Technical Assistant Project of ADB

Promotion of Renewable Energy,
Energy Efficiency and GHG Abatement (PREGA)

Overview of Renewable Energy, Energy Efficiency and Technologies for Reducing GHG Emissions in China

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Executive summary

1. Overview

In 2001 the population in whole country was 1.276 billion, account for 1/4 of the population and is the most population country in the world. China is abundant in the natural resources; the reserves of coal, iron, petroleum, etc. are rank in the front of the world.

China is a large energy producer and consumer. In 2000, the total amount of energy production of China was 1,090 million tons of coal equivalent (Mtce), at third place in the world, the total amount of energy consumption was 1,280 Mtce, the second place in the world.

By the analysis of the energy elasticity (which is defined as (growth rate of energy production) / (GDP growth rate)), the elasticity of the energy production and consumption were always less than 1 during 1991—1995. Total amount of China energy production reached the peak value in 1996 and 1997, and then, it decreased year by year progressively. So, the elasticity of energy production and consumption appeared minus values after 1997. It means that the growth rate of China energy production and consumption were minus.

The proportion of coal expressed a tendency of lowering down year by year, the proportions of petroleum, natural gas and hydropower raised unceasingly, it means that the energy structure was adjusted and optimized in all aspects. However, the development and utilization for some new and renewable energy, such as the nuclear energy, hydropower, solar, wind, tidal, geothermal, biomass energy and the secondary energy produced from them (e.g. hydrogen energy), occupied a small proportion.

China gained a good record in energy conservation, as lowering the consumption and raising energy usage efficiency in recent years, unit GDP energy consumption in China descended year by year.

Integrating the assumptions of population growth, economic development and the change of industrial structure form now to 2020, and assuming two scenarios for energy saving, forecast of commercial energy consumption demand of China in 2020 is presented in following table.

Forecast of commercial energy consumption demand (Mtce)

	2000	2010	2020
Commercial energy demand of China			
Scenario 1	1,303	1,614	1,962
Scenario 2	1,303	1,569	1,857

The commercial energy consumption demand in 2020 is among 1.86 billion to 1.96 billion tce. Given the two scenarios listed in table 2.14, scenario 2 represents a technology progress trend in social and economic development, which is the target China striving for. The energy consumption elasticity is

0.25 in scenario 2 during 2010-2020. The energy consumption elasticity is much lower than that by end of last century, and can keep lower value in the beginning of 21st century, which depends on energy consumption reduction due to technology progress. On the other hand, adding proportion of oil and natural gas in energy mix due to increasing demand for oil and natural gas while evident drop of coal share, which improve energy efficiency and reduce CO2 emission in general.

Following the total energy demand (scenario 2 is analyzed here), primary energy supply mix scenario in China is as follows.

Primary energy supply mix (%)

	2000	2010	2020
Coal	65.8	54.7	43.0
Petroleum	24.5	26.9	31.8
Natural gas	2.5	9.0	12.9
Hydro-power	6.7	7.8	9.2
Nuclear power	0.4	1.2	2.1
Renewable energy	0.1	0.4	1.0

The share of coal in energy mix will decrease in the future, and is expected to decrease to about 50% by 2015. Petroleum demand will increase quickly, up to 300 million tons by 2010, up to 425 million tons by 2020, its share will account for about 1/3 of total energy consumption by 2020. Also, the share of natural gas demand will increase to the third, up to 100-110 billion m^3 by 2010, up to 180-200 billion m^3 by 2020. With strengthening environmental protection, more attention will be paid to renewable energy. Although renewable energy only accounts for small share, its growth space is the biggest, and will be up to 1% by 2020.

In terms of total energy consumption and its consumption mix, CO_2 emission of fossil fuel consumption in China was about 822 million ton of carbon (Mt-C) in 2000, and will increase to 945 Mt-C in 2010, 1,060 Mt-C in 2020. Although the absolute amount of fossil fuel consumption is increasing, CO_2 emission of fossil fuel consumption will be controlled due to energy conservation and fuel substitution. The net increase of CO_2 emission would be 123 Mt-C in 2010 than that in 2000, and down to 115 Mt-C in 2020 than that in 2010.

2. REGA technology analysis and development potential

In energy conversion sectors, power generation is one of the main processes of primary energy conversion to produce secondary energy. In total power supply, thermal power takes about 80%, and hydropower and nuclear power take about 20%. Presently, in the total thermal power generation, coal power takes about 90%.

In this report, current status and future development of major power generation technologies are studied in detail for analyzing options of GHG emission reduction in this sector. The power generation technologies include seven types: thermal power, hydropower (including small hydropower), nuclear power, wind power, solar PV power, biomass power and geothermal power.

The emission reduction measures of China power sector are emphasized on improvement of energy saving technologies. Presently, the thermal efficiency of coal-burning plants is about 30%, which has a big gap with that in other countries. In the total capacity, those units, which are over 200 MW with large capability and high parameter, have a low proportion (less than 40%). At the same time, the thermal efficiency of 200 MW unit made in China is lower than those made overseas. And the small thermal power unit, which is less than 25 MW with medium temperature and pressure, takes one fourth. Now, the main measures of energy saving and technology improvement in thermal power plants include: on one hand, to phase out small coal power unit by using large unit with high parameters or combine supply of power and heat. On the other hand, to introduce advanced thermal power technologies.

The coal consumption of thermal power generation has decreased from 427 gce/kWh to 392 gce/kWh (gce: gram of coal equivalent), the difference between this index in China and the international advanced level has decreased from 28.6% to 24.1%. If the fuel consumption level in China can reach or approach the international advanced level, the primary energy consumption of power generation can be decreased by 20%. The hydropower, nuclear power and renewable power are the other power generation technologies in China, if their proportion increases one percentage in total power generation capacity, the coal consumption can be reduced by 4 million tons, and the CO2 emission can be reduced by more than 2 million tons (carbon).

In the energy end-use sector, major common used equipment is discussed such as industrial boilers, electric motors, pumps, fans, compressors etc.

The industrial boiler is a kind of thermal generation equipment utilized in industry and residential sectors widely. At present, the annual coal consumption of industrial boiler in China is 0.35 billion tons that is one third of total coal consumption. With the development of the economy, the demand of industrial boiler will continuously grow. If it can't be strictly controlled, the pollution will be more serious. Therefore, it is an important task to control the pollution emission of coal-burning industrial boiler for improving air quality. If the burning efficiency of industrial boiler in China can reach at the level of developed countries, coal can be saved 50 million tons and the carbon emission can be reduced 26 million tons every year.

Total installed capacity of all types of electric motor has exceeded 400 GW in China presently, and the power consumption is about 600 TWh accounting for about 60% of the total power consumption in China, in which the power consumption of small and medium-scale electric motor is bout 70% of total electric motor's power consumption. The equipment driven by the electric motor mostly includes pump, fan, compressor and machine tool etc. The efficiency of China's electric motor is 3-5% less than the average level of developed countries. In the operation process, the efficiency of electric motor system is 10-30% less than foreign level.

The electricity saved from the high efficiency electric motor replacing the traditional electric motors will be 36.6 TWh in 2010. In addition, the market occupation rate of speed variation electric motor is about 20% presently, and it is estimated that it will increase to about 85% in 2010. If the two electricity saving technologies mentioned above are used, it is expected that the electricity saving will exceed 91 TWh by 2010. Thus, the CO_2 emission reduction will be about 28.9 million tons (carbon).

3. Priority Areas of GHG Emission Reduction

CO_2 emission of fossil fuel combustion accounts for more than 90% of the total in China. Therefore, the main measure to slow down the speed of CO_2 emission is to reduce the consumption of fossil fuel. Dozens of study reports have pointed out that there are two main measures for China to reduce CO_2 emission, one is to raise energy efficiency, the other is to use low- or no-carbon energy instead of coal (the main energy in China).

Being a developing country, China is still limited of resources and capitals. To maximize the effects, China is in great need of centralized resources and capitals to support the implementation of CO_2 emission reduction activity in priority areas.

Methods on the selection of priority areas can be classified into several categories based on all results and experiences relevant to global climate change in China since 1990s as below.

First, through the analysis of national GHG emission development, it is clear to see which sectors are big emitters, how much did they emit and what kind of fuel consumption caused emission in GHG (mainly concern on CO_2, CH_4 and NO_x) resources and sinks. All these are valuable information for selecting priority areas of GHG emission reduction.

To select priority areas by ways of GHG emission inventory should do further analysis on the following issues:

- GHG emission of the selected emission reduction area should be apparently higher than other areas. Higher GHG emission sometimes means higher emission reduction potential.
- The selected emission reduction areas should be strategically important and be priority areas in the national social and economic development plan.
- The urgent and possibility of establishing emission reduction strategy for selected emission reduction areas.
- Whether the emission significantly changes according to time in the selected emission reduction areas and how does it change.

Second, cost of GHG emission reduction technology (CERT) curve indicates the relationship between the GHG emission reduction from project and the emission reduction cost per unit, so the establishment of CERT curve will be helpful to global climate change researchers and policy makers. On one hand, CERT curve can be used to select priority emission reduction measures or their combination to achieve certain emission reduction objective. On the other hand, it can be used to determine which emission reduction measures being selected and how much total emission reduction being achieved when limited to emission reduction cost or current expenditure. The cost and emission reduction in CERT curve are both comparative to the baseline of the sector and areas. Therefore, to select baseline scenario plausibly and accurately for drawing the CERT curve is important.

Third, the optimized model of energy system based on energy network chart is driven by energy

end-use consumption demand. It is a study on optimizing the energy system under the conditions of satisfying energy demand, emission restriction and energy supply resources. Besides quantitative calculation, it can make optimized selection of combination of various energy technologies and simulate and analyze the GHG emission reduction strategies, measures and policies. Currently, possible new technologies being developed or introduced in future are considered in the model. Compare with other quantitative analysis on GHG emission reduction measures, the optimized model of energy system has many advantages, so it is one of the popular evaluating instruments for researchers on either global climate change or policy making.

Fourth, to do optimization selection and influence estimation among various options that can be mutually substituted is difficult. Apart from other methods, the analytic hierarchy process (AHP) provides a new, tersely and useful way to solve this problem. Even the simple AHP analysis can also get results as other quantities analysis in solving the problems that are difficult to quantify. For example, AHP can give comparatively accurate and reasonable policy suggestions in the analysis of the priority areas of GHG emission reduction. But, the optimized results of AHP is comparatively qualitative and rough in general, if AHP is used in policy making of crucial issues, it is necessary to apply it with other quantitative analysis tools.

In the TCAPP (Technology Cooperation Agreement Pilot Project) project since 1998, AHP was applied for analyzing priority energy technologies and areas, the optimized results were (according to the precedence):

(1) High efficiency boilers
(2) Large thermal power generation (300-600 MW)
(3) Cogeneration
(4) High efficiency electric motors
(5) Green lighting
(6) Energy saving buildings
(7) Coal-bed methane recovery and utilization
(8) Biomass gasification
(9) Wind energy
(10) Solar thermal heat
(11) Biogas
(12) Waste heat and energy recovery
(13) Village hybrid renewable energy (wind & PV)
(14) High efficiency cook stoves
(15) Alternative fuel transportation for urban regions
(16) Small-scale hydropower
(17) Combined cycle natural gas power generation
(18) Central heating
(19) Waste gas recovery

4. Future and Obstacles of REGA Popularization

For the popularization of REGA, the government of China has published amount of policies and regulations, and energy development planning to support the exploration and utilization of new energy, energy saving and raise energy utilizing efficiency.

(1) New Energy Development and Solution

To improve energy efficiency, energy saving and popularization of renewable energy, China government has issued many laws and policies. Implementation of policies makes a foundation to popularization of REGA technology, and provides a policy supporting. Meanwhile the popularization of REGA may make the energy to be used more efficiently. Consequently, continuing development of new and clean energy will promote the implementation of related laws and policies. All of them will make sure that the development of new energy could be supported by laws and policies as well as could get the help of technology resulting in achieving progresses. In turn, it correspondingly pushes the economy and environment to be developed further in China.

(2) Policies and Measurements of Energy Development in China

The main policies and measurements in the "Tenth Five-year Plan" (2001-2005) of energy developments are mainly reflected in following six aspects:

1) Fast the steps of reform, gradually establish the energy industry system which should be adapt the socialism marketing economy, and provide an institution guarantees to energy industry.
2) Adjust the policies of investment and financing arrangements, research for creating a foundation of energy structure adjustments, increase the stress of energy structure adjustments.
3) Establish and improve the adjustment and control systems, which mainly based on the measurements of economic law and complementarily are supported by necessary administration measurements.
4) Positively research and draw up the policies and measurements for promoting energy development in central/west regions.
5) Positively support the exploration and construction of oil/gas bases in the overseas.
6) Carry out the 《Energy Conservation Regulation》 further to increase the energy efficiency.

However, because there are no perfect policies, regulations and uncompleted management systems, the popularization of REGA faces some obstacles. They are summarized as: (1) insufficient awareness about the strategy significance of developing renewable energy; (2) overlap of the government functions; (3) lack of incentive policies; (4) small input; (5) small scale production and high cost; (6) lack of production quality criterion and quality supervision system; (7) low economy development level; (8) insufficient technology application and information; (9) imperfect operation mechanism.

Analyses show that REGA technology has a certain degree base to be promoted in China, as it is consistent with the energy planning of China and supported by relative policies. Although there are some barriers, through continuous improvement of relevant laws and further development of the economy, they could be overcome. So, China has possessed good atmosphere and condition of REGA technology promotion. Meanwhile, the promotion of the REGA technology will also be benefit for further development of economy and environment in China.

5. Policies and Strategy Suggestions

(1) Strengthen Energy Program and Legislation

- Modifying "China Electricity Law" to meet the requirement of power sector reform

It has been eight years since enforcement of the 'China Electricity Law' issued in 1995. The Law has played important roles in ensuring safe operation of China's electricity sector, maintaining normal electric power supply, and protecting rights and interests of power investors, operators, and users. However, the economic relations regulated by the existing Electricity Law have been changed, some regulations and goals defined originally are no longer suitable for the needs of market oriented electricity power reforms. Therefore, modification of the Electricity Laws is needed in order to establish an electricity market system in the model of separating government administration from business operation, equal competition, opening and ordering, and healthy market development, and to fully explore the basic function of resources allocation optimization by market.

- Constituting the 'Renewable Energy Exploration Utilization and Promotion Law'

Promoting sustainable renewable energy development through legislation has been a successful experience in the developed countries. The government of China is taking active actions to implement its law and regulation systems for developing renewable energy. Goals of the China RE promotion law should speed up RE development and utilization, boost RE industrialization and commercialization, improve energy structure, ensure energy safety, protect environment, and promote the sustainable social and economic development.

- Securing the implementation of energy saving and renewable energy programs by mandated policies

The mandated policies should include: (1) reinforcing energy saving to improve energy efficiency. During the industry development process in the future, it will be ensured that energy efficiency target indicators of any new projects, including joint venture projects, will reach at the international advanced levels. (2) Using mandated policies for realizing RE development goals. It is suggested that based on the RE power development program, the MMS (mandate market share) policy should be clearly implemented, i.e. to require the RE electricity generation taking certain share in total power production, and to make it as a persistent objective for developing RE electricity. (3) Compulsively implementing Energy Efficiency Standard and Identification System. It is suggested to clearly define the validity of EE (energy efficiency) target indicators made for related products in the laws and regulations, specify procedures in making and implementing the EE standards, and encourage enterprises to conduct technical improvement in order to fulfill the set EE target.

(2) Establish market oriented energy management mechanism

Market-oriented reform in the field of energy in China has made some achievements, but it still remains in its initial phase and the reform is still a heavy task. Moreover, a series of fundamental conflicts and problems are not completely resolved, which puts impacts on deepening reform and long-term development in the field of energy. The main contents of reform include: (1) the reform of energy management system. (2) Reform of the administrative examination and approval system and change of the government's functions. (3) Reform of the current improper energy pricing mechanism and price regulatory approach. (4) Deep the reform of state-owned energy enterprises.

(3) Establishing a good operational mechanism to promote REGA technology

The proposed mechanisms include: (1) Accelerating new energy saving mechanisms. (2) Establishing PBF (public benefit fund) to support energy saving and RE development. (3) Implementing energy saving collaboration agreement. (4) Conducting DSM (demand side management) for electricity sustainable development. (5) Implementing bidding of wind power license project. (6) Gradually creating RE generation market guarantee mechanism. (7) Establishing economic incentive mechanisms.

(4) Propagandizing REGA Technology

Generally, only when more and more people recognize and understand the importance of energy saving and renewable energy, REGA technology can be well developed. Therefore it is suggested that:

- Focus on information services, including public know-how, energy statistics, information network, technical consultancy, energy audit, EE identification, learning international experience, and better services.
- Strengthen education on energy shortage, resource efficiency, and environment protection so that the entire society will actively use REGA technologies. Government agencies should have commitment to use energy saving and renewable energy products and encourage big companies to utilize REGA technologies. Implement action plans for voluntarily using EE and green energy and form a new style energy-consuming conception gradually.
- Create market-based energy saving information dissemination channels and break information barriers, to promote application of new technologies, new experiences, new technical processes, and new equipment.
- Establish training bases and conduct cooperative programs for information sharing and technical personnel training so that a larger group of skill persons can be brought up for need of development.

6. Conclusions

From the above description of energy supply and consumption in China, REGA technological analysis, the prospects and obstacles of REGA popularization as well as policy analysis, some conclusions are summarized as follows:

First, there are several problems in energy supply and consumption: energy structure was not reasonable, and the proportion of coal was greater. At the same time, energy efficiency was lower resulting in higher energy intensity per GDP. Now, the tasks facing China are: first, to optimize the energy structure by ways of exploring more new and renewable energy; second, to eliminate low-efficiency facilities and to use new technologies for increasing energy efficiency. In general, energy demand and supply in China are basically in a balanced status, energy structure is being optimized continuously, and the energy can match the demands of the national social and economy development. Considering the population growth, economic development and the change of industrial structure, commercial energy consumption demand projections for the next two decades indicate that energy consumption demand will increase, and the coal share will evidently drop. So it can improve energy efficiency and reduce CO2 emission.

Second, in energy conversion sectors, it is rather difficult to change the existing status that the coal-burning power generation is the main technology in a long time. Since the year 2000, there is large market potential for advanced thermal power generation technologies which leading to GHG emission reduction potential. But before 2010, the advanced thermal power technologies are just in the demonstration stage and can't play an obvious role in emission reduction. In the energy consumption sectors, owing to the popularization of energy saving technologies and wide utilization of new and renewable energy, it is expected that there will be a bright market prospect of REGA technologies in China.

Third, there are two main response measures for China to address CO_2 emission reduction, one is to raise energy efficiency, the other is to use low- or non-carbon energy instead of coal. Many sectors and alternative technologies in energy supply and consumption for CO_2 emission reduction are involved in these two areas.

Fourth, the government of China puts forward a series of new energy development programs, and works out corresponding policies of tax cut and tax exemption, price subsidies, stimulation and rewards. At the same time, the government carries out some development plans and policies in energy conservation and energy efficiency improvement, such as energy conservation law, regulations and standards of energy technologies, and stimulating policies etc. However, because of imperfect policies and regulations, as well as uncompleted management systems, the popularization of REGA technologies has to overcome some obstacles, such as lack of encouraging policies, overlap of the government functions, imperfect operation mechanism and so on.

Fifth, in order to save energy, improve energy efficiency, and speed up the development of REGA technologies, China should work out relevant regulations and laws, establish management mechanism adapted to the market, and utilize some encouraging policies. Meanwhile, various propaganda activities should be implemented to popularize REGA technology across sectors and the country.

Main report

1. National Background of China

People's Republic of China (PRC) is located in the eastern part of Asia, on the west coast of the Pacific Ocean. Its total land area of country is 9.6 million square kilometers. In China there are 23 provinces (includes Taiwan province), 4 municipalities directly under the Central Government, 5 autonomous regions and two Special Administration Zones, 265 cities of area level, 393 cities of county level, and 20,358 towns. In 2001 the population in whole country was 1.276 billion, account for 1/4 of the population and is the most population country in the world. In China there are 56 minorities, the Han nationality occupy 94%. Official language is Chinese. The capital of China is Beijing, has population 13.83 million, it is the center of politics, culture and economy in China.

The surface in China slopes down in steps starting from the west leading to the east. Mountains, plateaus and hills occupy 2/3 territories. The important rivers in China are Yangtze (Long) River and Yellow River. There are about 6,500 islands scattered over its vast territorial waters. The climate in the east areas is the monsoon climate of Southeast Asia, humid and rainy. In the Northwest the climate of inland areas is dry; on the Plateaus in Qinghai and Tibet the climate is cold.

China is abundant in the natural resources; the reserves of coal, iron, petroleum, antimony, tungsten, tin etc. are rank in the front of the world. In the current proven reserve of coal, the share of bituminous is 75%; hard coal, 12%; brown coal (lignite), 13%. Among them the coal as materials usage such as coke and chemical fertilizer account for 27%, power coal for 73%. The reserves of power coal are distributed in the North and Northwest China, account for 46% and 38% of the total reserve of coal in China. At the end of 1996, the proven reserve of petroleum in China is about 3.3 billion ton, ranked the ninth in the world.

The basic information for China is presented in table 1.1.

Table 1.1 National Fact Sheet for China

Items	Units	2001	Notes
Population:	Million	1276.27	
In urban areas	Million	480.64	
Land Area	Million Square Kilometer	9.60	
Sea Area	Million Square Kilometer	4.73	
Coast Line	Thousand Kilometer	18	
Island Area	Million Square Kilometer	0.0387	
Precipitation	Millimeter	648	
Cultivated Land Areas	Million Hectare	130	Agriculture survey in 1996
Waste Land	Million Hectare	108	
Glass Land	Million Hectare	400	General Investigation in 1991
Forest Area	Million Hectare	158.94	General Investigation number of 1994～1998
Forest Cover Rate	%	16.55	
Total Volume of Water Resources	Billion Cubic Meter	2819.6	
Reserve of Energy Resources	Billion tce	4046	As of 1999
Coal	Billion ton	5059	
Oil	Billion ton	100	
Hydro	Billion Kwh	5922	
Gas	Billion m^3	38140	
Water Areas Inland	Million Hectare	17.47	In 1988
Gross Domestic Product:	Billion Yuan	959.33	US $1 = 8.26 Yuan
Primary Industry	Billion Yuan	146.10	
Secondary Industry	Billion Yuan	490.69	
Tertiary Industry	Billion Yuan	322.54	
Total Value of Fixed Asset Investment	Billion Yuan	3689.8	
State Financial Income	Billion Yuan	1637.1	
State Financial Expense	Billion Yuan	1884.4	
Total Energy Output	Mtce	1210	
Total Energy Consumption	Mtce	1320	
Raw Coal Output	Billion Ton	1.11	
Crude Oil Output	Billion Ton	0.165	
Power Generation	Billion Kwh	1368.5	In 2000
Thermal coal and gas	Billion Kwh	1107.9	
Hydro	Billion Kwh	243.1	
Nuclear	Billion Kwh	16.7	
Natural Reserve Areas	Million Hectare	129.89	
Rate of Natural Reserve Areas to State Territory	%	12.9	

Ecology Demonstration Areas		215	Among which 87 are State National Reserve Areas
Emission Volumes of Waste Water	Billion Ton	42.8	Excluding the Waste Water of Livestock and Rear Poultry
Emission of Sulfur Dioxide	Million Ton	19.47	
Urban public green land	Million Hectare	0.143	In 2000

Notes：

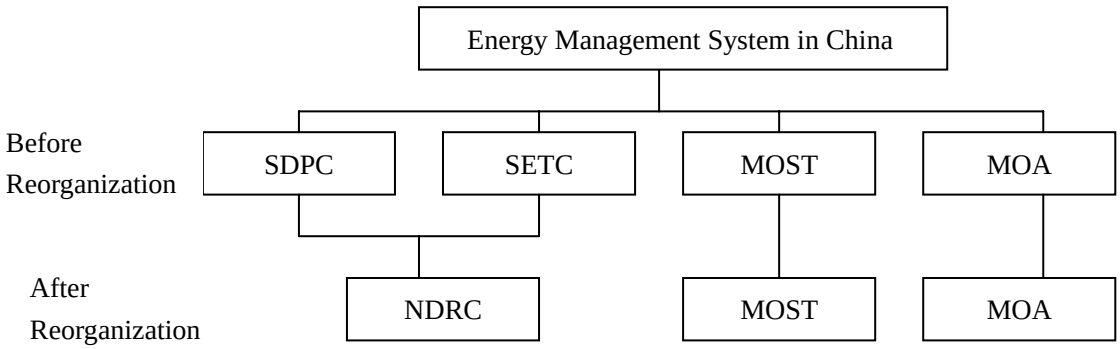
(1) Besides the territory area, sea area and precipitation, others didn't include the figures of the Special Administration Districts of Hong Kong, Marco and the Province of Taiwan.

(2) In the energy statistics system of China, the unit "tce" is officially used, its heat value is 7,000,000 kcal/tce, and 1 tce equals to 0.7 toe. In this report, tce is used.

2. Energy Supply and Consumption of China

2.1 Energy Management System

The organization reform of some state departments that related with energy management was confirmed in March, 2003. The original State Development Planning Commission (SDPC) has been reorganized as National Development and Reform Commission (NDRC). The original department of resource conservation and comprehensive utilization of State Economy and Trade Commission (SETC) has merged into the National Development and Reform Commission. An organizational chart describing the change of the energy management system is shown below.



1) Energy Bureau (State Petroleum Deposited Office) of National Development and Reform Commission

Its main responsibility is to study the issue of energy exploitation within China and abroad. Its major jobs include to work out development strategies and policies of energy, to draw out energy development programs and plans, to collect and assess suggestions on system reform, to keep management on petroleum, natural gas, coal and electricity power, and on petroleum repertory, to stipulate policies and measures on energy conservation as well as new and renewable energy.

2) Department of New and High Technology Development and Industrialization of Ministry of Science

and Technology (MOST)

Its main responsibilities are to study the development of the high and new technology and the industrialization policy in the field of the industries; organize the implementation of the development plan of the high and new technology research in the fields of information, energy and new material; organize the implementation of the state tackle-key-problem plan and technological innovation in the industries; be in charge of the relevant work in the high and new technology industry development, which is in the state level; promote the reform of technology system and the construction of the technology service system such as the productivity development center etc.

3) Department of Technology Education of Ministry of Agriculture (MOA)

Its main responsibility is in the renewable energy aspect: to organize the selection, implementation and the management in the key agriculture import items; to do international communication and work of agriculture technology education; to organize and instruct the comprehensive development, utilization, research and demonstration on key technologies in the rural area; to guide the construction and industry development of rural renewable energy.

2.2 Energy balance

China is a large energy producer and consumer. In 2000, the total amount of energy production of China was 1,090 Mtce，at third place in the world，the total amount of energy consumption was 1,280 Mtce, second place in the world.

By great efforts in many years, China basically resolves the problem of the energy supply that was unable to meet the demand, after the peak age of energy production and consumption in 1980s-90s, the total amounts of both energy production and consumption descended together in the period of “The Ninth Five-year Plan (1996-2000)”. In these 5 years, the total amount of primary energy decreased progressively 3.3% per year, the total amount of energy consumption decreased progressively 0.5% per year，the energy production decreased faster than the energy consumption, with the net energy import increasing (see Table 2.1).

Table 2.1 Balance between energy supply and consumption in China in 1990-2000

Year	Total Energy Production (Mtce)	Total Energy Consumption (Mtce)	Balance between Production and Consumption (Mtce)	Net Energy Import (+:Net import， -: Net export) (Mtce)
1990	1,039.22	987.03	52.19	-45.823
1991	1,048.44	1,037.83	10.61	-35.148
1992	1,072.56	1,091.70	-19.14	-22.576
1993	1,110.59	1,159.93	-49.34	-15.0
1994	1,187.29	1,227.37	-40.08	-16.20
1995	1,290.34	1,311.76	-21.42	-13.523
1996	1,326.16	1,389.48	-63.32	-5.979
1997	1,324.10	1,377.98	-53.88	17.552
1998	1,242.50	1,322.14	-79.64	8.547
1999	1,091.26	1,301.19	-209.93	27.373
2000	1,069.88	1,302.97	-233.09	47.057

Data source：《China Statistics Yearbook, 2002》by State Statistics Bureau, 2002, Beijing.

Table 2.2 Primary energy production & consumption in China in the period of "The Ninth Five-year Plan"

Year	Raw coal (Mt)		Crude Oil (Petroleum) (Mt)		Natural Gas (Mm^3)		Hydropower (TWh)	
	Production/ Consumption		Production/ Consumption		Production/ Consumption		Production/ Consumption	
1996	1939	1,447.34	157.33	174.36	21,014	20,114	188.0	188.0
1997	1373	1,392.48	160.74	196.92	22,703	22,703	196.0	196.0
1998	1250	1,294.92	161.00	198.18	23,280	23,280	198.9	198.9
1999	1045	1,238.71	160.00	211.31	25,200	25,200	196.6	196.6
2000	998	1,200.62	163.00	211.45	27,730	27,730	222.4	222.4

Data source：《China Statistics Abstract, 2001》by State Statistics Bureau, 2001, Beijing.

It can be seen in Table 2.1 that the total amount of energy kept a balance basically in recent years, the total amount of energy import increased year by year. It was relevant with the fast economic development in China, and the increase of energy demand. The total amount of primary energy production and consumption in recent years are shown in Table 2.2.

In these 5 years, the coal production and consumption in China decreased progressively year by year, but the petroleum production and consumption increased continuously, that is due to all industries in China developed fast, their energy demand increased unceasingly, and the energy structure changed. However, in general, the energy consumption and supply kept in balance. At the same time, consumption and supply balance of the natural gas and hydropower energy shows that those energy resources were developed insufficiently, the output is too small, that reflected the supply unable to meet the demand resulting in high dependence on oil imports. In general, energy consumption in China is higher, and petroleum was depended on the import oil.

The tendency of economic development in China determined its position as a main energy consumer in the world, the total amount of energy consumption reached the peak values in 1996 and 1997, it dropped back in 1998 and 1999, and it was increased again in 2000. The characteristic that the coal is the main energy source in China determines that the change in total coal consumption is consistent with the change of total energy consumption. The total coal consumption dropped continuously since 1996, and increased again in 2000.

By the analysis of the energy elasticity (which is defined as (growth rate of energy production) / (GDP growth rate)), the elasticity of the energy production and consumption were always less than 1 during 1991—1995, the elasticity of energy production and consumption appeared minus values after 1997. It means that the growth rate of China energy production and consumption were minus. China gained a good record in energy conservation, as lowering the consumption and raising energy usage efficiency in recent years, unit GDP energy consumption in China descended year by year. In 2000, the elasticity of the power generation and consumption exceeded 1.0, it means that the growth rates of power generation and consumption exceeded the growth rates of GDP, The total amounts of power supply and demand increased very fast. China's elasticity coefficients of energy production and consumption in recent years are shown in Table 2.3.

Table 2.3 The Elasticity of energy production and consumption in China

	Energy Production Elasticity	Energy Consumption Elasticity	Power Generation Elasticity	Power Consumption Elasticity
1991	0.10	0.55	1.00	1.00
1992	0.16	0.37	0.80	0.81
1993	0.31	0.21	1.13	0.70
1994	0.55	0.46	0.85	0.79
1995	0.83	0.66	0.82	0.78
1996	0.29	0.62	0.75	0.77
1997	- 0.002	- 0.008	0.57	0.55
1998	- 0.62	- 0.04	0.37	0.36
1999	- 0.12	- 0.02	0.89	0.86
2000	- 0.20	0.001	1.18	1.17

Data source：《China Statistics Yearbook, 2002》, State Statistics Bureau, 2002, Beijing.

Based on the total amounts of China energy production and consumption, the energy structure and its tendency, it can be found that energy demand and supply in China are basically balanced, the energy structure is optimized continuously，the energy "bottleneck" which restricted the economic and social development for a long time was relaxed greatly, and can match the demands of the national economy and social development.

2.3 Energy Supply Structure

The total amount of China energy production reached the peak value in 1996 and 1997, and then, it decreased year by year progressively. The proportion of coal expressed a tendency of lowering down year by year, the proportions of petroleum, natural gas and hydropower raised unceasingly, it means that the energy structure was adjusted and optimized in all aspects. However, the development and utilization for some new and renewable energy, such as the nuclear energy, hydropower, solar, wind, tidal, geothermal, biomass energy and the secondary energy produced from them (e.g. hydrogen

energy), occupied a small proportion.

In 2001 the total amount of China primary energy production was 1.17 Billion tce, the hydropower generation was 1,356 TWh. The total amount of China energy production and structure in recent 10 years are shown in table 2.4.

Table 2.4 Total amount of energy production and its structure in China

Year	Total Amount of Energy Production (Mtce)	Share (%) (Total Amount of Energy Production as 100)			
		Raw coal	Crude Oil	Natural Gas	Hydro Power
1990	1,039.22	74.2	19.0	2.0	4.8
1991	1,048.44	74.1	19.2	2.0	4.7
1992	1,072.56	74.3	18.9	2.0	4.8
1993	1,110.59	74.0	18.7	2.0	5.3
1994	1,187.29	74.6	17.6	1.9	5.9
1995	1,290.34	75.3	16.6	1.9	6.2
1996	1,326.16	75.2	17.0	2.0	5.8
1997	1,324.10	74.1	17.3	2.1	6.5
1998	1,242.50	71.9	18.5	2.5	7.1
1999	1,091.26	68.3	21.0	3.1	7.6
2000	1,069.88	66.6	21.8	3.4	8.2
2001	1,210.00	68.0	20.2	3.4	8.4

Data source：《China Statistics Yearbook，2002》, State Statistics Bureau, 2002, Beijing.

It can be seen in this table that the coal supply occupied the most part of the total energy supply of China in 1990--2000，the proportion descended in 2000，but it occupied still 67.2%，the crude oil supply reached the lowest level in 1995, then, it began to raise year by year，reached more than 1/5 of the total amount of energy. The supply of natural gas and hydropower were increased year by year progressively，but the proportions are quite small. The contributions of some new and renewable energy were very little. It means that the energy structure of China is optimized step-by-step, and some new type energy need to be more developed.

Power capacity and generation as well as their composition in 1990-2000 are provided in Table 2.5 and Table 2.6.

Table 2.5 Power capacity by major types in 1990-2000 in China

	1990		1995		2000	
	GW	(%)	GW	(%)	GW	(%)
Thermal power	102	73.9	163	75.1	237.4	74.4
Hydropower	36	26.1	52	23.9	79.4	24.8
Nuclear power	0		2.1	1.0	2.1	0.7
Wind power			0.05		0.4	0.1
Total	138	100	217	100	319.3	100

Table 2.6 Power generation by major types in 1990-2000 in China

	1990		1995		2000	
	TWh	(%)	TWh	(%)	TWh	(%)
Thermal power	494	79.5	804	79.8	1,117	82.4
Hydropower	127	20.5	191	18.9	222	16.4
Nuclear power	0		13	1.3	17	1.2
Total	621	100	1,008	100	1,356	100

Electric power, as the secondary energy，kept the trend of fast development in these 10 years，the installed capacity was increased 8.8% per year，the situation of serious shortage of power in a long time was changed essentially, the "bottleneck" of power which restricted the national economic and social development was eliminated. By the end of 2000, the installed capacity in China achieved 319.3 GW. New energy generation as wind, solar energy etc., 330 MW. The power generation achieved 1,369 TWh. The installed generating capacity and power generation ranked the top number two in the world. In the period of the Ninth Five Years Plan (1996-2000), the power generation increased 6.3% per year. The increase rate of power generation was 7.2% in 1996, 5.1% in 1997，2.1% in 1998, 6.5% in 1999, and 11% in 2000.

According to *the SDPC background report for renewable energy report*, the generation capacities for wind, small hydro, biomass and geothermal are 400 MW, 23,050 MW, 410 MW and 40 MW in 2000, respectively. The generation capacity targets for them in 2010 are 3,000 MW, 31,130 MW, 500 MW and 80 MW, respectively.

2.4 Energy Consumption Structure

During 1996—2000, the total amount of energy consumption decreased progressively 0.49% per year, the energy consumption elasticity was -0.06. The electricity consumption increased continuously, average annual growth rate was 6.10%, the power elasticity was 0.74. In these 5 years, the annual average energy consumption decreased 6.35Mtce, but the energy production decreased progressively

more than that of the consumption，the net energy import, especially the net petroleum import increased obviously.

Table 2.7 Energy consumption and its structure in 1990-2000 in China

Year	Energy Consumption Total Amount (Mtce)	Coal		Petroleum		Natural Gas		Hydropower	
		Consump-ption (Mt)	Ratio (%)	Consum-ption (Mt)	Ratio (%)	Consum-Ption ($Mm^{3)}$	Ratio (%)	Consum-ption (TWh)	Ratio (%)
1990	987.03	1,055.23	76.19	114.86	16.62	15,298	2.05	126.7	5.14
1991	1,037.83	1,104.32	76.10	123.84	17.10	16,073	2.00	124.7	4.80
1992	1,091.70	1,140.85	75.70	133.54	17.50	15,788	1.90	130.7	4.90
1993	1,159.93	1,209.20	74.70	147.21	18.20	16,765	1.90	151.8	5.20
1994	1,227.37	1,285.32	75.00	149.56	17.40	17,559	1.90	167.4	5.70
1995	1,311.76	1,376.77	74.60	160.65	17.50	17,947	1.80	190.6	6.10
1996	1,389.48	1,447.34	74.70	174.36	18.00	20,114	1.80	188.0	5.50
1997	1,381.73	1,392.48	71.50	196.92	20.40	22,703	1.80	196.0	6.30
1998	1,322.14	1,294.92	69.60	198.18	21.50	23,280	2.20	198.9	6.70
1999	1,301.19	1,238.71	68.00	211.31	23.20	25,200	2.20	196.6	6.60
2000	1,302.97	1,200.62	66.10	211.45	24.60	27,730	2.50	222.4	6.80

Data source：《China Statistics Yearbook, 2002》, State Statistics Bureau, 2002, Beijing.

Up to 2000, the proportion of coal in total energy consumption decreased from 74.6% in 1995 to 67.0%, lowered 7.6 percent；the proportion of petroleum increased from 17.5% to 23.6%, raised 6.1 percent. The proportion of natural gas and hydropower raised 0.7 and 0.8 percent separately from 1995 to 2000. The reasons for the increasing of petroleum consumption proportion by a big margin were: the scale of the crude oil exploitation was expanded and the output was increased, and the net petroleum import was increased. According to the calculation of power-thermal equivalent, the ratio of power consumption in total energy consumption raised from 9.8% in 1995 to 13.6% in 2000, increased 3.8 percent. The energy consumption and its structures in China are shown in Table 2.7.

Table 2.8 shows the coal and petroleum consumption for different sectors.

Table 2.8 Coal and Petroleum Consumption in China in Last 15 years unit: KT

Year		Agriculture, forestry, pasture, fishing, water resource	Industry	Building	Transport, warehouse, post and communication	Wholesale and retail sale trade, and restaurants	Others	Living Consump-tion
1985	Coal	2,208.6	58,613.3	531.9	2,307.1	738.2	1,579.5	15,624.4
	Oil	758.7	6,171.4	292.2	1,176.4	38.1	506.1	225.9
1990	Coal	2,095.2	81,090.9	437.6	2,160.9	1058.3	1,980.4	16,699.7
	Oil	1,033.6	7,321.6	327.3	1,683.2	77.6	757.8	284.5
1995	Coal	1,856.7	117,570.7	439.8	1,315.1	977.4	1,986.7	13,530.1
	Oil	1,203.2	9,349.3	242.8	2,863.6	333.9	1,390.3	682.0
1998	Coal	1,923.3	114,952.4	611.6	1,390.6	947.6	782.7	8,884.0
	Oil	1,294.7	10,870.8	293.9	4,245.3	426.0	1,704.8	983.3
1999	Coal	1,735.6	112,757.3	522.5	1,294.3	896.2	751.1	8,408.4
	Oil	1,422.1	10,852.8	323.0	5,004.3	537.2	1,800.3	1,133.1

Data source：《China Statistics yearbook, 1986－2001》by State Statistics Bureau, Beijing.

The coal was consumed in all sectors as follows: the industry consumed the largest proportion, the residential consumption was the next. China industry consumed a large amount of coal, and the energy usage efficiency was quite low, that caused the emission of atmospheric pollutants, such as the sulfur dioxide, dust and carbon dioxide, etc.， and caused heavy pressure on the environmental protection. Now, we are faced with the responsibility as follows: to optimize the energy structure, use the new and renewable energy; to eliminated the low-efficiency facilities, to adopt new technologies, to rise the energy usage efficiency.

The consumption of petroleum and its products increased stably. During last five years, China produced crude oil about 160 Mt every year, consumed about 200 Mt, various petroleum chemicals are unable to meet the demand. Following the development of national economy and the rising of people's living level, the consumption of petroleum and its products will raise more and more. Especially the ratio of petroleum and natural gas in total energy consumption will rise continuously. The proportion of crude oil in total amount of China energy production had a slight change from 23.8% in 1980 to 21.8% in 2000, the proportion of natural gas increased from 3.0% in 1980 to 3.4% in 2000. Now, sum of proportions of petroleum and natural gas in China energy consumption reached 23.6% in 2001, and it will increase continuously in the future as the large volume of oil and natural gas is explored in western China.

In the period of the Ninth Five-Year Plan, China's natural gas consumption was increased with the highest speed in the history, the domains of natural gas consumption expanded. In recent years, natural gas used for the manufacturing of chemical fertilizer, occupied 38% of total consumption; self use by oil/gas fields，26%；use by power generation and residential, 13% and 11%；the commerce, service and natural gas automobiles consumed a small part (see Figure 2.1). Natural gas is mainly consumed in central, northeast and southern areas of China, occupied 41%, 19% and 15% respectively; in the provinces and autonomous regions of Sichuan, Chongqing, Heilongjiang, and Xinjiang accounting for 66% of the total amount. These provinces and autonomous regions are main productive areas of the natural gas, or the areas near the gas fields.

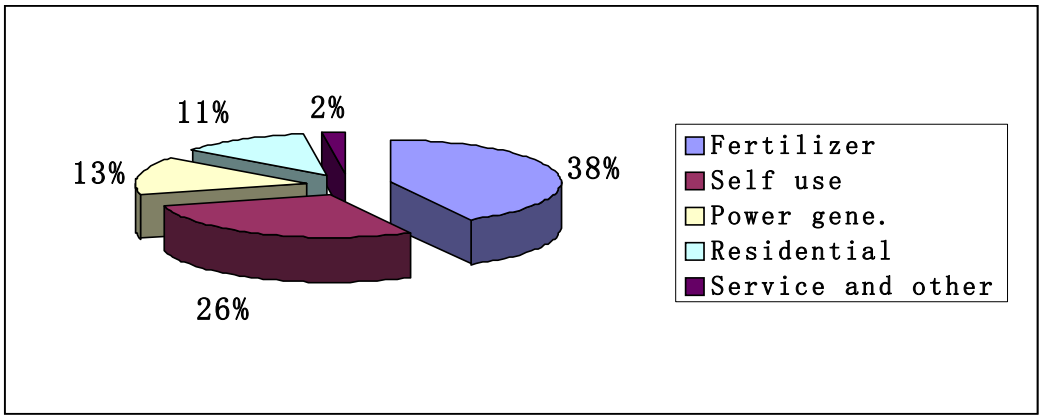


Fig 2.1 Structure of Natural Gas Consumption in China in the Period of the 9th Five-Year Plan

China's power consumption mix in 1990-2000 by sectors is given in Table 2.9.

Table 2.9 Power consumption mix in 1990-2000 by sectors

Sectors	1990	1995	2000
1 Agriculture	6.9	5.8	5.0
2 Industry	78.2	76.4	71.7
3 Construction	1.0	1.6	1.1
4 Transport	1.7	1.8	2.1
5 Household	4.5	4.4	7.7
6 Service and others	7.7	10.0	12.4
Total	100	100	100

In 2001, power demand was going to prosperous stage, power industry increased continuously. According to the statistics, total installed generating capacity achieved 338 GW by the end of 2001, including the new added installed capacity 17.13 GW. Total power generation reached to 1,478 TWh, increased 8% than previous year, the hydropower, thermal power and nuclear power increased 5.9%, 8.5% and 3.9% respectively than previous year; total power consumption reached to 1,454 TWh, increased 8% than last year. Power consumed by the primary, secondary and tertiary industries increased 5.1%, 7.9% and 9.1%, the tertiary industry was the highest. The growth rate of residential consumed power was 9.2%, just as that of the tertiary industry, the consumed power by the urban residents increased 10.5%, 3.3 percent higher than that of the rural residents. Comparing with the case in 2000, the growth rate of power consumed by primary industry increased obviously, the growth rate of the secondary and tertiary industries, as well as the residential consumed power dropped. It means that the high-speed increasing in 2001 was a feature in overall situation.

Total output of primary, secondary and tertiary industry and their total energy consumption in 1998 are shown in Table 2.10.

Table 2.10 Total output of primary, secondary and tertiary industry and their total energy consumption in 2000

		Energy consumption (in Mtce)	GDP (billion yuan)	Energy intensity (in kgce/yuan)
Primary industry		57.9	1,462.8	0.040
Secondary industry	Industries	896.3	3,904.7	0.230
	Construction	14.3	588.8	0.024
Tertiary industry	Transport, warehouse, post and communication	99.2	540.9	0.183
	Wholesale and retail sale trade, restaurants, others	28.9	731.6	0.040

Data source：《China Statistics Yearbook, 2002》, by State Statistics Bureau.

It can be seen，the primary industry，the construction industry of secondary industry and the wholesale, trade and restaurant in tertiary industry had low unit energy consumption: 0.04, 0.024 and 0.04 kgce/yuan, respectively. However, secondary industry and the transportation, post and communication in tertiary industry had high unit energy consumption and low energy efficiency, their unit output value consumed much more energy.

2.5 Forecast of Medium Term Energy Demand and CO_2 Emission

2.5.1 Analysis on main factors of impacting energy demand and CO_2 emission

Economic development and increasing people's standard of living will cause energy consumption to increase continuously. Research for decades shows that the main factors influencing energy demand are population growth and urbanization, economic development, industry structure change, progress of energy technologies (mainly including improvement of energy efficiency, energy substitution) etc. on one hand, population growth and economic development make energy consumption increase over time. On the other hand, sensible adjustment of industry structure increase the shares of low energy consumption sectors, improve efficiency to reduce consumption from aspects of technology, scale and management, which will effectively control and reduce energy consumption. In terms of statistical materials, during 1980-1990, annual average GDP growth rate was 9.4%, annual average energy consumption growth rate was 5.1%, which means energy consumption elasticity was only 0.54. During 1990-2000, annual average GDP growth rate was 9.9%, annual average energy consumption growth rate was 2.7%, which means energy consumption elasticity was only 0.27.

Energy consumption will still keep the growth trend with future sustained economic development. So, when outlook the future energy demand, it can be assumed that, energy consumption will continuously increase but moderately due to continuous improvement in energy efficiency and energy conservation.

During last two decades, the energy efficiency was improved greatly in China, the per GDP energy consumption decreased from 1.33 kgce/yuan to 0.46 kgce/yuan (at 1980 constant price), up to 65% reduction. Although improving energy efficiency compared with international level, there is still a big gap. The per GDP energy consumption is 2.3 times higher than that of average world level, energy consumption for main energy intensive products is 30-90% higher than that of abroad level. The average energy efficiency in China is about 32%, 10% much lower than that of the level of developed country. So there is a big potential to save energy, further reduction of energy demand can be realized

by keeping continuous efforts.

Based on the GDP and energy consumption data provided by World Bank and IEA, comparison of energy intensity of GDP in 2000 and their trends in 1990-2000 between China and major OECD countries are shown in Figure 2.2 and Figure 2.3, respectively. Because GDP indicated in terms of PPP is not a formal indicator adopted in the official statistical system so far, so the comparison in this report is only made in terms of normal GDP indicator.

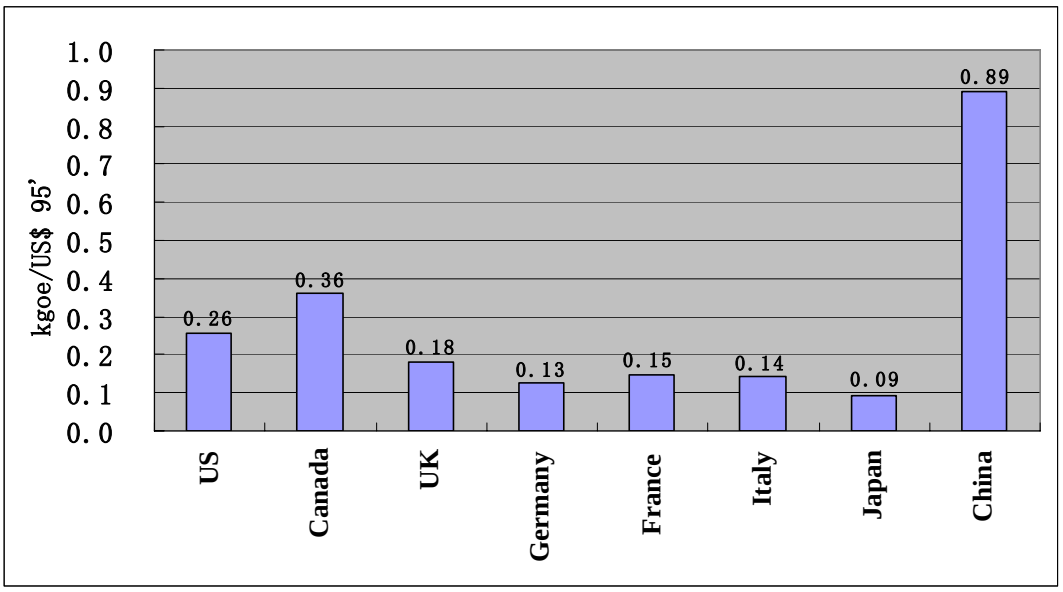


Figure 2.2 Comparison of Energy intensity per GDP between China and key OECD countries in the year of 2000

Data source: World Bank "World Development Indicators", IEA "Energy Balance of OECD Countries", "Energy Statistics and Balances of Non-OECD Countries".

It is known from figure2.2 that energy intensity per GDP in China in 2000 is much higher than that in OECD countries, for example, it is almost 10 times higher in China than Japan, who is the lowest country in OECD. The fact of higher energy intensity per GDP implies there exists a big potential for improving energy efficiency, which is the target of China in sustainable development in future.

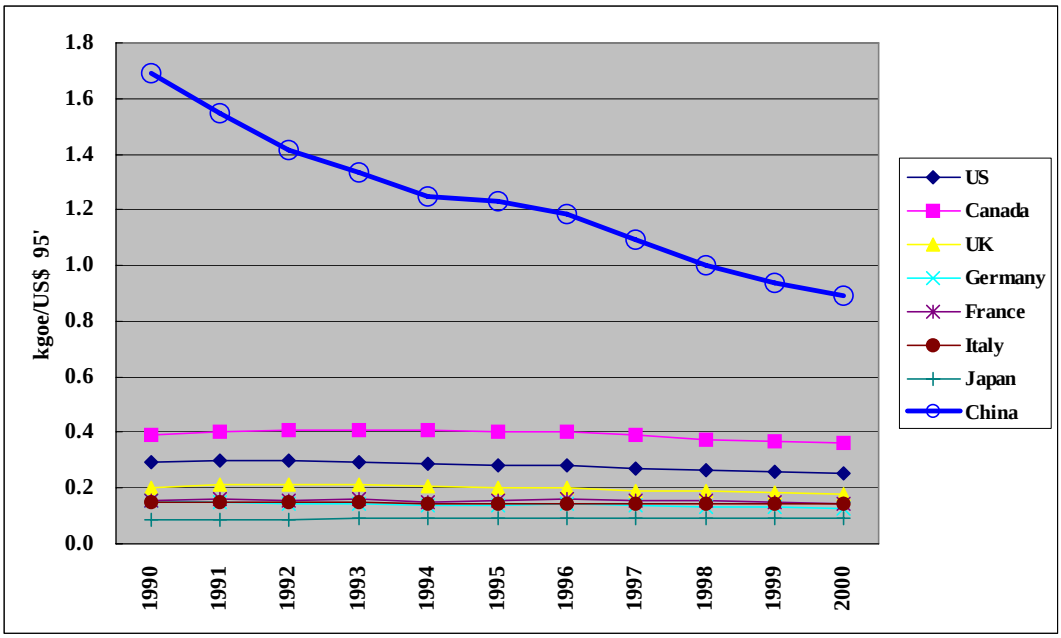


Figure 2.3 Trends of primary energy intensity per GDP in 1990-2000 in China and key OECD countries

Data source: World Bank "World Development Indicators", IEA "Energy Balance of OECD Countries", "Energy Statistics and Balances of Non-OECD Countries".

(1) Population growth

Population of China rank top one in the world, in 2001, there are 1.28 billion people in China, account for about 20% of global population. The population growth rate was 1.03% during 1990-2000. The population growth rate will steadily decrease in the future. Some reports show that the population of China will rise to the peak in the middle of the 21st century to about 1.5 billion and 1.6 billion, and then total population will be gradually decreased. In terms of the forecasting result of State Planned Parenthood Commission, the change of population in China is shown in Table 2.11 (including urbanization).

Table 2.11 Population change in China (billion)

	2000	2010	2020
Scenario 1 (TFR=1.8)	1.27	1.36	1.43
Scenario 2 (TFR=2.0)	1.27	1.38	1.48
Urbanization ration	36%	45%	55%

Note: TFR means Total Fecundity Rate.

During 2000-2010, annual average population growth is about 10 million; annual average population growth rate is 0.76%. Population is among 1.43 billion and 1.48 billion, average value is 1.46 billion by 2020, which means annual average population growth is about 8.5 million, annual average population growth rate drop to 0.6% during that decade.

(2) Economy development

An important document *"National social and economic development of the Ninth Five-plan and perspective objectives outline for 2010 year"* was approved by Session 4 of Conference 8, the National People's Congress in March 1996. The main objective for national social and economic development for 2010 is that GDP will double that in 2000. According to the objective, annual average growth rate (AAGR) of GDP will keep at 7.2%. Now, provided that AAGR is 6.8% during 2010-2020 (see Table 2.12), per capita GDP will be 1,580 US dollar in 2010 and 2,870 US dollar in 2020 based on those objectives and assumptions.

Table 2.12 Economic development scenario of China

		2000	2010	2020
GDP AAGR	%		7.2 (2000-2010)	6.8 (2010-2020)
GDP	billion	8,940	17,900	34,560
Per capital GDP				
	yuan	7,040	13,070	23,750
	US$	850	1,580	2,870

Note: GDP value is at 2000' constant price.

(3) Industrial structure of national economy

Current characteristic of GDP structure in China is that: excessive high proportion of primary and secondary industries, while lower proportion of tertiary industry. With the process of modernization in China, the proportion of primary industry will drop while tertiary industry, with lowest energy consumption of per value added, will increase. This will play a main role in reducing total energy consumption in China. The assumption of the change of industrial structure is shown in Table 2.13.

Table 2.13 Change of industrial structure of national economy (%)

	2000	2010	2020
Primary	15.9	13	10
Secondary	50.9	48	45
Tertiary	33.2	39	45

2.5.2 Forecasting of energy consumption demand and CO2 emission in China in 2020

Integrating the assumptions of population growth, economic development and the change of industrial structure form now to 2020, and assuming two scenarios for energy saving, forecasting of commercial energy consumption demand of China in 2020 is presented in Table 2.14.

Table 2.14 Forecasting of commercial energy consumption demand (Mtce)

	2000	2010	2020
Commercial energy demand of China			
Scenario 1	1,303	1,614	1,962
Scenario 2	1,303	1,569	1,857

The commercial energy consumption demand in 2010 is among 1.57 billion to 1.62 billion tce. The energy consumption elasticity is 0.30 in scenario 1 and 0.25 in scenario 2 respectively during 2000-2010. The commercial energy consumption demand in 2020 is among 1.86 billion to 1.96 billion tce. Given the two scenarios listed in table 2.14, scenario 2 represents a technology progress trend in social and economic development, it is the target China is striving for. The energy consumption elasticity is 0.25 in scenario 2 during 2010-2020. The energy consumption elasticity is much lower than that by end of last century, and can keep lower value in the beginning of 21st century, which depends on energy consumption reduction due to technology progress. On the other hand, adding proportion of oil and natural gas in energy mix due to increasing demand for oil and natural gas while evident drop of coal share, which improve energy efficiency and reduce CO2 emission in general.

Following the total energy demand (scenario 2 is analyzed here) listed in Table 2.14, primary energy supply mix scenario in China is listed in table 2.15.

Table 2.15 Primary energy supply mix (%)

	2000	2010	2020
Coal	65.8	54.7	43.0
Petroleum	24.5	26.9	31.8
Natural gas	2.5	9.0	12.9
Hydro-power	6.7	7.8	9.2
Nuclear power	0.4	1.2	2.1
Renewable energy	0.1	0.4	1.0

The share of coal in energy mix will decrease in the future, and is expected to decrease to about 50% by 2015. Petroleum demand will increase quickly, up to 300 million tons by 2010, up to 425 million tons by 2020, its share will account for about 1/3 of total energy consumption by 2020. Also, the share of natural gas demand will increase to the third, up to 100-110 billion m^3 by 2010, up to 180-200 billion m^3 by 2020. With strengthening environmental protection, more attention will be paid to renewable energy. Although renewable energy only accounts for small share, its growth space is the biggest, and will be up to 1% by 2020.

In terms of total energy consumption and its consumption mix, CO_2 emission of fossil fuel consumption can be roughly forecasted. The CO2 emission of China was about 822 million ton carbon (Mt-C) in 2000, increasing to 945 Mt-C in 2010, to 1,060 Mt-C in 2020. Although increasing absolute amount of fossil fuel consumption, CO_2 emission of fossil fuel consumption will be controlled due to energy conservation and fuel substitution. The net increase of CO_2 emission would be 123 Mt-C in 2010 than that in 2000, and down to 115 Mt-C in 2020 than that in 2010.

3. REGA technology analysis and development potential

By the supports of GEF, WB and ADB, the potential of emission reduction has been analyzed in China. Then the technology of emission reduction has also been deeply studied in many research projects. This

paper will review the existing researches, and discuss the status and potential of main energy saving technologies, renewable energy technologies, and emission reduction technologies in energy conversion and consumption sectors.

3.1 Energy conversion sectors

In energy conversion sectors, technology of power generation is focused on. Power generation is one of the main processes of primary energy conversion to produce secondary energy. In the total power supply, thermal power takes about 80%, and hydropower and nuclear power take about 20%. Using different power generation technologies, improving the equipment efficiency of thermal power generation technologies, increasing the proportion of hydropower and nuclear power and other renewable power in the total power supply are the important means of emission reduction. Presently, in the total thermal power generation, coal power takes about 90%. The coal consumption of thermal power generation has decreased from 427 gce/kWh to 392 gce/kWh，the difference between this index in China and the international advanced level has decreased from 28.6% to 24.1%. If the energy consumption level in China can reach or approach the international advanced level, the primary energy consumption of power generation can be decreased 20%. The hydropower, nuclear power and renewable power are the power generation technologies whose greenhouse gas emissions is zero. If their proportion increases one percentage in the total power generation, the coal consumption can reduce 4 million ton, and the CO2 emissions can reduce more than 2 million tons (carbon).

3.1.1 Thermal power generation technology

The emission reduction measures of China power sector are emphasized on improvement of energy saving technologies. Presently, in thermal power generation, the thermal efficiency of coal-burning plant is about 30%, which has a big gap with that in other countries. The main cause is discussed below. In the total units, those units that are over 200 MW, large capability and high parameter have a low proportion (less than 40%). At the same time, the thermal efficiency of 200 MW unit made in China is lower than those made overseas. And the small thermal power unit that is less than 25 MW, medium temperature and pressure takes one fourth. Now, the main measures of energy saving and technology improvement in thermal power plants include: on one hand, it is to phase out small coal power unit by using large unit to replace the small unit or change the small unit to thermal supply unit; to develop the unit with high parameters and large capacity; vigorously to develop the unit that combines power supply with heat supply and the unit that burning gas and steam cycle together. The other hand is to introduce advanced thermal power technology. The main advanced thermal power technologies include:

(1) Normal coal-burning unit with large capacity, high parameter and high efficiency. As the main

measure of energy saving in thermal power plant, China has set down the guideline that the new units must mostly be 300-600 MW sub-critical coal-burning unit with high efficiency and large capacity, to phase out small thermal power unit with high coal consumption and less than 50 MW, and to implement the development policy of "using large unit to replace small one" in power industry. The 300 MW and 600 MW sub-critical coal-burning unit with 37% power supply efficiency, and the super-critical coal-burning unit with about 40% power supply efficiency that is 600 MW and over will become the main unit of thermal power in China step by step.

(2) New technology of coal-burning power generation with high efficiency and cleanness. The new technology is an effective approach to advance the utilization efficiency of coal and to resolve the environment problem coming from the coal burning. The China power sector has listed the IGCC and PFBC into the forerunner projects of science and technology that began in 2000. ①IGCC power generation technology. On the hand of technical characters, IGCC is superior to the normal FGD pulverized coal plant. But the key of IGCC technology commercialization lies on its economic indexes. Presently the investment cost of ICCC plant is 20% higher than that of normal FGD pulverized coal plant, but its power generation cost is less than that of normal FGD pulverized coal plant. In the future with the large scale commercialization of IGCC power generation technology, its investment cost will greatly decrease, and its generation cost will further decrease too. Therefore in the 21st century, in the market of power generation technology, the IGCC technology will has its competition advantage.② PFBC power generation technology. PFBC has many advantages such as wide adaptability of coal, high efficiency, low pollution emission and fitting for the old plant's retrofit. The power supply efficiency of first generation PFBC plant can reach 40%, and its desulfurizing rate is more than 90%, and its emission of NOx has been reduced by 60～80% than that in normal coal-burning plant. The second generation PFBC has utilized the new technology of high temperature gas turbine，at the same time it reserves the first generation's advantage of low temperature reaction that can control NOx produced. Its power supply efficiency has come to 44-45% presently, so it has more predominant performance on environmental protection. PFBC technology cannot only be used to retrofit old plants, but also be used to build new plants. China has several hundred sets of coal-burning units that the capacity is 100 MW, 125 MW or 200 MW. For the future a set of new coal-burning plants will be built. Therefore, the PFBC technology has a great market potential in China.

(3) Burning oil and gas's combined-cycle power generation. Presently the power supply efficiency of advanced combined-cycle power generation has been 50-52% that is much higher than any other power generation technologies, and it can be collocated to large independent power plant that can undertake the basic load. Gas turbine power generation is the electrical source that develops fastest in the world in recent years. With the force increasing of developing natural gas resource in China, the adjusting of energy strategy and the growth of oil and gas's import, the technology of gas's combined-cycle power generation will be further utilized and developed in China. Especially, in those areas with rich oil and

gas resources but lack of power, and in coastal developed areas where it is advantageous to import oil and gas, the technology of oil and gas's combined-cycle power generation has an optimistic future.

The developing potential of thermal power technologies. The status of China's power generation that the coal-burning power generation is the main mode will be difficult to change in a long time. After 2000, advanced thermal power generation mode or technology will have large market potential and emission reduction potential. But until 2010, the advanced thermal power mode and technology will be the pilot stage and can't play an obvious role in emission reduction. Until 2010, the proportion of low-carbon fossil fuels in the total thermal power generation will not increase obviously, and the emission reduction of thermal power will mostly depend on the efficiency improvement of normal thermal power. Considering the fulfilling of above measures of improving energy conversion efficiency, it can be expected that coal consumption of thermal power can decrease to 320 gce/kWh in 2010, which compared with that in 1990, coal used in power generation will decrease 150 million ton and the emission of CO_2 will decrease about 100 million tons.

Table 3.1 Economic parameters of thermal power technologies（1994）

Power generation technology	Investment of plants (yuan/kw)	Proportion of the fixed operation cost in the investment (%)	Fuel	Net efficiency of power generation (%)	Load factor	Economic lifetime (Year)	Building period (year)
Normal coal power	5,300	3	Coal	33	65	20	2
Normal desulfurized coal power	6,300	3	Coal	33	65	20	2
GTCC	7,000	2	LPG	45	65	20	1
GTCC	7,000	2	Oil	45	65	20	1
AFBC	10,000-6,300	3	Coal	33	65	20	2
PFBC	10,000	3	Coal	40	65	20	2
IGCC	10,000-8,000	3	Coal	42	65	20	2

Source: 《The Research of Climate Change in China》，Tsinghua University Press.

3.1.2 Hydropower technology

There is rich of hydropower resource in China, which is the richest in the world. Presently, the rate of exploitation and utilization of total hydropower resource that can be exploited under the existing technologies is only 13.8% in China, so the hydropower resource has large exploiting potential. The capital investment of hydropower station construction is about 10,000 yuan/kW in China, but the power generation cost is rather low. The long period of the station construction, dispersed resource distribution and long distance between the station and load center have restricted the hydropower development in a certain extent in China. It is expected the installed capacity of hydropower in China

will be over 100 GW. Given in 2010 besides the boundary river in Northeast area and the four provinces in Southwest area, 80% hydropower resource in other areas can be exploited. While in the 4 provinces in Southwest area, because the distribution of hydropower resource is very centralized, and the capacity that can be exploited is very large, limited by the exploited capability, it is assumed that 50% hydropower resource can be exploited at that time.

3.1.3 Nuclear power technology

The installed capacity of nuclear power that has been put into operation is 2.1GW, which is about 1% of the total installed capacity in China. This proportion is very low. In the east coastal area where has developed economy but lack of energy resource, to develop nuclear power will play an important role on resolving these problems: lack of power energy, atmosphere pollution and burden on transportation.

Because the making capability of nuclear power equipment is very low in China now, in the short period the construction of nuclear power station will still depend on the imported units, this technology will still be a rather expensive one. But the power generation technology of nuclear power is less than that of coal power. So the area where the coal price is much high, the nuclear power has some economic competition capability. The relevant department has established the guideline of developing nuclear power that is called “taking myself as the main part, cooperating between China and foreign countries”, and quick up the process of nuclear power’s localization.

In the “863” plan of China, on the energy technology field, the advanced energy technology facing to the 21st century will be mostly researched. According to the principle of “limited objective and extruding key point”, the technologies of coal magnetism fluid power generation and nuclear reactor etc. Four subjects have been chosen as key point, and it is expected to increase the thermal energy conversion efficiency in a large extent, to reduce coal transportation and environment pollution problem brought by coal power generation, and to improve the utilization rate of nuclear fuel in a large extent. If after 2000, two 900 MW units can be put into production, and every year to establish a set of nuclear stations in the east coastal area with poor energy until 2010, the installed capacity of nuclear power will be about 20 GW and the power generation will be over 120 TWh.

3.1.4 Wind power technology

There is rich wind energy resource in China. It is estimated the total wind energy resource that can be exploited is about 235 GW, which means that the exploiting potential is very large. Presently, the total installed capacity of wind power is only 400 MW in China. Through the “By Wind Plan”, the total installed capacity of wind power in China is expected to be 0.5% of the total installed capacity of power in 2005, which is about 1.5 GW, and in 2010 it is expected to be 3 GW. The “By Wind Plan” is a

tactic plan to develop wind power that starts from the point of the national program and faces to the national and overseas markets. Its objective is to take the form of combining the technology with the trade to introduce, digest and absorb the overseas advanced technology, realize the localization of the 300 kW and 600 kW large-scale turbines, and quick up the construction of wind farm. In the future if the wind power generator can be completely localized and batch produced, the investment of the equipment in wind farm will be decreased in a large extent. In the north and some areas in southeast of China, there is rich wind resource, so the wind can be chosen to be one of the power generation technologies for emission reduction.

Until now, the localization rate of 200 kW turbine that is independently developed by China has been 90%, and it can be batch produced. The localization rate of 600 kW sample turbine for research has been 18%. But China has no the ability to produce the wind power turbine over 200 kW yet. According to the experts, the wind power technology will develop to the direction: large-scale, light, high reliability, further improving efficiency and reducing cost. In the future, the priority technologies to be developed in China are: 1) the research of light, long lifetime wind power turbine; 2) series design of advanced wing to improve the power generation performance of wind generator; 3) design and development of the self-adaptability advanced control system etc.; 4) the ability improvement of overall design and furnishment of large-scale wind power turbine.

3.1.5 PV power technology

China began to research and manufacture PV cell in 1958. In 1999, the annual output was 3 MWp, and the retaining capacity was 15 MWp. At present, the efficiency of the solar cell made in China is 10-13%, which is less 2 percentages than the international advanced level. In 1999, the cost of PV groupware made in China is 27-29 yuan/Wp, and the cost of system is 40-60 yuan/Wp and the price is 60-80 yuan/Wp, which are higher than those made abroad. It is estimated that the annual output of PV cell will be 15-20 MWp in China in 2002-2003, and the installed capacity of PV cell will be 150 MWp in 2010, 4-8 GWp in 2020, 15-30 GWp in 2050. Henceforth the trend of PV technology development in China is: 1) polycrystalline silicon cell will still be the leading actor, and develop to the direction of high efficiency and low cost; 2) film PV cell will be the new main type cell with best future; 3) the key balance equipment such as controller, spacer etc. will develop to the direction of high reliability, high efficiency, more function, intelligent zing and low cost; 4) more suitable storage cell with long lifetime, low cost, large capacity and non-maintenance and other more advanced energy-stored device will be developed; 5) system integration technology (including the grid-in technology) will develop to the direction of more scientific, standardization, intelligent zing and integrated.

3.1.6 Biomass power generation

The biomass gasification technology mostly is the simple movable gasification power generation device, medium-size gasification power generation system and biomass cycle stream bed gasification power generation etc. to dispose wood waste, rice hull, fruit hull with high heat value. The crop straw with low heat value is still in the stage of trail and research, and need further develop the application technology. The gasification power generation technology should be tackled for key problems as below: 1) the development of tar spiting and decomposing technology to completely resolve the problem of tar's secondary pollution; 2) improve the gasification process and advance the total thermal efficiency; 3) further reduce cost; 4) optimize system design and perfect technology standard.

3.1.7 Geothermal power technology

The geothermal power generation began in China in 1970's. Until now there are 9 geothermal power stations, in which there are seven demonstration stations and two business station. All these stations locate in Tibet. The key technology of building 10 MW geothermal station has been listed into the tackling problem plan of national key sciences and technology. If the tasks such as directional geothermal making hole and hole controlling technology, high temperature geothermal liquid transporting technology and the antisepsis and blocking dirty technology can realize the expected objective, the geothermal power generation technology will be advanced to a new level. The following technologies should be emphatically researched in the coming 10 to 15 years. 1) resolve some key problems in the geothermal station construction and high temperature geothermal resource development in west Yunnan and Tibet; 2) reinforce the ability of building large-scale high temperature geothermal stations, entirely improve the geothermal power generation technology in China to advance efficiency, reduce cost, and accumulate experience for utilizing the geothermal resource greatly and building 10 MW geothermal station, at the same time make a sufficient preparation in the technology.

3.1.8 Small hydropower technology

China is one of the earliest countries to utilize hydropower in the world. The technology of small hydropower is mature (the install capacity is less than 25 MW). It is a renewable energy with the largest size and quickest development speed in China. By the end of 1998, the installed capacity of small hydropower had been 25.2 GW, which supplies power for half national area, one third counties and 0.3 billion population in China. It has been an important force in the power construction in urban and rural area. The power sector reform and grid restructuring in rural area began in 1998, at the same time the pilot of the same price in the same grid in urban and rural area began too. Presently, supporting by the state, the construction of pilot rural electricilization county is being carried out, which has three groups (100, 200, 300 counties) and mostly are small hydropower. It will further promote the development of small hydropower construction in China.

3.2 Energy consumption sectors

3.2.1 General equipment technology of industry sector

The structure of end energy consumption can greatly affect the energy using efficiency. The general industrial equipment that China is using and producing is the main equipment of energy consumption in industry sector. The general industrial equipment includes industrial boiler, industrial electric motor, fan and water pump. All these equipment consume more than 80% energy in the total energy consumption in the industry sector. The industrial boiler has consumed about one third coal, while the industrial electric motor has used more than 60% power of the total industrial power consumption. Their integrated efficiency has rather big gap with the international advanced level. Through renewing the old equipment and increasing energy efficiency, the integrated energy efficiency of the general industrial equipment can be improved about 10% so as to reduce the energy consumption and GHG emission about 10%.

1) Industrial boiler

The industrial boiler is a kind of thermal production equipment that be utilized very widely in industry and resident sectors. At present, the annual coal consumption of industrial boiler is 0.35 billion ton that is one third of the total coal consumption. With the development of the economy, the demand of industrial boiler will continuously grow. If it can't be strictly controlled, the pollution will be more serious. Therefore, it is an important task to control the pollution emission of coal-burning industrial boiler for China's atmosphere environmental improvement. If the burning efficiency of industrial boiler in China can reach at the level of developed countries, coal can be saved 50 million tons and the carbon dioxide emission can be reduced 26 million tons every year.

The technology development status of China's industrial boiler is as below. The industrial boiler includes industrial steam boiler, heating and hot water boiler, residential boiler, cogeneration boiler, special use boiler and waste heat boiler. By the end of 1998, the total installed capacity of industrial boiler in China had been 500 thousand, about 1.25 million evaporation amount ton (EAT). According to types of boiler, there were 336 thousand steam boilers (about 856 thousand EAT), 165.8 thousand hot water boilers (28.87 MW, about 403 thousand EAT). According to the boiler's use, there were 238 thousand boilers used in production (686.7 thousand EAT) and 263 thousand boilers used in residential (570 thousand EAT). Considered by the quality grade, the boilers that the capacity is more than 10 EAT are increasing step by step (from 27.4% to 33.4%), while the boilers that the capacity is from 2 to 6 EAT are decreasing (from 62.9% to 57.6%). Considered by the fuel, the oil and gas boilers are increasing (from 3.2% to more than 5%), and in the coal-burning boiler, soft coal takes 87-88%, while the blind coal, poor coal and lignite coal takes no more than 5-6%. Considered by the burning

equipment, the chain stoke boiler keeps its leading location (more than two third), while the to-and-fro boiler has decreased from 17.3% to 10%. Presently, the throughput of industrial boiler corporations that have A-D grade production license is 120 thousand EAT. If the E grade corporations are included, the total throughput of industrial boiler corporations will be 150 thousand EAT.

The emission reduction technology of industrial boiler mostly is in four aspects as below.

The first is fuel pre-disposal. The main fuel of industrial boiler is coal in China. Screening coal, washing and selecting coal, reasonably matched coal, and using the technology of briquette coal, can realize the effect of saving coal and reducing GHG emission with lesser cost. It is estimated that the burning efficiency will increase 1%, once the ash in the coal decreases 10% by washing and selecting coal and reasonably matching coal. The cost of using briquette coal technology to reduce carbon dioxide is more than 100 yuan.

The second is to reasonably operating and using boiler. It is needed to optimize the reasonable deploy of boiler and train some technical personnel so as to advance the real using efficiency of boiler. The cost of these measures to reduce emission is very little.

The third is to retrofit and perfect the burning system of existing boiler in order to advance the burning efficiency about 5%～10%. The main measure in this aspect is to optimize the boiler's firebox, install coal-saving equipment, fulfill computer control etc. to increase the boiler's burning efficiency.

The fourth is to design and produce high efficiency boilers to improve the boiler's design efficiency. The high efficiency boiler's technologies that are being researched or produced in China include: (1) CFBC. CFBC uses the fuel such as coal gangue, soft coal, poor coal etc, and its burning efficiency is about 89-92%. A 75 EAT boiler can save coal 10 thousand tons and reduce the carbon dioxide 17 thousand tons every year. In its entire lifetime, the emission reduction of carbon dioxide is 254 thousand tons and the emission reduction cost is - 59.7 yuan/t. (2) The spreader coal burning boiler. Its heat efficiency is more than 84% and the capacity is 10-130 EAT. A 75 EAT boiler can save coal 8,100 t and reduce the CO_2 emission 13 thousand tons every year. In its entire lifetime, the emission reduction of CO_2 is 200 thousand tons and the emission reduction cost - 67.8yuan/t. (3) The vibration stoker-fired boiler. The heat efficiency of this boiler when it burns soft coal can be 87%. A 10 EAT boiler can save coal 500 tons and reduce the CO_2 emission 827 tons every year. In its entire lifetime, the emission reduction of CO_2 is 12 thousand tons and the emission reduction cost is -38.6 yuan/t. (4) The overturn boiler. The heat efficiency of this boiler is 80-82%, and its capacity is 4-20 EAT. A 6 EAT boiler can save coal 400 tons and reduce CO_2 emission about 666 tons every year. In its entire lifetime, the emission reduction of CO_2 is 9,989 tons and the emission reduction cost is –43 yuan/t. (5) The advanced water fire-pipe boiler. The heat efficiency of this boiler is over 80% which is 5-8% higher

than the national standard. A 6 EAT boiler can save coal 400 tons and reduce CO_2 emission 687 tons every year. In its entire lifetime, the emission reduction of CO_2 is 10.32 thousand tons and the cost of emission reduction is –80 yuan/t. （6）The corner-pipe boiler. The heat efficiency of this boiler is more than 85%, and its capacity is 10-130 EAT. A 20 EAT boiler can save coal 900 t and reduce CO_2 emission 1,463 tons every year. In its entire lifetime, the emission reduction of CO_2 is 21.95 million tons and the cost of emission reduction is –34.1yuan / t. (7) The down-feed stoker boiler. The heat efficiency of this small-scale boiler can be 70%-80% and its capacity is 0.4-4 EAT. A 4 EAT boiler can save coal 293 tons and reduce CO_2 emission 397 tons. In its entire lifetime, the emission reduction of CO_2 is 5,955 tons and the cost of emission reduction is –35.4 yuan/t.（8）The briquette coal boiler. This boiler's fuel is briquette coal and not the raw coal, which can increase the heat efficiency about 4-8% and reduce the soot emission 50%, and if the reagents of fixing sulfur is used, the SO_2 can be decreased 30-40%. A 6 EAT boiler can save coal 300 tons and reduce the CO_2 emission 467 tons every year. In its entire lifetime, the emission reduction of CO_2 is 7,003 tons and the emission reduction cost is –46 yuan/t. (9) Use of heat storage in the boiler's heat supply system. This can generally save fuel 3-20%. A 6 EAT boiler can save coal 200 tons and reduce CO_2 emission 345 tons every year. In its entire lifetime, the emission reduction of CO_2 is 5,175 tons and the cost of emission reduction is –44.5 yuan/t.

The development potential of industrial boiler. Presently, the number of industrial boiler is bigger than power station boiler. But with the development of urban gas and more abundant of power supply, the industrial boiler will relatively decrease. The residential condition in China is being improved, so the market prospect of heating boiler is very well. In the "Three North" area of China, new houses grows with an average speed of 150 million m^2 every year. The demand of heating boiler is very large. In order to increase the boiler's operation efficiency and control pollution emission, it is needed to develop centralized heat supply and large and medium capacity of hot water boiler. The growth of the tertiary industry, town & village corporation and indigent economy will be the market of industrial boiler development. It is estimated that the demand of small capacity, high efficiency and low pollution boiler will increase, especially the oil and gas boilers. If the national economy can develop with the growth rate of 8.5-9%, henceforth the annual growth rate of industrial boiler will keep the level of 3-5% (low) or 6～8% (high). It is expected that the saved coal will be 118.1 million tons in 2010 and the emission reduction will be 61.9 million tons (based on carbon) from above four emission reduction technologies.

2) Electric motor

The status of electric motor industry and application. Altogether 3,900 large-scale electric motor (3,360 MW) were produced in China in 1999 in which there are 966 large–scale synchronization electric motor (1,635 MW), 1,000 large-scale asynchronism electric motor (972 MW), 104 large-scale DC motor and 1,830 medium-scale DC motor (684.6 MW). At present, there are small and medium-scale

electric motor more than 300 series and almost 1,500 varieties in China. It is widely used in the equipment that takes the electric motor as drive resource such as fan, water pump, compressor and all engine vehicle. Its output in 1999 was about 42,000 MW and the sale income was 5.8 billion yuan, at the same time the exportation is about 7,000 MW. Up to now, 70% asynchronism electric motor has been Y-series and 10% has been 2-series. The total installed capacity of all electric motor has exceeded 400 GW in China presently, and the power consumption is about 600 TWh that is about 60% of the total power consumption in China, in which the power consumption of small and medium-scale electric motor is bout 70% of the total electric motor's power consumption. The equipment driven by the electric motor mostly includes pump, fan, compressor and machine tool etc. the efficiency of China's electric motor is less 3-5% than the average level of foreign countries. In the operation process, the efficiency of electric motor system is 10-30% less than foreign level.

The technology of high efficiency. As China will be the electric motor production base of the world, the new standard of electric motor products should be established and the basic and high efficiency product will be provided to the energy saving project. Of which, the typical products of high efficiency include: (1) Y(1P44) asynchronism electric motor. The weighting average efficiency of total series is 0.43 higher than J02 series, and its annual output is 20 GW. (2) YX-series high efficiency electric motor. The average efficiency of total series is about 3% higher than Y(1P44) series and close to the international advanced level. Based on the ways of adjusting speed, the typical products of speed variation electric motor can be divided as: electrode-changed, electric-magnetic slide valve, and frequency variation.

The analysis of energy saving potential in the China's electric motor system. After investigation, it is known that in the coming 10-20 years, if the energy saving plan in China's electric motor system can be rapidly and stably developed or not fully depends on the price namely how to continuously reduce the cost and price of transducer, especially the medium voltage transducer. Based on this result, it should add the application categories of 660 V, 2.3 kV, 3.3 kV etc. between the standard voltage of 380 V and 6 kV (or l0 kV). This is effective to reduce the price of electric motor and transducer. In the energy saving application of fan, water pump and compressor, it is very important to support the R&D and industrialization of economic speed variation device. If this work can be obviously promoted in the coming years, the energy saving plan's course of China's electric motor system will greatly quick up. The analysis shows that considering the new added capacity in the year 2001-2005 and 2006-2010, and 60% and 88% of new added capacity would be retrofitted, the capacity of energy saving retrofit electric motor will be 47,600 MW and 97,250 MW, separately. Given the average price of 1,000 yuan/kW and 800 yuan/kW, the investment will be 47.6 billion yuan and 77.8 billion yuan, separately.

The application prospect of high efficiency electric motor. It is estimated that the market occupation rate of the Y and YX series electric motor are 90% and 30% in 2010. The electricity saved from the

high efficiency electric motor replacing the J02 electric motor will be 36.6 TWh in 2010. The market occupation rate of speed variation electric motor is about 20% presently and it is estimated that it will be about 85% in 2010. If above electricity saving technology is used, it is expected that the electricity saving will exceed 91 TWh by 2010. And the CO_2 emission reduction will be about 28.9 million tons (carbon).

3) Other main general equipment

The fan, water pump and compressor is the main general equipment, the technology status of general equipment in China is as below.

Pump

Presently, there are 87 series and 1,288 varieties of pump in China, in which single stage and single suction clarified water pump is the basic product of pump. It has the largest yield and widest application. IS pump is a product that is designed for entire industry and follow out the international standard. Its average efficiency is 4% higher than old product. It is estimated that there are about 30 million pumps (about 80 GW) in China, and they are applied in metallurgy, chemical industry, power generation, machinery, building materials, oil, transport, spin, paper making, coal, agriculture and national defense etc. sectors. Based on the statistics from 164 enterprises, the feature of the pump market in 1999 was that the supply exceeded the demand. The power consumption of all pumps is about 20% of the total power generation in China presently. There also are some pumps driven by diesel engine. Their annual diesel oil consumption is about 5% of the total diesel oil consumption in China.

Electric fans

Presently there are more than 200 series and 2,000 varieties of electric fans. Total capacity of all fans is about 7 million (30 GW). 86 companies produced 237,384 fans in 1999. The annual output table of the main products shows that the share of centrifuges fans and axial flow fans has exceeded 50% in the total output of fans, in which the share of centrifuges fans is more than that of axial flow fans. The turbine compressor is one of the important equipment products and has great role in economic development. Its production value is about 20% of the total production value of fans. The making level of turbine compressor can delegate the whole level of the fan industry. The power consumption for driving fans is about 10.4% of total power consumption in China. The equipment's average rating efficiency of fans in China is about 75%, and the system operating efficiency is rather low (about 30%-40%). But the rating efficiency of international advanced level has exceeded 80%. Presently the new fans developed and made in China can increase the efficiency of 3%-6%.

Compressor

Presently there are 124 producing enterprises in pneumatic compressor industry in China. The total output in this industry in 1999 is 48,877 compressors. The annual power consumption of all kinds compressors is 9.4% of the total power generation of China. Most compressors' energy consumption index can correspond with the same kind products made in foreign countries. There also has few products that their index is better than that of the same kind products made in foreign countries and has good characteristic of energy saving. But in the machine's reliability and fittings' level, especially in the aspects of combination of machinery & electron and face quality, most products have obvious gap with the foreign advanced products.

The potential analysis of the energy efficiency of general equipment in China. More than 95% fans, water pumps and compressors are driven by electric motor, only 5% of them are driven by diesel engine. Based on the statistics, the power consumption of fan, water pump and compressor is, respectively, 10.4%, 20% and 9.4% (come to 39.8%) of the total power consumption in China, which can be called the largest power user. The potential of energy saving in these fields is big too. They are the key points of energy saving in electric motor system. The energy efficiency of general equipment lies on following three factors: (1) improving the performance in hydrodynamics; (2) reducing the cubage loss; (3) reducing the machinery loss during operation. Based on investigation, there are 75% fan, 90% pumps and 70% compressors are operated under the status of changing work condition. It is a necessary trend of widely using high efficiency speed adjustment devices, such as frequency variation motors from the point of those enterprises that manufacture and operate generate equipment.

3.2.2 Energy saving technology in residential and transport sectors

Energy consumption of residential sector is about 15% (excluding the biomass energy) of the total energy consumption of China. Based on the development trend, the growth of energy consumption of residential is inevitable. This shows that the GHG emission growth from the energy consumption of residential sector will be inevitable too. The energy consumption and GHG emission of transport is not outstanding in China, and is bout 4-5% of the total energy consumption and GHG emission. But, because of the growth of vehicle, it will be one of the main factors that make the GHG emission rapid grow in China.

3.2.2.1 The status and development potential of end energy technologies in residential sector

In recent 20 years, the utilization efficiency of end energy used by the residential has increased from 23% in 1980 to 36% in 1995. The future objective of residential energy technology development is the

advanced energy service technology and the low cost investment that the environment is considered. The status and develop potential of energy using technology in residential will be discussed from following aspects.

1) Technologies of conventional energy use

Technologies of conventional energy use refer to the equipment and technologies that provide service for residents in urban and rural area when commercial energy, such as coal, gas and electricity etc. are used in daily life. Presently the conventional energy consumption is less than 50% of the total residential energy consumption in China. Power consumption for lighting is almost 10% of total power consumption, the energy efficiency of lighting is only 17.6 lumen/w. If high efficiency lighting lamps and ballast are used, the energy efficiency would be more than 80 lumen/w. Equipment using electricity in households is a kind of energy consumption device that has big amount and is widely used. Especially, the refrigerators, air-conditionings and power thermal devices are “big users” of energy consumption, so in the GHG emission reduction its function cannot be neglected. The emission reduction technologies of household electricity equipment include: energy-saving green refrigerator, energy saving technology of the whorl in the evaporator of air-conditioning, high efficiency galvanothermy component—galvanothermy film used in power thermal devices, energy saving technology of hydrophilic disposal of the aluminum wing in evaporator of air-conditioning, and the mistiness control technology of the air-condition’s frequency variation etc. In recent years, the galvanothermy instrument is widely used. The thermal efficiency of traditional galvanothermy component is obvious low (about 70%). If the galvanothermy film, with thermal efficiency 90%, can be used to replace traditional galvanothermy component, the effect of energy saving will be very obvious. Presently the utilization of galvanothermy film in household power equipment is still in the beginning stage. It is expected that 50-60% of main galvanothermy instrument will be replaced by galvanothermy film in 2010.

2) Thermal utilization technology of solar energy

The technologies of heater and space heating of buildings have been mature and are widely used. Development of thermal power generation technology of solar energy is put in a priority place. Most experts think that the thermal utilization of solar energy can partly replace the mineral energy technology in 21st century, which mostly refers to the thermal power generation and buildings’ energy saving. Related experts forecast that solar heater will be 10-15 million m^2 by 2030, and its lifetime will increase from 5 years to 10-15 years. Each m^2 of solar heater can save 100-150 kg coal. The solar energy will be the main energy that is used by household and building space heating, so it has a wide market.

4) Biomass energy technology

The advanced conversion technologies of biomass energy include: ① The gasification of the anaerobic digestion. ② The utilization technology of biomass pyrogenation gasification and biomass liquefaction. Converting biomass into biogas is a way widely used in the rural area in China. Presently there are 5.7 million household biogas pools and the total biogas output is 2.98 million m^3. There are more than 1,400 large and medium-size biogas projects and the biogas power generation capacity is 3.29 GW.

5) Development potential of energy saving technology in residential sector

It is expected that total power generation will be 2,900 TWh in China in 2010. Assuming to adopt the present proportion that the lighting consumption is 10% of the total power generation, the lighting power should be 290 TWh in 2010. Based on the assumption that the new power-saving lighting source can be popularized, power saving of lighting will be 20%, the lighting power consumption will decrease from 290 TWh to 232 TW, and the emission potential is 68 Mt-C/year. According the timetable of reducing refrigerator's CFCs in China, 50% was reduced in 2000, and 100% will be replaced in 2005. It is estimated that there will be 50-60 million refrigerators that will not use CFCs. Assuming each refrigerator to use 800 gram CFC-11 and 150 gram CFC-12, it will reduce 40- 48 thousand tons CFC-11 consumption and 7,500-9,000 tons CFC-12 consumption in 2010. It is estimated all existing refrigerators that energy consumption is higher will be phased out. It is estimated that the popularization rate of air-conditioning will be 50% in urban area and 10% in rural area in 2010. By 2010, the amount of air-conditioning will be 62 million. Generally, the gasification efficiency of biomass stoves can exceed 70%. Utilization of high quality biomass will be 10.7 million tce in 2010. The biomass gasification (a biomass utilization technology) will have the most development potential.

3.2.2.2 Status and development potential of energy utilizing technology in transport sector

Energy consumption of transport sector is about 5-10% of total energy consumption. The railway sector plans to phase out steam engine in recent years and increases the proportion of electricity railway step by step, so the power consumption will increase and coal consumption will decrease year by year in railway. Total energy consumption of pipeline transport will not change so much. But energy consumption of other transport forms will greatly grow, especially the road traffic and energy consumption will directly relate with rapid growth of passenger transport. Therefore, fuel substitution has been warmly welcome as an important measure of resolving urban environment problem and reducing GHG emission in transport. The status and development prospect of compressed natural gas (CNG) car and fuel cell car is simply discussed below.

1) LPG, CNG and LNG vehicles

Test shows that the nocuousness gas emission is greatly reduced in natural gas vehicles. Compared with the oil-burning vehicles, CO_2 decreases 25%, and SO_2 decreases 70%, at the same time the nocuousness gas and mote decrease 41%. LPG has similar effect as the natural gas. Compared with the gasoline vehicles, CO_2 emission of LPG vehicles decreases by 20-30% and SO_2 emission by more than 90%. There are 30,000 natural gas vehicles in China in the period of 1996-2000 and the target is to be 100,000 vehicles in 8-10 years. The LGP and natural gas vehicles are greatly developed in big cities such as Beijing and Shanghai etc. In Shanghai, to build five gas-fueled stations has been included in the real program of municipal government, and the related tasks have basically completed such as the construction of 2-3 retrofit factories, retrofit of 2,000-3,000 hybrid fuel vehicles, and a bus line with 30 LPG buses.

2) Fuel cell vehicles

Fuel cell is a power generation device converting chemical energy stored in the fuel and oxidizer into power energy. Its fuel utilizing efficiency is 50～70% and the environment pollution is little. It has hardly SO2 and NOx emission, so it is a perfect clean and high efficiency form of energy conversion. The fuel cell can take many resources as fuel, such as natural gas, gas made from coal, methane, carbinol, liquid oil etc. The cost used for R&D of fuel cell is about 0.8 billion dollars in the world every year and it has a trend of increasing year by year. Some harvests have been for commercialization. The Ministry of Science and Technology of China is carrying out several projects of researching, developing and piloting fuel vehicles.

3) Development trend of energy utilizing technology in road transport

The strong growth of China’s road has been the necessary trend of the passenger transport development in the future. In the growth of passenger transport, the growth of the car’s proportion is the most noticeable. There has appeared the problem early or late that the car’s growth is several times of the road’s growth so that the urban traffic is more and more jam-packed in many big and medium cities in China. With the growth of the highway, the medium and long distance passenger transport will grow too. The energy consumption of passenger transport will lie on the growth of car’s proportion in the road passenger transport. With the improvement of income level, it is a necessary economy development that people buy more cars.

3.3 Brief introduction of sink technology

Tree plantation and forestation is an important means of improving environment and absorbing CO_2.

The target of China is to increase the forest covering rate from 14% in recent years to 28-30% in 2050, and increase forest 158 million km^2. Considering other increasing production measures of forest, the new increased amount of carbon sink will be 8.9 billion tons. In addition, reinforcing the forest protection is also a useful measure for improving the sink of carbon.

According to the plan, the woodland will increase 158 million km^2 in 1978-2050. Average 2.2 million km^2 forestation will be carried out every year. By 2050, the average age of forest will be 36 years, and average biology amount will be 56 t/km^2 while the average carbon storage will be 28 t/km^2 so the total amount of carbon sink will be 4.42 billion tons. If based on the cost of 210 $\$/km^2$ in America in 1990, it is estimated that annual forestation is 2.16 million km^2 and the investment will be 454 million dollars. If considering the inflation rate of 6%, the forestation is 158 million km^2 and the total accumulative investment will be 261 billion dollars, which means that if one ton CO2 is absorbed then 59 dollars investment is needed.

Based on the forest statistics in 1993, the area that the forest appearing illness, insect and rat damage is 10.5 million km^2, and the average cost of prevention and cure is 2.82 $\$/km^2$, so the investment should be 29.7 million dollars. The investment of preventing fire is 13.3 million dollars. The investment of forest police, court is 54.1 million dollars. All these add up 97.1 million dollars, which means that once one ton CO2 emission is reduced there need to invest 1.55 dollars forest protection cost. By 2050, the wood forest will double and the protection cost will be four times namely 6.2 $/t-CO2. All these will increase investment of 300.5 billion dollars and can increase the woodland 157.8 million km^2 which can stably increase the forest's annual amount of carbon sink is 8.9 billion tons. This means that there need 34 US$ investment once one ton CO2 is stored. Therefore, expanding and protecting forest is an effective measure of reducing GHG and delaying the climate changing speed and extent.

4. Priority Areas of GHG Emission Reduction

4.1 Selection

CO_2 emission of fossil fuel combustion accounts for more than 90% of the total in China. Therefore, the main measure to slow down the speed of CO_2 emission is to reduce the consumption of fossil fuel. Dozens of study reports have pointed out that there are two main measures for China to reduce CO_2 emission, one is to raise energy efficiency, the other is to use low- or no-carbon energy instead of coal (the main energy in China). Many sectors and energy supply, consumption and alternative technologies that have many CO_2 emission reduction measures are included in these two areas. Being a developing country, China is still limited of resources and capitals. To maximize the effects, China is in great need of centralized resources and capitals to support the implementation of CO_2 emission reduction activity in priority areas.

It is an important task to know how to select and determine the priority areas that could gain best benefit from CO_2 emission reduction recently from numerous of sectors and technologies. Methods on

the selection of priority areas can be classified into several categories based on all results and experiences relevant to global climate change in China since 1990s. All these methods will be utilized and improved through relevant study in future.

4.1.1 GHG emission inventory

The GHG emission inventory, especially the national GHG emission inventory, has done much effort in establishing the GHG emission reduction strategy. Large amounts of capitals were invested by the nation and the team of experts from different sectors was organized. The national GHG emission inventory completed through long-term work reflecting the basic situation of emission resources and sinks of different sectors with the social and economic development. Through the analysis of national GHG emission development, it is clear to see which sectors are big emitters, how much did they emit and what kind of fuel consumption caused emission in GHG (mainly concern on CO_2, CH_4 and NO_x) resources and sinks. All these are valuable information for selecting priority areas of GHG emission reduction.

To select priority areas by ways of GHG emission inventory should do further analysis on the following issues:

(1) GHG emission of the selected emission reduction area should be apparently higher than other areas. Higher GHG emission sometimes means higher emission reduction potential.

(2) The selected emission reduction areas should be strategically important and be priority areas in the national social and economic development plan.

(3) The urgent and possibility of establishing emission reduction strategy for selected emission reduction areas

(4) Whether the emission significantly changes according to time in the selected emission reduction areas and how does it change.

Further analysis of the issues above will do much help to select good GHG emission priority areas. However, to select GHG emission reduction priority area with the GHG emission inventory has disadvantages, which might block a further analysis and estimation of the prior emission reduction areas:

First, each member country is required by UNFCCC to make a national GHG emission inventory in the submitted national communication. The first emission inventory of developing countries is being undertaken and to be completed later. Static analysis is based on emission inventory of a certain year. Change trend and characteristics of each sector can be drawn through dynamic analysis if there are emission inventory of several years (contiguous or have certain interval), which will help to select the prior GHG emission reduction areas well.

Second, the technological data hardly collected for making emission inventory are frequently macroscopic. Most of them are descriptions of the entire area while lack of various individual technology data of certain sectors and areas. Yet, microscopic analysis is deeper and more correspond to the real situation than macroscopic analysis.

During the implementation of ALGAS project of ADB in China 1995－1998, experts of the project had made the 1990 national GHG emission inventory of China based on project tasks. It is the first

inventory reported from study, instead of a national communication. Though the inventory is compiled in a simple format and limited of data collection, it can be used as reference for relevant studies in climate change.

4.1.2 Cost of GHG Emission Reduction technology curve (CERT)

CERT curve indicates the relationship between the GHG emission reduction from project and the emission reduction cost per unit. It can be either the relationship between total cost and accumulated emission reduction in a certain period, or the relationship between annual average cost and annual average emission reduction. Cost can be either total incremental cost or marginal incremental cost. Former is applicable to the cost comparison and selection of different proposals while the latter is applicable to optimize final emission reduction of each proposal.

CERT curve can be established based on different analysis object. In national level, it is to analyze various sectors and energy technology areas comprehensively. In sector level, it is used to analyze the precedence order of various technologies in this sector. The cost and emission reduction in CERT curve are both comparative to the baseline of the sector and areas. Therefore, to select baseline scenario plausibly and accurately for drawing the CERT curve is important. Since the curve shows the potential emission reduction and the relevant cost of a sector in a certain period directly, comparison between potential emission reduction and emission reduction cost, selection of priority area or combination of areas of GHG emission reduction, the establishment of CERT curve will be helpful to global climate change researchers and policy makers all over the world. CERT curve can be used in two aspects in global climate study and decision-making. First, CERT curve can be used to select priority emission reduction measures or their combination to achieve certain emission reduction objective. Second, it can be used to determine which emission reduction measures being selected and how much total emission reduction being achieved when limited to emission reduction cost or current expenditure.

Most CERT curve is shaped as an escalation-ladder curve. Different emission reduction measures horizontally increased from left to right according to emission reduction cost. In fact, the latter reduction measure is not adopted after all the potential of former emission reduction measures is exhausted, but several emission reduction measures are applied simultaneously in a same period. Thus, it should be a continuous curve (which can be dawn through smoothing the escalated curve) that actually reflects the optimal selection of various emission reduction measures.

4.1.3 Optimization Model of Energy System

The optimized model of energy system based on energy network chart is driven by energy end-use consumption demand. It is a study on optimizing the energy system under the conditions of satisfying energy demand, emission restriction and energy supply resources. Besides quantitative calculation, it can make optimized selection of combination of various energy technologies and simulate and analyze the GHG emission reduction strategies, measures and policies. Currently, possible new technologies being developed or introduced in future are considered in the model. One of them is the Markal model, which is widely used in the world now.

Compare with other quantitative analysis on GHG emission reduction measures, the optimized model of energy system has many advantages. First, to analyze various technologies in different sectors and areas comprehensively, not only select, but also optimize the allocation in order to gain maximal

economic benefit. Second, to do dynamic analysis for each period and get to know the implementation and development process of different GHG emission reduction measures. Third, to link with other macro economic models to analyze the influences to national economic by the implementation of GHG emission reduction measures. Fourth, to be powerful in policy analysis of GHG emission reduction, easy creation of scenarios, simple and quick calculation, and intuitional analysis and results.

The model analysis needs apparently more inputs and longer preparation time than other quantitative analysis approaches since the running of the model is based on large quantities of dynamic data on economic, energy, technology and environment. It can be used together with other quantitative analysis approaches (e.g. optimization model of energy system can offer marginal incremental cost of GHG emission reduction and help drawing the CERT curve) or be applied solely. It is one of the popular evaluating instruments for researchers on either global climate change or policy making.

The optimization model of energy system was used to do quantities calculation of policy simulation analysis and optimal selection of GHG emission reduction measures both in the “Climate Change Country Study of China, 1994－1996” and the “ALGAS project, 1995－1998”.

4.1.4 Analytic Hierarchy Process（AHP）

What we meet during the analysis of priority areas of GHG emission reduction measures is a complicated system comprising issues of economy, technology, environment etc. To do optimization selection and influence estimation among various options that can be mutually substituted is difficult. AHP provides a new, tersely and useful way to solve this problem.

The basic rule of AHP is to decompose a complicated problem into a series of simple indicator. To justify and compare the indicators logically by experts based on their rich experiences and knowledge, and then to comprise them in a certain way to get analysis and judgment of the primitive issue.

Even the simple AHP analysis can also get satisfactory results as other quantities analysis in solving the problems that are difficult to quantify. For example, AHP can give comparatively accurate and reasonable policy suggestions in the analysis of the priority areas of GHG emission reduction.

Simultaneously, the AHP can solve problems in a comparatively simple way and its disadvantages should be noted and try to be avoid. First, AHP can only be used to do optimization selection from recommended options but unable to bring forward new options. Second, AHP mainly based on the justification of experts thus the results are influenced by their subjectivity and preference. Therefore，the optimized results of AHP is comparatively qualitative and rough in general. If AHP is used in policy making of crucial issues, it is necessary to apply it with other quantitative analysis tools.

4.1.5 Consultation of Relevant Document of Government

The SDPC and the MOST of China has established the “Priority Project Plan of the 21st Century Agenda of China” in 1994 and supplemented it in 1996 based on the “21st Century Agenda of China”. To sum up, the two documents of “Priority Project Plan” announced 128 prior projects. All these projects were listed in the national “Five-year plan (1996-2000)” and were operational.

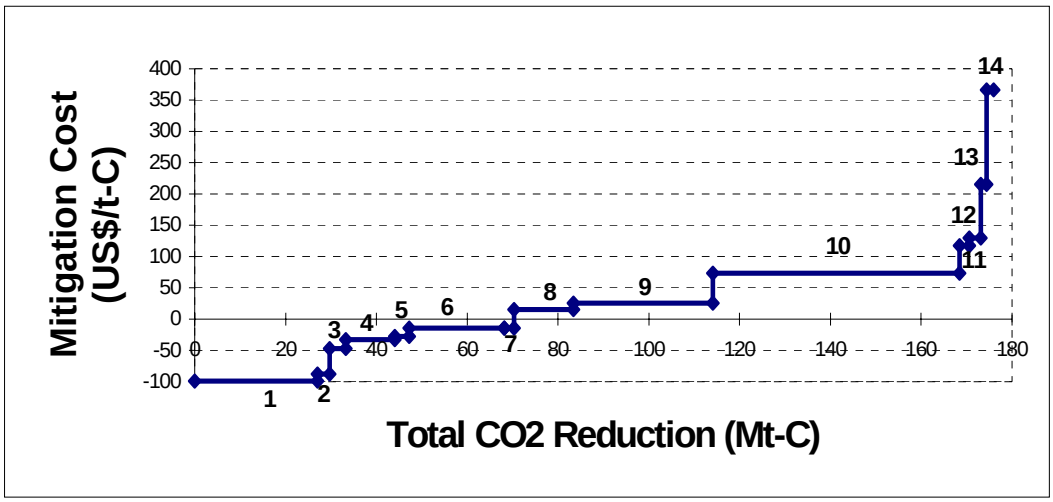
Energy sector is one of the nine priority areas in the “Priority Project Plan”. The priority projects include IGCC, PFBC, nuclear heating, solar heating, solar PV, large wind power farm, biomass, reform of medium and small boilers, coal bed methane development and utilization, green lighting etc.

All the projects in energy efficiency, new and renewable energy supposed by relevant sectors are surely the priority energy technology to be selected in GHG emission reduction analysis.

4.2 Priority Areas of GHG Emission Reduction

4.2.1 CERT curve

Chinese experts analyzed the priority technology areas of energy, agriculture and forestry in the ALGAS project 1995－1998 and got CERT curve of these three sectors. The CERT curve of energy sector is shown as below.



Notes: Mitigation technology options marked with numbers are as below

1. Technical renovation of motor for general use
2. Reducing ratio of iron/steel in steel & iron industry
3. Renovation of kilns for wet cement production
4. Energy-saving lighting
5. Comprehensive process renovation of synthetic ammonia
6. Renovation of industrial boilers
7. Continues casting of steel making
8. Renovation and reconstruction of conventional thermal power plant
9. Nuclear power
10. Hydro power
11. IGCC and other advanced thermal power generation technologies
12. Biogas and other biomass energy
13. Wind power
14. Solar thermal

4.2.2 AHP Application in the Selection of Priority Areas of GHG Emission Reduction

(1) “Climate Change Country Study of China” (1994~1996)

To analyze and evaluate the priority energy technologies of GHG emission reduction, an indicator system was established with the application of AHP in this project. Detailed indicators are concerned to major fields of economy, environment, technology and policy etc:

- GHG mitigation
- Other pollutants reduction
- Local bio-system influence

- Technology availability
- Energy efficiency
- Economy
- Social benefit
- Application validity of policy
- Uncertainty of technology and economic data

The optimized technology selections of eight technology areas are listed in the following table.

Comprehensive Evaluation Results of GHG Emission Reduction of the "Climate Change Country Study of China" Project

Area	Technology
1. Power Generation	Reference: Coal fired boiler unit (no desulphurization) 1.1 Hydropower 1.2 Wind power 1.3 Gas combine cycle 1.4 Nuclear 1.5 IGCC 1.6 Gas turbine units 1.7 PFBC 1.8 Coal fired boiler units (desulphurization, denitrification) 1.9 AFBC 1.10 Oil/Gas boiler units 1.11 Coal fired boiler units (desulphurization)
2. Gas	Reference: Direct coal fired 2.1 Nature gas 2.2 LNG (imported) 2.3 LPG 2.4 Bio-gas 2.5 Oil gasification 2.6 Gas from coal dry distillation 2.7 Coal gasification
3. Transportation	3.1 Road transport reference：Keep at the best running situation 3.1.1 Upgrade road class 3.1.2 Develop alternative automobile fuels 3.1.3 Develop advanced automobiles 3.1.4 Optimize organization and management of transport 3.1.5 Reasonably allocate the load-tonnage of automobile
	3.1.6 Truck transport with trailers 3.1.7 Use diesel oil automobile instead of gas automobile 3.1.8 Disseminate energy conservation of automobile 3.2 Railway reference: Expand gas engine/electric motor traction 3.2.1 Reform of general energy utilization equipment 3.2.2 Develop senior motorcycle 3.2.3 Enforce maintenance to improve the motorcycle efficiency 3.2.4 Improve energy efficiency evaluation and management 3.2.5 Improve railway line quality and loading capacity
4. Electric motor	Reference: Current technology and utilization level of electric motor 4.1 Large and medium size of fan, pump and compressor with speed regulator by variable frequency 4.2 Small size of fan, pump and compressor with speed regulator by variable frequency

	4.3 Precise mechanical driving with speed regulator by variable frequency 4.4 Wire winding un-synchronous motor with double feed speed regulator 4.5 Liquid viscosity speed regulator 4.6 Stage changed speed regulator 4.7 Wire winding electronic motor with speed regulator 4.8 Direct current electric motor 4.9 Liquid power coupler 4.10 Electromagnetic speed regulator 4.11 High efficiency electric motor 4.12 Maintenance center of electric motor
5. Industry boiler	Reference: Chain grate stoker boiler 5.1 Pretreatment of coal before combustion 5.2 Coal spreader boiler 5.3 Speed regulating technology of boiler fan 5.4 Circulated fluid bed boiler 5.5 Improved corner pipe boiler 5.6 Improved water-fire pipe boiler 5.7 Vibrated stoker boiler
	5.8 Down-feed boiler 5.9 Heat storage in boiler heating system 5.10 Overset stoker boiler
6. Lighting	Reference: traditional incandescent lamp 6.1 Metallic halides lamp 6.2 High pressure sodium lamp 6.3 Low pressure sodium lamp 6.4 Tightly packed fluorescent lamp (electronic ballast) 6.5 Canaliculus fluorescent lamp (electronic ballast) 6.6 Ring type fluorescent lamp (electronic ballast)
7. Refrigerator	Reference: traditional refrigerator, using CFCs as both refrigeration and adiabatic material vesicant and advanced energy conservation measures. 7.1 Green refrigerator with certain energy conservation partly or totally 7.2 Green refrigerator with no certain energy conservation 7.3 To use R-134a instead of R12 and use R-141b instead of urethane vesicant, apply certain energy conservation partly or totally. 7.4 To use R-134a instead of R12 and use R-141b instead of urethane vesicant, no energy conservation measures.
8. Non-industry CH_4 emission (paddy)	8.1 Change paddy variety 8.2 Use fen waste fertilizer instead of pure organic fertilizer 8.3 Water management

(2) TCAPP (Technology Cooperation Agreement Pilot Project) 1998

AHP was applied in part of the analysis of the priority area of the energy sector in China by GCCI in TCAPP project (1998). The selected indicator system is:

A. Environmental Benefit
- GHG mitigation
- Reduction of other pollutants

B. Economic Development
- New economic growth point
- Job creation

C. Technology Transfer
- Local capacity
- Localization of manufacturing

D. Investment
- Scale

- Invest time period
- State corporations
- Private

The optimized energy technology results generated by AHP are (according to the precedence):

(1) High efficiency boilers
(2) Large thermal power generation (300-600 MW)
(3) Cogeneration
(4) High efficiency electric motors
(5) Green lighting
(6) Energy saving buildings
(7) Coal-bed methane recovery and utilization
(8) Biomass gasification
(9) Wind energy
(10) Solar thermal heat
(11) Biogas
(12) Waste heat and energy recovery
(13) Village hybrid renewable energy (wind & PV)
(14) High efficiency cook stoves
(15) Alternative fuel transportation for urban regions
(16) Small-scale hydropower
(17) Combined cycle natural gas power generation
(18) Central heating
(19) Waste gas recovery

5. Future and Obstacles of REGA Popularization

With the economic development in China, the demand of energy gradually increases. While for the requirements of environmental protection, the requirements of energy quality will be higher. To explore clear energy, improve energy efficiency have been the main topic we are facing. Currently Chinese government has recognized this problem, and understands the necessity to popularize the REGA. For the popularization of REGA, the government of China has published amount of policies and regulations, and energy development planning to support the exploration and utilization of new energy, energy saving and raise energy utilizing efficiency. However, because there are no perfect policies, regulations and uncompleted management systems, the popularization of REGA faces some obstacles.

5.1 Economic Development needs REGA Technology

Because the structure of energy supply and energy consumption isn't so reasonable, it leads to unreasonable energy use in large scale. The energy efficiency is low. Meanwhile the energy utilization laid so much stress on the non-renewable energy – coal and oil etc., make the energy reserves decreasing year by year. This situation will impact on the economic development of China, and the energy consumption also makes pollution to environment. Thus, China has to use more new energy, improve energy efficiency, and decrease the emission of waste gases, in order to promote the economic development of China. Finally from the point of energy, economy and environment, China needs to

promote the REGA technology greatly.

5.1.1 Economic Development Needs REGA Technology

The main problems China confronted with in energy development are: shortage of oil, serious energy safety; backward technologies in coal utilization, low efficiency; energy, particularly coal development and use, leads to very serious air and land pollution. All the problems mentioned above constrain economic and social development in China.

The energy sustainable utilization is a very important part in the social sustainable development. The structure of energy consumption in China isn't perfect, the proportion of energy with high quality, such as petroleum and natural gas etc, is very low. In the remote areas and undeveloped areas non-commercial energy are still used, for example some kinds of biomass energy, such as firewood, leafs of tree and straw etc. In the energy consumption structure of China, coal is the dominative energy.

China has a variety of energy resources, but per capita energy is very low. The huge population results in a great pressure on energy demand, it makes China's characteristics different from developed countries and also developing countries. The differences mainly include following aspects:

1) China is one of the few countries, which take the coal as the dominative fuel. This kind of energy structure faces a great challenge of transportation and resources;
2) In the wide rural areas, household energy are mainly firewood, straw and animal manure etc. It is a big threatens to environment;
3) Total amount of energy reserves are not small, but per capita energy reserve is small;
4) Energy distribution can't match the economic layout. Because 80% of the energy reserves are located in West and North areas and 60% energy consumed in the Southeast areas;
5) Energy shortage and waste are existing side by side; the energy intensity of unit output value is very high;
6) Economy and social life are mainly depending on domestic energy resources.

Because the unreasonable energy structure and the huge pressure on energy demands will impact on the economic development in a long term inevitably and bring a great pressure on the environmental improvement. The REGA technology could provide a technological support for the development of renewable energy, improvement of energy efficiency, decrease of GHG emission and the environmental protection. The popularization of REGA technology could greatly resolve the problem mentioned above. It could make rational energy use possible as well as develop economy. From this point of view, the popularization of REGA technology will be irreversible.

5.1.2 Environmental Improvement needs REGA Technology

The environmental protection urgently needs to enhance the energy saving and the integrated resources utilization, and popularization of REGA technology. Currently in China the environment pollution is very serious and the speeded trend of ecology damaging hasn't been controlled effectively. In 2000 the emission of sulphur dioxide was 20 million tons, acid precipitation has covered 30% territory areas of China. The cities with standard of air qualification only account for 1/3, the rivers, which pass through the cities, have been polluted in various degrees. The stored volume of solid wastes has reached 7 billion tons. To resist the deterioration of ecology environment as soon as possible and to improve environmental quality have become an urgent problem for the sustainable development in China. Based on the calculation, if the energy utilization efficiency in China could reach at the advanced level in the

world, energy consumption will decrease about 300 Mtce every year, it will greatly improve the air quality. If the ratio of integrated Utilization of solid wastes could be increased 1%, 10 million tons of solid wastes will be decreased every year. The energy saving/integrated utilization of resources is one of important ways to solve the environmental pollution.

Because of the utilization of fossil fuels in large scale, it results in the continually increase of GHG, and impact on the global climate change greatly. Excessive emission of GHG has made a rising of global average temperature about 0.4 to 0.8 centigrade degrees in the past 140 years. If no strict measurements to the GHG emission will be taken, GHG emission will continuously increase in the next 100 years. The global average temperature would be increased probably about 1.4 to 5.8 centigrade degrees, the sea level could be raised about 9 to 88 centimeters, it will bring catastrophic results to many countries. Additionally, the global warming will lead to the frequent occurrences of extreme climate phenomena, such as cold wave, heat wave, rain storm and tornado etc, all of them will become the horrible threaten for the human society. At the same time, because the energy use can bring other pollutants, such as suspend, sulfur dioxides etc., they also make serious air pollution.

The decrease of GHG emission in China is related with the changes of energy policies. The changes of energy use include following several aspects, improving energy efficiency, upgrading coal qualification, switching energy use from coal burning to natural gas or electricity, technological innovation in the large energy consumers, and marketing policies of coal and electricity etc. It means that we should greatly develop clean energy (wind energy, solar energy, tidal energy and geothermal energy etc.), which is renewable as well as light impacting on the environment, and should strongly promote the popularization of REGA technology to improve the energy efficiency and fast the economic development in China.

5.2 New Energy Development and Solution

To improve energy efficiency, energy saving and popularization of renewable energy, China government has issued many laws and policies. Implementation of policies makes a foundation to popularization of REGA technology, and provides a policy supporting. Meanwhile the popularization of REGA may make the energy to be used more efficiently. Consequently, continuing development of new and clean energy will promote the implementation of related laws and policies. All of them will make sure that the development of new energy could be supported by laws and policies as well as could get the help of technology resulting in achieving progresses. In turn, it correspondingly push the economy and environment to be developed further in China.

5.2.1 Policies and Measurements of Energy Development in China

For the energy utilization rationally and efficiently, based on the current conditions and situations of economic development, China formulated related energy development strategies. In China in the near future the strategies of energy development are:

“On the bases of energy safety, give the optimization of energy structure a top priority in all of the key tasks. To make effective improvement of energy efficiency, protect ecology and environment, advance the energy development in west regions.” The main targets of energy development is that under the satisfaction of energy in the total amount to the requirement of economic and social development, make obvious progress in the adjustments of energy structure; increase the energy efficiency and benefits further. Establish the energy management systems initially to adapt the socialism marketing economic systems; Gradually formulate the systems of energy designing, equipment manufacturing, construction

and operation with international competitive capabilities; and the energy development in the west regions will make great achievements.

The Long Term Imagine of Energy Development in 2010 is based on the “Tenth Five-year Plan of China”. The energy industry must meet the requirements of economic and social development at first, and the adjustments of energy structure will achieve a historical progress. The energy efficiency and benefit has to reach at the advanced level of 1990’s in the world. The systems of energy designing, equipment manufacturing, construction and operation with international competitive capabilities will be basically shaped. Management systems of energy industry which adapt the socialism marketing economic systems will be more perfect, and the harmonizing development of energy, economy and environment will be achieved.

According to the changes of energy supply and consumption in China, in the coal industry its key points of development are to enhance the construction of coal mines and clean coal plants, advance the development of clean coal technologies. At the same time, pay great attention to the exploration of coal bed gas; in the petroleum industry its key points of development are to enhance exploration and development; to establish with full effort the supply bases of oil/natural gas and petroleum storage in country. In the power industry the key development are the construction and reform of distribution network in urban and rural areas, the construction and reform of transmission network, and the construction of transmission bases which transmits the power from west regions to east regions. In the areas of new and renewable energy the key points are to continue the implementation of “ Riding Wind Plan” to fast the nationalizing pace of wind power equipment; to promote the “Brighten (Guanming) Plan” to quickly solve the power supply in the non-electricity regions. To enhance the integrated energy construction in rural areas. In the energy efficiency areas, the key developments are: implement the planning of “Energy Conservation of Power Systems”, implement the demonstration projects in the key energy intensive industries. In urban areas to popularize the cogeneration in which the power generation should be based on the thermal energy output, combined production of heating, power and refrigeration, and combined supply of heating, power and city gas. Thus, up to 2004, about 30,000 MW steam condensed sets of 50 MW and/or less than 50 MW will be shut down. Wind power capacity will reach 1,200 MW. Furthermore, the key point is to develop the plants of wind power, solar power, solar photovoltaic cell, geothermal power and ocean energy with the capacity 0.6 MW and above per unit.

The implementation of energy development strategies and the achievements of energy targets should be supported by supplementary policies and measurements, the main policies and measurements in the “Tenth Five-year Plan” of energy developments are mainly reflected in following six aspects:

1) Fast the steps of reform, gradually establish the energy industry system which should be adapt the socialism marketing economy, and provide an institution guarantees to energy industry.
2) Adjust the policies of investment and financing arrangements, research for creating a foundation of energy structure adjustments, increase the stress of energy structure adjustments.
3) Establish and improve the adjustment and control systems, which mainly based on the measurements of economic law and complementarily are supported by necessary administration measurements.
4) Positively research and draw up the policies and measurements for promoting energy development in central/west regions.
5) Positively support the exploration and construction of oil/gas bases in the overseas.
6) Carry out the 《Energy Conservation Regulation》 further to increase the energy efficiency.

5.2.2 Planning of New Energy Development

As a result of the renewable energy development in many years, it has begun to occupy a tiny space in the strategy structure of energy supply in the world and every country attached great importance to it more and more. To develop and utilize the renewable energy become an important part of world energy sustain development strategy, and is the basic choice of energy development strategy in the 21 century for most of developed countries and part of developing countries.

In China after 20 years' researching, development, demonstration and popularization, the application of renewable energy has achieved great progresses, technology has been advanced, the market is expanded continually, and industrialization has begun to appear a shape. According to uncompleted statistics, in 1998 the total consumption of primary energy in China was 1.36 billion tce, the consumption of renewable energy was 0.2 billion tce.

Up to the end of 1998, following accomplishments have been achieved in the renewable energy development and rural energy construction in China:

- Popularization of energy saving stoves in 185 million households in whole country;
- Biogas development in 6.88 million households (about 0.109 million households belong to central biogas supply);
- 748 medium and large biogas projects;
- 50,000 biogas digesters of purred city's wastewater, total volume of digesters were 2.09 million cubic meters;
- Power generation capacity by the medium and large size biogas digesters was 0.77 MW and electricity generated was 1,300 MWh; Central straws gasified stations are about 200 and supply 30,000 households;
- Planted firewood 5.6 million hectares;
- Installed capacity of small hydropower about 13.6 MW (electricity generation 420 GWh);
- 7.89 million square meters of solar water heater;
- 240 thousand cookers;
- 5.37 million square meters of passive solar houses;
- 8,300 hectares of agriculture solar green houses;
- Solar photovoltaic cell was 11 MW, and 100 photovoltaic power stations were built in non-electricity county of Tibet;
- The gross installed capacity of wind power was 223.6 MW, 21 wind farms have been built, about 155 thousand mini wind generators (electricity generated was 35.9 MWh);
- And 86.5 thousand of mini hydropower stations have been built in the mountain areas and husbandry areas, and play a positive role in the remote areas for their TV watching and lighting. In the whole country installed capacity of geothermal energy is 35 MW, among which the Yanbajing station is 25 MW, the areas of geo-thermal greenhouse have reached 4,540 hectares.

The general targets of renewable energy in China are: increase the energy efficiency, decrease the production costs, and enlarge the share of renewable energy in the energy structure. Based on the output of 2,300 Mtce in 2000 (of which non-commercial energy 2,000 Mtce), the output of renewable energy will be 2,500 Mtce in 2005 and 2,700 Mtce, in 2010.

To satisfy the energy demands in the new period, develop the new energy, and decrease the pollution caused by energy use, the government of China puts forward a series of new energy development plan, including related sustainable developing plan, such as the <Tenth Five-years Plan of New Energy and Renewable Energy Industry> and the <Tenth Five-years Plan of Energy Conversation and Integrated

Resources Utilization> made by State Economic and Trade Commission

The <Tenth Five-years Plan of New Energy and Renewable Energy Industrials> published by the Bureau of Resources Conversation and Integrated Utilization under the State Economic and Trade Commission pointed out the guide principles of new energy and renewable energy industry in the period of "Tenth Five-years Plan" as followings:

Seriously implement the principle of 15^{th} general meeting and 5^{th} committee member meeting of CCP, take the marketing as leads, enterprises as principle part, technology advance as support; Enhance macro guidance, train and normalize the market, gradually realize the enterprises' scale economy, products' standardization, technology's nationalization and market normalizations, push the new energy and renewable energy industry to a new stage.

Main targets are as followings:

In 2005 the development and use amount of new energy and renewable energy will reach 13 Mtce (excluding micro hydropower station and biomass energy), the results are that decrease the emission of GHG 10 million ton and carbon dioxide more than 0.6 million ton; solve the non-electricity problem for 1.3 million households of farmers and herdsmen (about 5-6 million population) in the remote areas and provide the jobs about 200 thousand.

In 2005 the production capacity of solar collectors will reach 11 million square meters, the stock volume will be about 64 million square meters. Establish 5-10 core enterprises with international competitive power; the production capacity of solar photovoltaic cell will reach 15 MW, and form a solar photovoltaic industry with completed application devices, and total stock volume will be up to 53 MW. In 2005 the installed capacity of grid-in wind power will reach 1,200 MW, and have 150 – 200 MW of equipment manufacturing capacity to meet the demands of domestic market. The areas of geothermal heating will reach 20 million square meters. The high efficiency utilization in the medium and large biomass projects of industry's wastewater and the waste water of livestock and the projects of rear poultry biomass gasified will take shape of the supply capacity of gaseous fuel about 2 billion cubic meters. The key points of development include: solar thermal utilization mainly develop the flat plate heater with heat pipe, glass evacuated tube water heater with inside metal flow pipes, evacuated tube stuffy water heater and applied software and hardware of solar heat water systems. Research and develop the integrated technologies of solar energy utilization, heating and air conditioning in building; popularize solar photovoltaic power systems.

In the wind power areas, mainly develop the 0.6 MW and above of generator units, realize the scale production; research and develop new types of wind generators, such as non-gear box, multi and low speed generator, and varying frequency technologies etc; upgrade the production technology levels of wind generators (off-grid type, less than 10 KW), promote the hybrid systems of wind and solar, wind and firewood, and combined wind, solar and firewood cogeneration systems.

High efficient utilizing biomass, particularly develop the projects which using the anaerobic fermentation technology to process high intensive organic wastewater in the industries and agriculture; upgrade technological levels of special equipment. Speed the development and use of biomass briquette and direct burning advices with high efficiency.

Enhance the utilization of geothermal energy, fast the research of geothermal back-filling technology,

and develop the manufacturing technologies of equipment for the geothermal use and its completed set. Speed the technology import, digest and absorb of heat pump with geothermal resources to upgrade the localization degree of the equipment.

5.2.3 Policies and Measurements of New Energy Development

To make sure the smoothly implementation of energy development plan needs the guidance by relevant policies. To draw up the policies advantageous to the new energy and renewable energy is the best support to help the development of new energy and renewable energy. The State Development Planning Commission, Ministry of Science and Technology and State Economic and Trade Commission with the finance and tax sectors discussed, researched and worked out relevant favorable and classified policies on finance, investment, loan, tax and prices. The strength of financial supports and investments has to be increased. From the point of whole situation and long-term benefits, it is necessary to increase the financial supports and to strengthen investment to new energy and renewable energy in scientific research, the research and development of technological products. To guarantee the necessary financial investment, meet the requirements on time, speed the breakthrough of products' processions and technologies and the course of systems' development. Enlarge loan scales and provide low interest loans. Have more concrete and favorable investment policies than the traditional energy development, enlarge the loan scale of industrialization construction and its services systems and provide long term, low interest loans. Meanwhile enhance the propaganda, promote the enthusiasms of investment from various respects, increase the financial channels, and raise the effects of the finance usage.

<The Temporary Regulations of Project Management in New Energy Capital Construction> published by State Developing Planning Commission pointed out that drawing the new energy plan of development and application should be based on the full investigations of renewable resources. The state encourages that the projects of new energy construction will be developed to fit the economic scale. The resourceful regions may plan it in one time and implement it in different periods; the medium and long term planning of new energy and year's planning have to be drawn out by province government (autonomous, municipalities directly under the central government and the specially designate cities) and their responsible sectors at first, after the integrated balances by State Developing Planning Commission and then bring it into the state energy developing layout and planning. The economic scale of new energy capital construction projects are: 3.0 MW and above of the wind power installed capacity, 0.1 MW of the solar energy installed capacity, 1.5 MW and above of geothermal energy installed capacity, 2.0 MW and above for installed capacity of tidal energy, 1.0 MW and above of waste generation installed capacity, 5,000 cubic meters per day and above of biogas projects, and other new energy projects with investment above 30 million Yuan and above. All of the projects with economic scale as mentioned above are defined as medium and large new energy projects, the projects that cannot reach the economic scale are small projects.

To work out the policies of tax decreasing and tax exempt, price subsidies and rewards. Those policies' drawing will speed the entering market for the products of new energy and renewable energy, upgrade the competitive power, finally depend on own developing potential to establish and occupy the due marketing portion.

Central government offers the subsidies to the renewable energy, including following types:

Subsidies of administration operating expenses: To encourage the development and popularization of new energy and renewable energy, the organizations and management agencies have been created in the central and local governments. The sectors of central government in which the management offices have been organized include:

State Developing Planning Commission
- Energy Conservation and New Energy Division under the Transportation and Energy Bureau;

State Economic and Trade Commission
- New Energy Division under the Resources Bureau;

The Ministry of Agriculture
- Energy Division under the Environment and Energy Bureau;

The State Power Corporation
- New Energy Power Generation Division under the Bureau of Rural Electrifications etc.

Subsidies of Research and development: Central government provides the finance to the renewable energy technologies by State Developing planning Commission and State Economic and Trade Commission.

Paying interests and discount for investment: central government provides the interest subsidy to the technology projects loan of renewable energy by the related sectors, the resources of this kind subsidies are from the central government' finance.

Project subsidies: Central government also pays subsidies to the technology projects of renewable energy development by different channels. In the 70's and 80's, a large amount of subsidies had been used for household's biogas systems, the demonstration and popularization of energy saving stove, micro hydropower stations, small wind generator and solar photovoltaic power generation etc. Beside the special financial arrangements, part of aid-the-poor finance, rural electrification finance and afforestation finance from the central government was also used in the renewable energy development. Particularly, the aid-the-poor finance has played an important role in the popularization of solar photovoltaic power generation.

Additionally, the subsidies from local governments played important roles too in the technology development of renewable energy. First, one it supports the management, popularization, demonstration and research of local renewable energy; Secondary, the local governments support the popularization of renewable energy by different types. Because of the differences in resource conditions and understandings, the policies of subsidies to the renewable energy also have big differences. But all of the local governments take the measurements of the subsidies to the popularization of household's biogas systems and energy saving stoves. In some of the regions the

local governments offered a big supports and subsidies to the micro wind power generators and micro solar photovoltaic power systems.

From above data, the developing strategies and overall targets of the “Tenth Five-years Plan”, we can find that the State provided powerful support to energy efficiency improvement and development of renewable energy, and figured out fine developing plan. In addition, the <Energy Conservation Law of the People’s Republic of China> also stipulated that the State encourages the development and utilization of new and renewable energy. The State Council, the local governments of provinces, autonomous region and municipalities directly under the Central Government should make the financial arrangement for energy conservation among the finance of capital construction and technology innovation to support the rational utilizations and development of new energy and renewable energy. All level of people’s governments should enhance the new energy/renewable energy construction, development and utilization of biogas, solar energy, wind energy, water energy and geothermal energy to improve energy structure according to the principles of suit measure to local conditions. Multi-energy complemented with each other, utilization in a comprehensive way and pay attention to benefits. Thus, we can understand, in the areas of new energy development, China government greatly encourages to use the renewable and clean energy of solar energy, wind energy, and biomass energy to change the irrational energy structure, upgrade the energy efficiency, decrease the emission of GHG, and improve the environment quality. It is consistent with the requirements of the REGA technology. So the popularization of REGA in China has a very fine environment and foundation. The analysis from the point view of policy, China has possessed the basic conditions of REGA technology popularization.

5.3 Developing Plan and Policy on Energy Conservation and Energy Efficiency

5.3.1 Development Plan of Energy Conservation and Energy Efficiency

Currently the problems in energy conservation and resources integrated utilization are as followings. At first from the view of overall, people lack enough acknowledge for the importance and the urgency to the energy conservation and resources integrated utilization, and pay more attention to the extension and less to the intension. The consideration on the development hasn’t been got onto the track of rising enterprise’s economic benefits by adjusting the assets and exploring their own potential capacities. More discussion on principles and less on implementation. The “Consciousness of Resource” and “Consciousness of Conservation” must be enhanced. Secondary, the laws and legislations aren’t completed, lack of the stimulating policies to promote the energy conservation in enterprises. The favorable policies of resource utilization cannot be realized in some regions. Third, part of the energy prices are distorted, enterprises lack the competitive power, the power of enterprises for energy conservation and resources utilization aren’t big enough, Forth is the shortage of technology and equipment, overall level is behind the developed countries about 10-15 years. Fifth, no enough input, it is difficult for most of enterprises to arrange the finance, and the strengths to support the energy conservation from every level of governments aren’t strong enough.

The guiding principles of the <Tenth Five-year Plan of Energy Conservation and Integrated Resource Utilization> published by State Economic and Trade Commission are that to seriously implement and

realize sustainable developing strategies, to insist the principle of “Developing both of resources explorations and conservation at the same time and put the conservation at first”, to protect and rationally develop the resource, to upgrade resource utilization rate, to realize the permanent utilization, to take the market as a leading, the enterprise as main body, the increasing of energy efficiency and utilizing ratio of resource as a core; to enhance the creation of law systems, to enhance the guidance by policy, to lay on the advance of technology, to strengthen the management scientifically, to establish and complete the macro management systems and operating mechanism of energy conservation and integrated resource utilization which could fit the socialism market systems, and to promote the development of economy, resource and environment coordinately.

The main targets are as followings:

- Energy conservation

Up to 2005, the energy intensity per 10,000 Yuan GDP will decrease to 2.2 tce (1990 constant price), total energy saving and decreased energy use 340 Mtce, the yearly energy saving rate 4.5%. The saving and substitute of fuel oil and oil products will be 16 million tons and 5 million tons, respectively. The integrated energy consumption per unit of main energy intensive products will decrease comparatively. Up to 2005, the integrated energy consumption per ton of steel in iron and steel enterprises with medium and large size will be less than 0.8 tce; coal consumption of power supply in power plants to 380 gce/KWh, the integrated energy consumption of ten nonferrous metal products to 4.5 tce, the integrated energy consumption of large synthetic ammonia to 37 GJ, the average energy consumption of main cement and glass products will be decreased by 20%, the oil consumption for variety of car per 100 kilometers 10-15%. Up to 2005, in the new residential buildings the energy conservation for heating will be 50%, in the new public buildings, try to be 50%.

- Integrated resource utilization

In 2005, the output value in the integrated utilization of industrial “three wastes” will be 40 billion Yuan; it is 55 billion Yuan in the recovery and utilization of waste and old materials. The comprehensive utilization rate of industrial waste residues will be 60%, among which the integrated utilizing rate of coal gangue will be increased to 60%, and integrated utilizing rate of coal fly ash to 65%.

In China the energy intensity per GDP in 1999 was 60% less than in 1981, the energy conservation ratio close to 5%, during the 18 years the total energy saving was 949 Mtce in the whole country, equivalent to emission mitigation of CO_2 555 Mt-c.

5.3.2 Policies and Measurements of Energy Conservation

Since 1980’s China government had taken the energy conservation as a basic state policy, and drawn out the laws, regulations and standards of technologies and stimulating policies of energy conservation.

For promoting energy conservation in whole society, rising energy utilizing efficiency, protecting environment, guaranteeing the national economic and social development and satisfying the demands of people’s daily life, on the aspects of progression of energy conservation, management of energy saving, legal responsibilities and rational resource utilization, the <Law of Energy Conservation in China> was created.

- The general provisions of <Law of Energy Conservation in China> prescribe

The energy conservation is a long-term strategic policy of state economic development. State Council, the local governments of provinces, autonomous region and municipalities directly under the Central Government should enhance the tasks of energy conservation, rationally adjust the structures of industry, enterprise, products and energy consumption, push forward the technology progress of energy conservation, decrease the energy consumption per output value and per product production, improve the energy exploration, process and transfer, transportation and supply, gradually rise the energy utilizing efficiency, promote the switch of the national economy to the mode of energy conservation. The State encourages the development and utilization of new energy and renewable energy. The State encourages and supports the research and popularization of energy saving sciences and technologies. Enhance the energy saving propaganda and education, popularizing the energy saving sciences and technologies; strengthen the conscious of energy saving to the whole nation.

- The requirements of energy saving management

State council, the local governments of provinces, autonomous region and municipalities directly under the Central Government should pay attention to both of energy development and energy saving, put the energy saving in the first priority, based on the comparison and evaluation of technology, economy and environment to select the best projects of energy saving and development, draw the energy investment plan. The sector of standardization administration under the State Council work out the related national standards of energy conservation. For those kind of standards that haven't previous case yet, related sectors of State Council may figure out concern industrial standards of energy saving, and report to the sectors of standardization administration and will be kept on the files. The energy management sectors under the governments above the provincial level should create the limitation of energy intensity per unit for the higher energy consuming products with related sectors which are at the same level. And the drawn limitation of energy consuming per unit product should be scientific and reasonable.

- Regulations of rational utilizing resources

The companies that produce energy intensive products should obey the limitations for per product of energy consumption that are legally drawn. To set a deadline for the companies that seriously beyond the intensive limitations for per product of energy consumption in their production to change their situation. This decision of the deadline should be made by the management sector of energy conservation in the governments according to the limits of authority based on the regulations made by the State Council. Additionally, there are related regulations for the companies and persons about the production, sale of energy consuming products and energy using equipment.

5.3.3 State encouraged projects of energy saving technology and demonstration

For the energy saving and improve the energy efficiency, the State encourages the popularization of energy saving technologies and the implementation of some demonstration. They include that the demonstration projects of oil saving and substitute published by State Economic and Trade Commission, the demonstration projects of clean coal, the projects of speed adjustment motor, green lighting demonstration projects. The "Riding wind Plan", "Lighting Projects" and the demonstration projects of straw gasification planned by State Developing Planning Commission.

The State encourages and supports the development of advanced energy saving technologies,

determines the key points and directions of the development for advanced energy saving technologies, establishes and improve the service systems of energy saving technology, cultivates and normalize the market of energy saving technology. The State works out the favorable policies, provides the supports to the projects of energy saving demonstration and the projects of energy saving popularization. To encourage importing advanced energy saving technologies and equipment, forbid to importing old energy using technologies, equipment and materials. Every industry has to draw their own industrial policy of energy saving technology; develop, popularize new technology, new process, new equipment and new materials, limit and eliminate the old technologies, process, equipment and materials with high-energy intensity.

The State promotes the development of following general energy saving technologies:

(1) Popularization of cogeneration, central heating, rise the utilizing rate of thermal units, develop the step utilizing technologies of thermal energy, the technologies of combined thermal, electricity and cooling productions and combined thermal, electricity and gas supply, upgrade the rate of integrated utilization.

(2) Gradually realize the economic operation of motor, fan, pump equipment and systems, develop the electricity saving technologies by speed adjustment motor and by the power electronic, to develop, produce and popularize high qualified, low price and energy saving devices, rise the utilization rate of electricity energy. Specially, develop high efficient motor, the technologies of variable frequency, speed adjustment, high voltage and large power, the technologies of electric lighting resource with high efficiency and rectifier technology, the technologies of transfer above S9 and non-crystalline transfer made with alloy iron core, the technologies of cold and heat storage, the technologies of appliances, electrolysis, electroplate and power resources, the technologies of electricity transfer, transmission and power grid, and the advanced electricity saving technologies of industry's electric furnace etc;

(3) To develop and popularize the clean coal technologies of fluidized bed combustion adapted some domestic kinds of coal, no smoke burning, gasification, and liquefaction, to upgrade the coal utilization rate.

(4) To develop and popularize other general technologies of energy saving with mature characteristics and obvious benefits.

In the <"Tenth Five-year Plan" of Energy Conservation and Integrated Resource Utilization>, some important demonstration projects has been listed as followings:

The demonstration projects of saving and substitute oil: include the demonstration projects of substitute oil in the key sectors which produce oil intensive products, have to substitute oil mainly with the clean coal products of slurry, coal gasification etc. and natural gas; and the demonstration projects of fuel oil saving, which mainly are the optimization of process energy and plasma ignition with no oil; and the substitute oil product projects which mainly are methyl and ethyl.

- Clean coal demonstration projects

They mainly include the demonstration projects of power coal qualified processing, such as coal

preparation, briquette, blending coal, coal water slurry, screening and breaking technologies etc; the demonstration projects which mainly are the innovation of medium and large coal burning industrial boilers, such as qualified coal burning, screened block, sulfur fixed briquette, using cycle fluidized bed combustion, advance technologies of fine coal burning etc; The demonstration projects which are the improvement of large cycle fluidized bed boilers above 410 ton/per hour and the upgrade of total efficiency of operation; The sulfur dioxide mitigation demonstration projects in the whole process that are mainly the pollution dealing technologies of washing and desulphurization, sulfur fixing in the burning and gas desulphurization etc.

- Speed adjustment Motor projects

The high voltage, big power, variable frequency and speed adjustment projects, which mainly are elements and devices, electric technologies and the equipment manufacturing of variable frequency, the equipment unifying development of related completed set; the demonstration projects of variable frequency, speed adjustment with low voltage, medium and small power are mainly the special variable frequency and simplified equipment. The demonstration projects of systems optimization for fans and pump are mainly the high efficient motor and their driven fans and pumps, and the combination of software and hardware in the optimization and matching of speed adjustment systems, and upgrade the efficiency of motor systems to 10~12%.

- Green lighting demonstration projects

Include the demonstration projects of high efficient lighting systems, which have been evaluated and will be popularized in the key projects of 2008 Olympic Game in Beijing; In various building construction promote the large order or government purchase, realize the qualify guarantee, enlarge the marketing share of high qualified lighting devices.

The demonstration projects of the resources integrate utilization of coal bed gas: to selected regions that have broken through the exploration of coal seam gas, build 2-3 demonstration bases of developing and utilizing coal bed gas, upgrade the utilizing rate of gas, promote the industrialization of the coal bed gas in the areas of exploration, development, production and utilization.

The demonstration projects of coal gangue integrate utilization in the mining areas: in the key mining areas which have good condition build the big coal gangue power plants, and the projects to use coal gangue producing new types of building materials and re-cultivate in mining areas.

The integrate utilization demonstration projects of intergrowth and co-growth mine resources: to center on the overcome of technological difficulties in Kaolin, super fine, white-added, characteristic changing; organize some integrate utilization projects with in-depth processing of bauxite, refractory clay, pyrites, diatom clay, to in-depth process and utilize coal inter- and co-growth resources. Selected three bases of resources integrate utilization – Panzhihua, Baotou and Jinchuan to develop the utilization of vanadium-titanium magnet, rare earth, and the intergrowth and co-growth mine of nonferrous metal.

The integrate resources utilization demonstration projects: to establish the trinity systems of recovering and recycling waste and useless materials, establish the industrializing bases that will recover and deal waste plastics, waste rube, waste tires, waste appliances, waste computers, and waste cells, and the bases of recovering, disassembling and dealing the discard cars.

The demonstration projects of conservation type and clean type enterprises: in the key industries select some enterprises, to reach or close to the most advanced levels of system energy efficiency in the same industries in the world, and will close to or reach the “zero” emission of the pollutants.

The demonstration projects of the marketing systems of energy conservation services: based on the experiments of marketing energy saving technology services in the “Ninth Five-year Plan”, realize the new mechanics of Contract Energy Management in some selected energy saving service centers by reorganization, institution reforming, popularizing and applying the advanced and practical technologies in the medium and large enterprises.

To increase the energy efficiency and save the energy may decrease the energy demands, guarantee the energy supply, reduce energy intensity and raise the competitive power of the enterprises and their products. And it is the most real, economic and effective ways for decreasing the emissions of pollutants and GHG, also is the necessary requirements of sustainable development. The <Energy Conservation Law> and the related subsidy policies for the renewable energy utilization and energy saving that has been published and implemented have provided the policy supports, and made a foundation of popularizing of REGA technologies.

According to the “Tenth Five-year Plan of New and Renewable Energy”, in the period of “Tenth Five-year Plan” the tasks of State Developing Planning commission will be that center the demonstration projects of “Riding Wind Plan”, “Brighten Engineering” and the gasification of straw and the plan of “the construction of one hundred counties”, around the reform of governments’ responsibilities, start from the macro adjustments to figures out the favorable policies of new energy, normalize the market competitive behaviors, promote the development of nationalization, increases the proportion of new energy in the energy industry, improve the energy structure of China, finally would make contributions to the environment.

5.4 Development prospect and direction of other emission reduction technologies

The China policy about the global climate change is: based on the sustainable policies and measures, actively make contribution to the mitigation of global climate change; adjust the economic structure, increase the energy efficiency, optimize the energy structure, develop the renewable energy, strive to reduce the carbon dioxide emission rate; greatly develop the plantation, fast the rate of “return the plough land to woods and grasses”, step further to forbid the forest over-chopping, adequately realize the great potential of forest of carbon dioxide adsorption; persist in the family planning policy, control the population growth rate, increase the public awareness of the global environmental protection, construct a life style and consumption model which are helpful to reduce the greenhouse gas emission.

In the recent 20 years, there are altogether 0.45 billion tons carbon dioxide that have been adsorbed by the forests in China, which take up to about 3% to 4% of the total carbon dioxide emission of the industries. If the adsorption value by the non-vegetation is taken into account, it is estimated that the net adsorption by the forest system in China accumulates to 5% to 8% annually. So it is clearly that great efforts to develop the policy “return the plough land to forest” and plantation is an effective measure to control the greenhouse gas emission.

According to the “State ecology environment construction plan” issued by the State Council, combined by the woods Tenth-year plan, China determined the new woods construction target in the new period. Around the realization of the new target, the instruction idea, woods plantation types and mechanism

will change greatly accordingly.

The woods construction target in the new period is: by 2005 the area of the newly planted forest will reach 11.5 million hectares and the forest cover rate will reach 19.4 percent; by 2030 the newly added forest areas will reach 46 million hectares and the forest cover areas will reach 24 percent. The biology improvement in the middle and upstream of Chang Jiang River and Huang He River and the draught sand areas take great effects.

《China Forest Law》makes the relevant provisions about the tree planting and forest cutting. It is promoted to return the plough land to forests, to carry out the wood planting, to increase the forest cover rate and to realize the environmental function of the forest, so as to greatly contribute to the reduction of the greenhouse gas.

5.5 Main barrier in the promotion of the REGA technology

There are many difficulties in the promotion of the REGA technology, mainly the following nine aspects:

(1) Insufficient awareness about the strategy significance of developing renewable energy

China is a populous country and relatively in short of energy resources. The average energy resources occupation per capita of China is less than half of the world average values. The petroleum is only one tenth. The exploitable reserves of coal, petroleum and natural gas can only maintain for the middle period of this century or even earlier. The significance of developing renewable energy to implement the sustainable development strategy and to reduce the greenhouse gas has not been fully and widely understood. The guidelines from the central government that should actively develop the renewable energy and adjust the measures according to the local condition have not been adequately fulfilled. Some areas have not made the long term and the yearly plan of renewable energy.

(2) Overlap of the government functions

For a long time, the renewable energy and the rural energy affairs had been dispersed in several sectors. There are special departments or divisions that are in charge of part of the work in the State Economy and Trade Commission, Ministry of Water Resources, former Ministry of Electricity and former Ministry of Forest. Their works are overlapped. The finances were dispersed and some of the constructions were repeated thus weak the State macro controls force.

(3) Lack of encouraging policy

Although the extended application of renewable energy integrates the social, economic and environmental benefits, in the near future it is still in the preliminary stage and can not form the moderate economy scale. So there should be policy supports in the aspects of finance, credit, technology and prices according to different areas. In recent years it is planned to study the tax and electricity problems of the wind power and PV power. Efforts have been made for the finance support in order to develop renewable energy. According to foreign experiences, the government support is a key in developing renewable energy. Internationally, no matter the developed or the developing countries, renewable energy cannot develop without the government supports such as the stimulation, tax, subsidy, low interest loan, fast depreciation, exploiting the market and the favorable policy etc. It is

the initial drives of developing renewable energy industries. Most of the renewable energy use areas are the remote depressed areas. The social benefits are remarkable but the economic benefits are not so high. So the stimulation and support from the government and different levels governments are necessary.

(4) Too small input

Since the 1980s, the government adopted career subsidy, research and development subsidy, finance interest and project subsidy policies etc. But compared with the foreign ones, the Chinese government inputs on renewable energy are too small. Up to date, the renewable energy construction projects in China have not been formally included in the finance budget and plan of every level. This has been the main barrier for renewable energy development. Since the input is too small and is lack of sufficient research and development, many key facilities have to be imported from other countries, such as the large and moderate wind turbines. Thus its development is very slow and the industrialization and commercialization degree is low.

(5) Production scale is small and the cost is high

Most of the manufacture factories are very small and dispersed. The intensity degrees are low and the techniques are old, the production qualities are not stable, economic benefits are not high. Recently, number of solar water heater factories have accumulated to 500. But there are only 31 factories whose annual sales are higher than 5 million yuan. There are few factories that have really reached the economic scale. In recent two years, the solar heater with vacuum tube sold well. Many local places have constructed the glasses vacuum tube factories. Restricted by the capital, their scales are not large and the raw material resources are not stable. So the economic benefits are low, so the qualities cannot be guaranteed. There are thousands of conservation furnace factories all over the country, but few of their sales are more than 10 thousand. The indigenous large and medium wind turbines production plan is just preliminary; supports are necessary for its scale development.

(6) Lack of production quality criterion and quality supervision system

Now, types of renewable energy production have added up to more than one hundred. But the productions series have not formed. The qualities differ very much and there are no necessary production quality criterion and quality supervision system. so the consumers have no confidence about the production, thus the production standardization and series development will be greatly influenced.

(7) China economy development level is low

China is now at the preliminary stage of the socialism, the economic development level is low. There are insufficient inputs in the environmental protection; so some of the projects can’t be implemented favorably, which will restrict the REGA technologies promotion in China.

(8) Insufficient technology application and information

The conservation technology in China is not advanced so the conservation potential is large. REGA technology development in China is relatively slow; it is necessary to learn from other countries for reference. But the information is not sufficient. There are no timely information support and practical and suitable technologies, which delayed the whole promotion of REGA technology.

(9) Imperfect Operation mechanism

In the past years, the trinity of the energy management mechanism, that is the main director sector, every level of energy conservation service organizations and the enterprises management sector, mainly operated the energy conservation work of China. Under the former planning economic mechanism, this energy conservation system played an important role and made significant energy conservation achievements. But with the Chinese economic system conversion to the market, the former energy conservation management system can't adapt the new situation and have to be changed. Under the new condition, the resistance of the energy conservation mainly embodied as the market barrier of the energy conservation financing. Since there are multiple management sectors, and their work division is not very definite, the efficiency is very low. The approval procedure lasted too much time. Those questions encountered in the implementation can't be solved in time and effectively. At the same time the relative laws and policies are not matched, which make the promotion of the REGA difficult.

Currently, the international society brings out that the carbon dioxide reduction technologies are mainly on the efficiency increasing of the energy utilization and the renewable development, which are consistent with the sustainable development strategy of China. The substitution of the low-coal or no-coal energy for coal, and the energy efficiency increasing, are not only the need to reduce the carbon dioxide emission, but also the need to protect the local environment. Under the precondition of the non-approval any non-consistent obligation with the self-development level, it is hoped that the developed countries to use the CDM mechanism, to implement their obligation to transfer their finance and technology to the developing countries.

It can be seen from the aforementioned analysis: REGA technology has a certain degree base to promotion in China; it is consistent with the energy planning of China and has relative policy support. Although there are some barriers, through continuous improvement of the corresponding laws and the further development of the economy, they could all be correspondingly overcome. So, China has possessed the condition of REGA technology promotion, and there is good atmosphere. Meanwhile the promotion of the REGA technology will also improve the further development of China economy and environment.

6 Policies and Strategy Suggestions

6.1 Strengthen Energy Program and Legislation

1) Modifying “China Electricity Law” to meet the requirement of power sector reform

It has been eight years since enforcement of the ‘China Electricity Law’ issued in 1995. The Law has played important roles in ensuring safe operation of China’s electricity sector, maintaining normal electric power supply, and protecting rights and interests of power investors, operators, and users. However, along with the establishment of China’s socialist market economy and deepening the power industry reform, the economic relations regulated by the existing Electricity Law have been changed. Some regulations and goals defined originally are no longer suitable for the needs of market oriented electricity power reforms. Therefore, modification of the Electricity Laws has been scheduled in the recent agenda in order to establish an electricity market system in the model of separating government administration from business operation, equal competition, opening and ordering, and healthy market development, and to fully explore the basic function of resources allocation optimization by market. Modification of Electricity Law will be focused on issues of power sector monitoring and management, legal administration, openness, equity and fairness of dispatch and management of the power grid, power market establishment and operation, power pricing and tariff determination, order maintenance of power supply and end-use, and obligations of related legal entities.

The modification of the Electricity Law has been enlisted into SERC’s (State Electricity Regulation Committee) important tasks in 2003. In the aspect of modifying and improving electric power laws and regulations, the SERC will, by coordinating with related agencies, complete the following jobs as soon as possible, including issuing ‘Electricity Regulation Bylaws’, modifying ‘Statute of Electric Power Grid Operation Management’, ‘Statute of Electric Power Supply and End-Use’, and ‘Statute of Electricity Facility Protection’, formulating ‘Measures of Electricity Safety Monitoring and Management’, power market entry (License), and regulations of administrative punishment, and completing the formulation of ‘Rules of Cost for Electricity Transmission and Distribution Enterprises’.

2) Constituting the ‘Renewable Energy Exploration Utilization and Promotion Law’

Promoting sustainable renewable energy development through legislation has been a successful experience in the developed countries. The government of China is taking active actions to implement its law and regulation systems for developing renewable energy. The Environment and Resource Committee of the National People Congress (CPCERC) has scheduled the renewable energy legislation in its agenda, and consigned the job of formulating the suggested renewable energy exploration utilization and promotion laws (referred to RE promotion law) to the National Development and Reform Commission (NDRC). The formulated legislation draft is supposed to be submitted to the CPC Standing Committee by the end of 2004.

Goals of the China RE promotion law is to speed up RE development and utilization, boost RE industrialization and commercialization, improve energy structure, ensure energy safety, protect environment, and promote the sustainable social and economic development.

China RE promotion law will play roles of guidance and promotion in the following aspects:

- To increase RE strategic position. Through the RE legislation, the strategic importance of RE in the long-term energy development, the government responsibilities, and obligations of the entire society will be clearly defined. China will provide necessary incentive policies on the power sector reform, investment and financing system reform, and environmental legislation, while considering the needs of RE technologies commercialization process.
- To establish a fund guarantee system for RE development. While bringing the state investment into play, China will explore multiple sources of capital investment for RE development fund in order to guarantee capital need for large-scale RE development.
- To establish a government-guided and market-driven combined development policies. In the near term, these policies will include government project bidding, MMS (mandate market share) of RE, and Legal Purchasing Prices, to bring up the market requirement for RE technologies.
- To encourage development and establish a system of RE technology manufacturing industry. RE technology projects will be identified in the high-tech programs and in the key facility development programs to build up scientific research and initiative capabilities for RE technology equipment.
- To eliminate market barriers for RE development, including eliminating the discrimination against RE electricity market access and promoting scale utilization of RE power and heating production through legislations.

3) Securing the implementation of energy saving and renewable energy programs by mandated policies

- Reinforcing energy saving to improve energy efficiency

Because energy saving has extreme significance in China's energy strategy due to its dual benefits in economy and environment, it should be considered as one of the most important energy strategies of persisting 'focus both development and saving while prioritizing energy saving'. Policies include popularizing energy saving technologies and implementing energy saving projects, increasing the contribution of demand management to energy savings, decreasing the energy use intensity, improving people's energy saving consensus, and encouraging energy-saving life styles. In the industrial development policies, energy saving concept need be reinforced, and the energy efficiency should be taken as one of the important quantitative indicators in the industrial development policies and put into the industry development strategies, planning and designs of project, as well as in the project examination and acceptance procedures. During the industry development process in the future, it will be ensured that energy efficiency target indicators of any new projects, including joint venture projects, will reach at the international advanced levels.

- Using mandated policies for realizing RE development goals

According to China social and economic development goals in the coming 20 years, tasks of energy supply for the state development will be very formidable. Utilization of renewable energy will become an important development area. By the year 2020, total RE supply and total substituted energy will reach to 0.2 billion tons of standard coal (tce), which account for about 8% of total energy supply. Total RE power capacity will increase to 100 GW that represents about 10% of the national total. To fulfill the above RE objectives, national policy support is necessary. It is particularly important to guarantee

the accomplishment of the development goals by laws, regulations, and compulsive national policies. It is suggested that based on the RE power development program, the MMS policy should be clearly implemented, i.e. to require the RE electricity generation taking certain share in total power production, and to make it as a persistent objective for developing RE electricity.

- Compulsively implementing Energy Efficiency Standard and Identification System

Energy Efficiency standard and identification are one of the policy instruments for reducing end-product energy consumptions and have been successfully implemented in many countries and regions such as US, European Union, Canada, Australia, Korea, and Thailand, and resulted in remarkable economic and social benefits. The NDRC and State Authentication and Monitoring Committee will issue the 'Energy Efficiency Identification Management Regulations' in order to implement mandated EE grade identification. China will adopt an 'Enterprise Self Announcement plus Enterprise EE Data Record plus Market Monitoring' model. In order to work with the EE ID system, the newly modified EE standards for 4 types of products (home refrigerator, home washing machine, double end fluorescent light, and self-ballast fluorescent light) have added indicators for EE standards, in which the energy efficiencies of the home refrigerators and washing machines are classified into 5 grades, and 3 grades for the two lighting products. So as to enhance the EE standard and identification establishment and implementation, it is suggested to clearly define the validity of EE target indicators made for related products in the laws and regulations, specify procedures in making and implementing the EE standards, and encourage enterprises to conduct technical improvement in order to fulfill the set EE target values. In the aspect of implementation, the EE standards should be compulsive, and be strictly implemented under the related regulation framework so that the restricted EE targets be effectively reinforced. At the same time, some assisting economic and auxiliary measures should be worked together with other energy saving systems, such as energy saving product certification system, EE information identification system, and publication system for the eliminated high energy-intensity equipment.

6.2 Establish market oriented energy management mechanism

Market-oriented reform in the field of energy in China has made some achievements, but it still remains in its initial phase and the reform is still a heavy task. Moreover, a series of fundamental conflicts and problems are not completely resolved, which puts impacts on deepening reform and long-term development in the field of energy. The main contents of reform include:

First, the reform of energy management system

Since there exist outstanding problems such as the excessive decentralization of government's functions, the absence of an unified energy department which can represent national willingness, and too much liberty of policies, it is suggested to establish an unified governmental energy management department to conform to the country's overall interest, to coordinate the development and interest of all energy sectors, and to make integrated national energy strategies and policies. On the principle of "separating the administration and monitoring", there is a need to establish a relatively centralized energy monitor organization, which will implement an independently monitor, pursuant to relevant laws and regulations, upon the sectors possessing features of monopoly (for example, power and natural gas sectors), and obvious security problems (for example, coal sector).

Second, reform of the administrative examination and approval system and change of the government's functions

At present issues as the monopoly and low market openness in some industries are related to the current access control mechanism. In addition, the government makes much direct intervention in enterprises. Therefore, it is supposed that a) to reform the existing validation and approval mechanism; b) to relax economic control while enhancing social control; c) to shift government's functions to focusing on protection of national energy security, public interest and environment; d) to change our current investment management mechanism into the pattern keeping on file economically and on control socially so as to increase the transparency in the course of policy and decision making; e) to encourage private economy entering in the field of energy, and to introduce public auction and bidding mechanisms to the disposal of some energy resources at the proper time.

Third, reform of the current improper energy pricing mechanism and price regulatory approach

It is proposed that to deregulate the prices of those energy products that in relatively full competition, and allow both supply and demand sides of the market to determine their prices; to carry out reasonable prices control upon those energy products possessing monopoly features, mainly based on the market acceptability (currently emphasizing on resolving the problems of natural gas price). It is also needed that to form reasonable price parity among various energy products in terms of measures such as taxation policy, buy-down of environmental protection, and price regulatory approach reform etc. so that the energy mix restructuring can be smoothly carried out.

Fourth, deep the reform of state-owned energy enterprises

It is needed to resolve some problems such as "state-owned stocks being the biggest alone and controlled by internal stockholder", "non-standardized corporate governance structure", which currently exist prevalently in most state-owned energy enterprises; thoroughly to change the situation that there exist too many administrative-type of state-owned corporations in some sectors; to accelerate the reform of property rights system; to encourage the development of mixed ownership economy; to perfect the state-owned assets management system; all in all in the purpose of providing good conditions for creating an integration of both upstream and downstream crossing different regions, sectors and ownerships.

6.3 Establishing a good operational mechanism to promote REGA technology

- **Accelerating new energy saving mechanisms**

It becomes one of the most urgent tasks to adopt new energy saving mechanisms in China's energy saving efforts. Learning successful experiences in energy saving mechanisms from many other countries will get twice the result with half effort for introducing and promoting China's energy saving mechanisms towards a market economy transformation. Currently, by focusing on building policy environment, bringing up intermediary organizations, enhancing information dissemination, and extending international cooperation, five important mechanisms should be introduced: 1) Market-based

energy saving information dissemination mechanism. Making and publishing good energy saving examples will help to popularize application of new technologies, new experiences, new technical process, and new equipment, and to help overcome information access obstacles. 2) Technical service mechanism for contractual energy management. Purchasing energy saving potentials through contract will help overcome market obstacles in promoting energy saving technologies and products. 3) Electricity demand-side management (DSM) methods to guide end users self-consciousness in saving electricity. 4) Government purchasing energy saving products mechanism so that energy saving products will enter on the government stock. 5) Enterprise's voluntary energy saving agreement to lead business and government into their energy saving targets in a voluntary way.

- **Establishing PBF to support energy saving and RE development**

China needs a strong driving force in its energy saving efforts and RE development because the force is a strategic option in promoting the energy sustainable development under the country's development goals of a 'Xiao Kang' society. It is also the needs for energy supply in supporting quadruple GDP in two decades, for improving the country's international competition, for the environmental health, and for improving energy services in a general level. Financing experiences from some other countries on energy saving and RE development suggest that PBF (Public Benefit Fund) financing mechanisms for energy saving and RE development will help to support the sustainable energy development. Objectives of establishing PBF include promoting energy saving and RE technical advancement and application, reducing the social overall energy cost, and supporting establishment of energy saving and RE industries and market. The suggested PBF supports on energy saving include promotion and application of existing and mature energy saving technologies, R&D and demonstration of new energy saving technologies, energy saving industry development, and market establishment and development of energy saving products and services. The support of suggested PBF on RE development will include application of mature RE technologies with good commercialization prospect, R&D and demonstration of new RE technologies, RE industry development, and establishment and development of RE product and service market.

- **Implementing energy saving collaboration agreement**

Energy saving collaboration agreement is made between an enterprise and a government agency or a government entrusted organization for reaching a certain set of energy saving targets within a certain period of time. Meanwhile, government agencies should provide some relevant incentive measures to encourage enterprises joining into the agreement. By executing the energy saving collaboration agreement, corporation can improve its energy utilization efficiency, reducing pollutant emissions, and improve technology and management capabilities. Therefore, it is necessary for China to introduce energy saving collaboration agreement as a flexible and renovated new mechanism for enterprises provided by government under the socialist market economy system. It will help the enterprise establishing modern business institutional arrangement, reducing cost, and winning in the market by

means of technology, management, information, process, equipment, and business image. The suggested policies for China's energy saving collaboration agreement include: 1) At first, government agencies choose certain industrial sectors for demonstration in energy saving collaboration agreement and generalize the experience to other major energy use sectors; 2) Government agencies such as NDRC formulate accompanied supporting policies, including market-based incentive, mandated requirement, awards, technical assistance, training and information dissemination, and public participation, in order to encourage industries sectors setting up energy saving targets and taking actual actions. 3) Since the mechanisms of energy saving collaboration agreements can be implemented in both national and regional levels, so do the policies too. 4) Government is responsible for formulating 'energy saving collaboration agreement implementation procedures' according to the 'Clean Production Promotion Law' and the 'Energy Conservation Law' to guide and regulate the implementation of energy saving collaboration agreements.

- **Conducting DSM for electricity sustainable development**

Purpose of the Demand Side Management (DSM) is to effectively use electricity by changing end user's electricity usage mode, such as peak load cutting, peak load shifting, and electricity saving. Efficiency of electric devices of end users is so low in China that unit GDP electricity consumption is 3-5 times higher than that in the developed countries. Using DSM for saving electricity consumption and improving energy efficiency, the energy saving potential is estimated as about 200 TWh each year.

China should strengthen DSM activities so that it will play more important role in the country's industrial sustainable development. The suggested DSM policies include: 1) the government should actively introduce and support DSM activities in regional levels; 2) Since China has issued 'DSM Procedures for Energy Saving' and 'Electricity DSM Procedures', DSM should be introduced into the newly modified 'Electricity Laws' in order to legally support the DSM; 3) Fund raising channels should be explored to have necessary conditions for implementing DSM; 4) Appropriate electric pricing system and structure should be established, e.g. timing prices, interruptible prices, and reliability prices; 5) Establishment of corresponding EE standards. China should take international experiences as reference for the EE standards of industrial electric devices, home appliances, and building energy saving, so that energy saving activities can be implemented smoothly in all areas.

- **Implementing bidding of wind power license project**

Policy of wind power license (WPL) is a NDRC supported and promoted policy for wind farms. WPL is mainly using the license in the development of wind resource and is a joint operation between government and private companies. Purpose of WPL bidding program in China is to: introduce competition, create large-scale commercialization demonstration projects, introduce international advanced technologies and management, and promote domestically made equipment. So far the NDRC has issued 2 batches of WPL bidding projects and 5 wind farms each with capacity 100 MW are being

prepared for construction.

Pilot project experience from the WPL activities should be collected for future development. It is suggested: 1) to continue studies on the first round of WPL projects in Guangdong and Jiangsu provinces for learning experiences and lessons so as to create a set of WPL procedures and to work out a practical guidelines for common use of WPL activities in other areas; 2) to evaluate license agreement and electricity sales contract. From these pilot project experiences, standard agreement document formats for WPL agreement and electricity sales contract will be defined; 3) to assess public bidding evaluation procedures, improve evaluation methods and standards, so as to produce an entire set of bidding procedures, evaluation methods and standards; and 4) to formulate WPL management regulations, including WPL project monitoring process so that projects can be completed in time and operated successfully.

- **Gradually creating RE generation market guarantee mechanism**

Electricity generation is the most promising area for RE resources and RE power is a clean energy substitution. Currently, China's RE power still expresses its weakness of price in the conventional energy dominated electricity market. Therefore, it is very important to have some favorable policies to enable RE power entering the electricity market. Policy suggestions in the near future will include: firstly, to guarantee that grid operators at all levels must purchase qualified RE power; secondly, to demonstrate and promote WPL policy in the wind power area so as to establish a competitive market for RE electricity and for reducing cost; and in order to support RE power that with weak economical competition, stakeholders interests are coordinated through national pricing management process so that the additional cost shall be burdened equally by whole society. Once RE power meets the competitive market conditions, a more mature RE power market with green certificate trading will be created. The green certificate trade is an assistant measure for MMS policies. It will play an active role in RE technology commercialization through optimizing resources and competition mechanisms, and finally result in a competitive RE market under the national surveillance.

- Establishing economic incentive mechanisms

Based upon China RE development process, the current policy system is mainly a national dominated investment. That is, the establishment of RE industry in China depends on the national key construction projects and national capital investment on one hand, and the RE market depends on national favorable policies on tax and credit on the other hand. Special tax policies for RE development and utilization are again recommended. Value added tax (VAT) exemption is suggested for wind farm equipment, solar PV, thermal equipment, biogas generation equipment, and efficient firewood stoves. Concerning VAT on RE generation, it is recommended that 6% for small hydropower and exemption for other RE resources. Favorable housing tax rate for apartments installed with solar water heaters should be applied. It will create RE market requirement gradually and establish a competitive RE market finally.

Market lever and signal mechanisms such as pricing, taxation, and interest rates should be applied to promote energy saving in the entire society. Energy saving behaviors in business and society should be encouraged through carrying out price, financial, taxation, and credit policies that are beneficial to energy saving. An energy saving product list will help applying favorable tax policies for enterprises that produce or use the products on the list. Special policies of shortening depreciation period should be applied for the advanced and efficient energy saving equipment, as well as tax favorable policies for energy saving investment projects and business producing novel energy saving products. National banks should provide low-interest loans for energy saving targeted projects to lead commercial banks' investment towards energy saving activities. An energy saving development fund or foundation should be established to support research and development of energy saving technologies, demonstration of energy saving projects, and the relevant] capability construction.

6.4 Propagandizing REGA Technology

It is very necessary for governments at all levels and the public to realize the importance of developing REGA technology through information dissemination and information exchange. Public media shall introduce the important roles of REGA technology in improving ecological environment and in national sustainable economic development so that more people will support EE, and RE development and use clean, non-pollutant, and sustainable energy resources. At the same time, newspapers and Internet websites should provide useful information of these areas so that more policy makers and investors realize and support the investment and development of REGA technology. Training programs for energy saving and new energy researchers, producers, sales and service providers will help to improve management and provide new ideas so that good quality and low price products can be developed and enterprises. Generally, only when more and more people recognize and understand the importance of energy saving and renewable energy, REGA technology can be well developed. Therefore it is suggested that:

- Focus on information services, including public know-how, energy statistics, information network, technical consultancy, energy audit, EE identification, learning international experience, and better services.
- Strengthen education on energy shortage, resource efficiency, and environment protection so that the entire society will actively use REGA technologies. Government agencies should have commitment to use energy saving and renewable energy products and encourage big companies to utilize REGA technologies. Implement action plans for voluntarily using EE and green energy and form a new style energy-consuming conception gradually.
- Create market-based energy saving information dissemination channels and break information barriers, to promote application of new technologies, new experiences, new technical processes, and new equipment.
- Establish training bases and conduct cooperative programs for information sharing and

technical personnel training so that a larger group of skill persons can be brought up for need of development.

7 Conclusions

From the above description of energy supply and consumption in China, REGA technological analysis, the prospects and obstacles of REGA popularization as well as policy analysis, some conclusions are summarized as follows:

First, there are several problems in energy supply and consumption: energy structure was not reasonable, and the proportion of coal was greater. At the same time, energy efficiency was lower resulting in higher energy intensity per GDP. Now, the tasks facing China are: first, to optimize the energy structure by ways of exploring more new and renewable energy; second, to eliminate low-efficiency facilities and to use new technologies for increasing energy efficiency. In general, energy demand and supply in China are basically in a balanced status, energy structure is being optimized continuously, and the energy can match the demands of the national social and economy development. Considering the population growth, economic development and the change of industrial structure, commercial energy consumption demand projections for the next two decades indicate that energy consumption demand will increase, and the coal share will evidently drop. So it can improve energy efficiency and reduce CO2 emission.

Second, in energy conversion sectors, it is rather difficult to change the existing status that the coal-burning power generation is the main technology in a long time. Since the year 2000, there is large market potential for advanced thermal power generation technologies which leading to GHG emission reduction potential. But before 2010, the advanced thermal power technologies are just in the demonstration stage and can’t play an obvious role in emission reduction. In the energy consumption sectors, owing to the popularization of energy saving technologies and wide utilization of new and renewable energy, it is expected that there will be a bright market prospect of REGA technologies in China.

Third, there are two main response measures for China to address CO_2 emission reduction, one is to raise energy efficiency, the other is to use low- or non-carbon energy instead of coal. Many sectors and alternative technologies in energy supply and consumption for CO_2 emission reduction are involved in these two areas.

Fourth, the government of China puts forward a series of new energy development programs, and works out corresponding policies of tax cut and tax exemption, price subsidies, stimulation and rewards. At the same time, the government carries out some development plans and policies in energy conservation and energy efficiency improvement, such as energy conservation law, regulations and standards of energy technologies, and stimulating policies etc. However, because of imperfect policies and regulations, as well as uncompleted management systems, the popularization of REGA technologies has to overcome some obstacles, such as lack of encouraging policies, overlap of the government functions, imperfect operation mechanism and so on.

Fifth, in order to save energy, improve energy efficiency, and speed up the development of REGA technologies, China should work out relevant regulations and laws, establish management mechanism adapted to the market, and utilize some encouraging policies. Meanwhile, various propaganda activities should be implemented to popularize REGA technology across sectors and the country.

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