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Energy Use and Environmental Pollution in China

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In the 20th century rapid economic development has resulted in environmental problems caused by human beings. The greenhouse effect caused by the release of carbon dioxide for example has become a main focus in the world. The signing of the UN climate change framework treaty indicates that human beings have reached a conclusion about the need to control the exhaust of greenhouse gases, such as carbon dioxide, resulting in improvements in the environment and realizing sustainable development. China also commits itself to action to reducing pollution associated with energy use, including reduction of carbon dioxide.

1. Energy and Economic Development in China

Energy is the main strategic material to promote social and economic development. The use of energy is also a source of air pollution and the main source of carbon dioxide. Given the importance of production and use of energy in China, it will be helpful to have a policy of reducing carbon dioxide emissions and other pollutants. China is one of the energy-rich countries in the world. Total reserves of energy resources rank third in the world and include coal, petroleum, natural gas, water, solar, wind, biomass, geothermal, ocean energy and so on. However, the level of energy resources per capita is comparatively low.

1.1 The production and composition of the energy mix in China

The total amount of energy resources in China ranks high in the world. Coal is the main energy resource in China and represents almost 70% of total energy production. The total amount of this primary energy resource began to show a downward trend after a peak of production in 1997. In that year, the amount of crude coal produced declined, and the amount of crude oil, natural gas and hydro and electricity increased. The total amount and composition of primary energy production are shown in table 1.1.

TABLE 1.1 TOTAL AMOUNT AND COMPOSITION OF PRIMARY ENERGY PRODUCTION.

Year	Total amount of energy production (10^8 ton) (standard coal)	Composition (%)			
		Crude coal	Crude oil	Natural gas	Hydro
1980	63,735	69.4	23.8	3.0	3.8
1990	103,922	74.2	19.0	2.0	4.8
1995	129,034	75.3	16.6	1.9	6.2
1997	132,410	74.1	17.3	2.1	6.5
1998	124,250	71.9	18.5	2.5	7.1
1999	110,000	68.2	20.9	3.1	7.8

Note: the index used for electricity converts standard coal depends on the average cost of standard coal converted from electricity in that year.
Source: China Statistics Yearbook, Beijing. China Statistics Press, 2000

The electric power industry has developed very quickly in China. In 1998 the amount of generating capacity for electricity reached 11,662 hundred million (10^8) kWh. Table 1.2 shows that the electricity generated from thermal power was 81%, and the electricity generated from hydro power was 17.8%, while the electricity generated from nuclear was 1.2%.

Up to April 2000, installed generation capacity in China exceeded three hundred million kW, so the serious situation of power supply restricting economic development had begun to be alleviated. The balance of supply and demand of electric power has been basically reached. From the composition noted, the electricity generated from thermal power is the main source of electric power in China, and this situation will trend upward. However the amount of clean electricity, which is the electricity generated from water, is not high, and as a component of the electricity production it is trending downward.

TABLE 1.2 TOTAL AMOUNT AND COMPOSITION OF ELECTRICITY PRODUCTION IN CHINA

Year	Total (hundred million kilowatt-hour)	Composition (%)		
		Electricity from hydro	Electricity from thermal generation	Electricity from nuclear
1985	4106.9	22.5	77.5	--
1990	6212.0	20.4	79.6	--
1995	10077.3	18.9	79.8	1.3
1997	11344.7	17.2	81.5	1.3
1998	11662.0	17.8	81.0	1.2

Source: China Statistic Yearbook, Beijing. China Statistics Press, 2000

1.2 Total energy consumption and the composition of energy consumption by sectoral use in China

Before 1996, energy consumption had been increasing year after year, but after 1996 consumption gradually decreased. The industrial sector is the main consumer of final energy (almost 70%). Second comes the domestic sector. Total energy consumption and the composition of energy consumption by sectors in China are shown in table 1.3.

TABLE 1.3 TOTAL ENERGY CONSUMPTION AND COMPOSITION OF ENERGY CONSUMPTION BY SECTOR

Year	Energy consumption (ten thousand ton (standard coal)	Proportion (%)						
		1. Farming, forest, herd, fishing, water conservancy etc	2. Industry	3. Construction	4. Transportation, mail and communication	5. Business material supplying and marketing and storage	6. Others	7. Domestic Consumption
1990	98703	4.9	68.5	1.2	4.6	1.3	3.5	13.5
1995	131176	4.2	73.3	1.0	4.5	1.5	3.4	12.0
1997	138173	4.3	72.4	0.9	5.5	1.7	3.4	11.8
1998	132214	4.2	68.3	1.2	6.0	1.8	3.8	10.4

Source: China Statistic Yearbook, Beijing. China Statistics Press, 2000

1.3 The elasticity index of energy consumption in China

The high rate of growth of the national economy has been accompanied by a low acceleration of energy consumption in China. The index of energy consumption is rather low and it became negative recently. The elasticity index of energy consumption in China is shown in table 1.4.

TABLE 1.4 ELASTICITY INDEX OF ENERGY CONSUMPTION IN CHINA.

Year	Increasing rate of energy consumption (%)	Increasing rate of the elasticity index of energy consumption (%)	Increasing rate of national net product (%)	Elasticity coefficient of energy consumption	Increased rate of energy consumption/increased rate of GDP
1990	1.8	6.2	3.8	0.47	1.63
1995	6.9	8.2	10.5	0.66	0.78
1996	5.9	7.4	9.6	0.62	0.77
1997	-0.6	4.8	8.8	-	0.55
1998	-4.3	2.8	7.8	-	0.36
1999	-7.7	6.1	7.1	-	0.86

Source: China Statistic Yearbook, Beijing. China Statistics Press, 2000

1.4 The import and export of China's energy

China has a high level of energy production and also a high level of energy consumption. In recent years the amount of energy imported has increased very rapidly and the import of energy is now greater than the export of energy in China. The net amount of energy exported reached 1,321 ten thousand (10^4) ton standard coal in 1998 as shown in table 1.5.

TABLE 1.5 AMOUNT OF ENERGY IMPORT AND EXPORT IN CHINA (TEN THOUSAND TON) (STANDARD COAL))

Item	1985	1990	1995	1997	1998
Import	340	1310	5456	9964	8474
Export	5774	5875	6776	7663	7153
Net import	-5434	-4565	-1320	2301	1321

Source: China Statistic Yearbook, Beijing. China Statistics Press, 2000

1.5 Summary

1) Coal is the main component of the energy mix in China (70 per cent). The utilization of coal is the main source of greenhouse gases, such as carbon dioxide, and a source of other pollutants.
2) Energy consumption in the industrial sector accounts for seventy percent of overall energy consumption. The use of coke and coal accounts for fifty-two percent in China. However the level in the United States is 12.1%, and in the OECD it is 5%. In China, the key way to reduce emission of carbon dioxide is to enhance the efficiency of energy use in the industrial sector and to speed up the upgrading of energy technology.
3) Energy production is difficult in China, so saving energy and efficient use of energy are the most important ways to make progress.
4) New energy and renewable energy are developing very quickly but their contribution is still low. The exploitation of new energy and renewable energy is a meaningful way to reduce carbon dioxide emissions and to promote sustainable development.

2. The Greenhouse Effect on Climate and Research on the Source of Carbon Dioxide Emissions in China

In the past one hundred years, the warming of the earth atmosphere has been demonstrated by the scientific community. According to statistics, the average temperature has increased by 0.5 degree Celsius. In this process, the contribution of carbon dioxide is 55%. The temperature of the earth would increase about 1.5 to 3° Celsius as the density of CO_2 in the

atmosphere increased by a factor of one. The increase of carbon dioxide level influences the change of weather in different regions differently. Changes in China are different than those in the rest of the world.

2.1 Climate change in China and the greenhouse effect of CO_2

The overall air temperature in China tends to increase more than the global increase. According to analysis of air temperature statistics of 30 large cities, the average air temperature is 13.59° Celsius, which is 0.48° Celsius higher than the 13.11° Celsius recorded between 1951-1980 worldwide. History has demonstrated obvious changes in climate. Based on research of the China Climate Change Country Study Team, the air temperature in China in the 20th century reached a peak in the mid 1940s then fell with several fluctuations. In the 1970s, average air temperature went back up gradually and there was a second warm peak in 1990-1994 relative to the 1950s. The pattern is different from global climate change. But it still did not reach the level of the 1940s.

Air temperature in China tends to be polarized. The areas in which air temperatures become warmer are mostly located north of 35^0 N, (northeast area, north China, Inner Mongolia and part of the northwest area). Otherwise it is necessary to study the reason for air temperature falling significantly and what effect it may have on the national economy.

At some level, the greenhouse effect of CO_2 gas affects China's climate change and economic development. One reason that air temperature in the north of China falls is likely due to the greenhouse effect of CO_2 gas. The greenhouse effect aggravates the impact of natural disasters. In recent years in China, the area of drought and flooding has increased, resulting in serious negative effects to economic development. That increase in air temperature raises sea levels, threatening the littoral areas in China. As the change caused by greenhouse gas has been a global problem, China will, like other countries in the world, do research on its effect. The Chinese government also always pays great attention to the research on GHG mitigation, and puts this work into practice.

2.2 Research on emission sources and the total emission of CO_2 in China

2.2.1 Classification of CO_2 emission sources in China

According to the research results of IPCC/OECD and a research report entitled *China Climate Change Country Study* prepared by a research team of the China climate change country study, there are 5 categories of CO_2 emission sources in China: energy exploitation and utilization; industrial processes; agriculture; vegetation and forest; and trash deposits.

Energy exploitation and utilization can be classified into 3 categories by the type of process: stationary sources; mobile sources; and development, processing and transport. The details are as follows:

TABLE 2.1 EMISSION SOURCE VARIETIES OF ENERGY ACTIVITIES

Stationary sources		Mobile sources		Development processing and transportation
Sector	Combustion equipment	Sector	Emission equipment	Source categories
1. Energy industries and transformation	Power generation boiler, industrial boiler, others	1. Road	Vehicles	1. Underground mines
2. Industry	Power generation boiler, industrial boiler, industrial kiln, others	2. Aviation	Airplanes	2. Surface mines
3. Residential Commercial Agriculture	Residential oven, industrial boiler, others	3. Railway	Engines	3. Oil systems
4. Others	Others	4. Navigation	Ships	4. Natural systems
		5. Others		

CO_2 emitted from industrial processes identifies the gas from industrial product process only, without that produced by fuel combustion. It includes steel, non-ferrous metals, inorganic chemicals, nonmetallic minerals and other manufacturing processes.

Vegetation and forest absorb carbon dioxide, and at the same time emit it in a lower rate than the rate of absorption. It is an important resource to balance the atmosphere.

Agriculture and landfill mainly generate methane gas.

2.2.2 Estimates of CO_2 emissions in China

The *China Climate Change Country Study* prepared by the research team is based on detailed technology classifications and reported CO_2 emission as 2,083,014 Gg[1] in 1990. The details are as follows:

TABLE 2.1 CHINESE CO_2 EMISSIONS IN 1990

Source type	Carbon dioxide	
	Emission (Gg)	Percentage (%0
1. Energy	2,004,107	96.2
2. Industry process	78,907	3.8
3. Agriculture	--	--
4. Land use change & forestry	-315,333	
5. Landfill wastewater		
Total emissions (without forest)	208,3014	100
Net emissions (forest included)	1,767,681	

Note: only cement production calculated in industrial process.
Source: China Climate Change Country Study research team of China climate change country study

[1] Gg = 10^9 grams

TABLE 2.2 CO_2 EMISSIONS IN FRACTION OF ENERGY ACTIVITY IN 1990

Sector	Emissions (Gg)	Percentage (%)
1. Energy transformation and industries	637,711.7	31.8
2. Industry	834,048.1	41.6
3. Transportation	113,447.2	5.7
4. Small users, residential, commercial, agriculture	369,697.9	18.4
5. Other sectors	49,202.2	2.5
Total energy activity	2,004,107.1	100

Carbon dioxide emission relating to the energy activity in China can be summarized as follows:

1) Coal is the dominant fossil fuel emitter of carbon dioxide in China.
2) Stationary sources are the major source of CO_2.
3) Industry is the biggest carbon dioxide source.
4) Power generation boilers and industrial boilers are two major types of emitting equipment.

3. Technologies for mitigating carbon dioxide in China

In China, the reasons for high levels of carbon dioxide emissions are the lack of modern producing technology and producing techniques, using resources at low levels and not prudently, resulting in low efficiency and excess energy consumption. This section discusses the mitigating carbon dioxide technologies, which include: improving production techniques; updating the technology; improving thermal efficiency; and increasing energy saving production. This is explained by sector.

3.1 Industry Sector

3.1.1 Enhancing the effectiveness of technology

Compared to developed countries, the effectiveness of China's industry sector's technical equipment is quite low. The average efficiency of industrial boilers, water pumps, fans in current equipment is lower by 10% than the international advanced level. Efficiency of coal use, which is consumed by the industrial boilers, is about one third less than the international advanced level. In China, electric motors are 60% below these standards. Improving the design and usage level of industrial boilers and industrial electromotors in current equipment will have a notable effect in mitigating carbon dioxide.

1) Mitigating carbon dioxide technical measures for China's industrial boilers.

1. Fuel pretreatment technique. These techniques include the technique of coal sieving, coal washing, coal blending and coal molding. These measures will enhance the burning efficiency of the boiler. In addition, a boiler ordinance improves run management
2. Alteration and perfection of the burning system of boilers. Such as installing economizer, controlled by computer.
3. Design and use of high efficiency boilers. These boilers include CFBC, spreader-stoker boilers and others, and include more than ten types of highly efficient boilers.

For the mitigation potential for industrial boilers in China, refer to table 3.1.

TABLE. 3.1 MITIGATION POTENTIAL OF INDUSTRIAL BOILERS IN CHINA

Technologies	Pre-fuel process	Operational improvement	Optimizing combustion	High efficiency boiler	Total
2000 year market share	0.15	0.15*	0.15*	0.10**	
2010 year market share	0.50	0.50*	0.50*	0.50**	
2000 year mitigation (Mt-C)	2.09	3.45	6.68	0.91	13.13
2010 year mitigation (Mt-C)	11.12	21.18	23.46	6.17	61.92

*Considering only those boilers available for the technology.
**Only for newly built boilers
Source: China climate change country study, research team of China climate change country study, Beijing. Tsinghua University Press, 2000

2) Mitigating carbon dioxide technical measures for industrial electromotors in China.
   1. A public proclamation prohibits production of the J02 series asynchronism electromotors, eliminating 63 high-energy consuming electromotors.
   2. Efforts are under way to tackle science and technology key problems, involved in designing high capability electromotors. These energy saving electromotors can be classified into two types. 1) High capability electromotors with enhanced efficiency, such as Yx series high efficiency electromotors. 2) Timing electromotors such as pole variation adjustable speed motors.

The mitigation potential for industrial electromotors in China is presented in table 3.2.

TABLE 3.2 MITIGATION POTENTIAL OF INDUSTRIAL ELECTROMOTORS IN CHINA

Technologies	Yx series motors	Pole variation motors	Electric -magnetic speed adjusting motors	Frequency variation motor	Total
2000 mitigation (Mt-C)	1.8	2.09	6.26	1.00	11.15
2010 mitigation (Mt-C)	2.08	10.43	26.07	15.64	54.12

Origin: China Climate Change Country Study, research team of China climate change country study, Beijing. Tsinghua University Press, 2000

3.1.2 Other measures

1) Import foreign advanced equipment technology, production techniques and administrative experience. These measures will begin soon, but cost is very high and it is not easy to move in this direction.
2) Require the elimination of laggard production techniques, close down those enterprises which are widely dispersed, of small size, seriously pollute, and use energy in low efficiency. Actions to be undertaken include: introduction of advanced techniques and equipment; closedown of small steel mills, elimination of obsolete techniques such as even-stove steel making; regroup small and middle size cement factories, and continue to clamp down and closedown "fifteen" small enterprises.[2]
3) Develop economies of scale to carry out more intensive production.

[2] "Fifteen" small enterprises refer to the small mills which produce paper, leather, dye and which produce coke, refine sulphur, refine arsenic, refine mercury, refine lead and zinc, refine oil, pick gold, produce pesticides, dye, plate, produce asbestos, produce radioactive materials using indigenous methods.

3.2 Thermal power sector

Electric power in China is mainly generated by thermal power (80%). The mitigation technologies of China's electric power sector include:

1. Elimination or replacement of those generation units with capacity below 100MW or retrofit them into cogeneration units. In 2001, the state electric power company plans to close small generation plants equivalent to 1,406 megawatts.
2. Conducting technology renovation on units with capacity equal to 100MW and over. To develop high parameter or big capacity units, introduce 300 or 600 megawatt units as the main new building units with energy consuming not to exceed 300g (standard coal) kWh; improve the 300 and 600 megawatt units which have already been imported to decrease the energy consumption of power supply to under 330 g (standard coal) kWh.
3. Endeavoring to increase cogeneration so that net fuel rate will be reduced to no more than 280 g/kWh. Build a batch of oil/gas fired combined cycle units in coastal regions to satisfy the demand for electric power.
4. Developing and adopting advanced thermal power technology at a specified future date. These technologies include: supercritical and ultra-supercritical steam parameter units with per set capacity equal and over 1,000 MW, large-sized FBC generating units, large-sized PFBC generating units, IGCC generating technology and cogeneration.
5. Increasing the use of small power dispersed high technology plants to generate and supply electricity. In a high technology small power plant such as mini type CHP and mini-type CCHP's energy consumption is low and its efficiency is high.

For a foreecast of the mitigation potential of nuclear generation in the thermal power sector of China, refer to table 3.3.

TABLE 3.3 POTENTIAL FOR REDUCING CO_2 IN THE THERMAL POWER SECTOR IN CHINA

Alternatives	Real	Planned`	
Year	1990	2000	2010
Nuclear generation (TWh)	4,949	10,958	22,480
CO_2 mitigation (Mt-C)*	0	0.33	1.17

*Compared with 1990

Source: China Climate Change Country Study, research team of China climate change country study, Beijing. Tsinghua University Press, 2000

3.3 Traffic and transport sector

Five types of traffic and transport systems: railways; water carriage; roads; civil aviation and pipelines have come into being in the fifty years since the People's Republic of China was established. In conjunction with economic development, the number of vehicles, ships and airplanes has increased very fast. The number of civilian autos in China has increased from 5,513,600 in 1990 to 14,529,000 in 1999. The number of locomotives was 15,176 in 1998; the number of civil airplanes has increased from 421 in 1990 to 801 in 1998. This increase in vehicles has put pressure on the environment. In large cities, the major cause of air pollution has changed from coal to autos. Mitigating carbon dioxide technical measures in China's transport sector is discussed below.

3.3.1 Mitigating carbon dioxide technical measures in China's road transport sector

1) Developing high efficiency engines and reducing fuel consumption rate. The fuel consumption rate of autos is higher (10-20%) than overseas gasoline engines. Auto engines in China will be updated with imports of foreign advanced technology to achieve international levels established in the 1990s.
2) Developing diesel cars and replacing gasoline motorcars by diesel cars because diesel engines are more efficient than gasoline engines . At present there are more gasoline motorcars than diesel cars.
3) Developing a range of car production to better configure the tonnage composition of auto production. At present, there are more medium-sized autos than large and small autos. The availability of more medium-sized autos will be more effective in affording appropriate carrying capacity, resulting in more efficient use of gasoline.
4) Strengthening the construction of basic infrastructure by enhancing the quality of roads. Good quality road surfaces can reduce oil-consumption and lessen vehicle wear and tear.
5) Exploiting "green" automotive production. Using and producing leaded gas was forbidden in China in 2000. New types of high tech green vehicles are also exploited using natural gas, LPG, solar fuel, electric power, etc. Many achievements have been made in this respect in China. These achievements include: a solar energy car developed by Tsinghua University in Hong Kong, wheel-driven electric car developed by the Academy of Sciences of China, "yuanwang" electric bus developed by the Commission of Science Technology and Industry for National Defence, electric coach developed by DongFeng Company, etc. Furthermore, the General Research Institute for Nonferrous Metals in Beijing has successfully developed a truck using a high-energy air-cooled nickel and hydrogen power battery, under the sponsorship of a state program. Experts forecast nickel and hydrogen power battery will be about 2/3 of all the power batteries used by electric cars before 2005. These high-tech green vehicles discharge small or zero amounts of carbon dioxide.
6) Perfecting the system of discarding old cars. Older cars consume a great deal of energy as they have lower thermal efficiency and are harder on roads.
7) Strengthening the control of gas emissions by cars. It is stipulated in the law on preventing and curing the pollution of the atmosphere that the gas emission of automotive vehicles must reach this standard, otherwise the vehicle cannot be produced, sold and/or imported.
8) Speeding up the construction of underground and light rails in big cities, decreasing thereby the heavy problem of pollution by car emission. A first line of underground (20.06 km), a second line of underground and an orbit traffic *mingzhu* line have been constructed in Shanghai. A civil magnetic levitation underground will be constructed in 2001. The number of customers carried by underground was 434,785,000 in 2000 in Beijing, which is 12.2 % of the number of all civil traffic customers.

3.3.2 Railway transportation sector

Railway transportation has the characteristics of low energy consumption, large carrying capacity and high security. Railway construction developed very quickly since China was established. The state railway working mileage was 57,900 km in 1999. The number of locomotives in China is 15,562.

TABLE 3.4: NUMBER AND COMPOSITION OF LOCOMOTIVES

Year	1990	1998
Total number of locomotives (region locomotives)	13,970 (378)	15,562 (386)
steam engine locomotives (region locomotives)	6,532 (253)	2,292 (231)
gas engine locomotives (region locomotives)	5,805 (125)	10,159 (155)
electric power locomotives	1,633	3,111

Source: China Statistical. Yearbook, Beijing, China Statistical Press.

Technical measure for reducing carbon dioxide emission of the railway sector in China:

1) Eliminate steam engines. Burning coal provides motive power for steam engines. Steam engines consume a great deal of energy and their efficiency is very low (refer to chart 3.5). It was decided to stop producing steam engines in 1988 and to retire existing ones in a step-by-step approach. At present the number of steam engines has decreased from 6,532 in 1990 to 2,292 in 1998 in China. The elimination of steam engines could reduce carbon dioxide by 3,000 kg/tons.

TABLE 3.5 COMPARISON OF ENERGY CONSUMPTION AND EFFICIENCY OF RAILWAY TRANSPORT MODE

Transport mode	Proportion of energy consumption (%)	Efficiency of energy use (%)
Steam locomotives	68.0	6.1
Gas engine locomotives	22.5	19.0
Electric locomotives	9.5	20.8

Source: China Climate Change Country Study, research team of China climate change country study, Beijing. Tsinghua University Press, 2000

2) Give priority to gas engine locomotives and develop electric power locomotives. The number of gas engine locomotives in China is 10,159. At the same time, electric power locomotives are developing very fast in China, about 12.9 % annually. (Refer to table 3.6)

TABLE 3.6 STATE RAILWAY CARRIED MILEAGE (TEN THOUSAND KILOMETER)

Year	1996	1997	1998	1999
Carried mileage	5.67	5.76	5.76	5.79
Electrified railway carried mileage	1.01	1.20	1.30	1.40

Source: China Statistical yearbook, Beijing. China Statistical Press.2000

3) Make greater efforts in developing high load carrying and high-speed railways as both approaches can save energy. At present make great efforts at developing the use of super long welded rail systems, increase the proportion of heavy rail and raise the speed. Adopting these synthesis measures will save 10 percent of energy. Correspondingly, the potential for reducing emissions is over 10%.

3.3.3 Mitigating carbon dioxide technical measures of China's shipping sector.

Eliminating old ships and using modern design. Over 54% of China's ocean fleet is over fifteen years old. Many were built before the 1970s. These ships use 30% more energy than advanced ships. Riverboats represent 35% of shipping but carry only 15% of cargo, leading to waste of energy.

Other mitigating carbon dioxide technical measures are presented in table 3.7

TABLE 3.7 TECHNICAL MEASURES AND EFFECT OF MITIGATING CARBON DIOXIDE OF THE SHIPPING SECTOR

Technical measures	Energy saving and mitigation effect	Comments
1. Reducing ship speed	The fuel consumption in the same transport duty will be 75% when the ship speed is reduced by half.	
2. Propeller edge-fixing	Generally this measure can save fuel by about 5%	
3. Minimizing friction	Average 4%-10% of fuel can be saved	By keeping the ship in the best posture, resistance caused by waves and water flow can be minimized.
4. Ship body cleaning	The fuel saving rate is about 15%-50%	Energy is saved by reducing sailing resistance
5. Propeller ducts	8% energy will be saved	
6. Low speed and large diameter propellers	Decreasing propeller rotational speed from 100r/min to 60r/min can save about 12%fuel.	
7. Diesel engines waste heat recovery	Can result in energy saving of 2%	
8. Meteorological navigation	3%-5% fuel will be saved	Make use of tidal currents.

Origin: China Climate Change Country Study, research team of China climate change country study, Beijing. Tsinghua University Press, 2000

3.4 Domestic sector

The domestic sector uses energy for heating, lighting and home appliances. According to statistical data, the proportion of energy used by China's domestic sector has decreased year after year but the proportion is still high. In 1998, 10% of all energy was used by the domestic sector. Statistical data indicates that 10% of electric power was used for lighting in China. Economic development has increased people's living standards. Refrigerators, air conditioners, color TVs are available for average families. This has increased the consumption of energy. In China's countryside, which has a hundred million population, the majority of families still use dried up straw, livestock dung and grass as the main fuel. This releases great amounts of carbon dioxide to the atmosphere. Adopting new types of energy saving lighting, cooking and household electric appliances will contribute to decreasing carbon dioxide emissions.

3.4.1 Lighting

A new series of energy efficient lighting products are being developed by importing foreign production equipment. They include high-pressure sodium lamps, metal halide lamps for agriculture and industry, and thin tube fluorescent lamps and compact fluorescent lamps for domestic use. Government supports the production of energy efficient lamps. Because of the age of equipment for producing lamps, the energy efficient lamp production is of low quality and high prices result in limited use. The government will adopt policies to accelerates the development of energy efficient lamps.

1) Speed up the use of energy efficient lamps and gradually replace the incandescent lamps. Because the energy efficient lamps have a higher price and inferior quality and consumer

awareness of energy efficiency and environmental protection is weak, they are slow in gaining consumer acceptance.

2) Speed up the building of rural transmission-lines of electric power and replace oil lights by electric lamps.

3.4.2 Household electric appliances

In China, household electric appliances came into use in the average family at the beginning of the 1980s. Since then, their use has spread rapidly. As the population of China is great, many of electric appliances are used so the potential for energy efficiency is also great. The energy efficiency measures for household electric appliances are:

1) Exploiting environmentally oriented production. Continue to replace CFCs. A most favorable project to environmental protection will be adopted using HFC-134a, isobutene 600a or mixture TH series as refrigerating medium and using cyclopentane or HCFC – 141b as a desiccant. At present, environment-friendly electrical appliances, including refrigerators, air conditioners and TV sets are being used in China.
2) Developing science and technology to promote energy efficiency. Household electric appliance trade began at a late date in China, so the gap between this trade and advanced countries is great. In the future, China will make efforts to develop energy efficient technologies for electric appliances.
3) Actively develop labeling of energy efficient products. The China Certification Management Commission for Energy Conservation Products warranted by the State Quality and Technology Supervision Bureau and led by the State Economic and Trade Commission is the only authority implementing the certification of energy efficient products. It has set up a China certification center for energy conservation products. Products having energy conservation certification include: household refrigerators; and tubule fluorescent lamps. Soon to be certified are: lighting, room air conditioners; household washers; and household electric appliances. Carrying out the certification will improve producer's consciousness and techniques of energy conservation and strengthen awareness of energy conservation products.

3.4.3 Domestic use

In line with the growth of the economy and energy use, the fuel supply of China's citizens has changed. Manufactured gas, liquefied petroleum gas and natural gas have come to be used by families. By the end of 1999, in all cities of China, the population using manufactured gas, liquefied petroleum gas and natural gas reached 164,790,000. Gradually, liquefied petroleum gas has been introduced in rural areas. This is a convenience to farmers and can save energy. Manufactured coal gas, liquefied petroleum gas and natural gas developed quickly in China, but the quantity produced is still low so its availability is limited. Overtime, the proportion of manufactured coal gas will drop off because of its high cost which cannot compete with imported liquefied petroleum gas. Liquefied petroleum gas also is a high quality low-coal energy, which can be used in rural areas although the domestic potential for liquefied gas is limited so the future requirement will depend on imports.

Natural gas will be an important energy of the 21-century. It is a cleaner energy because the CO_2 emitted by natural gas is only 15% that of oil. Natural gas reserves will last about 60 years; oil reserves about 40 years. Puyehao, the chairman of the International Natural Gas

Association said: “the outlook for exploiting natural gas resources is very good over a period of several hundred years”.

At the same time China’s government is actively adopting plans for the import of natural gas and liquefied natural gas to satisfy increasing demand. The Fance Coal Gas Company has predicted that in the next ten to twenty years the increasing rate of consumption of natural gas will be 12% to 15%. The China State Developing Plan Commission has also estimated that by 2010, 6% of all China’s energy consumption will be natural gas. Miaochengwu, head of China’s Oil and Natural Gas Group Company, has said that until 2015 natural gas imported by pipeline and ships will meet 40% of all requirements. This company is one of the biggest oil and natural gas state-owned enterprises in China.

4. Strategic Measures for Developing Energy Sources

A shortage of energy is a common problem China will face. The total amount of natural resources in China ranks seventh in the world and the amount of energy resources ranks third in the world. It is equivalent to 4,000 billion tons standard coal. The coal reserves of China are 1,002.5 billion tons but the exploitable reserves are only 89.3 billion tons. The ratio of the exploitable reserves to the total reserve is 219 years. The oil reserve totals 93 billion tons and the natural gas reserve totals 38,000 billion m^3. The proven reserves of oil and natural gas account for 20% and 6% of the total resource sum, respectively, and they can be exploited only in several decades. On a global basis the remaining exploitable oil reserves are only 140.9 billion tons and exploitable reserves will last for 41 years. The 15^{th} world oil conference considered that the proved degree of the oil reserve mentioned above is 79% and that availability of oil will be a serious energy problem that humankind will encounter in the 21^{st} century. The resource in China of coal-bed-gas is 35,000 billion m^3, equal to 45.0 billion tons of standard coal and ranks third in the world. Compared with other countries China has relatively rich energy resources but the average energy resource base per person is less than half of the world level (1/10 of the oil reserve). Energy shortages will emerge in the foreseeable future. Developing energy resources and uncovering new energy sources and renewable energy have significant strategic importance and will contribute greatly to the reduction of carbon dioxide discharge.

4.1 Coal cleaning technologies

4.1.1 The current status of the utilization of coal-cleaning technologies in China

Coal cleaning technologies can increase efficiency and decrease pollution in the course of the mining, processing, transforming and use of coal. Nowadays, the coal technologies which are developed and used in China are as follows:

1. Sorting technology. To wash and select coal is an effective measure to enhance the quality of merchant coal and reduce pollution from the mine head. There is a wide gap between the sorting technologies of China and those of the rest of the world. In 1997, the proportion of coarse coal sorted in China was 25.73% while it was more than 90% in developed countries.
2. Water-coal-slurry technology can highly augment the combustion efficiency so as to decrease energy consumption.
3. Integrated gasifying combining cycling (IGCC) technology is a type of electricity

generating technology with high efficiency and low pollution, which can meet the need for environmental protection. Its efficiency of electricity generation can reach more than 45%. Research on this key technology has been started in China. It includes the technologies of the IGCC process, coal gasification, coal gas cleaning, gas fueling engines and residual heat systems.

4. Coal-gasification is an important technology for energy transformation, which is widely used in the field of chemical engineering, metallurgy, building materials and civil burning of gas. Presently, the coal used to produce gas totals 60 million tons every year in China.
5. Coal-liquefying technology. In a current joint venture projects in China the production ratio of liquefied oil from the coal liquefying process is between 50% and 70%.
6. Other coal cleaning technologies. In China other coal-cleaning technologies include flue-purifying technology, synthesis technology for utilizing powder coal.

4.1.2 The importance for China of developing coal-cleaning technologies

1. China is rich in coal resources and coal is widely used in China. So developing coal-cleaning technologies matches the situation in China.
2. Coal-cleaning technologies, which can increase combustion efficiency, are important approaches to solving the problem of low efficiency of coal utilization in China and reducing greenhouse gases.

4.2 Exploitation and Utilization of Coal-Bed-Gases

Coal-bed-gas is a type of superior and clean fuel: 1,000 m^3 can produce as much heat as 1 ton of oil. There are 1000 billion tons of coal reserves in China, 80% of which are soft coal and anthracite which holds a great deal of coal-bed-gases. There are coal-bed-gases worth exploiting even in transmulative lignite (wood coal). According to a preliminary estimate, coal-bed-gas reserves buried below 2,000 meters are about 35,000 billion m^3. Proven reserves are about 12,000 billion and possible reserves are about 23,000 billion.

The Chinese central government is emphasizing the exploitation and utilization of coal-bed-gases. Early in 1982, the State Planning Commission began to incorporate coal bed methane utilization into the state capital construction plan for energy conservation. In 1989, the State Council drafted a "list of current priority industries" in which coal bed methane development was designated as one of the "industries and productions to be particularly supported in capital investment". The state provision of investment loans and subsidies to coal bed methane development was stressed as a priority. In May 1996, the Ministries of Coal Industry, Geology and Mineral Resources and the China National Petroleum Corporation jointly established China United Coal Bed Methane Corporation Ltd. to uniformly plan for and develop coal bed methane.

4.3 Strategy for development of renewable energy

4.3.1 The current status of utilization of renewable energy resources in China

Bio-energy, wind-energy, solar energy, small-scale hydro-energy, ocean energy, geothermal energy, are plentiful in China. Such renewable energy is not only an important supplemental energy to solve the problem of energy shortfalls in the future, but also important in

replacing high carbon-containing fossil energy with a kind of clean and environmentally benign energy.

Status of the utilization of renewable energy resources in China is shown in table 4.1.

TABLE 4.1 THE UTILIZATION STATUS OF RENEWABLE ENERGY RESOURCES IN CHINA

Renewable energy	Exploitable potential	Utilization status in 2000 (Incomplete Information)
1. Hydropower	378 million kW capacity for engine load	23 million kW capacity of little-scale hydraulic engine load
2. Wind energy	253 million kW	170,000 kW capacity of small-scale wind power, 344,000 kW capacity of large-scale wind power
3. Solar energy absorbed on global surface	17 trillion tons standard coal	26 million square meters of solar water heater 19MW capacity of solar power 9 million square meters of solar rooms
4. Bio-energy	0.65 billion tons standard coal	7 million family-use methane pools 1000 methane projects
5. Geothermal	Perspective reserve 135.35 billion tons of standard coal, proven reserve 3.16 billion tons standard coal	28.8 MW terrestrial heat electricity 9 million square meters for terrestrial heating
6. Ocean energy	0.44 billion kW	5.64MW capacity of tide engine load

Data source:

1. Chen Hoping, Energy Conservation Planning Scheme of "10th Five years" of China, Energy Conservation and New Energy Division, Fundamental Industry Department, State Planning Commission. http://www.chinacogen.com
2. Development status of the ocean energy in China, http://www.newenergy.org.cn
3. Renewable Energy Action program of "10th Five years".

4.3.2 Policy in China for developing renewable energy

The Chinese central government highly regards the development of renewable energy. A series of directing policies have been established, which include objectives and timing. The 1996 – 2010 Program for developing new energy and renewable energy of China, which was developed in 1995, brought forward the material plan for new energy and renewable energy of China in 2000 and 2010. (See Appendix 1).

The Chinese central government is taking a series of stimulating policies to accelerate the development of renewable energy in China. These policies include:

1. Allowance policy. To encourage the development and spread of renewable energy technologies, the Chinese central government provided subsidies of 9.2 million Yuan as enterprises fee allowances in 1990-1996. The State Science and Technology Commission has also spent 60 million in the development of renewable energy in the "9th Five-Year Plan". Local governments also are making major contributions, even acting in a decisive role in the development of renewable technologies. For example, Ina, Gansu, Qinghai, Xinjiang provinces have 200-300 Yuan user allowance for every set of "solar system" and "micro- wind-engine" introduced.
2. Tax policy. The Chinese central government and local governments have established tax-reduction policies, including reductions of import, value-added, value-added appendix and ownership taxes.
3. Price policy. The announcement of further supporting renewable energy development of State Planning Commission and State Department of Science and Technology

issued in 1999 by the Planning Commission and the State Department of Science and Technology prescribed that in the project of electric-net combination, the principle of "principal, interest and profit all included", the superabundance part over average price should be apportioned by the electric net.

4.3.3 Blueprint of development of renewable energy in China

During the "10th Five-Year Plan", the focus of work of the State Planning Commission covers:

1) Implementing "Harness the Wind Plan" to speed the localization of wind-electricity equipment. The gist of "Harness The Wind Plan" is to combine technologies with trade, to import, digest and absorb foreign advanced technologies, to realize the localization of 300KW, 600KW large-scale wind-power-generation electricity units. The prospective objective of "Harness the Wind Plan" is that during the 10th Five-Year Plan, localization ratio of the wind engines reaches more than 60-80%.
2) Implementing "Light Plan", to bring electricity to rural areas using renewable energy. The objective is to supply electricity to a population of 8 million, with a 100W capacity per person, before 2005 using wind-power and solar-power, thus helping to complete rural electrification.
3) Implementing demonstration of straw gasifying projects, to spread straw-gasifying technology in rural areas and try to set up 5000 demonstration villages during the 10th Five- Year Plan.
4) Constructing energy systems in one hundred rural counties. During the 10th Five-Year Plan, besides building on the energy systems constructed in the 100 rural counties outlined in the 6th Five-Year Plan, and consolidating and furthering the achievements of rural energy systems, work will proceed on the development of the three types of rural energy systems construction at the county level, based on the level of economic development between areas. These three categories are: eliminating poverty, attaining a comfortable level of living and maintaining an efficient life style.

5. Forests and the Reduction of Carbon Dioxide

To increase tree planting and forestation, and to enhance the nitrogen-fixing function of forest, the Forestry Ministry of China has established the "Action Program for Forestry in the 21st Century Agency", and set up the strategic aim for Chinese forestry development. At the end of the past century, the forest coverage ratio reached 15-16%, and total products of forestry amounted to 304 billion Yuan. By the middle of the 21st century, a fairly complete forestry ecosystem and a fairly developed forestry manufacturing system are to be built. Up to now, man-made forests of China total 46.667 million hectares. Forest acreage is 0.158 billion hectares, the coverage ratio reaches 16.55%.

Through reinforcing the vitality of city gardens, the concentration of carbon dioxide can be reduced effectively. According to statistics, at the end of 1999 the acreage of city gardens green area was over 0.778 million hectares.

To start up a public volunteer tree planting, following the proposal of Deng Xiaoping, in December 1981, the 4th meeting of the Fifth National People's Congress issued a decree to initiate a national movement for volunteer planting. The National Delegate Conference

issued “The decree of initiating national movement for volunteering planting”, which required that wherever the conditions allow, except the disabled, any citizen of China who is between 11 years and 60 years (55 for female) old should accomplish every year the task of planting 3-5 trees or equivalent labor strength for breeding, maintaining or other work to increase greenery, adjusting measures to local conditions. Since 1982, nearly 4 billion man-hour were devoted to volunteer planting, and 20.5 billion trees were planted. In 1994, there were 0.49 billion people in the movement, and 2.52 billion trees were planted. The far-ranging expansion of the national volunteer planting movement promoted the progress in the greenery of China and heightened national awareness for greening and environment protection.

6. The Establishment of Management System and the Development of Rules and Policy in China for Promoting the Reduction of Carbon Dioxide and Other Pollutants

China is a large developing country which produces significant pollution. Although limited by technologies, capital, energy, and so on, the Chinese government pays great attention to environment protection on a continuing basis. Through setting up institutions, establishing rules and policies for environment protection and reinforcing the strength of monitoring and executing the laws, the Chinese government has reduced environmental pollution while maintaining a high speed of economic development. Sustainable development strategy has been one of the national development strategies of China.

6.1 The management system for environment protection in China

In 1984 the State Department of China set up an environment protection commission, which led and organized national environmental protection work. The Environment Protection Agency of China, all levels of environmental administrative organizations and environmental protection division in respective industry, came into existence one after the other. In 1979, the environment science association was established, this led to the development of many guilds and civil organizations such as the Association of Environmental Protection Industry of China.

In 1980 China established the Institute of Environmental Science, and built corresponding research organizations in the respective departments of China and in local areas. Founding of such organizations exerted enormous momentum to increase the reduction of environmental pollution and the saving of energy, through unfolding very effective work for environmental protection, communicating and cooperating with international partners, publicizing of environmental protection, tackling key technological problems in the environmental protection and energy saving.

6.2 Development of policies to promote environmental protection

A number of steps are being taken to develop policies to promote environmental protection:

1. Directing of industry policy to: implement a sustainable developing strategy; establish and exert environmentally benign industrial policies; boost the environmental protection industry; reinforce the configuration and coordination between environmental management and environmental protection policies.

2. Implementing price policies to: reform and arrange the price system; avoid the situation of inappropriately low prices and free usage of natural resources; and facilitate the careful and efficient use of resources via adjusting resource prices in a market oriented way, thereby reducing the discharging of environmental pollutants.
3. Developing tax policy to: impose tax on the discharge of pollutants; provide tax discounts for projects aimed at environmental protection; carry out preferential tax policy on the business profit associated with synthesis of products from "3 wastes", products for environmental protection and the management
4. Implementing financial policies to: sequester special funds for pollution treatment from the waste discharge fees; appropriate special funds from the State for environmental treatment; and at the same time prescribe several investment and financing channels to be used in protecting the environment.
5. Stimulating policies for energy usage through economic stimulating policies to direct and encourage investors to produce and use clean energy, new energy and renewable energy.
6. Developing ecologically sound agriculture and an ecological industry and building up natural protection areas. In the whole country, there are more than 300 ecological agriculture counties. Such measures are helpful to heighten the public awareness of environmental protection and encourage the public to support sustainable development strategies.
7. Implementing the national basic policy (family policy). By implementing this family policy, China has controlled the increasing rate of population successfully and slowed down the pressure on the environment from enlargement of the population and consumption of resources.
8. Setting up action plans for environmental protection in China. To take purposeful measures for the work on environmental protection on a step by step basis; constituting action plans; and unifying deployment of resources. In the 10th Five-Year Plan, ten purposes for environmental protection in the country have been defined (see Appendix 2).
9. Strengthening international cooperation to boost the development of careers in environmental protection. China has joined many international organizations and subscribed to 25 international conventions in succession in past ten years. At the same time China has obtained environmental cooperation via the credits and free aids from multi and bilateral international organizations. In the period of 1993-1996 for example 405 projects were undertaken with a value of US$3.19 billion.

6.3 Strengthening environmental law and regulations

The system of environmental protection laws and regulations of China has been constructed in the past 20 years. At the present time there are several laws in the process of being drafted and implemented, such as the Environmental Effect Evaluation Law, The Sand Prevention and Remediation Law and the Clean Manufacturing Law. These laws and regulations play an important role in environmental protection. In March 1993 the Standing Commission of the National People's Congress established an Environmental Protection Commission. This Commission plays a significant part in leading the development of laws and regulations and taking measures to ensure these laws and regulations are implemented. The selected list of the laws and regulations constituted in China which are conducive to reducing the discharge of carbon dioxide are presented in Appendix 3.

6.4 Strengthening environmental monitoring and law executing power.

Presently there are environmental protection management divisions and law enforcement divisions at all levels of government (central and local). The laws and regulations and environmental standards are being continually improved. These measures guarantee the reduction of environmental pollutants discharges, environmental protection and the reduction of carbon dioxide emissions. From past experience, it has been recognized that laws were not followed or implemented strictly. Nowadays work is focusing on strengthening environmental laws and regulations and the power to enforce the environmental standards as follows:

1. Constituting and implementing three major environmental policies. The first and primary policy is to prevent and remedy pollution. The second is the policy prescribing that "those who pollute are those to remedy" and "those who exploit, are those to protect the environment". The last is the policy of strengthening environmental management.
2. Pushing forward a series of systems to deepen environmental management. Such comprehensive systems should include: the system for waste discharge fee; the license system for pollutant discharge; the responsible system for environmental protection aims; the system for environmental evaluation; the access system for enterprises environmental protection; and the system for central controlling pollution.
3. Reviewing projects and product lines. On the one hand, projects that do not meet the standards for environmental protection cannot be built. On the other hand, product lines that cause serious pollution and are high-energy consumers should be replaced.

7. Conclusion

The earth is the common home for all human beings. Reducing overall pollution and the excessive discharge of greenhouse gases like carbon dioxide are problems that every country is confronting. These problems need to be solved by cooperating.

The Chinese government pays attention to the problem of saving energy and reducing emissions on a continuing basis. Through positive and effective measures, the Chinese government successfully achieved rapid sustainable economic development and a low increment of carbon dioxide discharge and pollution. These achievements came through successfully implementing sustainable development strategies; correct policies and plans for environment protection; improvement of energy efficient technologies; the advancement of renewable energy technologies; and development of these technologies through industrialization and promotion of the public awareness of energy saving and environmental protection.

The Chinese government will continually to make contributions to the reduction of pollution and carbon dioxide while implementing rapidly increasing economic development by carefully summarizing these experiences of success, by going ahead aggressively, and developing new ideas.

China is one of the developing countries which seeks to meet the basic living needs of its people through economic development. Referring to the developing mode of the world civilizations, China is in an inevitable situation of increasing the discharge amount of pollutants and carbon dioxide in the process of economic development.

The Chinese government has not promised yet formally to implement policies to reduce carbon dioxide discharge in the present time, as it has to take into account its level of economic development. However it is important to note that China's annual output of carbon dioxide has declined in the last four years in a period of rapid economic growth. When energy consumption per person reaches the world average level China will start to reduce the discharge of carbon dioxide.

The Chinese government cooperates with international partners closely on a continuing basis. To seek the proper approaches for reduction of the discharge of carbon dioxide China particularly needs input of capital and technologies from developed countries. In their history of development, advanced countries have discharged more carbon dioxide than developing countries, so they should take more responsibilities for the global greenhouse effect. One important item of the resolutions in the conference on world environment and development in 1992 indicates that advanced countries should supply capital and technologies to developing countries with no strings attached. China is expecting capital investments and technologies transfer from advanced countries to make more progress to reduce the discharge of pollutants and carbon dioxide.

Appendix I

The developmental objectives of new energy and renewable energy in 2000 and 2010

Energy types	unit	Objective in 2000	Objective in 2010
Firewood and charcoal forest	Ten thousand hm^2	640	1,340
Firewood	Ten thousand t	18,000	27,000
Saving-brushwood stove (amount-saved p.a.)	Ten thousand t	10,000	10,000
Firedamp	Hundred million m^3	22.6	40
Abc warfare energy	Ten thousand t standard coal	250	1700
Small water and electricity Installed capacity/generating amount	MW/TWh	19,850/74.4	27,880/117
Solar energy	Ten thousand t standard coal	123	467
Wind power electricity	MW	300-400	1000-1100
Geothermal heat	Ten thousand t standard coal	88	151
Tide energy	MW	50	310
Electricity generated from abc warfare	MW	50	300

Data resource: "The developmental program of new energy and renewable energy in China from 1996 to 2010"

Appendix II

The ten objectives in the fifteenth national environmental protection

1 The exhausting of contamination in the industry and corporation is up to par completely.
2 The air and water conditions of 100 environmental protection focus cities are up to par according to function.
3 To establish 50 model cities of environmental protection and 200 good environment towns.
4 The water condition of the Hua river area is up to par according to function, and centrally provided water in Haihe and Liaohe area and towns satisfy the use function.
5 To keep control on the total amount of contamination exhaust efficiently, and endeavor to decrease the total amount of contamination exhaust in 2005 by 10% over 2000.
6 The water and air and sound condition in Beijing reach the standard of national environmental condition, and the environment have improved noticeably
7 The water quality in Baohai along shore and maritime space is up to par according to the function of ocean environment
8 To establish 100 national zoological demonstration districts and 100 important zoological demonstration districts, and keep the ratio of natural protection area in rural areas at 12%
9 The input of environmental protection reaches 1.2% of GDP
10 The daily report of air in 100 cities, and the daily report and forecast of air quality in 42 cities.

Appendix III

The selected list of China environmental protection law

1. The temporary way to collect exhaust fee 1982.2.5
2. The forest law of PRC 1984.9.20
3. The grassland law of PRC, 1985.10.1
4. The mine resource law of PRC 1986.3.19
5. The management way to control soot in city 1987.7.21
6. The preventable way of atmosphere pollution of PRC 1987.9.5
7. The temporary way to report the environmental pollution and destroy accident, 1987.9.10
8. The temporary way to use the special item of fathering pollution resource 1988.7.28
9. The environmental protection law of PRC 1989.12.26
10. The management way to supervise the auto exhausting pollution 1990.8.15
11. The actualizing detailed rules to prevent the air pollution of PRC, 1991.5.24.
12. The administrative punishment by law to protect environment 1992.7.7
13. The decision about amending the preventable way of atmosphere pollution in PRC 1995.8.29
14. The saving resource law of PRC 1997

Appendix IV

The catalogue of environment protection standard of China

1. Emission standard of air pollutants for boilers, 1992.05.18
2. Emission standard for odor pollutants, 1993.07.19
3. Emission standard for exhaust emissions from motorcycles, 1993.09.07
4. Emission standard for exhaust pollutants from light-duty vehicles, 1993.09.07
5. Emission standard for pollutants at idle speed from vehicles with gasoline engine, 1993.09.07
6. Emission standard for smoke at free acceleration from vehicles with diesel engine, 1993.11.08
7. Emission standards for smoke at full load from diesel engines, 1993.11.08
8. Ambient air quality standard, 1996.1.18
9. Emission standard of air pollutants for cement plants, 1996.03.07
10. Emission standard of air pollutants for industrial kilns and furnaces, 1996.03.07
11. Emission standard of air pollutants for coke ovens, 1996.03.07
12. Emission standard of air pollutants for thermal power plants, 1996.03.07
13. Integrated emission standard of air pollutants, 1996.4.12

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