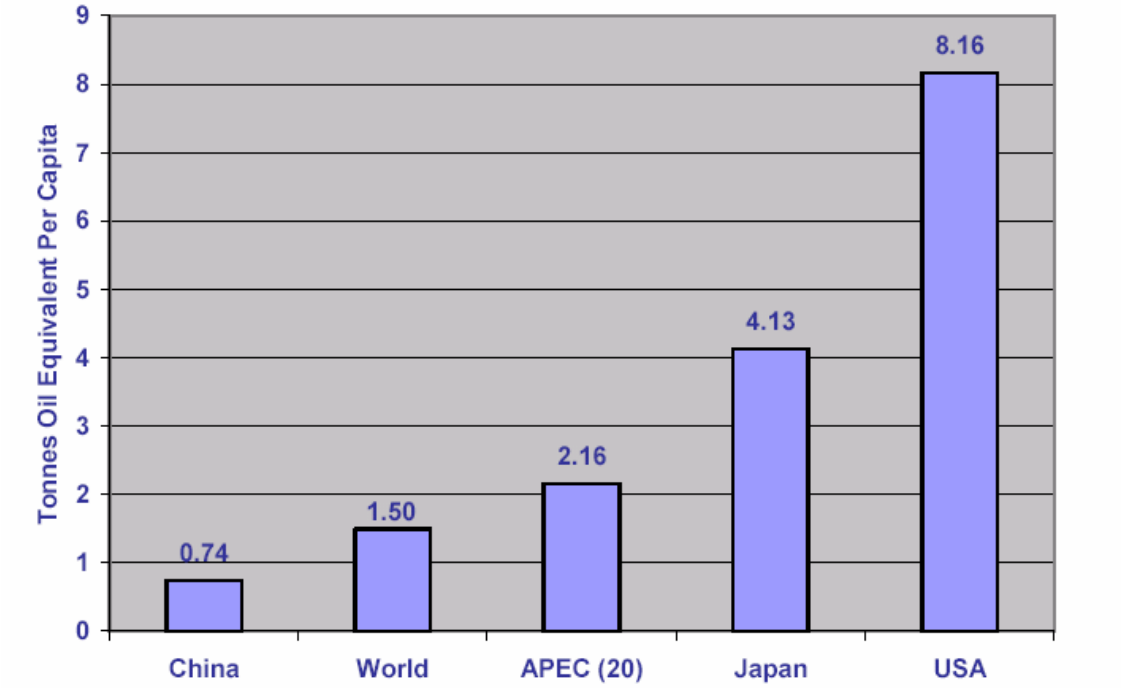


Figure 3.4 Primary Energy Consumption per Capita in 2000 (Tonnes Oil Equivalent) Source: {IEEJ, 2003}

Those phenomena indicate that conventional energy supply has been less able to matched well sustainable developmental demand of both economy and environment. Diversification of energy application has been required in China. This provides a good opportunity for renewable energy development. Renewable energies will play a more and more important role in the China's energy supply structure.

In China renewable resource normally are turned into form of electricity, heat and gas to supply the demand of society.

- **Electricity market status**

Electricity is main energy form to meet the demand of industries, agriculture, service and daily living of people. It plays a significant role in economic development. However, currently the electricity supply can not meet demand of rapid economy growth. In the 2003, electricity power shortage happened seriously and power brownouts were imposed on a total of 21 provincial areas in China. {China5e. 2004}

Uneven distribution of energy resource is another reason that causes current situation. Almost without exception, energy resources are in the wrong places. They are far from consumption

centres and hard to reach. Energy resources are found everywhere but in south-central China, where huge amount of energy is being consumed. This means that to supply electricity, energy resources must be transported from the north and west. For example, coal is brought to thermal plants from far middle and north of China by rail, tying up 42% of the freight capacity. Oil is sent through long and expensive pipelines. Unfortunately, present transportation capacity of China can not carry such heavy burden completely. Hydropower has to come from the construction of large dams which raise environmental concerns and occasionally require the relocation of entire districts (the controversial Three Gorges Project is an example of this). {Supply, 2001}

In addition, there is still some rural population living without electricity and under the level of poverty condition. According to statistics, the country's power access rate in townships, villages and households reached 98.56 percent, 98.53 percent and 98.40 percent respectively. Power is not yet available in 4.78 million households, 10,952 villages and 629 townships in three counties in China. {RPSG, 2004} Those people usually live in remote area where the power grid is hard to reach or residence is too dispersive. So government usually have to pay much higher price to solve the power usage problems in these areas.

As we know, renewable energy can uses indigenous resources to supply power in small area without power distribution facilities and fuels transportation demand. And theoretically it can supply energy ceaselessly. Therefore renewable energy probably is best solution to solve such problems and finally improve the local living quality. Currently few kinds of renewable energy have been made use to meet demand of electricity in China. They mainly supply power to off-grid and connected grid users, e.g. wind power, PV, etc.

a) off-grid power market

Off-grid power manly serves those people who live in the remote area where the power grid is hard to reach, e.g. remote rural area, pasture area, fishing area, island and so on. The off-grid power capacity normally is very small and only can supply the application of household, e.g. radio, Television, lighting, communication and so on. With the governmental policy supports (e.g. sunlight program and ride on wind program) the off-gird power application of renewable energy has been well developed in China as a measure to release poverty.

Small wind turbine is one of the major facilities to supply off-gird power. Currently the wind turbine technology of capacity less than 1 KW has been mature enough and has applied in

mass production. The output of small and mini wind turbine reaches more than 10000 per year ranking No.1 in the world. They have been widely applied in 26 provinces, municipalities and autonomous regions in China; seven of them possess more than 1,000 small wind generator development units. See table 3.2 *small turbine distribution and application* In recent years small wind power generators in limited quantity have been exported to Southeast Asian countries, Japan, Germany and Cuba.{Wind, 2002}

Name	Number (unit)
Inner Mongolia	140,000
Gansu	3,120
Henan	2,710
Ningxia	1,720
Xinjiang	1,680
Shandong	1,330
Anhui	1,080

Table 3.2 *small turbine distribution and application* based on the {Wind, 2002}

Solar postvocalic is another main source of off-grid power. At present, solar PV in China is mainly used as power source for microwave communication systems and stand alone power systems for remote homes. Solar PV systems either as small (20 - 50Wp) solar home systems' (SHS) for single dwellings, or larger village-scale installations (typically around 5 kW) are therefore a viable near-term option for providing basic electricity services to households, small businesses and communities in these rural and remote areas of China.

China produced 3 MWp of photovoltaic cells in 1999, and the total cumulative amount in operation was 15 MWp. Only about one percent the 15 MW is attached to the grid. Of this, 50 percent was used by telecommunication projects. By 1997, for example, half of Tibet's 889 townships had PV-based satellite land receiving stations. Thirty percent were household systems, and 10 percent were used by industry. {PV, 1999} See figure 3.5 *consumption of PV (15MWp)*

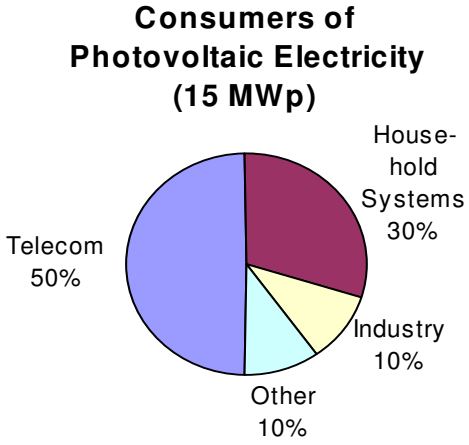


Figure 3.5 *consumption of PV (15MWp)* {PV, 1999}

Sometime the solar PV system is used with wind turbine together to insure the reliability of power supply. In addition mini hydropower also is major way to solve daily power demand of those people who live in hilly areas with small rivers.

b) Connected gird power market

The power connected with gird will be distributed to wider areas, where the grids are able to reach and involve in conventional electricity market. Normally the capacity of power is huge enough to meet the demand of manufacturing sector, commercial sector, agriculture sector, ordinary living of people and so on. It plays an important role in economy development.

Hydropower is an important part of China's energy structure. There are many large and medium-sized hydropower dispersed widely in China. However, there are some controversial issues about ecosystem degradation caused by large and medium-sized hydraulic dam. In contrast, Small hydropower is relatively easy to manage and control. So far, small hydropower generation is the largest and fastest growing renewable resource in the country. At the end of 1997, 22,000 enterprises were involved in small hydropower – with nearly 1 million employees. Being a major component of China's power industry, these enterprises have fixed assets worth Rmb 82.1 billion. Small hydropower provided power to one third of the counties and 300 million people – one quarter of China's population. About 782 counties rely primarily on small hydropower for their electricity supply.

Wind power has largest short-term potential to contribute to power supply among the non-hydropower renewable energy technologies. Unfortunately, lower financial returns on wind farm confine the development of connected grid wind power. However, under huge pressure of energy crisis the more and more endeavours have been made by government and international organization to boost wind industry in China. And some progresses have been achieved. By the end of 2001, there were 399.895MW of grid-connected 27 wind farms in China. Hereinto, 87 set wind turbines summed to 54.96MW were added in 2001. {China power, 2002}

In addition, geothermal and tidal electricity generation also have been applied to grid-connected power supply. However, the market potential is confined by the geographic factors and technological factors. So they only can plays important role in certain location. For example, the largest geothermal power plant, Yangbajin, with a capacity of 25.18 MW is near Lhasa, the capital of Tibet, and provides almost half the electricity for the city. The price of geothermal electricity from this plant –0.64 Yuan/kWh – is quite high but still not enough to cover the generation cost. The local administration subsidizes the plant's operation. {Review, 1997}

- **Heating**

In addition to the renewable technologies that provide electricity, many also provide heat and hot water and therefore play an invaluable role in displacing coal and biomass for everything from cooking to hot water.

Solar is the most important thermal resource of renewable energy. China is by far the world's largest manufacturer and user of solar water heating. Currently three typed solar water heating products have been formed in different price level. Therefore, they can meet the demand of people living in different level. By the end of 2002, the total installed area of solar domestic hot water systems there was about 40 million m^2; annual production and sales volume reached about 8 million m^2 in 2002. There are now more than 1000 manufacturers producing and selling solar thermal systems, and a total turnover of more than €1 billion has been achieved. Evacuated-tube collectors dominate the Chinese domestic and export markets {Solar, 2003}

In addition, the solar house heating and solar stove also has been applied in rural areas. With technology progress and cost decline they will have huge potential in rural areas and townships.

- **Gas**

Biomass supplies a considerable part of energy in traditional energy consumption, especially in the rural areas. With growth of concern on environment, health and energy efficiency the modern technologies have been applied in biomass utilization. Currently the modern biomass utilization account 16% of total biomass use. {Biomass, 2001} the main usage of biomass is to turn into biogas or methane for cooking and lighting. Currently it mainly is applied in rural areas and townships. It greatly resolves the problem of rural energy and supply a healthy living surrounding. Besides, sugar cane slugs (bagasse) have been used to generate electricity. Relevant power and heat cogeneration demonstration projects are developing.

3.3.2 Renewable energy development phase

With advancement of technology and environment awareness enhancement, as well as worse energy crisis, China's renewable energy application, from primitive and simple usage of burning firewood and stalk for cooking to scientific utilization of hybrid small wind turbine and solar PV for power supply of households or village, has had great progresses. Some renewable energy technologies have formed scale production and sell to both national and international market, e.g. solar water heater.

However, different renewable energy respectively has different technology characters and application situations. They could have different performance and meet different degree difficulties accordingly with variable geographic condition, economic level, local policy etc. So the different renewable technologies development phases are different in China. Here the table2.2 summarizes the development phase of some China's renewable energy technologies.

Types of technologies	Maturity and development phase			
	R&D	Demonstration	Early commercialization	commercialized
Small hydropower				#
Solar water heater				#
Passive solar house				#
Solar stove				#
Grid-connected wind turbines			#	
Small and mini wind turbines			#	
Geothermal heating				#
Geothermal power generation				#
Boimass gasfication		#		
Municipal organic waste power generation		#		
Hydrogen technology	#			
Tidal power genration			#	
Wave power generation	#			

Table 3.3 phased assessment of China's renewable energy technology development. Based on source: {RED, 2000}

3.4 barriers for renewable energy commercialization

Renewable energies have an enormous potential in China. However, many facts and experiences have pointed out that some unavoidable barriers are limiting the development of renewable energies since China has depended on the coal-energy industry heavily for a long time and energy market is still mainly under the control of state enterprises. Here the barriers faced by renewable energies have been generalized into two categories: one is price and another one is information communication. All of barriers finally will directly or indirectly cause the higher price of renewable energy or insufficient understanding to renewable energy, therefore lead to the uncompetitive performance of renewable energy in China. Some of barriers own both features.

-high cost

- Infrastructure: developing new renewable resource will require large initial investment and will take relatively longer time to construct infrastructure. E.g. potential wind sites can require several years of monitoring of determine whether they are suitable. The famous three-gorge dam also spends plenty money and time to construct the infrastructure, besides it has to watch the ecosystem impacts and new types of issues involved by dam construction. And for most renewable technologies, certain amount workers have to be trained to install, operate, and maintain new technologies.
- Economies scale: Industrial learning curve theory suggests that costs decrease by some 20% each time the number of units produced doubles. This can differ even for similar industries when the conditions factors change. The experiences also have proved that for the most renewable energy products which are manufactured on assemble line, the mass production can greatly reduce costs. For example, as of the late 1990s, manufacturing cost for photovoltaic had declined 20 to 25 percent for each doubling of production volume. {utility, 1994} Economic scale also leads to cost reduction for wind facility according to the European paradigms. It would be likely to happen to fuel cell, biomass and so on. Unfortunately, as we have mentioned before, present higher price cause low demand, low demand lead to the lean production volumes, and therefore higher price of renewable energy products. This typical chicken-and-egg problem is especially difficult with renewable technologies that need huge up-front capital investment.
- Technology issues: In China most of renewable energy companies do not have big scale and sufficient capital to support technologies research and development. So most of them have to apply financing from government and banks. However, only less companies have chance to be granted. Beside government did not put a lot of money into research and development of renewable energy in the 1990s. As the result of lack of financing and less concern in renewable energy during past years, the research and development of renewable energy technologies lag far behind some developed countries. Many facilities have to import abroad. This largely increase the costs of renewable energies cost and make commercialization of renewable energies more difficult. Currently the backwards renewable energy technologies is a major barrier for China renewable energy industry development.
- Government policy: Although Chinese government has adopted active attitude to make many supportive energy strategy policy in the sector, actual implementation has lagged far behind. For example, one of the most concrete laws was the 1994 Regulation for Grid-connect Wind Power Generation Management. This document stipulates that wind power shall be allowed access to the nearby grid and that the network shall purchase all

output. The wind power tariff shall be determined based on the cost (both principal and interest repayment) plus a reasonable profit. The incremental cost of wind power above the average electricity tariff is also supposed to be shared by the whole grid. The regulation would appear to encourage wind projects, however it is not clear if the law applies to independent power producers. The central utility authorities argue it only applies to them. Thus since the utilities do not want to invest in wind power, none gets built. Central utility authorities can refuse to sign power purchase agreements with independent wind developers. In this case it is too difficult for wind companies to compete with conventional energy companies by reasonable price and profit. China's energy policy in the next several years will have to focus on implementation and not on general policy statements in each five-year plan. Creating real incentives for the private sector to deliver renewable energy will be the only effective way to lower the cost of technologies and have more wind, solar, biomass and geothermal facilities come on-line.

-Information

- Commercial and industrial customers: industry and commerce is the main user of energy. So if renewable energies want to increase scale, renewable energies have to persuade them to accept renewable energy. However, commercial and industrial customers are also generally unfamiliar with renewable energies and worry these intermittent technologies can be highly reliable to fit into their systems. Besides industrial energy managers are trained only to find low-cost solutions. Industrial environmental managers look for ways to reduce in-house pollution and are unlikely to consider pollution associated with their electricity purchases.
- Citizens: most of common citizens have less information to make choice of energy uses even they support renewable energies use since utilities provide little or no information about their emission or the fuels they use. In fact, the most of citizens in China know little about renewable energy and its environmental protection significance.

- Market failure to value public benefits

As we have known the renewable energies are much expensive than conventional energies (fossil fuels) in China. One of the reasons which cause so high cost is that market fails to internalize the externality of conventional energies (fossil fuels). For many years Chinese government concentrates on developing economy, the fossil fuel based energies (e.g. coal) also have occupied the main part of Chinese energies market with rapid growth of economy. Renewable energies have been mainly used to shake off poverty of remote rural people.

Environmental protection has been put in secondary concern. There are no practical measures that insure the external cost caused by fossil fuel pollutions is counted into the energies prices. Under this situation, renewable energies developments in China have been largely limited. In addition the externality feature of renewable energies has not been understood or accepted by the most of companies and citizens in China. The education in this aspect should be broadly disseminated and reinforced to create better surrounding for renewable energy development.

3.5 conclusion

As we have discussed, with those barriers renewable energies will be unable to compete on a same level of playing field with conventional energy industries unless new and effective policies are adapted and create a favourable circumstance for renewable energy industry development to break through the present situation of chicken-and-egg. Only in doing so, a well-ordered circulation energy market can be gradually formed, therefore effectively stimulate renewable energy industry self-development. The past experiences from some developed countries have proven the method feasible.

Chapter4: Technology development and international technology transfer

4.1 The demand of technology in China

As we have mentioned above, renewable energy utilization in China has been a critical issue to ensure Chinese energy security and reduce pollution, therefore guarantee sustainable economy development. However, massive scale of renewable energy use has to take relatively longer time if China just develops it alone without external assistance since of less investment in science and technology and weak technical infrastructure in this field in China. Technology is a key factor in determining the real costs of economic and social development and environmental effects. How to improve the technology level in China to breakthrough the technology bottleneck is a hard topic and process. Currently, China's renewable energy industries are mostly small and lack capacity in research, development, and marketing. Besides, lack of information and international contacts also have been one of major barriers in the promotion of renewable energy development in China.

Developed countries dominate advanced technology because much more support has been provided for technology R&D. There is a huge gap on technology development between developed countries and China. It is clear that broad international cooperation will largely speed up the Chinese renewable energy industry development and benefit the global environment as well, since large scale of renewable energy utilization can greatly reduce Chinese greenhouse gas emission. Therefore, to impetus Chinese renewable energy technology development the additional assistances for renewable energy development are needed from bilateral and multilateral development agencies, as well as non-governmental organization and the private sector to achieve well-oiled development situation.

4.2 The renewable energy development in China

Looking back the history of renewable energy development, we may separate the developing procedure into three phases with different emphasis. See *table 4.1 RE developing phase emphasis.*

<table>
<tr><td>1950s---</td><td>1990s---</td><td>End of 1990s--</td></tr>
<tr><td colspan="2" rowspan="2"></td><td>Energy security</td></tr>
<tr><td colspan="2">Environmental protection and sustainable development</td></tr>
<tr><td colspan="3">Emphasis on rural energy supply in order to shake off poverty</td></tr>
</table>

Table 4.1 RE developing phase emphasis

- The first phase was from 1950s: focused on poverty mitigation

China is the biggest developing country in the world, with more than 900 million populations living in the rural areas. Therefore, the rural economic problem is also the main problem for the whole nation. The renewable energy is main fuel source for rural people production and living. So once the Peoples Republic of China found in 1949, the Chinese government started to solve the rural poverty problem by improvement of hydro utilizations. During the 1950s and 1960s, a special fund was allocated by the state to support the development of small hydro in rural areas to meet the demand for electricity by construction of water conservation works. In the 1970s, subside was offered to mitigate the shortage of electricity in rural areas and extend biogas, fuel wood and coal saving technologies. In the 1980s, with the reform of the rural economic system, the demand for electricity increased steeply. To meet the demand for rural electrification, the government reinforced the financial and economic support for the utilization of small hydropower resources by increasing the amount of finial grants and loans, and by giving certain amount of subsidy.

- The second phase was from 1990s:focued on the environment and sustainable development

After the 1992 United Nations Environmental and Development Conference, the Chinese State Council formulated ten tactics and measures to tackle the problems in the aspects of environment and development. With the emphasis on environmental protection and sustainable development, the government further reinforced its support for renewable energy; the technologies receiving support were extended from small hydropower, biogas and fuel wood-saving stoves to wind power, solar energy, including photovoltaic power, biomass utilization technologies and so on. The type of support changed from subsidized supply to tax reduction or exemption, preferential price and credit guarantee, etc.

- The third phase is from the end of 1990s: focus on energy security

With the rapid growth of economy huge amount of energy is been constantly consuming. As a result, the energy shortage problem has become more and more serious in recent years. Some areas in China have implemented brownout to control electricity consumption. This situation is severely handicapping the Chinese economy development. To ensure rapid economy growth, China has to build more power plants and increase the dependency on coal, which fires more than two-thirds of China's power generators, and oil. China has become the world's second-largest oil consumer and its oil imports leapt an estimated 16 percent in 2004 from the previous year. {Probe, 2005} In this several years, under surgent international energy situation the Chinese government suffer huge energy shortage pressure and start with actual action to ensure energy security. The renewable energy as an important approach for energy security has been given high priority to develop. For example, in 28 February 2005 the Renewable Energy Promotion Law has been voted and passed. The law will takes effect on the 1st of January 2006. {Greenpeace, 2005} The Renewable Energy Promotion Law will allow the renewable energy industry in China to take off, therefore gradually mitigate the dependency on import energy.

As we have seen, after so many years renewable energy development the significances and functions of renewable energy have been gradually recognized by Chinese government. Currently, under the combination of three emphases(poverty, environment, energy security) plenty of endeavours have been put on R&D, management, finance, policy, market, etc to pursue prominent progress in Chinese renewable energy industry. The existing Chinese technology consists of two parts: one part is national research and development, which the investment on it was accounting for 1.09% of GDP in 2001, another part is from technology transfer including high-tech product import and foreign investment on the technology. In 2001 this part investment accounts for 9.27% of GDP. The latter is far higher than the former. That indicate that present Chinese technology development mainly depends on technology transfer from foreign countries, the national innovation only has secondary contributions to Chinese technology development. {Tech, 2003}

4.3 The endogenous renewable energy technology transformation in China

The innovation process is conventionally conceived as made up of a uni-liniar chain of events that happens in a number of different phases over time, e.g. from invention over innovation to diffusion. See *figure 4.1a the conventional uni-liniar conception of the phases of the technological innovation*

process. However, this simple model does "hide" two crucial characteristics of the innovation process: (a) the innovation process as a *selection* process, and (b) as a highly *iterative* process. {Müller, 2001}

.Currently the Chinese renewable technology development is also following a linear model in general: from research and development of technology to project demonstration, then to small and big scale commercialization. See figure 4.1b The Chinese endogenous linear development of the technological innovation process. There are many institutions, organizations and enterprise, as well as assistance and cooperation from international level involved in the procedure of renewable energy development.

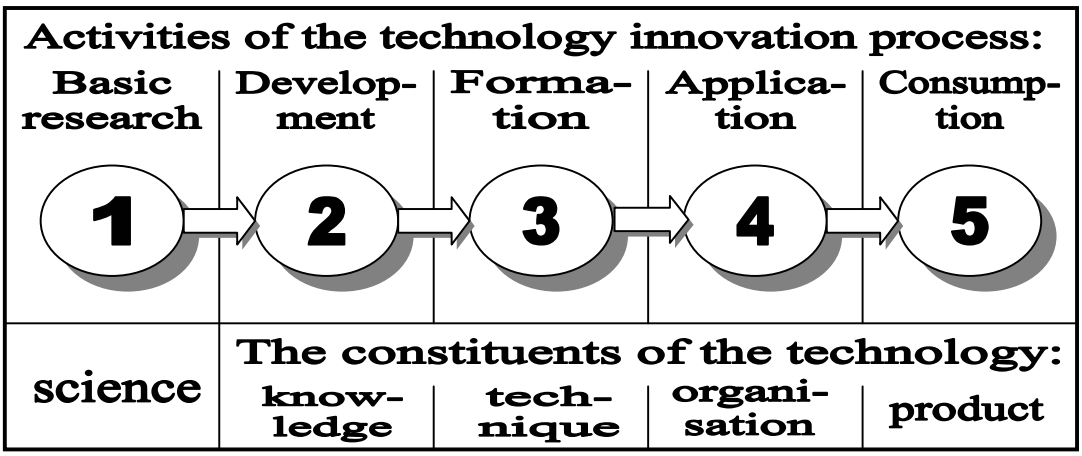


Figure 4.1a: The conventional uni-liniar conception of the phases of the technological innovation process. Source from {Müller, 2001}

Figure 4.1b: The Chinese endogenous linear development of the technological innovation

Figure 4.1 endogenous linear development models

The Chinese government has a declared policy of encouraging innovation and has implemented a program to develop Chinese technology standards in a number of strategic industries as well as renewable energy industry. On May 6, 1995 the Chinese government

issued the 'Decision of the Central Committee of the Chinese Communist Party and the State Council on the Acceleration of Progress in Science and Technology'. The Decision set the goal of overall (both public and private) to attain Chinese R&D spending equivalent to 1.5 percent of GDP by the year 2000. It urged scientific academies and institutes of higher education to set up high tech companies. The Decision noted that science and technology are the chief forces of social and economic development. {Technology, 2003}

Currently the renewable energy development initiative in China is from both national and international side. The endogenous renewable energy technology development in China is coming from both the top and the bottom: technology transformation pushed by national system and innovation launched by enterprises.

4.3.1 The national renewable energy technology transformation system.

There are many entities involved in the Chinese renewable energy technology transformation procedure; those entities mainly can divide into central government level and local level. The central government level mainly consists of four ministries, one commission and one research institute. The local level includes the relevant local government sectors and entities, universities and local research institutes, as well as relevant enterprises. In addition, the NGOs (non-government organization) also are play a very active role in renewable energy development. E.g. the Chinese Renewable Energy Industries Association (CREIA). See *Figure 4.2 endogenous renewable energy technology R&D framework in China*

- **The National Development and Reform Commission (NDRC)** is the former state planning commission. In March 2003, it changed the name to National Development and Reform Commission and took over the responsibilities of state economic and trade commission (SETC).

  The National Development and Reform Commission (NDRC) is a department of the State Council. NDRC is macro-economic regulatory department, with a mandate to develop national economic strategies, long term economic plans and annual plans, and to report on the national economy and social development to the National People's Congress. NDRC has fourteen major areas of responsibility, one of which is to make the energy resource development plan, and the guideline for advancement of hi-tech industry. {NDRC, 2005}

- **The Energy Research Institute (ERI)** is a part of the National Development and Reform Commission. It is responsible to construct energy development strategies, planning, policy, law and standards for the Chinese government, and public and private

sector clients; to conduct cooperative study and academic exchange in energy areas with relevant international agencies, foreign governments, organizations and academic entities; to offer relevant consultant services. And one of its research scopes is to study the pathways and measures for new and renewable energy industrialization at home and abroad; furnish a decision-making base to government agencies for formulating mid-and long-term development plans and relevant industrial policy; disseminate information on new and renewable energy industrialization. {ERI, 2004}

- **Ministry of Science and Technology (Most)**'s responsibilities are to research, set forth and conduct the macro strategies, guidelines, policies and regulations for science and technology to promote economic and social development; to guide and coordinate the science and technology management work of various ministries and commissions under the State Council as well as that by provinces, autonomous regions and municipalities; to take charge of the budgets and final accounts of science operating expenses.{ Most, 2005}
- **Ministry of Water Resource:** mainly manage and utilize water resource, including hydropower.
- **Ministry of Agriculture:** mainly manage and develop agriculture and rural resource, include rural renewable energy resource utilization.{MoA, 2005}
- **MoEP:** this is the former Ministry of Electric Power of PRC. Now it consists of several state grid corporations, power corporations and power construction corporations. It responsible for electricity management and development.
- **NAoF:** National Administration of Forestry is responsible for fuelwood and other wood energy resources
- **863 program:** named Hi-Tech Research Development program of China. In line with national objectives and market demands, the program addresses a number of cutting-edge high-tech issues. One of the issues is to achieve breakthroughs in key technologies for environmental protection, resources and energy development to serve the sustainable development of our society. {863, 2005}
- **973 program**: named National Basic Research program of China. The purpose of this program is to strengthen basic research in line with national strategic targets. Based on the existing basic research programs conducted by the National Natural Science Foundation and early-stage basic research key projects, the 973 Program organize and implement key projects to meet the national strategic needs. The strategic objective of the Program is to mobilize China's scientific talents in conducting innovative research on major scientific issues in agriculture, energy, information, resources and environment, population and health, materials, and related areas. {973, 2005}

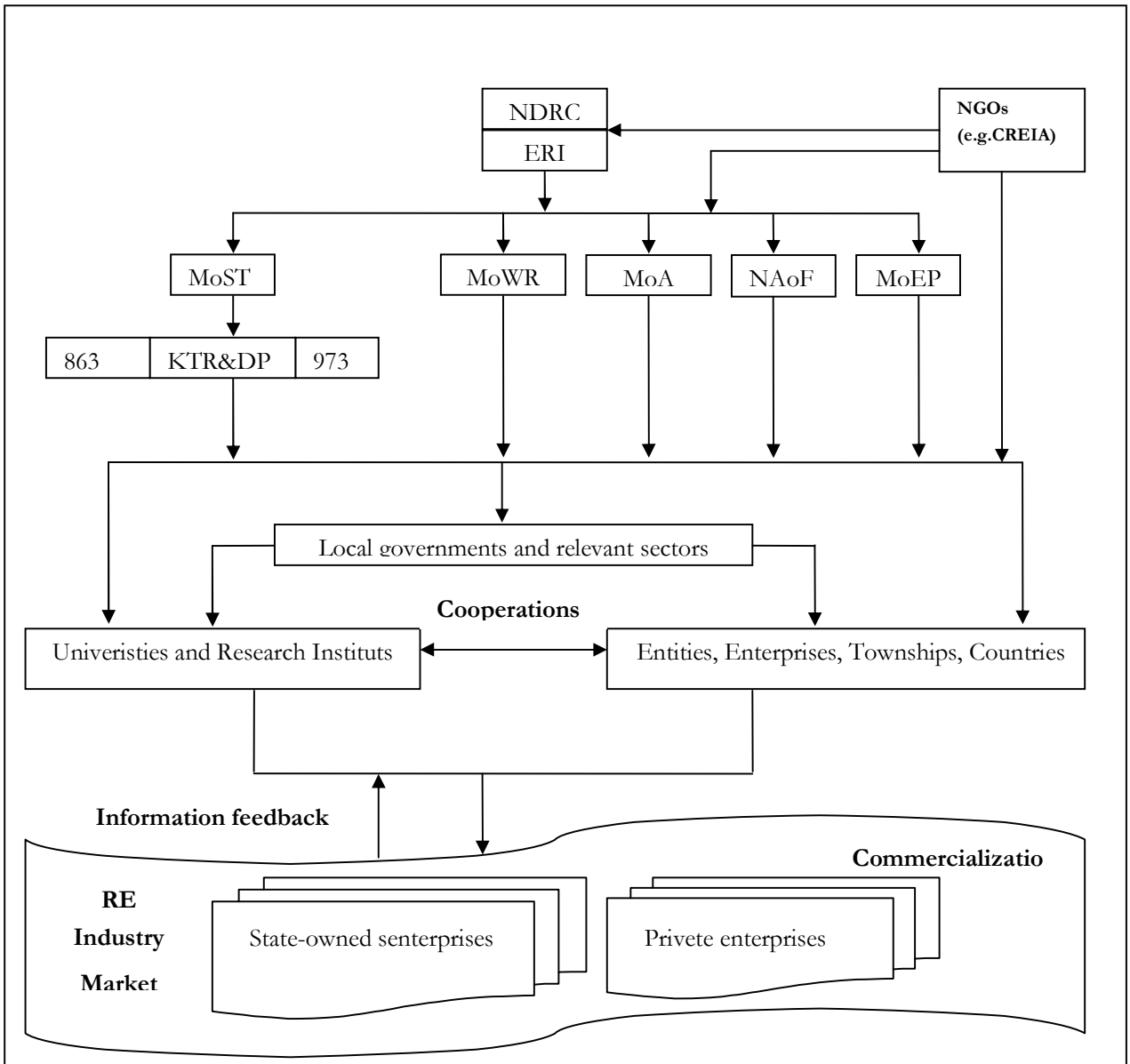
- **KTR&DP**: called Key Technologies R&D Program. The major goal of the Program is to address pressing major S&T issues in national economic and social development. Environmental protection and rational utilization of resources also is one of its priorities.{KT, 2005}
- **NGOs**: the NGOs are also very important support for Chinese renewable energy development. One of the representational organizations is the Chinese Renewable Energy Industries Association. The Chinese Renewable Energy Industries Association (CREIA), established through the UNDP and Global Environmental Facility (GEF) project, is a business-led, independent, and self-financed association, working for the interests of its industry members. CREIA serves as a middleman between regulatory authorities, research institutes and industry professionals. It provides a forum to discuss renewable energy development at the national level and subsequently to advise the central government on strategic policy formulation. CREIA is intended to be a window bringing together national and international project developers and investors. It plans to promote technology transfer and raise awareness of renewable energy investment opportunities through the development of an online Investment Opportunity Facility, and through regional networking meetings and training activities.

a) Planned technology pushes

Chinese government regards renewable energy technology as key HI-technology and given a high priority for its development. They implement a top- down, research and development oriented approach to develop renewable energy industry. The central government provides fund to support science and technology research in renewable energy field, and sets up demonstration projects in order to obtain the practical operation experiences, and makes favourable policies for renewable energy commercialization

The ERI is a very important sector and has big influences for renewable energy development in China. The ERI owns many experts in energy field. They make plenty researches and investigations about renewable energy resources, technology development, energy deployment, commercialization, etc. Basing on those research results, they work out the preliminary proposals, plans and policies for the NDRC. According to those suggestions, the NDRC makes formal renewable energy strategies and policies. With the guidelines the NDRC assigns tasks to the MoST, the MoWR, the MoA, the NAoF and the MoEP. Then those ministries will make embodied schemes according the practical cases in the scope they manage.

The MoST is major sector for Chinese science and technology development. It manages three key state science and technology programs: KTR&DP, 863 program and 973 program.



NDRC: the National Development and Reform Commission

MoST: Ministry of Science and Technology

MoWR: Ministry of Water Resource

MoA: Ministry of Agriculture

MoEP: former Ministry of Electric Power

ERI: Energy Research Institute

NaoF: National Administration of Forestry

863 program: Hi-Tech Research Development program of China

973 program: National Basic Research program of China

KTR&DP: Key Technologies R&D Program

Figure 4.2 endogenous renewable energy technology R&D framework in China

According to different emphasis, renewable energy research projects are put into the three programs separately. Those Programs has provided a more streamlined form of funding that enables the Chinese government to target specific goals through directed R&D spending. The Program funds are allocated directly to experts rather than through a large bureaucratic system. Thus, the government is able to fast-track its S&T priorities. E.g. the MW wind turbine technology research project of the 863 program. Sometimes, some of ministries jointly perform certain project. E.g. the Rural Electrification plan performed by the MoA and MoEP.

Local governments charge the local industries, agricultures, energies supply etc. they are responsible for local economy development. According to central government policies and local facts, they make local strategies and plans, including technology development plan and project. The local government will provide fund to support those science and technology research projects. Generally, those research projects closely combine the locally practical demands. Sometimes local and central entities cooperate to implement a project accordingly.

All of the renewable energy research and development programs and projects finally will invite public bidding and adopt project management system which includes calculation of the full budget, total cost accounting, and a project leader responsibility system. The bidders come from national research institutes, universities, local research institutes and the enterprises which own the capacity of research. Sometimes, some entities jointly undertake one project, e.g. one university and one enterprise. This kind of combination would be beneficial for technology industrializations

b) Market-driven technology development

Since 1978, along with the dismantling of the planned economy system and the deepening of the reform of the economic system, commodity, capital, labor service and technology markets have appeared one after the other in China. Now China has transformed its planned economy system into an initial socialist market economy system. As a result the regulatory function of the market has been strengthened tremendously. {China window, 2005}

Before the reform of the economic system, the China only had the two types of enterprise: state-owned enterprises and collective enterprises. Via total privatization of state-owned and collective enterprise in these years, the nature and amount of Chinese enterprises have changed largely. See *table 4.2 the change in Chinese enterprises.* From this table we can see that the state-owned and collective enterprises have been fading out the market gradually. Except few

state-owned enterprises controlled by government, most of enterprises have to undertake sole responsibility for its profits or losses without government support and compete with the other enterprises in market. Under this kind of circumstance, the enterprises have to strive to strengthen the capacity of product quality, technology advancement, financing in order to survive from market competitions.

Enterprises (In China)	1995 Year (%)	2002Year (%)
State-owned	70.6	31
Collective	18.7	9.9
Private	0	5.6
Foreign	2.6	13.4
Hongkong and Taiwan	3.2	11.4
Mixed	5.8	28.6

Table 4.2 the change in Chinese enterprises based on {Economy, 2004}

At the beginning, the renewable energy sectors consist of state-owned and collective enterprises. They were set up to mainly meet the energy demands in term of government plans, e.g. hydropower companies in rural areas, wind power companies in Xinjiang. They construct the initial basis of Chinese renewable energy industry. With the deepening of economic reform most of them have changed to joint-stock or another type enterprises, which completely or incompletely broke away from government control. Therefore, they have to face the competition from market directly. Especially after China entered the WTO, without government trade protection the international competitors are giving them huge pressures. Under this situation, the Chinese companies have to strengthen individual capacity in aspects of management and technology to make survival and self-development. For example, the Chinese wind turbine companies are looking for advanced technology to make technology breakthrough. Currently, they are actively cooperating with universities and research institutes to catch up with developed countries technology level. Because the backward wind turbine manufacturing technology and unreliable quality have caused Chinese wind turbine weak competitiveness and less market proportion.

Besides, from the 1990s onwards, with the great advocations from both central and local governments for environment protection and energy diversifications a number of policies have been implemented to create favourable renewable energy industries market surrounding, e.g. part value-added tax exemption. No matter if those policies had had actual effects; the positive atmosphere had been created and greatly strengthened the confidences of investor. Some of renewable energy markets start booming in some of cities and provinces. Many enterprises are involved into the market since the profit potential seems huge, e.g. solar water heater market.

The solar water heater developing procedure is one of the good paradigms to demonstrate the effects of enterprises technology innovation. The solar water heater sector has rapidly developed in the recent years. Its annual productive capability and sale volume has increased at average rate of 20-30%. At present, there are about 1,000 enterprises engaging in the research, production, sale and installation of the solar water heater, with annual output of solar heaters of more than 3,000,000 and the value of 3 billion RMB yuan. Solar water heater production capacity in China is the first in the World. The product sale not only in China but also in Southeast Asia as well as in Europe and America, brings better economic and social benefits. The reason why solar water heater sector developed rapidly and was more competitive is mainly the improvement of the solar heater technology and the development of the product according to the market requirement. {Enterprise, 1998} The types of the solar heaters on the market are mainly integrated solar heater, plate solar heater and vacuum tube solar heater. The vacuum tube is currently the most popular type of collector in China. In 1996, the flat-plate collector was still dominant, with a market share of about 70%. However, the market for vacuum-tube collectors grew so quickly from 1999 that it soon took the lead, with an 85% share in 2002. {China solar, 2003} These solar heaters have different technical character and price, and can meet the need for the different consumers. Besides, a number of manufacturers are working together with universities to develop suitable new products and technologies for future customers' demands from both domestic and international markets. Apparently the constant and reasonable technology self-improvement have provided solar water heater enterprises strong viability

The drastic market competition forces Chinese enterprise to constantly strengthen self-viability from multi-aspects. Currently some of enterprises have moved developing emphasis on the technology innovation in order to lead the others competitors. Some signs indicate that this trend is gradually boosting up. According the joint proclamation from statistics bureau, the ministry of science and technology and ministry of finance the spending for science research and development in 2003 increased 19.6% than last year and accounted for 1.31% of GDP. It

was highest history level. Hereinto, the national finance input reached 97.55billion RMB Yuan, the enterprises input reached 96.02 billion RMB Yuan, only 1.5 billion RMB Yuan less than national finance input. The experts forecast that the enterprises technology research and development input will surpass the national input. {Beijing, 2004} Apparently, with this kind of situation and atmosphere the renewable energy enterprises will more and more focus on the sustainable technology progress instead of simple labour-intensifies production.

4.4 The international technology cooperation

4.4.1 Why international technology cooperation happens

- The need caused by huge technology gap

Although the Chinese technology R&D expenses are constantly increasing in recent years, see *table 4.3 R&D expenses,* the investment intensity in R&D is still very low compared to the developed countries, e.g. the Sweden's technology expenses reached 3.78% of GDP in 2001 {DG, 2002}.

Year	1994	1995	1996	1997	1998	1999	2000	2001
R&D Expenses (million US$)	3692	4222	4873	6135	6640	8180	10795	12560
As% of GDP	0.66	0.60	0.60	0.64	0.69	0.83	1.01	1.09

Table 4.3 R&D expenses data provided by Ministry of S&T and State Statistic Bureau

The long-term lower input in science and technology development causes the big technology gap with developed countries. Backward technology level undoubtedly has impeded the Chinese economy development seriously. Under this situation even Chinese government has started to put more money on it in recent years, however, if only depending on china alone to develop science and technology, it still will cost a very long period to catch up with developed countries technology level considering Chinese present total science and technology basis. Therefore, the technology assistance and cooperation from the developed countries would be a short cut for speeding up Chinese science and technology development as well as Chinese economy growth.

- The benefits for technology suppliers

In recent years, a number of international technology cooperation addressing renewable energy application happens in China by different cooperation types, e.g. international technology communication or cooperation, joint ventures, poverty alleviation and so on. The technology suppliers will benefit in the longer run by delivering technology which enters into sustainable technology transformation processes in the receiver end. {Müller, 2001} For example, in the specific case about renewable energy technology transfer, they can benefit by exploitation of Chinese renewable energy market, green house gases reduction and so on. A good example is the Clean Development Mechanism (CDM), which can link the industrialised and developing countries together to combat the climate change. It intends to assist developing countries achieve sustainable development by providing incentives for industrialised countries to invest cost-efficient GHGs reductions projects in these countries. The developed countries can receive some credits by investing and implementing GHGs emission reductions projects in the developing countries, then use these credits to fulfil their legally binding quantitative obligations laid down in the Kyoto Protocol. The developed countries have made commitment to provide official development assistance at 0.7% of their GDP to developing countries and transfer sound environmental technologies on preferential terms. {Kyoto 2004} China has a large potential to implement CDM projects. The technologies, which can improve the air quality while reducing CO2 emission, will have more advantages. These technologies include wind power, solar energy, biomass and geothermal energy.

4.4.2 Renewable energy technology international cooperation

In last 40 years China made a big progress in scale, technology source, pattern and channel for technology transfer. See *table 4.4 Technology phase in China* {Chen, 1997}

Before 1979 (1950-1978)	• Technology transfer was controlled by centre government. • Size and focus of technology import strictly follow the economic development requirement, which was made by central government as long-term plan. • Localization of the technology cooperation was unified managed by responsible ministries. • Pattern and channel of technology import mainly relied on trade and complete set. • Total contract payment for technology transfer is US$14.8billion
After 1979	• Local government participated the management for technology import. • Parties of technology import started to shift from government to enterprise. • More and more laws were made to replace government regulation

	management. • Total contract payment reached US$30.2 billions from 1979 to 1990.

Table 4.4 Technology phase in China {Chen, 1997}

As we have mentioned in the research methodology section, we convince renewable energy technology as a combination of technique, knowledge, organization and product (so called hard ware, soft ware, org-ware and ware). {Müller, 2001} Therefore, the renewable energy technology transfer can be easily understood as an all-around cooperation from part of technique, knowledge, organization and product. In China, with the further deepening of economy reform the options and strategies for renewable energy technology transfer have changed gradually. The emphasis of import technology trends to know-how and know-what rather than simply a product, e.g. the big capacity of windmill initially depends on importation in China. However, under the heavy pressure of high facility cost and demand of self development and survival the windmill manufacturers currently are interested in the windmill design data and producing skill much more than simple assembling the imported parts of windmill. See *figure 4.2 Dynamic assimilation of renewable technology transfers in China. Based on* {Müller, 2001}. And for those enterprises who have high capacity in R&D, they even start the cooperation in development level with foreigner partners.

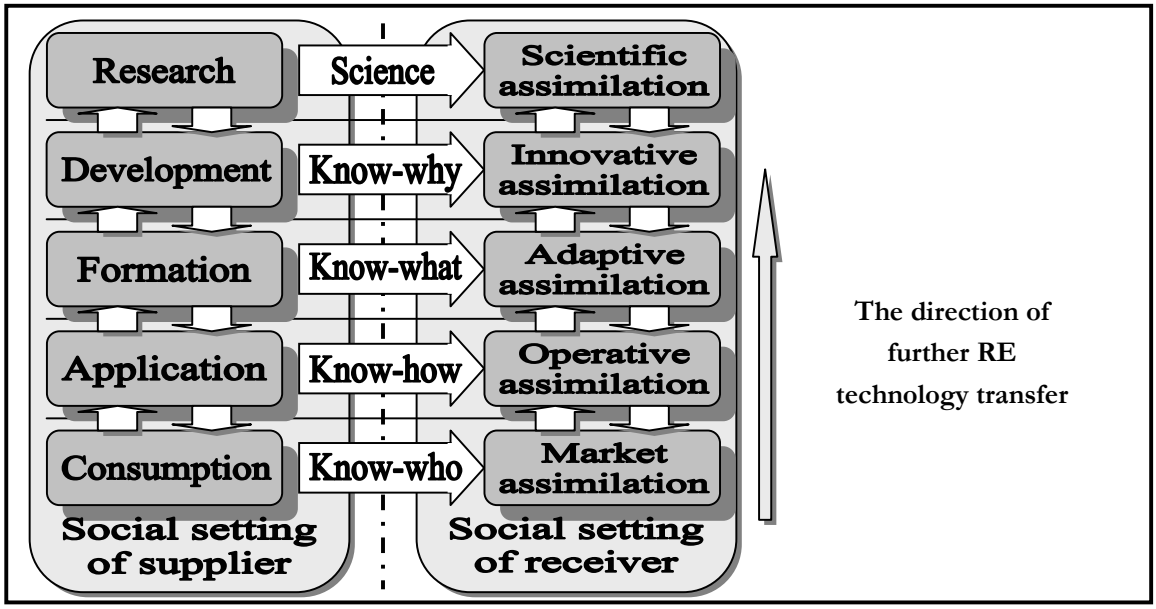


Figure 4.2: Dynamic assimilation of renewable technology technology transfers in China.Based on {Müller, 2001}.

In addition we have to be clearly aware that the technology transfer processes happen between two different societies. It is not simply about the supply and shipment of hardware across international borders. It is about the complex process of sharing knowledge and adapting technology to meet local conditions. To successfully perform a technology transfer, both the technology and social setting are changed or "moved" to fit each other at some point, which hardly can be predetermined. {Müller, 2001} see figure 4.3 the technology transfer problem symbolically illustrated. Therefore, the technology transfers from developed countries are not only simply improve the Chinese renewable technology level, but also make significant influences on the Chinese institutional, financial and infrastructure aspects as well as policy making.

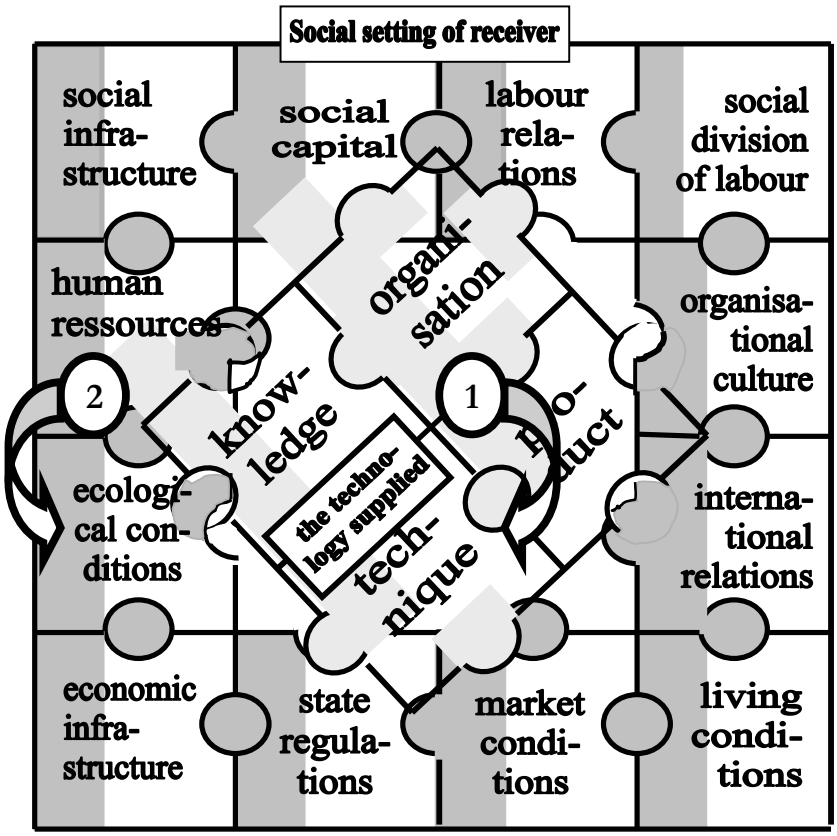


Figure 4.3: The technology transfer problem symbolically illustrated {Müller, 2001}

A paradigm is the project named "Capacity Building for the Rapid Commercialization of Renewable Energy" sponsored by the UNDP/GEF in China. See *table 4.5 international cooperation project: Capacity Building for the Rapid Commercialization of Renewable Energy*

Name	Capacity Building for the Rapid Commercialization of Renewable Energy
Sponsors	UNDP and GEF
Financing (Million)	GEF $8.8M, Australian AusAid Program $3.0M, Netherlands Government$2.5M, Chinese $11.5M
Project focus	1 village-scale power for household electrification and rural industry using hybrid wind and solar PV system with battery storage and diesel backup generators 2 biogas from industrial and agricultural organic waste effluents 3 solar hot water heating for building 4 wind power for grid-based power generation 5 bagasse cogeneration for gird-based power generation
The direct and indirect achievements of project	● Demonstration installation, training activities, national standards(4 solar hot water industry standards), resources assessment(solar and wind) ,national testing institutions(solar water heaters). ● Policy facilitation, financing studies, business models market information, best practice guide, China Renewable Energy Industries Association (CREIA), and so on.

Table 4.5 international cooperation project: Capacity Building for the Rapid Commercialization of Renewable Energy {CREIA, 2002}

Currently the project is still mid-way through implementation. However, as we have seen in the table, the project has made significant influences on Chinese society. One of the major outcomes is the project indirect influence on the successful introduction of renewable energy policy targets in the national Tenth Five Year Plan. These targets call for 5% of new power generation to come from renewables by 2010. {CREIA, 2002} Whereas, the project also adjusted itself in order to accommodate the Chinese changing policy circumstance. For instance, the village-scale power program was restructured to adapt to the government's National Township Electrification Program in western China. {CREIA, 2002}

4.5 The barriers for renewable energy technology progresses in China

The participants in renewable energy technology transformation include those involved in the direct transactions – private firms, state-owned companies and individual consumers. But others play important roles "behind the scenes" – financiers, aid agencies, national governments, international institutions and local community groups. All of units make up a innovation net work. The renewable energy technology transformation works best when all stakeholders communicate and actively participate. However, inevitably there are some barriers hindering the renewable technology transformation process, especially in China, which did not put in plenty of capital and manpower in this area in the past decades. Here we will discuss the barrier mainly from two aspects: one is endogenous renewable technology and another one is exogenous technology.

- Barriers for endogenous renewable technology transformations

- **Not suitable technology research and development with market demands**

a) Currently the renewable energy technology development is still mainly supply-driven by national planning system since many kinds of renewable energy have not formed favorable market surrounding and have weak or inadequate response for user needs.

b) Further, R&D for development/upgradation of RE products is constrained by the limited budget. The total R&D budget in the PRC is less than US$ 10 million per year for all RE technologies. There is only about 10 million RMB yuan for bioenergy, which leads to slower technology development than the market demand. Besides, the most of renewable energy enterprises are SMEs and have less financing capacity to support R&D of technology. It leads the slow development of renewable energy products. For example, there are more than 100 villages that have biomass gasification systems for cooking fuel; however, the technology itself is still in the R&D stage. This will result in limited market penetration of RE technologies.

c) As most of renewable energy technology R&D need plenty investment, in China almost all renewable energy R&D activities are carried out by the central government. Local government and industry rarely participate in renewable energy R&D. Therefore, the achievement of R&D can not be turned into practices immediately and it will need more procedures and time.

- Barriers for exogenous renewable technology transfer and dissemination

- **Repeat technology import:** The phenomenon of repeated technology import still happen very often. There are some reasons behind it. One of them is that the imported technology

localization is still not promoted too much. Another reason is that the enterprises and research institute which have already own the technology do not often communicate to each other.

- **Hardware and product import rather than software:** The most of technology transfer still concentrate on product and simple technique (hardware), rather than knowledge (software). Therefore the present renewable energy technologies are heavily rely on some developed countries. .
- **Different focus on technology transfer:** parties in developed countries hope to extend their market in China, while parties in China expect to get the best and completed technology to improve economy development.
- **Weak capacity to accept advanced renewable energy technology**

a) Lack of access to relevant and credible information on potential partners to select, import, develop and adapt appropriate technologies.

b) Lack of relevant experiences for renewable energy technologies transfer.

c) Lack of financial institutions or system to ensure initial investment for utilization and extended use of transferred renewable energy technologies. Especially for the privet renewable energy enterprise (most of them are small and medium size) without the sufficient capital, it is hard for them to obtain timely and reliable science, engineering and technical knowledge.

d) The relevant renewable energy technology infrastructure is relatively weak. The productions of these new technologies heavily rely on basic material, processing level and labor quality. Besides, localizations and disseminations of advanced renewable energy technologies have higher demands on many aspects as well. E.g. the plenty professionals trained with expertise

- **The imperfect renewable energy market blocks the relevant technology transfer**

a) Lack of full-cost energy pricing, which internalizes environmental and social cost; therefore, hinder the renewable energy technology development including foreign technology transfer.

b) Inadequate policy and incentives also hamper the renewable energy development. For instance, low and often subsidized conventional energy price results in negative incentives to adopt renewable energy technologies, e.g. wind power.

c) The huge investment and unsure future profit margin from renewable energy industry cause the wait-and-see attitude of financial institutions.

4.6 The conclusion

Under the existing development statement of renewable energy industry in China, both domestic R&D of renewable technology and technology transfer from abroad is urgently needed to enhance Chinese renewable energy technology level, therefore reach the purpose of technology localization and lowering cost, and promote the competitiveness of renewable energy industry. However, without additional incentives this goal will not be easily realized in the near future since of the big investment capital and unpredicted future risk. The only way to break the dilemma is that the Chinese government implements effective measures and takes actual actions to strengthen the investors' confidence.

Chapter5: Government and policy instruments

5.1 summary

The China has substantial potential of renewable energy resource. During the last decades the big progresses have been made to meet the demand of economy growth in utilization of renewable energy resource in China. However, with more and more rapid growth of economy, the new situation which consists of urgent energy crisis situation, huge international pressure of green house gases emission reduction, and national energy security, etc., put forwards higher request for the Chinese renewable energy utilization. The renewable energy has been expected to play a more and more important role in Chinese energy structure in the 21st century.

As we have discussed before, without the additional assistances from government the renewable energy technology can not easily pass through the existing barriers to reach commercialization phase in a short term. Unfortunately, the existing supports from government seem unable to accelerate the renewable energy development further. The problems existing in the policy instruments should be examined and corrected immediately. New and effective policies are needed to create more favourable development spaces for renewable energy industry and to ensure faire competition with conventional energy. The powerful supports are especially important in the initial stages of renewable energy development, since most of renewable energies in their initial stages have the characters of high capital cost, small scale production and low profit margin, which can not be overcome by self-development.

In this chapter it is to analyze the Chinese energy policy framework, to examine the existing problems in the policy implementation and to device the measure to overcome the barriers we have identified before.

5.2 Institutional and policy framework for renewable energy development in China

5.2.1 Institutional framework in China

In China the institutional framework for renewable energy development consists of some agencies from central government level and local level. The central government level includes the National People's Congress (NPC), State Council (SC), NDRC (the National Development and Reform Commission), and some relevant departments including Ministry of Science and Technology (MoST), Ministry of Agriculture (MoA), Ministry of Water Resource (MoWR), National Administation of Forestry (NAoF) and State Power Corporation(SPC, the former Ministry of Electricity). See *figure 5.1 the institutional framework for renewable energy policy*

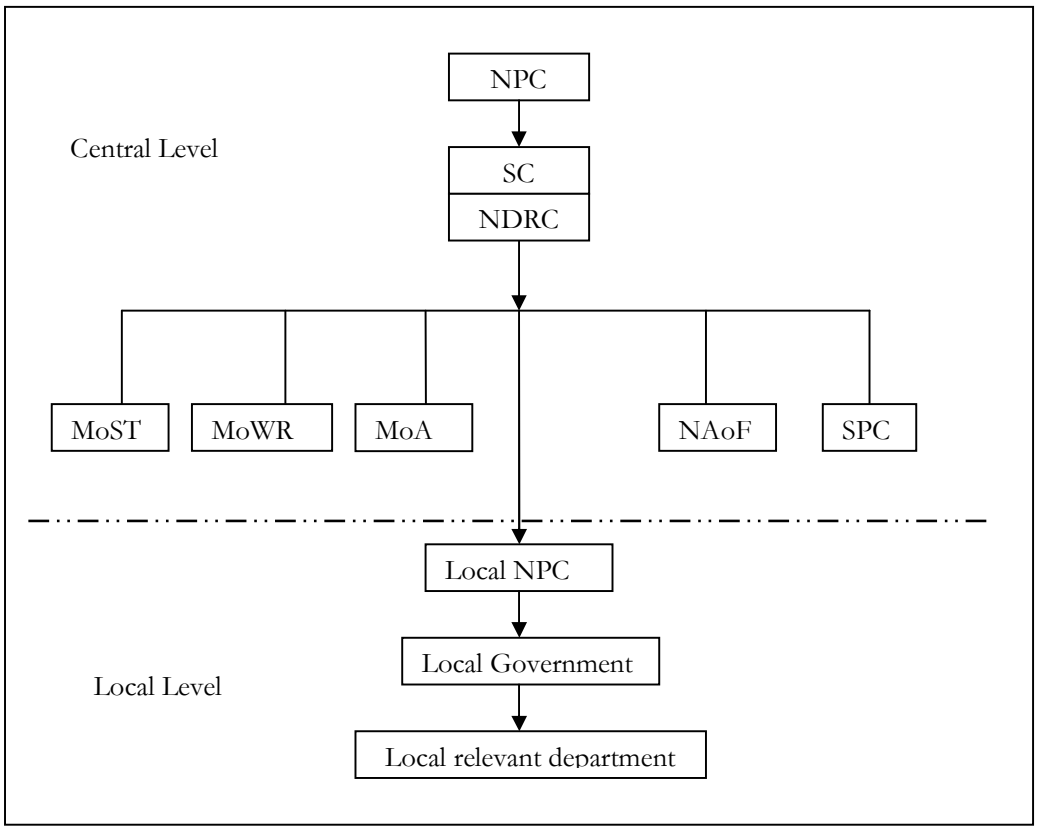


Figure 5.1 the institutional framework renewable energy policy

- NPC (National People Congress)

The NPC is the paramount institution involved in the development of renewable development in China. It is responsible for approval of national level of legislation and policy, as well as the government planning and budgeting for all facets of economic development.

- SC (State Council) and NDRC

The State council takes the responsibility of making policies for setting standards, pricing, customs duty, taxation, etc. VAT and customs duty reduction should be approved by the state council. The SC is also responsible for all national development and budgeting. The State Council also can lay down regulations by itself to promote renewable energy or it can authorize any of its ministries or commissions. NDRC is a powerful government agency under the State Council. The functions refer to chapter 4.

- The other institutions

The other institutions respectively are responsible for R&D of science and technology, the development of water resources, rural energy, and forestry resources accordingly.

- The local level

The same institutional arrangement exists as at the central level. They consist of local NPC and relevant local government agencies.

5.2.2 Policy framework in China

Policies on renewable energy (RE) development can be categorized into three classes in terms of their scope and characteristics. See *table 5.1 renewable energy policy frameworks.* At the first level are those that provide general direction and guidance. At the second level are those specifying goals/objectives and development plans. The third level consists of practical and specific incentives and managerial guidelines. The three levels support one another and are linked closely together. Directions and guiding policies included in the first level provide the foundation and environment to facilitate the implementation of the other two, while the second level also serves as guideline for the third level. The third-level policies realize ultimately what the previous two levels require [Zhao et al., 1998].

Level	Enacting institutions	Note
First level	Central government and relevant departments	General direction and guidance. E.g. speeches of state leader. 1995,Outline on New and Renewable Energy Development in China 1992, Ten Strategies on China's Environment and Development, etc.

Second level	Central government and relevant departments	Specifying goals/objectives and development plans, e.g. 1994, Brightness Program and Flow Wind program 1996, Ninth Five-Year Plan of Industrialization of New and Renewable Energy Development, etc.
Third level	Local government including provincial governments and municipal governments as well as country governments	Practical and specific incentives and managerial guidelines, which is crucial to realize the objectives of renewable energy development, e.g. In Inner Mongolia, 3% value added tax on wind power generation (normal value added tax is 17% in China)

Table 5.1 renewable energy policy frameworks of China

5.23 The objectives of Chinese renewable energy policies

In recent years, the surging international energy situation and the ever increasing pressure on the environment including greenhouse emission mitigation, pollution prevention, etc. have turned the attentions of many countries to the renewable energy resources. Many countries have adopted various policies to accelerate the development of renewable energy technologies with a goal of having renewable energy become an important part of the energy supply system. There are two different but complementary approaches to achieve the goal. One type is aimed to improve the performance and reduce the cost of renewable energy technologies. This group of policy initiatives includes publicly supported research and development efforts to refine renewable energy technologies. Another type of policies is designed to enhance market opportunities and remove market barriers for renewable energy technologies. It includes policy initiatives to create a demand for renewable energy, increase production, and improve renewable energy technology sales and services systems. {Comparison, 2004}

In China the objectives of renewable energy policy were clearly defined in the outline of renewable energy technology development program in 1995. The overall policy objectives and tasks which will be carried out for the next 15 years for renewable energy development in China are: {Outline, 1995}

- To raise efficiency;
- To lower production cost;

- To increase the contribution of renewable energy in the energy structure

These objectives will be achieved in two phases. See *table 5.2 renewable energy developing phases*

First phase (1996-2000):	In this phase, the quality of most local RE technologies will get close to or catch up with the advanced level of developed countries through research and development (R&D), and demonstration. Some mature technologies will be commercialized, applications will be extended, and markets will be developed gradually. The traditional less efficient bioenergy systems will be improved, and wind/solar energy systems will be developed to contribute to the electrification of remote areas and islands, where electricity is unavailable.
Second phase (2001-2010):	In this phase, RE technologies will be fully commercialized. The R&D facilities and efforts will be of high standard and the utilization of all kinds of RE will increase from the present figure of 8800 TJ to 11400 TJ.

Table 5.2 renewable energy developing phases

5.3 The Chinese renewable energy policies and actual effect

To realize the objectives and promote renewable energy development, a series of supporting policies were stipulated by central and local government during various development period of renewable energy. Actually the conscious effort to develop renewable energy resources was started with the Eighth Five-Year Plan. Since that, Renewable energy development and utilization have been an important part of the national development strategy. It is included in the "China Agenda 21," the "Guidelines of the Ninth Five-Year Plan," and the "Long Term Objectives on Economic and Social Development of China" as one of the national programs. To promote the renewable energy development, the State Council approved the "New and Renewable Energy Project in Priority" in 1995. These efforts have led to substantial development of renewable energy in China.

5.3.1 The functions of current renewable energy policy in China

The current policies mainly promote renewable energy utilization from following two aspects: cost and price. Only if the cost of renewable energy product decreases, the price can be competitive with conventional fossils-fuelled energies. In order to realize the purpose, the

Chinese government use many kinds of policy to stimulate the renewable energy market. See *table 5.3 the means to regulate the renewable energy cost and price*

	Reglating aspect	Policy means
Cost reduction	Mass production	Normally the regulatory approach is effective for increase production. E.g. mandatory purchase, renewable energy certificates (experimental phase), subsidies for consumer, etc.
	Transition cost reduction	From starting renewable energy project to renewable energy production, to renewable energy products trade-off, to consumption, there are many barriers among the procedure. Therefore, according different type energy, setting up standard procedure for implementing project, energy trade-off, etc. will effectively reduce transition cost.
	Facility localization	Subsidies, tax reduction and low interest loan, etc. for R&D and technology transfer of renewable energy, and domestic project bid
Price reduction	Market competition mechnism	Public bid of project, renewable energy certificate trade, etc.
	Internalize externality of conventional fossil-fuelled energy	According polluter pay principle, Charging the conventional fossil-fuelled energy pollution fee

Table 5.3 the means to regulate the renewable energy cost and price

Currently the Chinese renewable energy policies mainly can categorized into following four types: Regulatory approach, Economic incentives, R&D supports and Market development

The government uses these four types to realize the purpose of reducing cost and decreasing price of renewable energy technology, therefore obtain consequence of broad utilization of renewable energy. Some of those policies have been put into corresponding column according different policy type as reference of following discussion. See *Appendix B.*

- Regulatory approach

Regulatory approach is applied in form of law and is a kind of mandatory means. The government adopts regulatory approach to insure the realization of renewable energy development. It has a safeguard function for the initial development stage of Chinese renewable energy industry. For example, in 1995 the Chinese Government promulgated the Electric Power Act. The Electric Power Act is the first Chinese law that discusses energy policy.

- Economic incentives

The economic incentive approach is also called the marketed-based incentives approach. As environmental policy, it is established in terms of the Polluter Pays Principle (PPP). It adopts the economic instruments such as taxes charge, subsidies etc. to stimulate enterprises' interests for participations in the renewable energy industry and create a favourable marketplace for renewable energy development, therefore cause the well-ordered and sustainable development. For example, The average import duty now stands at 23%, but renewable energy technologies enjoy special low rates: of 3% for components of wind power plants, 6% for wind turbines, and 12% for PV systems.

- R&D supports

Central government supports renewable energy by establishing R&D strategy and plan for the renewable energy industry and funding many R&D projects directly therefore attain the purpose of decreasing cost of renewable energy product. For example, central government invested 7 million RMB in four PV generation stations (total capacity 85 kW) as the demonstration project during the Eighth Five-Year Plan.

- Market development

Establishing technical standards and codes for renewable energy technologies and renewable energy resource assessment are two other activities that are supported by Chinese governments. Although it is not directly related to the improvement of technology performance, technical standards and codes are important in establishing customer confidence and accelerating the commercialization of renewable energy technologies. Resource assessment activities provide valuable information to advance the renewable energy market. Knowing where a renewable energy resource may exist is valuable to developer or energy user because it allows them to focus on a general area for more detailed examination. General resource information also helps policy-makers devise sensible strategies to develop renewable energy.

In addition, the policies made for poverty alleviation and environmental protection also give huge impetus for renewable energy development in China. For example, according air pollution prevention and control law (promulgated on Sept.5, 1987 and revised on Aug.29, 1995) "the lowering of sulphur and ash content shall be promoted and mining of caol with high suffer and ash contents shall be limited." In March 2000, the penalty fees on excessive SO_2 discharge were raised from 200 Yuan/ton to 1,200 Yuan/t. Although this has started only in Beijing, the law will be adopted in other cities and eventually throughout the entire country. The sharp rise of SO_2 discharge fees will weaken the competitive edge of coal and enhance the competitiveness of renewable energy.

5.3.2 Some existing problems about Chinese renewable energy policies application

Many experiences from developed countries have proven that the renewable energy policy instruments have significant influences on the renewable energy development. Those countries have made big progresses on renewable energy utilization by effectively implementing renewable energy policy instruments. The experiences and lessons concluded by those counties undoubtedly are precious for renewable energy industry development in developing countries

The Chinese government also made some policies to accelerate the renewable energy development. However, as we have discussed before, though some significant achievements have been attained, many factors that have hampered the progress still remain. Issues such as the market failure to value public benefits of renewable energy, not enough investment in R&D, and lack of necessary infrastructure on market and technology development, etc. continue to limit the development and commercialization of renewable energy. As a result, progress of renewable energy development fails to keep pace with the economic development

Here some discussion will be made by following renewable energy policy of comparison between China and some developed countries; therefore we can achieve some significant enlightenment on some of the existing problems of the Chinese renewable energy implementation. See *table 5.4 policies comparisons between China and developed countries*

Policy type	Comparison of embodied measures	Comments
Regulatory approach: **Mandatory Purchase with Set prices**	• In 1995 the Chinese government enacted the Electric Power Act, which explicitly encourage power grid to employ renewable energy resources for electricity generation. The MOEP issued the "Parallel Operation Regulations for Wind Power Generation" in 1996 that required power grid to purchase energy from wind farms and established a pricing principle. • In the 1978, the Public Utility Regulatory Policies Act (PURPA) of USA required utilities to purchase electricity from power plants using renewable energy at utility's avoided cost.	There are two key differences between this law and the similar PURPA regulation in the United States: • PURPA requires utilities to purchase all electricity from independent power producers – not just wind. • The U.S. law, approved by Congress and signed by the President, is well enforced. China's regulations are more alike to plans approved by governmental agencies – they are not enforceable without the review and ratification by the State Council or the National People's Congress. In addition, they lack detailed implementation rules and regulations.
Economic incentives: **Government subsidies**	• Both Chinese government and many others countries adopt subsidies to stimulate renewable energy development. However, the capital investment has to be large enough in order to make significantly effect.	• In China, it is from the government's general revenue. Facing financial constraints, fund for subsidy is limited and its long-term availability is uncertain. • In the United States, funding for subsidies comes from special levies of electricity consumption (system benefit charge). • In the U.K. the fee on fossil-fuelled generation covered the incremental cost of nuclear and renewables. • In other European countries, a carbon tax is used to fund renewable purchases. These types of fees can be used for a variety of purposes. They help to internalize externalities and when the fee

Economic incentives: Tax reduction, low interest loan	• This is a common policy option in the United States. China also has similar tax incentives for renewable energy technologies (reduced income tax and reduced VAT). It is effective in increasing investment.	• This policy option does not have direct impact on reducing the renewable technology cost. It is very important to link tax incentives with technology improvement and market performance. An impressive lesson is the favourable tax credit for solar water heater in the United States in the 1980s. Although the tax credit did create a boom in the solar water heater market, the market collapsed after the tax credit expired.

Table 5.4 policies comparisons between China and developed countries

5.4 suggestions and conclusion

The experiences from many developed countries have proven that policy instrument is one of the most effective means to advance renewable energy development. In the recent years Chinese government has adopted many active policies to accelerate the renewable energy industries development. As the result, many significant achievements have been attained. However, some barriers still remain to restrict the further progress of renewable energy technology and commercialization. In order to realize the government objectives on renewable energy development and to meet the demand of rapid economy growth, Chinese government needs to take further actions to supplement and improve existing renewable energy policies and incentive measures. To this end, aiming at the barriers concluded from the discussion of prior two chapters and this chapter as well, we would like to make the following suggestions.

- Strengthen legislation and practicability of renewable energy policy

a) In China, the policy can be compulsory only when they have been approved by the State Council and National People's Congress. However, many of existing renewable energy policies is only the general plans or statements, which show out the government's attitude about energy development and environmental protection.

b) Some of existing regulation is vague and unpractical. A typical example is that the Ministry of Electric Power issued an executive order establishing a pricing principle in 1994. The price principle requires power grid to include production cost, debt service, taxes, and

reasonable profits in determining purchasing price of wind energy. However it is not clear if the law applies to independent power producers. The central utility authorities argue it only applies to them. Central utility authorities can refuse to sign power purchase agreements with independent wind developers. In addition, the costs for premium energy investments can not often spread across the entire province. Local distribution companies on the county or city level may bear all of the costs for wind power built within their jurisdiction. That means the higher the wind power proportion, then a higher burden for local power grid companies. Therefore, we suggest that this order be revised to clarify the confusion and also extend the purchase principle to cover all renewable energy technologies in addition to wind.

Many renewable energy policies have been implemented for a considerably long time. It is time to supplement and improve those policies that have suffered difficulties during the implementation according to the lessons and experiences we have learned. In addition, endowing law ad effect to policies can ensure the renewable energy policies implementation successfully. Good news is the Renewable Energy Law of the People's Republic of China has been approved by National People Congress and This Law shall become effective on Jan 1st, 2006. The law has formed a law framework for renewable energy utilization and development. It stipulates the mandatory energy purchase to all kinds of renewable energies. The relevant detailed pricing methods are been establishing. {Relaw, 2006}

- The more efficient institutions and managements

a) There are many institutions involved in the renewable energy utilization and development in China, due to the renewable energy (including electricity and heat) related to many aspects of society. There is no definitive explanation which government agency should undertake the overall responsibilities. The overlap and duplication often happens between relevant government agencies and make the renewable energy development inefficient. Therefore, setting up a responsible and powerful government agency is necessary to coordinate the management for renewable energy development. As we have anticipated, currently a government agency called Energy Authority has been set up under direct lead of State Council. The Energy Authority is responsible for coordinating and organizing the management of renewable energy resource and making middle and long-term plan for renewable energy development. It will exert its functions completely while the Renewable Energy Law enters into force.

b) Project management: to move a project from idea to reality, there are many procedures need be done, including obtaining agreements and approvals, making decisions, financing arrangement, and other similar activities. They cost plenty time and money, especially for

China that do not have too much experiences on this kind of project. These costs are strongly influenced by the societal institutions in which projects are being developed. The most effective mechanism for reducing costs is to standardize the analyses used to determine project, and the basic terms of agreements and contracts to implement them for different type project. So that all parties know exactly what is to be done and, more importantly, how to interpret the results.

c) Contract management for purchasing renewable energy: the renewable energy purchase is the most important support for renewable energy development. However, it also is very complicated and hard to attain because the current purchase policy, as we have discussed above, is still not very complete and practical. Therefore, a standard purchase contract mode will be necessary supplement for renewable energy purchase. In addition, the standard purchase contract has to be supported by national law and is opened for all of potential power producer who are seeking connection with gird. The standard purchase contract also will improve the efficiency of energy trade-off.

- Increase the investment in R&D of renewable energy technology and technical infrastructure construction

a) Currently the Chinese government is still the main supporter for R&D of renewable energy technology. However, the investment proportion is low compared the developed countries. There is a big gap between China and developed countries in renewable energy technology. Therefore, it is necessary for Chinese government to increase the investment on the renewable energy technology R&D so as to promote technology level and cut off existing high cost.

b) It is also necessary for government to make detailed assessments for renewable energy resource. For example, wind, solar and biomass etc. This will provide a reliable basis for policy and project planning and design.

c) In addition, due to the renewable energy industry is still in the initial stage in China, so the sufficient skilled and trained staffs are required to construct, operate and maintain the facilities.

- Import foreign experiences and lessons

The foreign experiences and lessons in the aspects of policy making, project management, energy purchase contract and technology are valuable for Chinese renewable energy development. Therefore it is beneficial for Chinese government and enterprise to closely cooperate with foreign government, organization and enterprise.

- Reasonable economic incentive design

Reasonable economic incentive design will attain good effect. Whereas, the bad scheme of policy will hamper the renewable energy development. For example, imported wind turbines have no customs duty. But components of wind turbines have a three-percent customs tax. This policy provides an incentive to import complete turbine units from abroad and not to use as much local equipment as possible. As a result, this discourages the development of local manufacturing capability.

- Strengthen pollution control policy

Strengthening the pollution control policy, for example increasing the intensity of penalty for so_2 emission, will greatly decrease the advantage of competitiveness of conventional fossil-fuelled energy and therefore, create more developing space for renewable energy.

- Increase the public awareness

Broad publicizing the renewable energy' significance on environment protection, energy security, and economy development will be helpful to assistant renewable energy development. For example, more people are willing to use solar heating.

Chapter6: Wind energy industry in China

6.1 The Chinese energy situation

In recent years, with the rapid growth of Chinese economy energy consumption of every year also has been constantly increasing. As a result, China now has been the second biggest energy consumer after the United States - having displaced No. 2 consumer Japan in 2003. {Economy, 2004} In 2003 electricity consumption in China grew by 10 percent. The new increase runs over the Chinese existing capacity of electricity supply and causes serious power shortage in some area of China, especially in the coastal economic developed provinces. The Chinese government had to adopt an emergency measure to mitigate this energy crisis. The power brownouts were imposed on a total of 21 provincial areas. However, the serious situation was not solved completely. The identical energy crisis happened again in 2004. An industrial report of the State Information Center with the National Bureau of Statistics forecasts that China will face more severe power shortage this year. Severe energy crisis causes huge obstacles for China's rapid economy growth. Under heavy pressure of energy crisis as well as environmental protection claim, China government starts to actively adjust existing energy structure so as to ensure sustainable economy development.

China's traditional power heavily depends on coal and big scale hydro. Unfortunately, there is only limited coal storage in China. And, the burning coal can produce a large amount green house gases and release harmful particulate emissions that cause breathing problems. The hydro resource is plentiful in China, but there is a controversial issue that the big scale hydro power construction probably causes seriously negative environmental impact e.g. Three Gorges Dam, there are many negative reports about the environmental impact of the Three Gorges Dam project now, even the project has not been accomplished completely. Therefore, it seems that the other competent alternatives are required to get China out of present dilemma.

6.2 The global wind developing situation

Wind power today is one of the most promising and cost-effective alternatives to the use of fossil fuels. Especially in recent years the cost per unit of wind-powered electricity has already

reduced dramatically as manufacturing and other costs have fallen. It makes wind power more competitive in electricity market. In some developed countries that have actively developed wind power in advance, e.g. USA, the wind power price has decrease to 0.04 US dollar/KWh and closed to the price of conventional fossil-fuelled power. See *figure 6.1 average wind power cost in USA.*

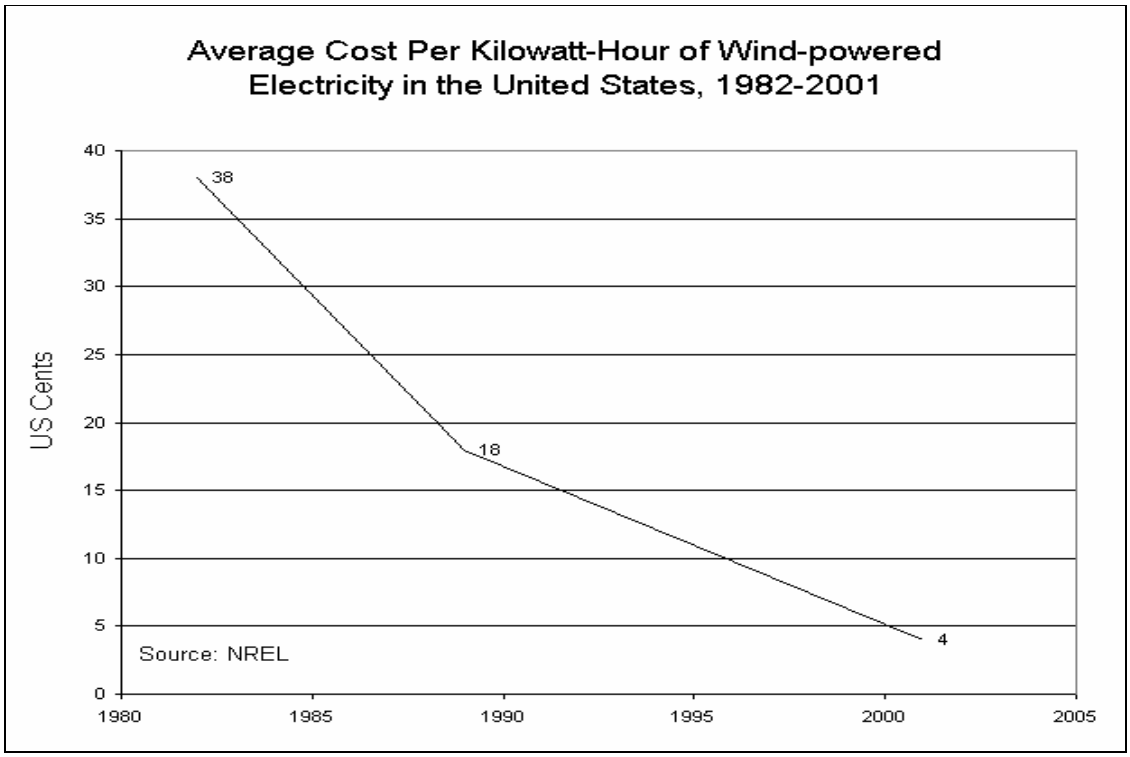


Figure 6.1 the average wind power cost in USA. Source :{ Earth, 2002}

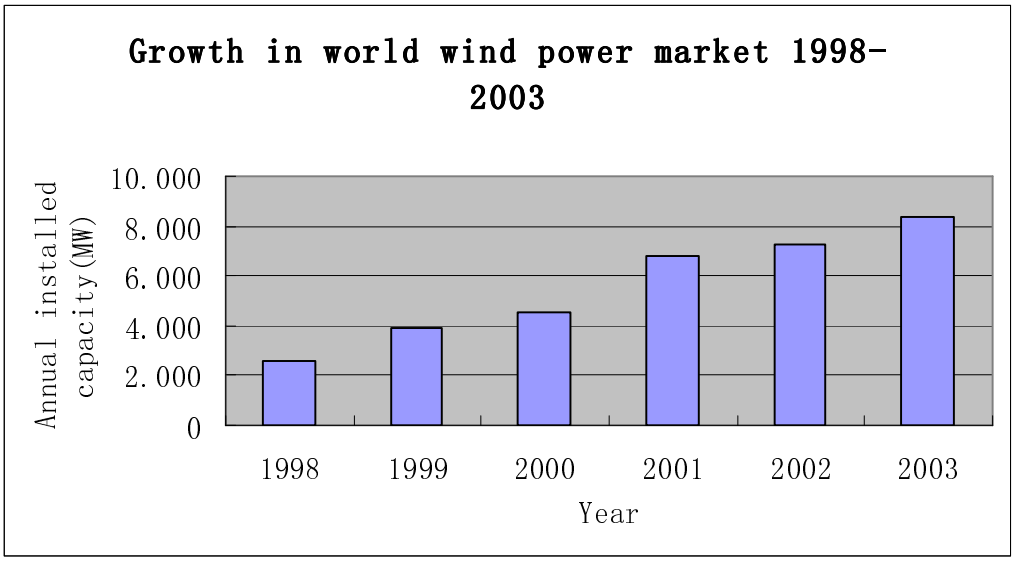
One of the main reasons that lead to significant cost reduction of wind power is the constant advancement of wind turbine manufacturing technology. The newer designs are more efficient, so more electricity is produced from more cost-effective turbines. The size of wind turbines is also increasing - from around 100 kW in the mid 80's, to around 200 kW in the late 80's, 500 kW in the early 90's, through to 1-2 MW now. 4-5 MW wind turbines can be expected in the future which, for logistical reasons, will mostly be for offshore applications. The industry has been characterised by short development periods of 2-3 years to double individual wind turbine capacity. This has all reduced infrastructure costs, as fewer turbines are needed for the same output. {ISEO, 2002}

Another reason that greatly stimulates wind power development is the successful polices implementation for wind industry development. Many countries' successful experiences have proved that the favourable energy policy is effective way to decrease wind power cost and expand wind power market share. Generally those countries can skilfully create an attractive wind power market and lead to a number of wind turbines being manufactured and wind power being generated and utilized, therefore effectively cut down the wind power cost. For example, the feed-in law for renewable power purchase applied in some Europe countries, e.g. Denmark, Germany, has achieved prominent achievements. The law obliges the utilities purchase renewable power from renewable energy developers in a high enough price. As a result, a warrantable market for renewable electricity is created. This greatly stimulates the renewable electricity development in those countries. (Based on {EUpolicy, 2003})

Besides, wind power does not produce health risks and air pollution. It uses indigenous resource and is a completely renewable fuel. It eliminates the risk of environment degradation and energy crisis.

With those advantages, currently wind power has been accepted by many countries as the priority of development and become the fastest growing energy in the world.

During the past five years, globally installed wind power capacity has kept on growing at an average cumulative rate of almost 32%. The increase in year-on-year installations has been an average of 26%. In 2003 alone, over 8,300 MW of new capacity was added to the electricity grid worldwide. See *figure 6.2 growths in the world wind market 1998-2003*{wind 12, 2003}



Year	1998	1999	2000	2001	2002	2003	Average growth over 5 years
Annual installed capacity(MW)	2.597	3.922	4.495	6.824	7.227	8.344	
Increase		51%	15%	52%	6%	15%	26.3%

Figure 6.2 growths in the world wind market 1998-2003 (source: {wind 12, 2003})

The World Energy Council has estimated that wind energy capacity worldwide may total as much as 474,000 MW by the year 2020. Another study named Wind 12 made by Green Peace indicates that: "By the end of 2020, the scenario shows that wind power will have achieved a global installed capacity of over 1.2 million MW. This represents an output of 3,000 TWh, a penetration level equivalent to 12% of the world's electricity demand." According to all of the optimistic forecasts and currently developing trend, apparently it is possible for wind power to gradually take over the fossil-fuelled power in the near future.

6.3 The wind power development in China

China owns the world-class wind resources. It is estimated that the practical wind energy potential on the Chinese mainland is 235 GW (at a height of 10m). And the offshore wind energy potential may be three times greater than onshore potential. The richest wind zones mainly are

distributed in eastern coast and northern wind zone of Xinjing autonomy, Gansu province and Inner Mongolia. {Wind, 2000} The abundant wind resources provide China excellent conditions for wind power development.

During the last twenty years, China has obtained some progresses in wind energy utilization. Especially in some remote rural areas, the off-gird wind power has become one of the main power sources for the ordinary living and makes great contributions for poverty alleviation. However, although stand-alone, mini and small wind generation systems are important for supplying power to remote areas beyond the reach of the power grid, they will have limited impact in changing the whole power supply system. {windassess, 1998} Comparatively, with rapid growth of Chinese economy the gird-connected wind power industry has been endowed with more and more important responsibilities and expectations. In recent years Chinese government has dedicated a lot of endeavours on the gird-connected wind power development by policy adjustment and implementations. Even the progresses attained on gird-connected wind power development are still limited, but China government has optimistically expected the installed wind capacity will reach 20 GW by 2020. {ADB, 2004}

6.3.1 The small-scale wind turbine development in China

China starts to develop wind power from small scale wind turbine. The initial purpose is to supply power for remote, pasture areas and fishing area near coast where are difficult for the gird to reach economically. This is accomplished either through on site generation or a mini grid. In the early '80s the Integrated Rural Energies Development Programme (IREDP) was initiated by the Ministries of Agriculture, Forests and Water Resources. Renewable energy was recognised as having a large part to play in raising the living standard of the rural poor people and those without electricity. With this programme, the hydropower was greatly developed, and the efficiency of biomass utilization had been largely promoted. As the part of the programme plans, the small-scale wind power utilization also had been broadly utilized in some rich wind resource area, e.g. Inner Mongolia.

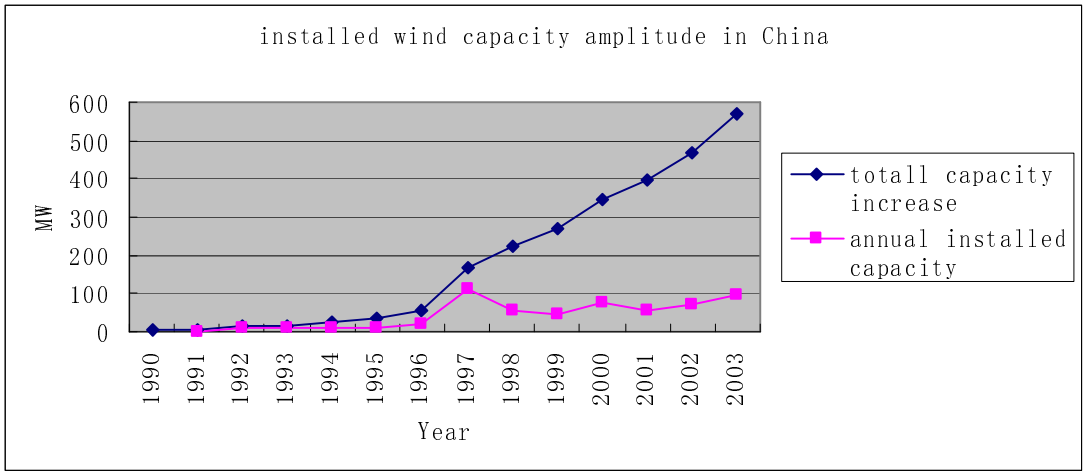
After more than 20 years of effort, small-scale wind generation technologies have matured and more than ten types of wind generation units with a range of capacity between 100 W and 10 kW can be manufactured in China. Twenty-five manufacturers produce small household wind power units. China's current assembly capacity for small wind power generator is 30,000 units per year. Over 170,000 sets of small-sized wind turbine generators with a capacity of 100Ws and

a few off-grid hybrid generation systems with a capacity of 1kW–10kWs have been installed. Most of these products have found extensive applications in grazing areas such as Inner Mongolia, Xinjiang and Qinghai as well as coastal areas. Around 80% of which (140,000 sets) were installed in Inner Mongolia Autonomous Region {Techwind, 2000} In addition limited quantity small wind power generators have been exported to Southeast Asia countries, Japan, Germany and Cuba in recent year.

6.3.2 The grid-connected wind power development in China

- The history of grid-connected wind power development

The initial step for gird-connected wind power development happened in 1986. The Rongcheng of Shandong province imported three Danish Vestas 55KW wind turbines to build China's first wind farm. The strategy intention was to strengthen China's wind power industry by the long-term cooperation with foreign countries which own advanced wind power technology as China did not have enough capacity to manufacture large-scale wind turbine. Then, in the period of 9th five-year plan(1991-1995) the former State Development Planning Commission (SDPC) clearly expressed that the central government will not support the wind project installed capacity under 3000KW and set a target to install 400 MW and 1,000–1,100 MW of wind turbines by 2000 and 2010, respectively. It showed out the resolution of government to develop large-scale wind power. To realize the goal, the SDPC implement the "ride on wind" plan, which intend to obtain promotion of wind power facility manufacturing technology in the model of "demand created by the government, production by joint venture enterprises, and ordered competition. {White book, 1999} From then on, china has kept on building wind farm through technology trade, intergovernmental cooperation and joint ventures. So far, 27 wind farms have been constructed and employed. The installed capacity from 4.1MW (in 1990) reaches the 567MW (in 2003).See *figure 6.3 installed wind power in China* below.



Year	1990	1991	1992	1993	1994	1995	1996	1997
Installed capacity(MW)	*4.1*	*4.9*	*14.5*	*17.1*	*26.3*	*37.6*	*56.6*	*166.6*
Increase		*19.5%*	*196%*	*17.9%*	*53.8%*	*43%*	*50.5%*	*194%*
Year	1998	1999	2000	2001	2002	2003		
Installed capacity(MW)	*223.5*	*267.9*	*344.3*	*399.3*	*468*	*567*		
Increase	*34%*	*20%*	*28.5%*	*16%*	*17.2%*	*21.2%*		

Figure 6.3 installed wind power in China source based on *the electrical power construction department of State Electrical Power Corporate*

Even the wind power development has obtained significant progress. However, comparing with some developed countries, the Chinese wind power's speed of development still remains slow. In 1990 Germany only owns 62 MW wind power. After 12 years effort currently it already is the world leader in wind power, with more than a third of the world's installed wind capacity. As of 2002, Germany had a large number of wind turbines in operation, with an installed capacity of 12 GW, according to Germany Association for Wind Energy. {Earth, 2002} See *figure 6.4 wind power development comparison between China and Germany.*

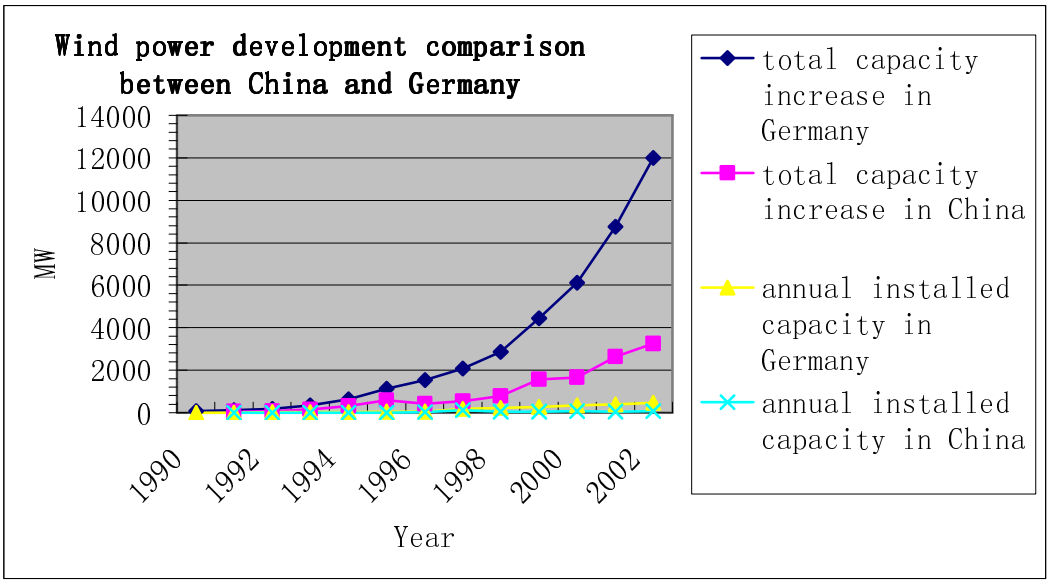


Figure 6.4-wind power development comparison between China and Germany. Source: {Earth, 2002}

Apparently, there must be some reasons behind the slow development of wind power in China. According the experiences and lessons resulted from developed countries e.g. Denmark, Germany and USA etc. The implementation of policies combination on renewable energy development also plays a very important role to impact the effect of renewable energy expansion. The appropriate policy combination will effectively drive the renewable energy well-ordered development. Conversely, the unpractical policies will just have little influences on improvement of renewable energy market circumstance or even impede seriously the expansion of renewable energy utilization. It seems, therefore, there is a necessity to explore the existing policy mechanism and measures of China so as to further speed up Chinese wind power development.

6.4 The analysis for grid-connected wind power development in China

6.4.1 The main barriers for Chinese wind power development

Currently the Chinese electricity consumption still heavily depends on coal power. The wind power industry is only in the immature period and plays a minor role in the energy structure.

Although the installed wind power capacity has reached 567MW in 2003, the price of wind power still keep relatively higher than that of conventional fossil-fuelled power, See *table 6.1 the*

comparison of price between wind power and coal power. It also is much higher than the price of wind power of most developed countries. The wind-generated electricity cost of USA has dropped from 38UScent per kilowatt-hour in the early 1980s to 4UScent or less in prime wind sites in 2003. {Eco, 2004} In comparison, in China now the wind power farm construction cost just decreases 200 US$ or so per KW from the 1200US$ in the mid of 1990s.{New, 2004} Undoubtedly the existing higher cost of wind power leads the higher price and less competitiveness with conventional power. It has seriously impeded the Chinese wind industries development.

Province	**Coal power grid price(1)**		**Wind power grid price (2)**		**(2)/(1)%**
	RMB/KWh	*US$/KWh*	*RMB/KWh*	*US$/KWh*	
XinJiang	0.32	0.039	0.533	0.065	167
Inner Mongolia	0.35	0.042	0.609	0.073	174
Liaoning	0.45	0.054	0.9	0.108	200
Zhejiang	0.50	0.060	1.2	0.144	240
Guangdong	0.60	0.072	0.65-0.74	0.078-0.089	108-123

Table 6.1 the comparison of price between wind power and coal power. Exchange rate: 8.2. Coal price: source :{ Repolicy, 1999}*, Wind power price: source* {Goldwind, 2004}

We consider that there are some historically inherent reasons behind the high cost of wind power under the specific Chinese society circumstance.

- The weak capacity of manufacturing large-scale wind turbine

The large-scale wind turbine can decrease the construction cost, therefore lower the cost of wind power. So, in recent year, developing large-scale wind turbine has been a kind of trend. However, in China the domestic capacity for manufacturing large-scale wind turbine is relatively weak. Only 7 manufacturers can produce 600KW wind turbine (96% of equipment localizations) with some import parts. Few of them have the capacity to produce 750KW (89% of equipment localizations) wind turbine. Currently the R&D of 1.3MW and 1.5MW is partly undertaking by two companies named Goldwind and Windy respectively under the national Hi-Tech Research Development program and Key Technologies R&D Program. (Based on

{Firms, 2005}) As a result, most of installed wind turbines are imported from foreign countries, e.g. Denmark, Germany, and USA etc. It leads to the higher up-front cost for wind farm construction, therefore causes the relatively higher wind power price.

- The distortion of cost

The existing pollution caused by fossil-fuelled power production has still not counted into the product cost and reflected on the price. This correspondingly weakens the competitive capacity of wind compared the conventional fossil-fuelled power.

- Lack of resource assessments

The accurate exploration and assessments of wind resource is very important for location of wind farms. Excellent wind resource location can effectively increase the rate of wind turbine utilization. Therefore, produce much more electricity and reach the goal of decreasing wind power cost. However, the existing wind resources data is not completed and detailed. The Chinese wind resource assessment and data collection started from 1980s. But the assessment and cumulative data still can not meet the present demand since of the limited technology and funding in that time. {Resource, 1992}

- The reform of electric system

As the electricity system reform happed in China, the monopolization of electric system was broke up into more independent electric production and distribution companies respectively the newly liberalized power networks that are more than ever concerned, and required, to keep the cost of supplies as low as possible. Therefore, without additional assistance the higher cost wind power is not able to compete with conventional power.

- The lack of financing supports and commercial investment

The barrier mentioned above and insufficient policy supports lead the high risk of investment. Consequently, commercial investors and banks have less interest to involve this area.

- Lack of infrastructure

Besides, the wind industry in China currently is still in the initial period of development and just plays a less important role in energy structure. So the relevant infrastructure and experienced personnel is scarce.

Referring to the foreign wind industry developing history, the main barriers happened in China are not exclusive. They also happen in most of other countries. The relatively consistent measures adopted to overcome these barriers in those developed countries are constant technology advancement and effective policy regulation. In China, the relevant measures also have been adopted to handle the barriers for wind industry development in recent years. However, the persistent high price of wind power has implied that the existing measures need be improved and more new measures need be applied to breakthrough current deadlock.

6.4.2 The governmental interventions for Chinese wind power development

Apparently, the high cost causes the wind power less competitive with conventional fossil-fuelled power in Chinese energy marketplace, therefore, leads to less market share and consequently less production scale. With small-scale production the high cost of wind power will not be able to effectively decrease. If the wind power is considered as non-profitable business, of course, nobody will invest money in this business, and the relevant infrastructure, e.g. wind resource assessments, training skilled workers and so on, will never be developed. Clearly, without additional interventions the vicious circle will not be broken up. As a result, the further development of wind industry will be very difficult. The chief problem for wind energy development in China is, therefore, similar to that in the rest of the world. A market needs to be created by effective government interventions so as to breakthrough the deadlock.
Figure 6.5 the factors relationship diagram of Chinese wind power industry

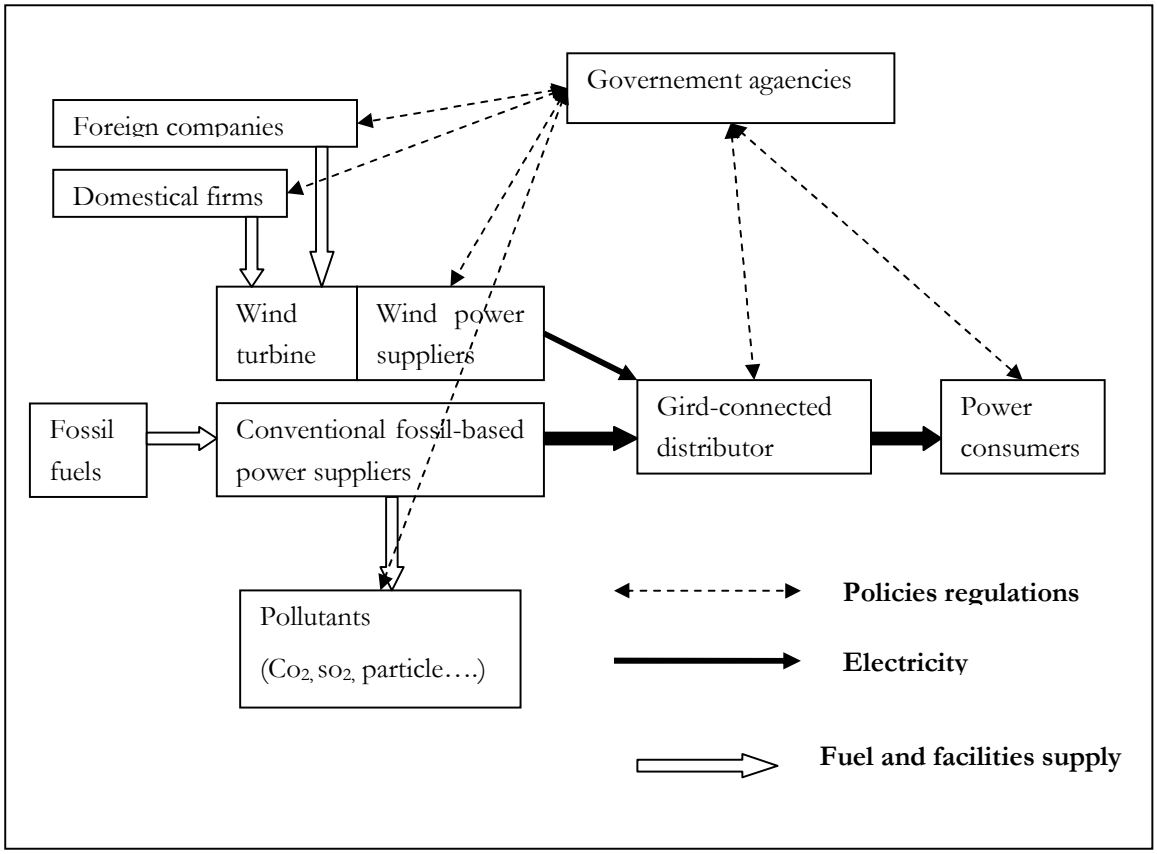


Figure 6.5 the factors relationship diagram of Chinese wind power industry

Then, how to create a marketplace for wind power development under existing circumstance in China? According to the foreign experience, the most effective policies that increase market demands are market-mandated police. For example, the Public Utility Regulatory Policies (PUPRA) in USA, Feed-In Law in Germany, Renewable Portfolio Standard (RPS) adopted in many countries. These policy measures have successfully created a marketplace for wind power development and greatly decrease the cost since some competitive mechanisms have been joined in those measures. The rapid growth of wind power capacity in those countries, e.g. Germany, Denmark and so on, has proven these policies are very effective.

a) Creating a marketplace for wind power development

- Ineffectual pricing regulation

The Chinese government also adopts similar policy instrument and try to create marketplace for wind industry development. The most significant one is that the former Ministry of Electric Power (currently the State Power Corporation) in 1994 put forward an ambitious goal to install

wind turbines with a total capacity of 1,000 MW by 2000. Under this goal the former Ministry of Electric Power provided the pricing and purchase of wind power policy that all power grids must purchase all the electricity generated by wind farms and the electricity must be priced according to the repayment of principal and interests. The portion above mean electricity price is shared by the whole power grid. In 1999, the State Development Planning Commission and the Ministry of Science and Technology confirmed this policy. However, this goal was not successful. In 2000, the total installed wind power capacity only reached 344.3 MW. See *figure 6.3 installed wind power in China*. The fact proved that the pricing and purchase regulation of wind power is failed to create a effective marketplace for wind power development. There are several barriers, which impede this policy implementation.

-- Firstly, after the reform of electric system the electricity production enterprise and distribution enterprise have been separated completely. They keep economic independence. Therefore, the distribution enterprise will no be willing to purchase higher price wind power.

-- Secondly, current the electricity price is decided by the provincial government agencies. It is valid only in province range. So when the distribution enterprises purchase wind power, the company only can pass the price difference to consumers in the province range. It is very difficult to sell the wind power out of province range since there is not specific explanation about the price arrangement between provinces. Therefore, it is hard for small power grids with a bigger proportion of wind power to bear the higher cost. For example, the Inner Mongolia accounts for 40% wind resource of the whole country. The wind power industry has been well developed there. However, the further large-scale wind power development has been limited since of smaller local electricity demand and the difficulties to delivery wind power to other provinces, which lack electricity.

-- Thirdly, the policy is not clear if it is applicable to independent power producers, the central utility authorities argue it only applies to them. Since the utilities do not want to invest in wind power and they also refuse to purchase power from independent wind power developers. Then no one wants to build wind farm except demonstration projects supported by government agencies.

As the problems discussed above, the pricing regulation enacted by the former Ministry of Electric Power can not effectively improve the Chinese wind power development. But it is still meaningful since it has attracted the people's attention and cumulates many experiences and lessons. It is very good basis and preparation for further wind power development in China.

- The consideration about wind power concessions

In late 2001 the Chinese government introduced a wind concessions approach in order to create a stable market in a certain period for large-scale wind power development and bring down the cost of wind power through a tendering procedure. {NREL, 2004} The wind concession approach is good way to turn the government wind power strategies and polices into the real commercial activities. The government guarantees the long-term sale of wind power from concession projects by contract; therefore create a stable market for large-scale wind farms development and strengthen the confidences of wind industry developers. Consequently, the wind equipment industry will obtain big developing space as well. Furthermore, the wind concession project adopts the public tender model. The lowest wind power price will be confirmed by the competition among the bidders. With the fixed wind power price the wind farm investors will strive to decrease the cost in order to obtain the maximum profit. It will greatly help the Chinese wind industry to promote the competitiveness and speed up the commercialization procedure. In addition, the wind concession projects are open to both domestic and foreign enterprises. Therefore the advanced technology and management experience could be imported and absorbed by the wind farms construction, operation and maintenance.

As the application of wind power concession approach, China's wind power market starts to expand rapidly in these two years. According to an uncompleted statistics from Chinese renewable energy association, Until Sep 30, 2004, there are 52 wind power projects proceeding in 16 provinces and autonomy areas. Among them, there are 5 wind farm projects in proposal phase, 18 wind farm projects in ratified and feasibility study phase and 29 wind farm projects in building phase. The total capacity reaches 1854.8MW. See *table 6.2 proceeding wind farm projects*. Some of Chinese and foreign wind turbine manufacturers have been involved in these projects, including Vestas, NEG Micon, GAMESA ENERGÍA, GE Wind, MADE, Goldwind, YunDa,, Xi'An Made and so on.

	Proposal phase	**Ratified and feasibility study phase**	**Building phase**	**Total**
Project Number	**5**	**18**	**29**	**52**
Capacity(MW)	**130**	**1174**	**550.8**	**1854.8**

Table 6.2proceeding wind farm projects based on Chinese renewable energy association

Undoubtedly, as a most promising approach to push Chinese wind power commercialization, the wind concession owns advantages for wind industry development. However, on another hand it also takes on some risks since the wind concession is a new experiment in China. Although there are some successful samples abroad, e.g. the NFFO biding project in England, the experience could not completely be transplanted to different country as every country has different policy and economy circumstance as well as geographic and technological conditions. The wind is a kind of interval resources. The uncertainty of wind resources is the biggest risk for both government and wind power developers. In addition, the wind concession project is an integrative system including many complex steps. Without any experience it probably would make some serious mistakes unknowingly. Especially for the first group of projects, once fail, it would make very bad influences to the potential investors.

- The local content requirement approach

The local content requirement approach requires the wind farm project to use the domestically manufacturing wind facilities. It often is integrated with government projects. For example, the developers bidding on the most recent concession projects in September 2004 had to demonstrate the ability to utilize wind power technology that met a 70% local content requirement. The Hainan government, meanwhile, recently released a request for bids on a 300MW project that encouraged the use of "technologically matured domestic turbines" {WPM, 2004}.The local content requirement creates a protective market for domestically manufacturing wind turbine. It correspondingly brings a series of beneficial influences on the wind industry development.

Firstly, the Chinese wind turbine output will largely increase to meet the demand of the large wind concession projects as there are nearly not foreign wind turbine factories in China. Therefore, it is good opportunities for Chinese wind equipment manufacturers to occupy existing civil market. The increasing wind turbine output also will effectively cut down the wind equipments cost, consequently increase the competitiveness of Chinese wind power equipment.

Secondly, the wind turbine accounts for a big part of wind farm investment. And the wind turbine made in China is much cheaper than import one from abroad since of the cheaper labour and material. An initial studies have estimated that local production of wind turbines could reduce the cost of the technology by anywhere from 20 to 40% {Taylor & Bogach, 1998}. It will lead to significant price reduction of wind power.

In addition, these local content requirements will urge those foreign firms interested in selling wind turbines in China to develop a manufacturing strategy in China. Those companies are either establishing manufacturing facilities in China or assembly facilities by using components that would be contracted out to Chinese manufacturers. And therefore, strengthen the capacity of wind turbine localization.

- The recommendation about REC(Renewable Energy Certificate)

Currently the one of the mainly existing problems for wind power development is that the wind power price is much higher than conventional fossil-fuelled power. The pollution produced by fossil-fuelled power generation does not count into the cost and reflect on the price. It leads the wind power less competitive. Besides, as the richer wind resources are often located in remote areas with less population the excess price of wind power compared the conventional fossil-fuelled power only can be shared in a small amount of people. It is unfair since less people pay cleaning cost for common environment that everyone enjoys.

The REC approach was designed to solve those type problems. The REC generally is used with the MMS (Mandated Market Share) together. The precondition for use is that central government obliges the local electricity suppliers to purchase or generate a set percentage of wind power. If suppliers can not meet their quota of wind power by generation or local purchase, they can freely purchase REC from other places by bid. The REC is equivalent to certain amount unit wind power. They can be sold to the highest price-bidder.

Under this mechanism, as the REC can be trade freely, the problem of unbalanced wind resource deployment can be handled properly. In China the most of rich wind resources are located in the northwest area, where the economies are less developed. In these areas the wind power can be produced in lower cost since of the good quality of wind resources. In comparison, the southeast area‘s economy is well developed and own plenty capitals. But the average quality of wind resources is not as good as northwest area. The price of wind power produced in those areas is higher than that of northwest. For instance, the wind power price of Xinjiang municipality located in the northwest is 0.533 Yuan RMB/KW, much lower than the 1.2 Yuan RMB/KW of wind power price of Zhejiang province located in the southeast of China. See *Table 6.1 the comparison of price between wind power and coal power.* Then, according to the REC mechanism zhejiang province can buy REC from Xinjing municipality in cheaper price to attain the quota required instead of generating by themselves. The Xinjiang municipality obtain money to further expand wind power production scale, consequently more cost of wind power is reduced. If this system can be formed in the range of the whole country,

then every province will be involved in this system to supports the wind power generation. That also means everyone in the country pays for wind power value of both economy and environment.

Currently the REC system has been used in some countries. For instance, the Netherlands has developed a REC program called the Green Label. The Chinese government also is making some experiments in several provinces to study the feasibility of REC system.

b) Economic incentive application

- the existing problems on economic incentive application

To develop wind industry, the government adopts some supportive economic incentives. But the effect of implementation is not remarkable. Those controversial issues are listed below:

Custom duty: custom duty is very important measure to influence the domestic wind industry development. It was changed several times during the last decade. In the early 1990s a preferential policy on customs duty exemption for imported wind turbines was implemented to develop local capacity of manufacturing wind facility, in 1996 adjusting the tariff rate to12% for wind turbine units and 3% for major components. The latest amendment in 1998 restored the policy to exempt imported grid-connected wind turbine units from customs duty, but kept a tariff of 3% for major components. (Based on {Creia, 2005}) Since the domestic wind turbine manufacturers have not had the capacity to produce the complete large-scale wind equipment, some key components still need to import. So the latest custom duty regulation seems not a protective umbrella for domestic wind turbine manufacturers, but rather blocks the progress of localising wind turbine production.

Value Added Tax (VAT): In 2002 the Ministry of Finance and the State Duty Bureau implemented a new tax policy that reduced the Value-Added Tax for wind generation from 17% to 8.5%. {NREL, 2004} The amendment has been greatly cut off the wind power price. However, wind power developers still think the VAT reduction is not big enough. They argued that wind power just use wind as fuel, there is no input VAT deduction. So the existing 8.5% VAT applied to wind power actually still result in the higher price than that of conventional power generation, which does not form the completely fair competition between wind power and conventional power. {Liaowang, 2004}

The financing measures: the current wind power financing is mainly from domestic commercial loan, foreign government low interest loan as well as the supports of World Bank. The domestic commercial loan does not have preferential interest for wind project and the debt service period is very short, only 7 years. It will largely increase the wind power price during the debt service period. See *table 6.3 wind power cost reduction potential*. If wind power developers use the lower interest loan from foreign governments, they will be required to purchase wind power equipment from those countries. But the foreign wind turbine price is much higher than local wind turbine, it will largely increase the wind power cost as well. Besides, it will also restrain the process of wind turbine localization. The financing support from the World Bank currently only is applied to the governmental demonstration project. So it is clear that there is not strong and preferential financing support in China.

The subsidy for R&D of wind turbine: As we have mentioned before, the Ministry of Science and Technology (MOST) is responsible to support and push the renewable energy technology development. During the Ninth Five-Year Plan (1996-2000) MOST funded research to develop technologies for 600 kW machines. And during the Tenth Five-Year Plan (2001-2005) MOST is supporting R&D programs to develop megawatt-size wind turbines by the 863 Wind Program, including technologies for variable pitch rotors and variable speed generators. The main undertakers of R&D projects are professional wind turbine and component manufacturers, e.g. Goldwind and Windy Company. Generally they cooperate with relevant research institutes or university to attain the task. (Based on {Firms, 2005})

- the indirect economic incentive

Pollution charge: At present the Chinese government has enhanced the standards of preventing pollution and reinforced punishment intensity for improper pollutant disposal, This kind of measure probably will largely increase the fossil-fuelled power cost since many generation factories have to buy new facilities to improve the quality of pollutant treatment in order to avoid high penalty. For instance, the coal-fired power generation will produce plenty of co_2 emission and the coal washing procedure before burning will produce a lot of waste water. These pollutants will cost more money under stricter rule. Therefore, increase coal-power price and indirectly increase the compositeness of wind power.

- Suggestion for the economic incentives application

The economic incentive is a very useful approach to stimulate the initiative of market participants and lead market to develop towards a preplanned direction. According to a report

written by Tsinghus University, the smart incentive policies combination will lead the significant wind power cost reduction. See *table 6.3 wind power cost reduction potential.*

Item	Tax reduction	Cost reduced by
Income tax of 33%	To15%	4.3%
	To 0%	8%
VAT of 17% for wind power	To 6%	9.6%
	To 0%	14.6%
VAT of 17% for wind turbine purchase	To 6%	8%
	To 0%	12.4%
15% interest of bank loan	Interest reduces to 7%	21.7%
7-year bank loan	Extend to 15 years	18.2%

Table 6.3 wind power cost reduction potential. #every time just change one parameter

In contrary the lessons from the other countries, e.g. the California wind rush happed in 1980s', also remind the policy makers that the improper economic incentives application could cause serious consequences.

Based on the discussion above, we think there are two more aspects that deserve to consideration: one is the economic incentives should link to the performance of enterprise. For instance, the subsidy can be provided by government according to output of wind power. Another one is the implementation of economic incentives should set a reasonable time limit, otherwise the enterprises will never inspire with their initiatives.

6.5 The conclusion

In recent years with the constantly rapid growth of Chinese economy the safe and stable energy supply has become a very important issue for Chinese sustainable economic development. Currently wind as a clean and sustainable energy source is becoming one of the most promising energy alternative to replace fossil fuel in the world. The drastically decreasing cost of wind power and fast growing installed capacity in recent years has definitely proven the wind energy utilization is cost-effective and feasible.

China owes world-class wind resource. Wind power is considered to have great development potential and attractive prospects in China. China started to develop wind power as early as

1980s. The initiate intention was to alleviate the poverty in the rural area. Then, via the 1990's "China Agenda 21", the China government formulate "Ten strategies" on China's Environment and Development. Since then on, the wind energy development has been vested new meaning and start to take off the ground. After nearly 20 years development the China has already obtain the significant progresses and cumulate some experiences and lessons.

However, with the constantly rapid growth of Chinese economy the wind energy, consequently, has been required to play more important role in Chinese energy structure in the near future. Unfortunately, currently wind energy is still less cost-effective than other conventional power generation in China. The further development of wind energy has been seriously blocked. And it seems that the current institutional framework can not effectively help the wind energy out of the deadlock. Apparently, the improved energy polices are need to breakthrough the current dilemma.

The same problem also exists in the other places of the world. According to the experiences resulting from those countries that have obtain a good achievement in wind energy utilization, the smart designated combination of mandated regulation and economic incentive is effective measure to handle this kind of problem. Then mandated market share guaranteed by law and the inducement of economic incentive companied by competition mechanism will effectively accelerate wind energy well-ordered development until it can be self-sufficient.

Based on the past lessons and experiences resulting from both China and some other countries, the Chinese government has ambitiously adopted the concession approach to explore the mandated market for large-scale wind power development. The long-term wind power purchase contract guaranteed by government has largely decreases the risk for investment. Once the wind concession projects succeed, the Chinese wind industry will attain the historically substantial progresses. And another measure to expand wind power market called REC also enters the experimental phase in China. In comparison, the Chinese government has not improved the performance very much on the application of economic incentive. The economic incentives intensification is still weak. The variety and flexibility is not good either compared the emerging measures in some foreign countries. However, every country is different; the China owns the relatively unique social, economic and cultural circumstances. We believe, with the constant advancement of technology and improvement of policy instrument, the Chinese wind industry will play an important role in the near future.

Chapter 7: Recommendation & conclusion

7.1 recommendations and conclusion

During the past 20 years the Chinese economy has obtained huge development. However, as a result, the energy shortage and environment pollution has been increasingly noticeable problems that need to be handled so as to insure sustainable economy development.

The china owns abundant renewable energy resources. Renewable energy as environmentally sound fuel source has the potential to provide energy services with zero or almost zero pollutant. It will effectively cut off growth in pollution from coal-fired generation if renewable energy can be widely used on a large enough scale. Besides, renewable energy just uses indigenous resources, and theoretically it can supply energy ceaselessly. So effective utilization of renewable energy resources will helpfully reduce China's growing dependency on imported oil and provide a strong support for sustainable economy growth. With these advantages the development and utilization of renewable energy is becoming one of the important options to realize sustainable development of the energy system.

However, the large-scale renewable energy utilization in China would not be realized if the existing policy circumstance and technology level of renewable energy was not effectively improved. Under pressure of energy crisis and environmental protection, currently the China has adopted some relevant measures to stimulate domestic renewable energy development. However, those measures do not lead to significant progresses in renewable energy industries. Apparently China lacks enough experience in this area. So if China develops renewable energy alone without external assistance, perhaps it will spend longer time and much more money to obtain prominent achievement.

Some developed countries have been in leading positions in renewable energy utilization. They have accumulated rich experiences and own advanced renewable energy technology. Cooperation with these countries and consulting some beneficial polices and technology

according to existing cases in China would be a short cut to promote Chinese renewable energy industries development.

Wind energy is the most promising renewable resource to face the challenge in China. Because China owns the world class wind resource. Especially in recent years the cost per unit of wind-powered electricity has already reduced dramatically as manufacturing and other costs have fallen in many developed countries, e.g. Denmark, Germany, and USA etc. Those successful cases have proven the feasibility of wind power development and greatly decrease the development risk. Those advantages provide the big potential for extensive wind energy utilization in China. Furthermore, wind energy also is a kind of typical renewable energy that owns the many common characters of renewable energy. Therefore, the successful wind energy exploitation and utilization will be not only moderate current energy and pollution problems, but also will be a very good paradigm that can provide valuable experiences for the other kind of renewable energy development in China. In this report many cases about wind power have been studied in order to make significant enlightenment for future renewable energy development.

In China, the present renewable energies developments and relevant activities mainly are undertaken by government conduct. The Chinese government should take further actions to create more favorable policy surrounding so as to attract more enterprise to join in renewable energy industries. Only if the market-driven renewable energy industries are formed, the wide and sustainable utilization of renewable energies in China can be realized.

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Appendixes list:

Appendixes A:

The definition of renewable energy:

Renewable include the following categories:

- Combustible Renewable and Waste* (CRW):

1. Solid Biomass and Animal Products: Biomass is defined as any plant matter used directly as fuel or converted into other forms before combustion. Included are wood, vegetal waste (including wood waste and crops used for energy production), animal materials/wastes, sulphite lyes, also known as "black liquor", and other solid biomass. It also includes charcoal produced from solid biomass.
2. Gas/Liquids from Biomass: Biogas is derived principally from the anaerobic fermentation of biomass and solid wastes and combusted to produce heat and/or power.
3. Municipal Waste:* Municipal waste consists of products that are combusted directly to produce heat and/or power and comprises wastes produced by the residential, commercial and public services sectors that are collected by local authorities for disposal in a central location. Hospital waste is included in this category.
4. Industrial Waste:* Industrial waste consists of solid and liquid products (e.g. tyres) combusted directly, usually in specialised plants, to produce heat and/or power and that are not reported in the category solid biomass.

- Hydro Power: potential and kinetic energy of water converted into electricity in hydroelectric plants. It includes large as well as small hydro, regardless of the size of the plants.
- Geothermal Energy: Energy available as heat emitted from within the earth's crust, usually in the form of hot water or steam. It is exploited at suitable sites for electricity generation after transformation or directly as heat for district heating, agriculture, etc.
- Solar Energy: Solar radiation exploited for hot water production and electricity generation.
- Wind Energy: Kinetic energy of wind exploited for electricity generation in wind turbines.
- Tide/Wave/Ocean Energy: Mechanical energy derived from tidal movement or wave motion and exploited for electricity generation.

** Some of the waste (the non-biodegradable part of the waste) is not considered renewable as such. However, proper breakdown between renewable and non-renewable is often not available. (The information comes from Renewables in Global Energy Supply- An IEA Fact Sheet http://spider.iea.org/leaflet.pdf)*

Appendix B: Chinese renewable energy policy

Type of policy	Some of typical renewable energy policies
• **Regulatory approach**	**(1)** In 1995 the Chinese Government promulgated the Electric Power Act. The Electric Power Act is the first Chinese law that discusses energy policy. In the first chapter (Introduction) it clearly states that Chine encourages the use of renewable and clean energy sources. Again in the sixth chapter (Rural Electric Systems Construction and Agricultural Sector Electric Supply) it emphasizes that China wants to develop water resources in rural areas and promote small hydropower systems for rural electrification. The deployment of solar energy, wind, geothermal, biomass, and other renewable energy resources will be encouraged and supported by the government. **(2)** The Guidelines of the Ninth Five-Year Plan and 2010 Long-Term Objectives on Economic and Social Development in China, approved by the Eighth National People's Congress, have become the primary guidelines for the Chinese government in energy development. Both stress that electric power development will be the core task of China's energy development and coal will be the fundamental energy resource. The guidelines also call for strengthening the explorations of oil and natural gas, actively developing new and renewable energy resources, and improving energy infrastructure. For rural electric development, the guidelines emphasize the importance of small hydro, wind, solar energy, geothermal, and biomass resources and that the development strategies should adapt to local conditions. **(3)** In 1996 the Ministry of Electric Power (MOEP) issued the "Parallel Operation Regulations for Wind Power Generation." It requires that the

	power grids must allow interconnection and parallel operations of wind farms, and that the power grids must buy all the electricity generated by the wind farms. It further specifies that the purchase price should include production cost, repayment of debt and interests, taxes, and a reasonable profit. The difference in prices between the wind energy and the average market price should be borne by all the customers of the power grid, not just the customers closest to the renewable energy projects. **(4)** The 1998 Energy Conservation Act again recognizes and emphasizes the importance and strategic role of using renewable energy to reduce emissions and to protect the environment.
● **Economic incentives**	**(1) Import Duty Reduction** Import duty reduction is one of the most direct economic incentives offered to renewable energy development by the Chinese government. China has adjusted the import duty several times in the past few years to bring the overall import duty level compatible to that of the most of the countries in the world. The average import duty now stands at 23%, but renewable energy technologies enjoy special low rates: of 3% for components of wind power plants, 6% for wind turbines, and 12% for PV systems. **(2) Reduction in Value Added Tax** The rate of value added tax (VAT) is 17%. Although not all renewable energy technologies enjoy reduced VAT rate, two of them do. Vat for biogas is only 3%, and VAT for small hydro is only 6%. **(3) Reduction in Income** Tax The income tax is collected by local government. Currently the corporate income tax rate is 33%. Governments of several provincial and autonomous regions have initiated special low income tax rates to encourage the development of renewable energy technologies. (See table)

	(4) Favourable Purchasing Pricing In addition to the pricing policy for wind energy established by MOEP in 1996, several local governments have decided to establish special favourable purchasing prices for electricity from renewable energy sources. For example, the municipal government of Shanghai has set special price for biogas for household cooking. **(5) Low Interest Loans** Chinese government has established specific low interest loans for rural energy development since 1987. The primary targets for this low interest loans are large and medium biogas projects, solar energy applications, and wind technologies. Interest rate of this special low interest loan is only half of that from a compatible commercial loan. The amount of low interest loan was increased to 120 million RMB in 1996. In addition, China also establishes special low interest loan programs for small hydro projects. **(6) Subsidies** Subsidies are often provided by the Chinese government to support renewable energy technologies. Subsidies provided by the central government usually support research, development and demonstration projects. Local governments also subsidize renewable energy development through price reduction of raw material For example; Sichuan and Guangdong provinces offer special low prices for cement to be used to construct biogas facilities.
• **R&D supports**	**(1)** Support various renewable energy research institutes and research projects. **(2)** Target specific technologies for improvement and provide necessary training. Incomplete figures suggest that more than 100 million RMB will be used for this purpose during the Ninth Five-Year Plan. **(3)** Subsidize renewable energy demonstration projects. For example, central government invested 7 million RMB in four PV generation stations (total capacity 85 kW) during the Eighth Five-Year Plan.

● **Market development**	**Standards and specifications:** By the end of 1996, China had promulgated 30 state standards concerning renewable energy and rural energy, 6 trade standards and 3 sectoral technical specifications, including home biogas pits, large and medium-sized biogas projects, solar energy water heaters, solar house, solar dryers, solar stove, wind power generation, mini hydropower and energy-efficient stoves.