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Energy and Sustainable Development in China

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Summary of Report

China's main indigenous energy resources are coal, with a small reserve of oil and natural gas, as well as hydropower resources. Currently renewable energy accounts for less than 8% of China's energy mix. The Chinese government has set the ambitious target of increasing the share of hydropower, wind power, solar power and other renewables to 15% by 2020.

Preface

This Sustainable Energy Watch report is prepared by Prof. Jiahua PAN and Xianli ZHU from the Research Centre for Sustainable Development, Chinese Academy of Social Sciences.

In the process of preparing this report, the biggest problem was data availability. Like in other developing countries, statistics are often incomplete and not readily available. For example, in the official energy statistics released by the Chinese government, the data on renewable energy is only limited to medium and large hydropower. Among the 750 million Chinese rural residents, many are still using firewood and stalk as the fuel for cooking and heating. Traditional use of biomass, biogas, small hydropower, solar thermal water heaters, PVs, geothermal, and wind power contribute 232.4 Mtoe of clean energy, however they are neglected in the official statistics.

Data about investment is also lacking. One indicator is the burden of public investment. However, in China, the economy used to completely consist of State-owned enterprises and collective enterprises, the State-owned enterprises lack decision-making rights and all investment, production, and management decisions were made by the government. Therefore, the energy investment of state-owned enterprises could be regarded as state investment. However, over the years, the ownership structure of Chinese economy has becoming increasingly complicated. Not only is the role of private sector and foreign-funded enterprises improving, mixed ownership is more and more common. Today listed companies contribute around 1/3 of the industrial enterprises' output but it is difficult to say whether they are state-owned or not. To make it simple, in the calculation of this indicator, investment by State-owned enterprises is used, however this may be imprecise.

Ideally, 2006 China renewable energy watch should be based on the 2004 data and the base year should be 1990. However, due to lack of data, in some cases data for 2002 and 2003 are used to indicate the current status.

Another problem is inaccuracy of the data, especially with the indicator energy-related local pollutants. The Chinese government has monitored the ambient air quality of more than 379 Chinese cities (this accounts for 57% of the 661 cities in China). In recent years, many large Chinese cities have carried out air pollution control measures, one of them is moving polluting enterprises to the outskirts of large cities or to small cities and rural areas, where the emission control is not less rigid. Thus, while the official statistics show that the ambient air quality in the cities monitored has improved significantly since 1990 statistics also show that during the same period,

China's total emissions of SO2 and suspended particulates have increased substantially. Under such circumstances, total emissions may be a more accurate indicator of Chinese sustainable energy performance.

Generally, through extensively gathering data from various sources, comparing them, and selecting the most plausible ones, the analysis presented in this report offers an accurate profile of the energy sustainability in China: in the course of rapid economic development, China has made remarkable achievements in improving its energy sustainability. However, in view of its coal-dominated energy endowment and robust economic growth, energy security and sustainability remain tremendous challenges that have to be tackled with care during the up-coming years.

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Executive Summary

China, due to its large population and coal-dominated energy structure, is now the world's second biggest CO2 emitter (IEA, 2002) and the number one SO2 emitter (IEA 2002). China has set a remarkable example of de-coupling CO2 emissions from economic growth: it has halved its CO2 per GDP ratio from 1.2 to 0.6 from 1990 to 2003. This is higher than the overall ratio of CO2 per GDP in the Annex II countries which decreased by 15% over the same period (IEA, 2005b).

As a developing country, the per capita primary energy consumption is only 1.10 toe in 2003, less than two-thirds of world average level of 1.69 toe/capita and much lower than that of developed countries (IEA, 2005a). As a result, China's per capita CO2 emissions from energy combustion were 2.89 tonne in 2003, about 72% of the world average level in the same year, despite the fact that fossil fuel, especially coal, contributes a much higher share of primary energy consumption in China. Since 1990, economic growth, higher income level, and consequently higher household appliance and automobile possession, the per capita CO2 emission from energy combustion in China increased by 45.3% from 1990 to 2003. This is much faster than the 0.8% growth of the world over the same period (IEA, 2005b). In the 11th Five-year Plan, China for the first time explicitly set the tasks of "controlling greenhouse gas emissions".

In China, the most significant energy-related local pollutants are SO2 and suspended particulates. Coal accounts for 67.7% of the total primary energy consumed (CNSB, 2005) and a large share of the coal is burned without being washed. Consequently, over 90% of the SO2 emissions and more than 70% of the suspended particulates come from coal combustion which results in serious air pollution, especially during the winter seasons in the northern part of the country (EIA ,2005). The Chinese government has invested a lot in air pollution control. In large and medium sized cities, industrial enterprises have been moved out of the downtown area. As a result, among the more than 300 hundred cities monitored both the SO2 pollution and the suspended particulates pollution has been significantly reduced. In the 379 cities where air quality is monitored, the density of suspended particulates has dropped from 387 µgr/m3 in 1990 to 275 in 2004, that of SO2, from 115 µgr/m3 in 1990 to 49 in 2004.

However, total emissions of SO2 and suspended particulates grew significantly over the period. China's total SO2 emissions increased from 14.95 million tons in 1990 to 22.55 million tons in 2004, up 51%. Its emissions of suspended particulates grew from 13.24 million tons to 19.998 million tons in 2004, also up 51% (CNSB, 2005; LBNL, 2004).

China has an outstanding performance in making electricity supply available to its 1.3 billion people. The share of population with electricity access sees further increase during the period, from 89.6% in 1993 to 98.44% in 2003 (Chinese Ministry of Water Resources, 2004). These rates are much higher than many other developing countries of equivalent or even higher economic development level. Electricity has been used as a weapon to fight poverty eradication and has been quite successful. Since 1986, China has developed small hydropower as a solution to rural electrification. In the past 20 years, four phases of a county electrification program have been carried out in 1000 counties (out of 2836). In addition to government-driven rural electrification, incentives are offered to encourage private investment in the electricity generation sector. Moreover, through grid renovation and the restructuring of the electricity pricing mechanism, electricity tariffs have been lowered, making electricity supply more affordable to farmers (CMWR, 2005).

The share of clean energy investment in total investment is very difficult to calculate in China. The majority of renewable energy is used in rural areas by households and on a small scale and which are not usually in official statistics. After extensive researching, the authors found it almost impossible to obtain a reliable estimate about investments on renewables in 1990. Instead the authors focused on the investment in energy efficiency in total fixed assets investment. Over the report period, the share of energy efficiency investment in total energy investment has declined, from 6.6% in 1990 to 4.6% in 2003.

China became a net oil importer in 1993. Since then, its oil importation has been increasing. In 2004, oil imports contributed to 40% of China's total oil consumption; oil supply and security has become a major concern in China. However, as the share of oil in total energy consumption is low and China is still exporting coal and coke, China's overall reliance on non-renewable energy import was only 6.8% in 2004. Since 1990, China has changed from net energy exporter into a one of the biggest energy importers. In 1990, its energy export accounted for 4.6% of its total energy consumption, by 2004, 6.3% of the country's total energy consumption is imported in 2004. In 2004, China imported over 100 million tons of oil, making it one of the biggest oil importers on the international market.

The burden of energy investment is another indicator that is difficult to calculate. During the 1990s, the Chinese energy-sector was still dominated by State-owned enterprises, and as the decision-maker for economic life, the government made the investment decisions. Thus, it can be said that all the investments by State-owned enterprises are public investment. However, today, the situation has changed substantially. State-owned business only accounts for around one-third of the economy, private sectors,

foreign-funded enterprises, and listed companies are playing an increasingly important role in the energy sector. Moreover, as energy offers large profit margin, in many cases the entry of private sector and foreign investment is blocked by market monopoly and direct government budget support is small. The burden of energy investment has lightened, from 3.9% 1990 to 2.5% in 2003 (CNSB, 1991 and 2004).

Through vigorous and diversified policies and initiatives for energy conservation and technology renovation and upgrade, the energy intensity of the Chinese economy has been rapidly decreasing, from in 0.49 toe/thousand 2000 PPP US$ in 1990 to 0.23 toe/thousand 2000 PPP US$ in 2003 (IEA, 2005b).

Since 1990, the deployment of renewable energy in China has declined and the share of renewable energy in China's total primary energy consumption has dropped from 25.0% in 1990 to 21.2% in 2003 (Zhou et al, 2005). The major reason is that in the course of rapid urbanization, hundreds millions of farmers are entering towns and cities. Consequently, they no longer use firewood and stalk as the main fuel but now use commercial energy.

China's energy sustainability performance is a mixed picture. Among the eight HELIO energy sustainability indicators, four have decreased, indicating higher sustainability. These four are ambient pollution, electricity access, energy productivity, and public sector investment. The improvement is especially significant in terms of energy productivity and ambient pollution control. The energy productivity has more than doubled since 1990, which represents a remarkable achievement. However, although the air quality in the 379 cities monitored has improved, total emissions of both SO2 and particulates went up 51% during the period. It can therefore be said that the overall ambient pollution has not improved, but has actually deteriorated.

At the same time, the other four HELIO Indicators have fallen since 1990, showing less sustainability in the areas of per capita CO2 emissions, dependency on international energy supply, share of renewables in total energy supply, and clean energy investment. The per capita CO2 emissions increased as a result of increases in total energy consumption, however, China's per capita emissions are still lower than the world average. Rapid increase in energy consumption, especially in oil consumption, has turned China from a net energy exporter into one of the major energy importers on earth.

The HELIO Manuel provides 2 ways of calculating Indicator 5 - Vulnerability, one for countries that are net importer of energy and another for those that

are net exporter of energy. In the first case, the aim of indicator five is to check if the country is very dependent from energy imports (units in Joule). The indicator is estimated by the ratio between non-renewable energy imports and non-renewable energy consumption. In case of net exporter of energy, the indicator is estimated by the ratio between energy export and total export (in monetary terms). Such a design cannot fully reflect the changes in vulnerability in countries like China: which changed from a net energy exporter into a net energy importer. In 1990, energy export contributed 8.4% of China's total export revenue; in 2004, non-renewable import accounted for 6.8% of China's non-renewable energy consumption. The indicator values indicate that between 1990 and 2004, China's reliance on international energy trade has declined. This is not true because in today's international energy market, the prices have increased significantly in recent years and the competition among the buyers are much fiercer than that among the exporters. Therefore, the HELIO indicator calculated in the above ways may underestimate the deterioration of China's vulnerability to risks on the international market since 1990. To solve this problem, the indicator has been calculated as the share of non-renewable energy import in total non-renewable energy consumption for both years. The results show that the share of non-renewable energy import in China's total non-renewable energy consumption has increased from 1.4% in 1990 to 12.3% in 2003.

Another factor of note is the shrinking share of renewables in total energy consumption, which is mainly caused by urbanization and the shift from the use of traditional fuels (firewood and stalk) to commercial energy which in most cases consists of coal, LPG, LNG, and natural gas.

The future prospects of China's energy consumption and supply is a hot topic in China and the international community. The Chinese economy will continue its rapid growth in the years to come and as a result, China's energy consumption will dramatically increase. The Chinese government has set the target of quadrupling its GDP while doubling annual energy consumption for the first 20 years of the 21st century. The IEA, in its estimates about future world energy prospects, assumes that the Chinese economy will report an average annual growth rate of 5% over the 2002-2030 period. Its energy demand will grow by an average annual speed of 2.6% (IEA, 2004c).

The continual fast increase in energy demand, the pollution of coal consumption, and the higher reliance on the instable oil market for supply is the anticipated picture of energy use in China. In face of these problems, four policy recommendations are made: more effective incentives and instruments for energy efficiency improvement and conservation, better use of coal mine methane, coal bed methane, as well as gas from oil extraction;

greater support to renewable energy development, and intensified effort on clean coal technologies.

China's Profile

Geographic and Economic Setting

Located in East Asia, on the western shore of the Pacific Ocean, China covers a land territory of approximately 9.6 million km2 and an adjacent sea area of 4.73 million km2 and is the third-largest country in the world, next only to Russia and Canada (CIA, 2005).

Distinct Climate: China's climate is characterized by two distinct types, the continental monsoon climate and the complex climate. The precipitation in China varies markedly between the seasons, with rain falling mostly in summer, and is distributed very unevenly from region to region. Topographically, China slopes from the west to the east, forming three distinct terraces. Mountainous regions, hilly areas and plateaus comprise 66% of the total territory. China has a shortage as well as an uneven distribution of water resources. China's per capita water resources are about one fourth of the world average and per capita energy resources are less than half of the world average (NDRC, 2005).

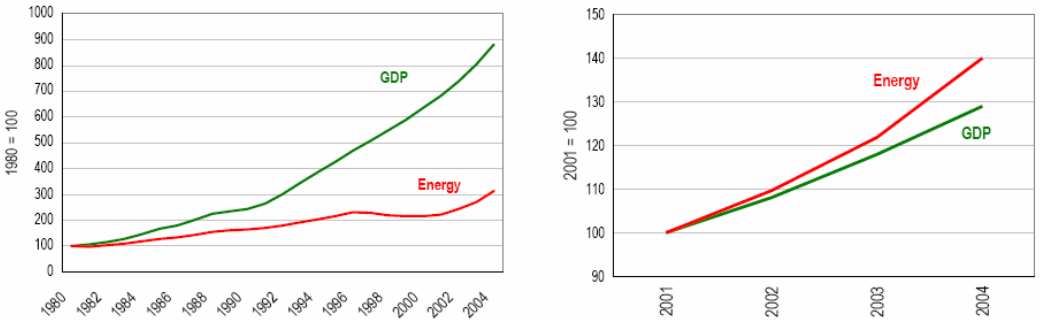
Limited Arable Land: In China, 15.4% of the land is arable land. China's cultivated lands, forests and grasslands are among the world's largest in terms of sheer area (CIA, 2005). But due to the large population, the areas of cultivated land, forest and grassland per capita are small, especially in the case of cultivated land—less than 0.08 ha per capita, or only one third of the world's average. Arid climate and the vegetation destruction caused by human activities lead to desertification. Today, 13.5% of the Chinese land is desert and the desert area continues expanding, at a speed of 2100 km2 per year (CNSB, 2005).

Large Population: China is the most populous country on earth. In 2005, China's total population reached 1.3 billion, accounting for 21% of the world total (World Bank, 2005). Although due to the birth control policies, in the 12 years between 1991 and 2002, China's average annual population growth is only 1.0%, lower than the world average of 1.4%, its total population still increased by from 1143.3 million in 1990 to 1300 million in 2005 (CNSB,2005). According to the Chinese government estimates, the country's population will reach a peak of around 1.47 billion around 2040 before it begins slow declines (CNSB, 2004). The large population, while providing large supply cheap labors and a huge market, also generates enormous unemployment pressure on the Chinese economy.

Rapid Economic Growth: With the foundation of People's Republic of China after the World War II, China realized independence and set up a socialist system. The reform and opening up to outside world starting in late 1970s put the Chinese economy on the track of rapid development. For nearly 30 years the Chinese economy achieved an average annual growth of 8.2%. As a result, the Chinese GDP has more than quadrupled in the last two decades of the 20th century (UNDP, 2005). After entering the new century, the Chinese economy continues high speed growth and it is widely expected that the ambitious target of further quadrupling its GDP by 2020 could be reached (IEA,2004c).

Remarkable Energy Intensity Reduction: In the course of economic development, China has set a good example of energy efficiency improvement. From 1978 to 2004, China maintained an annual GDP growth of 9.4% while its annual energy consumption only grew at an annual speed of 4.8%. From 1990 to 2004, the energy intensity declined 45% (CNSB, 2004). Since 2001, the trend has changed. Due to the rapid growth of such energy intensive sectors as steel, cement, and chemicals, China's energy consumption has been growing faster than the country's GDP and causing wide shortage of electricity and coal and blackouts in over 20 of the country 32 provinces, autonomous regions, and municipalities. However, the latest news is that in 2005, China successfully maintained a 10% GDP growth at no further growth in total primary energy consumption.

Figure 1: China's GDP Growth and Energy Consumption Growth



Source: CNSB (2005)

The large energy demand of Chinese economy can be partly explained by its GDP structure. As indicated in Table 1, compared with other major developing countries, industry contributes a large share of GDP. To generate the same amount of added value, industrial production tends to consume more energy than the service sector and the agricultural sector. A larger share of industrial production means higher overall energy intensity of the economy.

Table 1: Industry As Percent of GDP,2003

Brazil	China	South Korea	Mexico	Middle-income Countries
19%	52%	35%	26%	36%

Source: World Bank, 2005

Large Imports and Exports: China is now the 4th biggest foreign trader on earth. China exported over 593 billion US$ of services and commodities in 2004, accounting for 34.4% of the country's GDP, such a high export dependence rate is rare even among developed countries (Zhang, 2005). China's powerful global competitiveness consists of cheap labor force, raw materials and service and hence low production costs. Not surprisingly, a large share of its exports are energy-intensive and bulk commodity such as machinery and equipment, plastics, optical and medical equipment, iron and steel. The rapid increase in automobile ownership had led to an increase in oil imports. In 1980, China was the biggest oil exporter in East Asia; in 1993, China became a net oil importer and in 2003, its net crude oil import has exceeded 78 billion barrels (CNSB, 2005).

Private economy: Prior to 1978 there was virtually no private enterprise in China. After China's reform and opening up, the private sector has been booming and China is now the biggest destination of foreign direct investment flows. Private sector is now officially recognized as an important component part of China's socialist economy. In 2004, among the total profits realized by industrial enterprises about the scale level1, 36% comes from State-owned and collective-owned enterprises, 34% from listed companies, and 29% from private and foreign-funded enterprises (CNSB, 2005).

Energy Endowment and Structure: China has a coal-dominated energy resource endowment. Coal makes up 96% of the proven fossil fuel reserve. In contrast, petroleum and natural gas together only account for 4%. China's share of the world total coal, hydropower, oil, and natural gas reserves in 1999 are respectively 11.6%, 13.4%, 3.4% and 0.9%(LBNL, 2004). Today, coal accounts of two thirds of China's total primary energy consumption (see Table 2).

[1] In China, the industrial statistics only cover non-state enterprises each with an annual sales revenue of RMB 5 million (around 60,000 US dollars) or more and all state-owned enterprises.

Table 2: Primary Energy Consumption Structure

	China		World	
Year	**1990**	**2003**	**1990**	**2003**
Coal	76.2	67.1	28.6	26.5
Petroleum	16.6	22.7	39.9	37.3
Natural Gas	2.1	2.8	21.8	23.9
Hydropower and Nuclear Power	5.1	7.4	9.7	12.3

Source: CNSB (2004) and IEA (2004b)

In recent years, due to the rapid increase in oil demand, China's oil import has been increasing quickly. The sky rocketing of recent oil price s on the international market and the country's high dependence on oil imports has make energy security, especially oil security, a major concern for China. Moreover, the country's population and economic activities are concentrated in the east coastal areas, while the majority of the country's coal, natural gas, and hydropower resources are located in the west, making it difficult to explore and requesting long distance of transportation or transmission.

Rapid Urbanization: China is under-going a process of rapid urbanization. In 2003, 41.8% of the Chinese population is registered as urban residents, up from 17.4% in 1975. It is estimated that by 2015, about half of the Chinese population will live in urban areas. Each year, around ten million farmers become urban residents. How to create jobs for them has become a major issue in China (CCICED,2005). The large land needs during urbanization are also generating pressure on arable land.

High Income Inequity: Widening income gap among Chinese residents is a serious problem. Generally, rural residents are in a disadvantaged economic position who have on average a per capita income of US$ 355 (RMB2936), less than one third of the US$ 1,139 (RMB 9422) per capita income of urban residents (CNSB, 2005). According to the international poverty line of US$1 per day per person, 10% of the Chinese people are still living in poverty (UNDP, 2005). The Chinese economy is imbalanced in spatial distribution. The coastal east is of economically advanced while large parts of the central and west region are left behind in economic development. Since 2000, the Chinese government has launched a western region development program, offering preferential policies to investment to the western regions, aimed at addressing the imbalances in the regions' economy.

Severe Environmental Pressures and Pollution: High population density, rapid industrialization and urbanization, low levels of technology and lack of waste water and solid waste treatment facilities, as well as ineffective environment law and regulation enforcement have resulted in severe air,

water, and soil pollution in China. In 2004, only 90.7% of the industrial wastewater was treated and met relevant environment standards before being discharged into rivers. 6.4% of the industrial wastewater was directly discharged into sea (CNSB, 2005). The treatment rate of urban municipal wastewater is only 42.12%. Some small and medium-sized cities do not have wastewater treatment facilities. As a result, all seven of China's big rivers have been polluted to some degree. In some parts, the pollution is so serious that the water stinks (SEPA, 2005).

In 2004, China consumed 1379 Mtoe of energy resources, of which 1292 Mtoe is coal (CNSB, 2005). Such a high level of energy consumption and unfavorable energy structure has resulted in severe air pollution, especially in cities. The most important air pollutions are particulates: SO2 and N2O. In 2004, 58.6% of 319 cities monitored are of Class III or worse air quality (SEPA, 2005). In 2004, China emitted 22.55 million tons of SO2 (CNSB, 2005).

China's Energy Policies: In reaction to the severe environmental pressure, the strong and ever-increasing energy demand because of rapid economic growth, the dramatic increase in oil prices, as well as an increasing dependency on oil imports, China is making an effort to optimize its energy structure, control air pollution, and increase energy security. The government has set ambitious plans for energy efficiency improvement and renewable energy development from now till 2020. Top priority is given to energy conservation and efficiency improvement. In the 2020 Energy Conservation Program, the Chinese government has set the target of lowering GDP energy intensity by 43% during the period from 2002 to 2020.

Another priority is boosting the development of renewable energy. China plans to increase the share of renewable energy in total primary energy consumption from the 7% to 15% by 2020 with the share of nuclear power from less than 1% to 4% by 2020. Large hydropower projects are planned. It is recognized that coal will continue to be the most important fuel for China in the upcoming decades therefore the clean use of coal has been identified as the most important issue for China's energy security.

In the recent months, the Chinese state-owned oil and gas companies have made several major attempts through overseas mergers and acquisitions, to acquire overseas oil fields and market share. China is trying to diversify oil import sources through cooperation with major oil and natural gas exporting countries.

The need for clean coal technology makes China ripe for international cooperation in the energy field. In 2005, China entered a partnership with EU

and the US (the Asia Pacific Partnership), some analysis said this is mainly because of the urgent need for technology.

Controlling pollution and improving the safety in energy production are increasingly reiterated. Enterprises are required to pay SO2 emission fees. The retail prices of gasoline increased 4 times in March, May, June, July 2005, respectively. Despite a decrease in May the retail price was still significantly higher than previously. In 2005, the retail price of the most commonly used #93 gasoline climbed from o.41 US$/liter (RMB 3.39/liter) at beginning of the year to 0.52 US$/liter (RMB 4.26/liter) (Sina Corporation, 2006).

The most important social issues for China are:

(1) Poverty, unemployment, and social inequity;
(2) Population;
(3) Education;
(4) Hunger and Nutrition;
(5) Energy security;
(6) Unsustainable use of resources; and,
(7) Environment pollution.

Poverty, unemployment, and social inequity: In 2003, based on the international poverty line of US$1 per day per person, 10% of the Chinese people, or 130 million people, are still living in poverty (UNDP, 2005). The sharp rise in both rural and urban inequality in recent years is a reflection of the recent growth that is largely bypassing the remaining poor. The unemployment rate is 9.8% in urban areas; substantial unemployment and underemployment exists in rural areas. An official Chinese journal estimated overall unemployment (including rural areas) for 2003 was at 20% (EIA, 2005). In the course of rapid urbanization, how to create sufficient jobs for the large and ever-increasing labor force is a critical issue in China.

Population: China is the most populous nation on the earth and continual increase of its large population has been regarded as a constraint to development. To tackle the problem, China introduced, in the 1970s, the family planning policy where each couple was encouraged to have only one child. As a result of this policy, the growth rate of Chinese population has slowed. From 1975 to 2003, China's average annual population growth rate was only 1.2%, lower than both the world average of 1.6% and the developing countries' average of 1.9% annual growth rates over the same period(UNDP, 2005, p.233-235). The total fertility rate (births per woman) has seen a dramatic decline, from 4.9 during the period of 1970-75 to 1.7 during the period 2000-05.

Gender-related inequality is not a serious problem in China. Among 140

countries and areas, China's gender-related development index ranked the 64th is much higher than its Human Development Rank of the 85th (UNDP, 2005). However, although Chinese women have a longer life expectancy than men, they still face some gender inequality in obtaining education and achieving the same income level.

Education: The Chinese government has made education a priority and has identified science and education as a cornerstone for national prosperity. Intensified efforts were made to widen educational reform and implement a nine-year compulsory education. In 1986, the "Compulsory Education Law" was promulgated making it legally binding for parents or guardians to send school age children to school to receive compulsory 9-year primary and junior middle school education. China's official statistics indicate that 2004, the net enrollment rate of primary school age children attained 98.9%, and the proportion of primary school graduates continuing their studies in junior secondary schools (including vocational ones) reached 98.1% (CNSB, 2005).

Hunger and Nutrition: When China introduced secure household land contracts and started investing heavily in rural infrastructure and agricultural research in the late 1970s, agricultural production soared and hunger fell rapidly. Over the next two decades, total grain output increased by 65 percent and the prevalence of hunger was reduced by almost two-thirds. In 2004, 17% of the people in China's mainland is living below the international poverty line of 1$ per capita per day and 10% are undernourished, much lower than the average of around 16% of undernourishment rate in the developing world (UNFAO, 2005). To narrow the income gap and boost the income growth of farmers, in the past 3 years, the Chinese government has dramatically reduced the taxes and charges on farmers and agricultural products.

Energy security: Energy is an important factor in China's development. To realize the country's economic development goals, reliable and sufficient energy supply is indispensable. The recent electricity shortage has led to wide-spread blackouts and production interruption resulting in heavy economic losses. While China is rich in coal, it is scarce in oil and natural gas, which are cleaner fuels. Moreover, oil and gas not be substituted by coal in some aspects (e.g. vehicle fuel). China's dependence on oil import is already 40% in 2004 and it is expected that both the absolute volume and the dependence rate will further increase in the years to come (Zhang, 2005). Given the supply situation in the world and the fact that much of the world's current supply of oil and gas come from politically unstable countries, this is clearly a risk factor for the country's future.

Unsustainable use of resources: Natural resources are used in an unsustainable way in China. Water is typical. China is a relatively water scarce country; its per capita availability of renewable water resources is only about one-fourth of the world average. Furthermore, its water is not distributed in the same way as population. Most of the water is in the south, whereas more than 40% of the population lives in the north. Not only are the natural sources of water scarce in China, but the resource has not been well taken care of. As a result, there is serious pollution in all major river systems, especially in the north.

Environment pollution: Pollution has become a serious problem in China. All the major rivers in the country face some degree of degradation. Of the 30 most air-polluted cities in the world, 20 are in China (Dollar, 2005). The air pollution results from the combination of (a) coal use for power, industry, and home heating and (b) growing motorization. Acid rain has become a serious problem in China, causing huge economic losses and health costs.

China's Indicators

Table 3 lists the scores and ranks of China in major sustainability and environmental performance . As a developing country, China achieves a moderate human development level. Compared with many other developing countries, human poverty is not a severe problem in China. China's overall environment sustainability is very poor. Although its economy is big, due to its large population, its per capita GDP is low. From a per capita perspective, CO2 emission is not high in China.

These figures show that China has a long way to go to become a country of high income, and in the course of its development, improving environmental sustainability will be a big challenge.

Table 3: Indicators of China

Indicator	Value	Rank	Year	Source
Human Development Index	0.755	The 85th among 177 countries in the world	2004	UNDP (2005)
Human Poverty Index	12.3%	The 27th among 103 developing countries and areas	2004	, UNDP (2005)
Environmental Sustainability Index	Score: 38.6	The 133rd Among 146 countries	2004	SEI (2005)
CO2 emissions from fuel combustion	3 759.9 Million tons of CO2	14.9% of world energy-related CO2 emissions, 2nd biggest among 186 countries	2003	IEA (2005)
	2.89 ton CO2/capita	Around 72% of the world average of 3.99 ton CO2/capita		
GDP	US$ billions:1,417.0	7th	2003	UNDP (2005)
	PPP billions US$ 6,445.9	2nd biggest		
GDP per capita	US$ 1,100			
	PPPUS$ 5,003 f			

Overview of National Sustainable Development (SD) Strategy

China's sustainable development strategy, China's Agenda 21, was formulated and released in 1994 (ACCA21, 1994). It sets the framework and objectives of China's pursuit for sustainable development. The overarching objectives are to guarantee the long-term and harmonized development of China's economy, society, resources, and environment. There are four main sections: (1) the overall sustainable development strategy; (2) social sustainable development; (3) economic sustainable development; and (4) rational resource utilization and environment protection. China Agenda 21 also lists the areas for priority action and the identified objectives for each priority areas. It is clearly specified that the Agenda 21 "will function as a guide document for drawing up medium and long-term plans on economic

and social development. Its goals and contents will be embodied in the Ninth Five-Year Plan (1996-2000) and the Plan for 2010".

As the strategy is comprehensive and cross-sectoral, it requires the participation of the whole society and the enforcement and supervision of multiple government agencies. In 2003, the Chinese government formulated the Program of Action for Sustainable Development in China in the Early 21st Century. In compliance with the principles and spirit of sustainable development, China enacted numerous laws on protecting natural resources and the environment.

How actions are assured

The sustainable development actions are assured in the "Five-year Plans" regularly issued by the Chinese government to steer the country's development, legislation, and economic, social, and environment policies. The government established energy efficiency standards and energy conservation targets for key enterprises, major energy-intensive products, as well as industrial processes and buildings. These standards are regularly updated to request continual improvement in energy efficiency.

The Administration Centre of China Agenda 21 established under the Ministry of Science and Technology, is only responsible for coordinating capacity building, local sustainable development zone construction, technology promotion, and information sharing. The implementation of sustainable development strategies and objectives is secured by legislation and supervision by the National People's Congress.

Energy policies have always been an important component of China's sustainable development strategies and actions because of its role in economic development and as the main cause of air pollution and acid rain. Beginning in the late 1980s, the Chinese government started paying more attention to promoting resource utilization efficiency and economic structure optimization. A key component of China's industrial policies is to reduce consumption of energy and other resources, improve the comprehensive utilization and efficient use of resources and energy, promote cleaner production and prevent and control industrial pollution. The State Council and its relevant departments respectively promulgated the Decision on the Focus of the Present Industrial Policy, the Outline Program of State Industrial Policy in the 90s and the List of Industries, Products and Technologies Currently Encouraged by the State.

Since the 1990s, the government has closed down a large number of enterprises that used out-dated technologies or had high consumption of energy and materials or caused serious pollution. It has drafted and

implemented a series of incentive policies in terms of finance, credit and taxation toward energy conservation projects, including interest payment rebates, differential interest rates, revoking of import taxes, the reduction of income tax of enterprises and accelerated depreciation. These measures have been applied to energy conservation technical upgrade projects and purchases of energy conservation equipment. Other tax reductions or exemptions have been applied for projects in the areas of comprehensive utilization of resources, power generation from municipal wastes, wind power generation and renewable energy in rural areas.

Strengths and weaknesses

The strengths of China's sustainable development strategies are clear vision, definite targets, and extensive coverage.

With a strong planning economy background, the Chinese government has the tradition of specifying social, economic, and environment development targets in the long-term and medium development plans, the Five-year development plans, and the annual government work plans. For instance, in the China's 2020 Energy Conservation Plan, the government even specifies the energy efficiency improvement targets of some energy intensive products by 2010 and 2020. Similarly, the China 2020 Renewable Energy Development Plan also stipulated that the share of renewables in China's total primary energy consumption should reach 10% by 2010 and 15% by 2020. Such clear targets make it easier to assess implementation results and find the areas for further improvement and more efforts and provide valuable signals to the investment decision-making of enterprises.

The wide coverage of the strategy is reflected in how it addresses the same issue but from different aspects. It not only sets specific objectives, but also assures the realization of the objectives with legal requirements, policy incentives, financing arrangements, as well as capacity building. The major electricity generation corporations are required to ensure that at least 5% of their generating capacity increase comes from renewable sources. Investment in renewable energy is also encouraged in the form of requesting the grid operators to purchase all electricity from renewable sources with a preferential process. And the extra cost is shared by all users of electricity from a grid.

The weakness of the strategy lies in the fact that GDP growth has been overstressed and overshadows the needs for environment protection and rational resource use, leading to poor enforcement of laws and regulations. In the pursuit for local economic growth and more fiscal income, local governments tend to impede environmental law enforcement, protect local enterprises, and neglect the environment and sustainable development

requirements and considerations (PRC, 2004).

Other Energy-Related Developments

Since the second half of 2002, China overcame the impact of the Asian financial crisis and the Chinese economy entered a period of sustained rapid development. The energy sector emerged from a state of oversupply (that had started in 1997) and in some provinces, electricity blackouts occurred. From 2001 to 2004, China's GDP grew by 30%, while its total primary energy consumption increased by 46%, far exceeding the government expectations and causing a wide energy shortage, especially electricity shortage. By the end of August 2005, electricity growth continued a 40-month double-digit growth on year-on-year basis. Among the coal produced, around 980 million tons of coal was used for electricity generation, which in turn resulted in a shortage of railway freight transport capacity. In 2004, daily total train freight transport volume was approximately 100,000 train wagons, of which half is utilized for coal transportation (Zhang, 2005).

China is the 5th biggest crude oil producer in the world. In 2004, China reported a net import of 117 million tons of crude oil, accounting for 6.31% of the world crude oil trade and representing an import dependence rate of 40% (Zhang, 2005). China's domestic petroleum production is near estimated maximum production capacity of 200 million tons per year (EIA, 2005). However, with the rapid development of the Chinese economy, especially the rapid increase of automobile possession, it is widely predicted that China's petroleum demand will further increase and most of the additional increase in petroleum supply will have to be imported. Some experts estimate that by 2010, China's dependence on petroleum import will reach 50% (IEA, 2004). The recent rocketing of oil prices on the international market has made energy security, especially oil security, a major concern in China.

Legislations and government plans

To tackle the economy's hunger for energy resources, China has resorted to developing legislation, government plans, and policies. In June 2004, the State Council passed the Outlines for 2020 Energy Development Plan (draft) (2004-2020), which gives top priority to energy conservation. In November 2004, the State Development and Reform Commission released the 2020 Energy Conservation Plan (2004-2020).

(1) Energy Conservation Law, 2020 Energy Conservation Plan
(2) Renewable Energy Laws, 2020 Renewable Energy Development Plan
In Feb. 2005, the National People's Congress passed the Law of Renewable Energy Development Promotion, which formally took effect on 1st January

2006. Moreover, the State Council is now review the draft of Medium and Long-term Renewable Energy Development Plan (2004-2020), while is expected to be issued in the near future. The detailed rules about the implementation of the Renewable Energy Promotion Law are also under preparation.

Partnership with developed countries for technology

China's rapid increase of fossil fuel use and CO2 emissions has aroused concerns of the international community, especially regarding future international efforts for curbing greenhouse gas emission mitigation and climate change control. Negotiations on the international climate regime started in November 2005 and the international community is still divided about future actions.

The Asia-Pacific Partnership

In July 2005, six nations - the US, Australia, India, China, South Korea, and Japan formed the new "Asia Pacific Partnership for Clean Development and Climate (APP-CDC)". The 'vision' of this pact is to develop and implement new technologies that will allow the economies of these nations to grow, while mitigating the environmental degradation that has always accompanied such rapid economic growth. Central to this economic strategy is a suite of new technologies that will allow the exploitation of coal with relatively low emissions of pollutants, including greenhouse gases such as carbon dioxide (CO2)2.

Partnership with the EU

In September 2005, a similar technology cooperation partnership was formed between China and the EU. During the 8th China-EU Summit held in Beijing on 5 September 2005, a Joint Declaration on Climate Change between China and the EU was issued, which confirmed the recognized a China-EU partnership on climate change. The two sides were determined to tackle the serious challenges of climate change through practical and results-oriented cooperation. This partnership will strengthen cooperation and dialogue on climate change including clean energy, and will promote sustainable development. It will include cooperation on the development, deployment and transfer of low carbon technology, including advanced near-zero-emissions coal technology through carbon capture and storage3.

The traditional use of biomass and urbanization

China's official energy statistics do not cover the traditional use of biomass,

[2] US Department of State, Vision Statement of Australia, China, India, Japan, the Republic of Korea, and the U.S. for a New Asia-Pacific Partnership on Clean Development and Climate, July 28, 2005, http://www.state.gov/g/oes/rls/fs/50335.htm

[3] EU External Relations, EU-China Summit, Joint Statement, 5 Sept., 2005, http://europa.eu.int/comm/external_relations/china/summit_0905/

e.g. the direct combustion of firewood and stalk for cooking and heating by rural residents, which still contributes around 20% of the energy consumed in China (Zhou etc, 2005). At the current urbanization rates each year around 10 million farmers become urban residents. Their use of commercial energy is a major contributor to increased energy consumption in the household sector.

Recent developments in the energy sector

The recent electricity shortage has triggered a new surge of investments in power stations. China's total installed capacity of electricity generation for the first time reached 100 GW in 1987, by 2004, the figure has reached 440 GW, making China the biggest market for turbines. In 2004, China's newly added installed capacity was 50 GW, and it is estimated that in 2005, the increase is between 60 and 70 GW. Due to electricity shortage, in the coastal areas, especially the Yangtze Delta and the Pearl Delta, some diesel-firing power plants are being built and along the large rivers, some medium and large hydropower stations are also under construction. But the majority of the installed capacity will come from coal-fired power plants.

China's oil sector includes 3 major companies: in 1998, the Chinese government reorganized most state owned oil and gas assets into two vertically, integrated firms -- the China National Petroleum Corporation (CNPC) and the China Petrochemical Corporation (Sinopec). This reorganization created two regionally focused firms -- CNPC in the north and west -- and Sinopec in the south, though CNPC is still focused on crude oil production and Sinopec toward refining. The China National Offshore Oil Corporation (CNOOC) was established in 1982 to explore China's offshore petroleum resources. CNOOC has four regional subsidiaries (Bohai, East China Sea, Nanhai East, and Nanhai West) and several specialized subsidiaries and account for over 10% of China's domestic crude oil production. The three largest Chinese oil and gas firms - Sinopec, CNPC, and CNOOC - all successfully carried out initial public offerings (IPOs) of stock between 2000 and 2002, bringing in billions of dollars in foreign capital.

With China's expectation of growing future dependence on oil imports, the country has been acquiring interests in exploration and production abroad. CNPC has acquired oil concessions in Azerbaijan, Canada, Kazakhstan, Venezuela, Sudan, Indonesia, Iraq, and Iran. The most significant deal thus far is CNPC's acquisition of a 60 percent stake in the Kazakh oil firm Aktobemunaigaz, which came with a pledge to invest significantly in the company's future development over the next twenty years.

According to its WTO commitments, China will open up its finished oil product market in 2006. To prepare for the competition from foreign companies, the

Chinese government is opening up the sector to domestic private companies.

Coal makes up 65% of China's primary energy consumption; China is both the largest consumer and producer of coal in the world. China's coal consumption in 2003 was 1.53 billion short tons, or 28% of the world total (EIA, 2005). The Chinese government has made major upward revisions to coal production and consumption figures covering the last several years. The new figures show coal consumption rising sharply in 2001-2005, reversing the decline seen from 1997 to 2000.

Coalmine safety is a serious problem in China. Many of the small private coalmines lack the property measures and the result is serious casualties. In 2004, China produced 1.956 billion tons of raw coal at the price of over 100,000 deaths, representing a rate of around 50 lives for per 1 million tons of coal production. To improve coalmine safety and harness coalmine methane, the Chinese government has identified the capture and energy utilization of coalmine and coal bed methane as a priority area for the development of Clean Development Mechanism projects in the country.

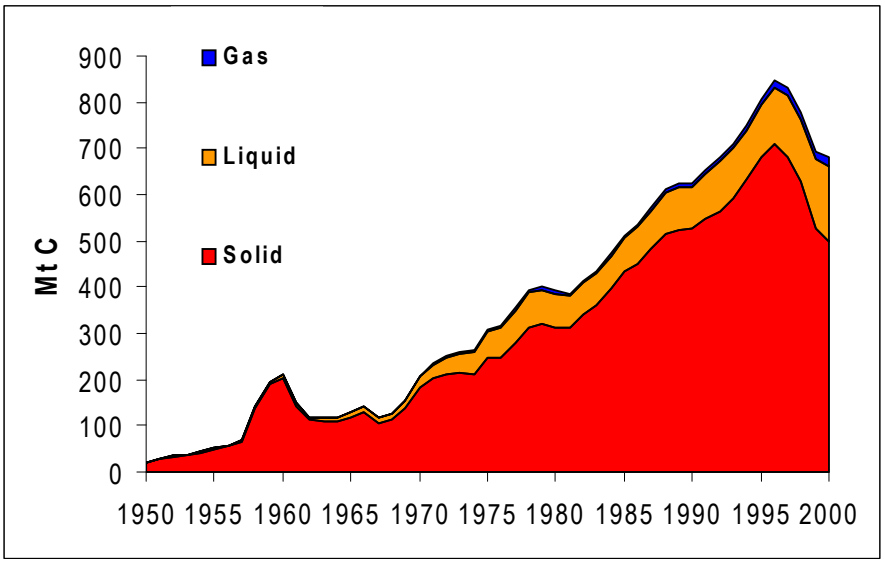
Environmental Sustainability

Indicator 1: Per Capita Energy Sector Emissions

China contributes 14.9% of the world total energy-related CO2 emissions in 2003 and ranks the 2nd after the United States (IEA, 2005(b)). During the period 1990-2003, China's annual energy-related CO2 emissions increased 64.9%; the increase in absolute term, 1463.4 million tons of CO2, was by far the biggest increase among all countries during the same period.

As indicated in Figure 2, China's energy-related CO2 emissions mainly come from coal and oil combustion. With time passes, the large energy demand driven by economic growth and higher living standard has led to increased fossil fuel consumption which has caused more CO2 emissions. China has made remarkable progress in de-coupling of CO2 emissions from economic growth. During the period 1990 to 2003, China's GDP growth was 236%, much faster than its energy-related CO2 emission growth. As a result, its CO2 per GDP ratio was halved. By comparison, the overall ration of CO2 per GDP in the Annex II countries decreased by only 15% during the period.

Figure 2: China's Energy Related CO2 Emissions



Source: LBNL (2004)

China intends to support the quadrupling growth of its GDP by doubling its energy consumption. This means that by 2020, China's total energy consumption will reach 1960 Mtoe (CNSB, 2005). According China's Medium and Long-term Renewable Development Plan (2020), renewable energy will account for 15% of China's total primary energy consumption, and nuclear power shall account for 4% of China's total installed capacity for electricity generation. If China realizes its ambitious goals of energy efficiency improvement and renewable energy promotion, more than 80% of its total primary energy consumption will still come from fossil fuel, inevitably leading to major increases in CO2 emissions. The IEA estimates are that by 2030, China will surpass the United States and become the biggest CO2 emitter on earth (IEA, 2004).

China is a developing country, and its per capita energy use in 2004 was still only 1.08 ton of oil equivalent per year, about two-thirds the world average of 1.63 toe and 13.4% of the level in the United States (Zhang, 2005) (see Table 4). In rural areas, many families still rely on firewood and agricultural waste as the main fuel for cooking and heating. Moreover, the household appliance and automobile ownership is much lower than in developed countries.

Table 4: Per Capita Energy Consumption in China, Selected Countries, and World in 2003, toe

World	EIT	OECD	Brazil	China	USA	Japan	India
1.71	3.48	4.67	1.10	1.09	7.84	4.05	0.52

Source: IEA (2005b)

Therefore, despite the fact that China's CO2 emission ranks the 2nd largest on earth, the per capita CO2 emission in China is still lower than the world average and is only one-sixth the level of the United States (see Table 5).

Table 5: Per Capita CO2 Emissions in 2003, tones

China	Japan	EU-15	USA	World
2.89	9.41	8.67	19.68	3.99

Source: IEA (2005b)

The high CO2 emissions and lower than world average per capita emission of China help to explain one of the major disputes on future international climate regime: as a pre-condition to US involvement in emission mitigation commitments, the United States inisists that China and other major developing countries must also undertake some emission reduction obligations. However, China emphasizes its low per capita emission, and maintains that it is still a developing country with poverty reduction and economic development as top priorities and refuses to make binding emission reduction commitments in the near future

Table 6: HELIO Indicator Result

Description		Data Points		Parameters		Z	Results	
Indicator	Unit	X (2003)	X (1990)	W (reference)	Y (goal)		I (current)	I (1990)
1) CO2 emissions	kgC/cap	736	600	1130	339	791	0.502	0.330

Indicator 2: Most Significant Energy-Related Local Pollutants

In addition to emitting CO2 and causing global warming, fossil energy combustion also emits SO2, NO2, and particulate emissions and causes local air pollution and acid rain. Compared with other petroleum products and natural gas, coal is a dirty fuel. To generate the same quantity of energy, coal causes more CO2, SO2, and particulates emissions. The increase in burning of coal has lead to severe local air pollution and acid rain, especially in the north during winter when the lots of coal is burned in small low-efficient boilers and stoves to supply heat.

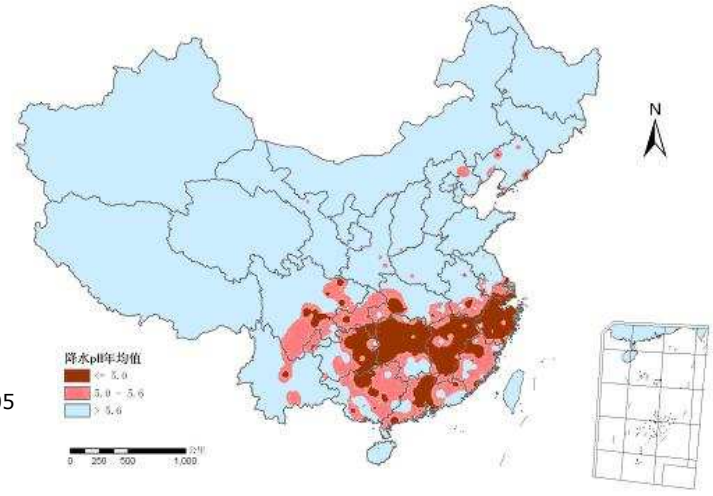
Figure 3: Air Pollution in Beijing

In many Chinese cities, air pollution exceeds the WHO standards and among the 30 cities of the worst air pollution on earth, 20 are in China.

Air pollution in Chinese cities was very severe during early 1990s. In 1990, the annual average daily level of total suspended particulates in Chinese cities was 287 mg/m3, with levels as high as 475mg/m3 among northern cities and 268 mg/m3 in southern cities. Acid rain was also a problem.

The SO2 emissions are serious. Large SO2 emissions bring about acid rains and cause huge impacts on people's health and ecological systems. As shown in Figure 4, acid rain is extremely severe in the southern and eastern part of the country, regions characterized by high population density, economic activity concentration, and advanced economy.

Figure 4: Acid Rain Distribution in China-2004



Source: SEPA, 2005

Serious air pollution has also resulted in the following:

- 40% of China's land receives rainfall with a pH value below 5.6 – the international definition of acid rain. Acid rain also affects neighbouring countries.
- According to a 1998 report of the World Health Organisation, seven of the ten most air polluted cities in the world are in China (Taiyuan, Beijing, Urumqi, Lanzhou, Congqing, Jinan and Shijiazhuang); the other three being Milan, Mexico City, and Teheran.
- The cost of air and water pollution, in terms of damage to people's health and to the economy, is in the tens of billions of dollars, which represents several percentage points of the country's GDP.
- Hundreds of thousands of people die prematurely because of excessive air and water pollution.

The coal-dominated energy structure is largely to blame. Coal-burning is estimated to be responsible for 85% of SO2, 70% of soot and TSP, 85% of CO2 and 60% of NOx that are released into the atmosphere across the country. Nearly half of coal is burnt directly with minimal or no emission controls by hundreds of thousands of small boilers. Moreover, as coal is the main fuel for heating in urban areas, air pollution tends to be more serious in cities in northern China where it is cold in winter. For the same reason, air pollution is more severe in winter and spring than in summer and autumn (IEA, 2002).

Therefore, China has taken numerous measures to control and reduce its impacts, including multiple legislations in the last few years, collecting emission charges on the polluters, requesting the coal-fired power plants to be equipped with desulphuration devices, and efforts for the establishment of a SO2 emission trading market.

The Environmental Impact Assessment Law which entered into force in 2003 stipulates that all engineering construction products must conduct environmental impact assessments the results of which are a factor in the government's approval of the project. In the last few years, the following laws have been passed and have taken effect:

- The Law of Clean Production Promotion took effect in January 2003;
- The Law of Ambient Air Pollution Control was updated in 1995 and again in 2001;
- The Energy Conservation Law took effect in Jan. 1998;
- The Coal Law entered into force in Dec. 1996;
- The Desertification Prevention and Control Law-Jan. 2002; and,
- The Ordinance on the Environment Protection of Engineering Construction Projects, passed by the State Council in Nov. 1998.

In 2002, China initiated the total SO2 emission licensing and trading system in 7 demonstration provinces and cities, e.g. Shandong, Shanxi, Jiangsu, Henan, Shanghai, Tianjin, and Liuzhou.

Fees for SO2 emission have been imposed since March 1, 2000 at 0.20 RMB/kg (2.5 US cents/kg) (IEA, 2002).

Coal-fired power plants and large industrial enterprises are required to install desulphurizing and dedusting facilities. In 1995, for the first time, China included acid rain pollution control in the Law of Air Pollution Control. In 1998, the State Council approved the plans of establishing acid rain and SO2 pollution controlling zones and the targets of pollution control. In the National Economic and Social Development Plan for the 2001-2005 period, it is required that: "by 2005, the total emissions of major pollutants should be further reduced and the national SO2 emission shall mitigate by 10% from the level in 200; in areas of SO2 and acid rain pollution control, the total emissions of SO2 shall be cut off by 20% from the 2000 level."

Although data reported by the State Environmental Protection Administration indicates, that among the over 300 cities where SO2 and total suspended particulates and other air pollution are monitored, air pollution has improved since 1990. This is in contradiction with the reality that during the same period, China's total emission of both SO2 and particulates saw a major increase. As indicated in Table 7, from 1990 to 2004 both the total SO2 emissions and particulate emissions in China increased by 51%. Therefore, the level of SO2 and particulate pollution in the cities monitored may not represent the air quality of all the nearly 700 Chinese cities and the numerous towns where air quality is not monitored. To improve the air quality of large cities, local governments are moving industrial enterprises with severe pollution from downtown areas out to the outskirts and neighbouring counties.

Table 7: Total SO2 and Particulates Emissions from China

Total SO2 Emissions (Mt)		**Total Suspended Particulate Emissions (Mt)**	
1990	2004	1990	2004
14.95	22.55	13.24	19.998

Source: CNSB (2005) and LBNL (2004)

Table 8: Sulfur Dioxide and Particulate Pollution in Major Chinese Cities, µg/m3

Year	1990	2004
SO2	115	49
Total suspended particulates	387	275

Source: SEPA (2005)

Table 9: HELIO Indicator Result

Description		Data Points		Parameters		Z	Results	
Indicator	Unit	X (current)	X (1990)	W (reference)	Y (goal)		I (current)	I (1990)
2a) Particulates	µgr/m3	275	387	50	10	40	6.625	9.425
2b) SO2	µgr/m3	49	115	60	12	48	0.771	2.146
							3.698	5.785

Social Sustainability

Indicator 3: Households with Access to Electricity

Access to electricity and other modern energy sources are necessary to escape from poverty. Electricity provides the best and most efficient form of lighting; household appliances require it. Electric light extends the day by providing extra hours for reading and work, and as a result helps to improve education levels and productivity.

China's rural electrification program has been very successful. China secured electricity access for almost 700 million people in two decades, enabling it to achieve an electrification rate of more than 98% in 2002. From 1985 to 2000, electricity generation in China increased by nearly 1,000 TWh, 84% of it coal-fired, most of the rest hydroelectric (EIA, 2005).

The electrification goal was part of China's poverty alleviation campaign in the mid-1980s. China carried out preliminary electrification county construction on the basis of small hydropower supply: 109 rural hydropower preliminary electrification counties were built during 1986-1990; another 208 such counties were built during 1990-1995; 300 counties were further built during 1996-2000. This work was also known as the rural hydropower 123 poverty alleviation program. In the electrified counties, electricity supply is made available to more than 90% of the local households. The Ministry of

Water Resources and the local water resource agencies plans to build 400 hydropower electrification counties during the 2000 to 2005 period. Each year the state offers RMB 400 million of subsidies. Due to these efforts, the coverage of electricity supply has significantly increased.

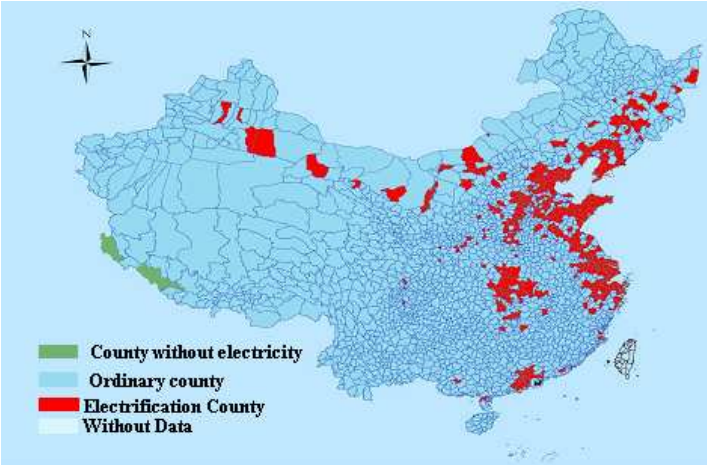
The price of electricity supply to farmers was effectively lowered through three major measures: 1) reforming the rural electricity administration regime to improve the efficiency of electricity management and operation in rural areas; 2) renovating rural electricity grid to reduce wire losses; and 3) linking the urban and rural electricity prices to the same grid so as to more to distribute the burden of grid-wide wire losses. As a result of grid renovation, the wire loss of Chinese grids is only around 7% in 2001 (World Bank, 2004), one of the lowest among developing countries. In this way, the costs of electricity supply and level of electricity charges was dramatically lowered, making electricity affordable to rural residents.

The central government boosts rural hydropower development mainly by exerting administrative power, offering subsidies and low-interest lows, providing preferential taxation policies (the value-added tax is much lower for rural electricity projects), as well as deregulating the rural electricity market and encouraging private investment.

Local governments also actively participate in rural electrification because they want to promote local economy development. The provincial governments standardize the regulatory system and offer some direct subsidies; many county governments: carry out county-wide rural electrification construction; while township governments raise fund for electrification and facilitate project construction and operation.

With the strong support of government at various levels, preferential policies as well as increasing rural electricity demand among farmers (due to income increases and booming township enterprises), China’s electrification program has made a great success.

Figure 5: China Electrification County Map



Source: China Electricity Yearbook

As indicated in Figure 5, in 2005, only 12.9 million people are without access to electricity yet and in terms of counties, only 3 out of the 2862 Chinese counties are not electrified (Ministry of Water Resources, 2005). Those counties without an electricity supply are in Tibet near the border, where the population density is low, is scattered among high mountains, and is largely composed of herdsmen who migrate regularly.

Table 10: Percentage of Chinese Families with Electricity Access

1993	2003
89.6%	98.44%

Source: Chinese Ministry of Water Resources, 2004

Table 11: HELIO Indicator Result

Description		Data Points		Parameters		Z	Results	
Indicator	Unit	X (2003)	X (1993)	W (reference)	Y (goal)		I (2003)	I (1993)
3) Access to electricity	%	98.0	89.6	-	100	-100	0.020	0.104

Indicator 4: Clean Energy Investment

Several studies show that investment in clean energy —renewable energy and energy efficiency— create more jobs and generates faster growth than comparable investment in conventional energy. For this social indicator new employment in clean energy projects are measured, e.g. employment in cleaning up conventional energy projects through the installation of pollution control equipment or the reclamation of mined areas or wetlands restoration etc.

In the HELIO Reports, clean energy investment is used as a measurement of energy sustainability from social aspects (HELIO, 2005). Rough estimate indicate that currently the Chinese renewable industry creates over 1 million jobs in China and tens of billion RMB of economic output (Zhou etc, 2005).

As in other developing countries, the lack of reliable data is a major problem for calculating this indicator. China has been transitioning rapidly from a centrally planned economy to a market economy. And in the process the energy industry's organizational structure and governing agencies have also been undergoing multiple changes.

Moreover, the Chinese statistics tend to focus on large economic entities (industrial enterprises with registered capita above RMB 5 million (around 62,000 US$)) and cities, while data on the private sector and the economic activities in rural areas are much lower.

In the Chinese Energy Statistics Yearbooks, there are data on fixed assets investment in energy sector, which include capital investment and update and renovation investment. Both capital investment and update and renovation investment contain some energy conservation investment, but the share and amount of energy efficiency investment is not clearly indicated (see Table 12).

Table 12: Annual Update and Renovation Investment in the Energy Sector of China, Expressed in RMB and in US Dollars

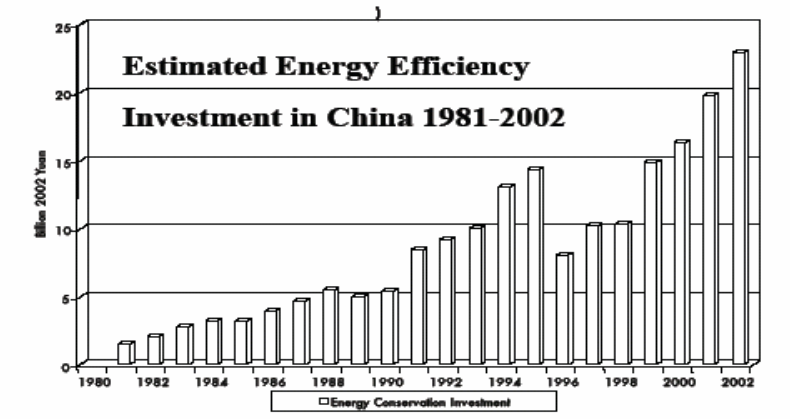
Year		**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Amount	RMB billion)	2.78	3.35	4.14	4.96	7.99	9.29	8.07
	US$ billion4	0.34	0.41	0.50	0.60	0.97	1.12	0.98
Year		**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	
Amount	RMB billion)	10.22	10.31	14.88	16.36	19.81	22.93	
	US$ billion	1.24	1.25	1.80	1.98	2.40	2.77	

Source: CNSB, 2003

[4] Exchange rate: 1US$ = 8.27 RMB

Some foreign researchers have done estimates about the size of energy efficiency investment in China. A study by LIN Jiang from Lawrence Berkeley National Lab notes that in China, energy efficiency investment fell during the period 1996-1998. Since then, it has been climbing quickly. Generally, over the last two decades, the amount of energy efficiency investment has dramatically increased (See Figure 6).

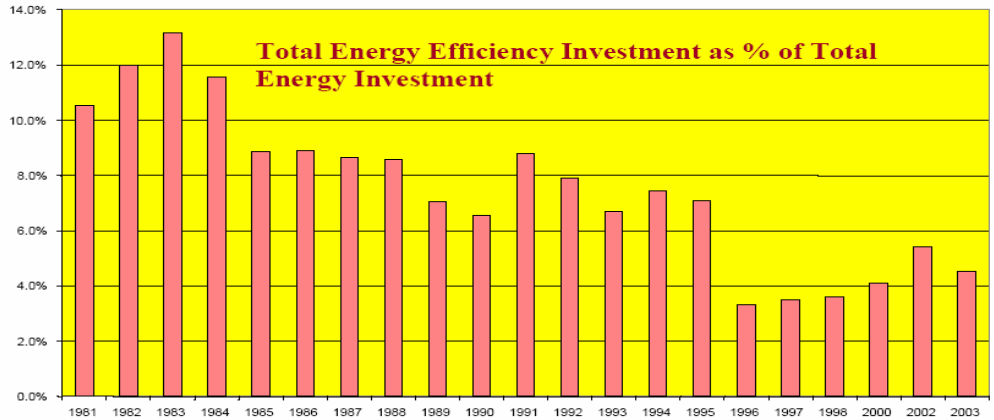
Figure 6: Estimated Energy Efficiency Investment in China



Source: LIN (2005)

Research by David Moskovitz of the Regulatory Assistance Project of US Raponline shows that energy efficiency investment failed to keep pace with the growth of total energy investment. As a result, the share of energy efficiency investment has shrunk in total energy investment (Moskovitz, 2005) (see Figure 7).

Figure 7: Share of Energy Efficiency Investment in Total Energy Investment - China



Source: Moskovitz, (2005)

In the Annual Statistics and Energy Yearbooks published by the government, the traditional use of biomass, e.g. the combustion of firewood and stalk for cooking and heating, as well as biogas, wind power, solar thermal heater, and PVs are not mentioned despite the fact that together they provide over 20% of the total primary energy consumed in China. Although some official reports give data on the application of these renewables, they are in physical terms, and there is no data about the associated investments.

The total installed capacity of wind power grew 82 MW to 567 MW in 2003 (Zhou et al, 2005). The use of photovoltaic panels grew from 20 MWp in 2001 to 50MWp in 2003 (Zhou et al, 2005). By the end of 2003, there were over 13 million household biogas tanks in China, with an annual biogas output of 4.63 billion m3 and more than 2500 large and medium-sized biogas facilities, with a biogas output of 1.2 billion m3 per year. The annual sales revenue of solar thermal heaters was 11.0 billion RMB (1.36 billion US$), of which only 10 million US$ came from exports. By the end of 2003, the installed capacity of small hydro had reached 3.1 GW, with over RMB 100 billion (12.3 billion US$) worth of net assets (Zhou et al, 2005).

As data are lacking on renewable energy investment and the two components of clean energy investment, i.e. energy efficiency investment and renewable energy investment, are generally influenced by similar factors and show similar development tendencies, the share of energy efficiency investment in total energy investment is given as the indicator of clean energy investment.

Table 13: Clean Energy Investment as a Percentage of Total Investment in the Energy Sector

1990	2003
6.6%	4.6%

Source: Moskovitz, 2005

Table 14: HELIO Indicator Result

Description		Data Points		Parameters		Z	Results	
Indicator	Unit	X (2003)	X (1990)	W (reference)	Y (goal)		I (current)	I (1990)
4)Investment	%	4.6	6.6	6.6	95	-88.4	1.022	1.0

Economic Sustainability

Indicator 5: Resilience to External Impacts: Energy Trade

Before the early 1970s, China was generally energy self-sufficient. From then and until the early 1990s, China was a net exporter of petroleum. However, this status changed in 1993. For the first time, China became a net oil importer with ever increasing demand for petroleum from the international market. In 2004, China's total energy consumption was 1379 Mtoe, making China the 2nd biggest consumer in the world, only after the United States (see Table 15). China's share of the world total energy consumption is approximately 10.6%. It mainly imports oil from Mid-Eastern countries and Southeast Asian countries, including Iran, Saudi Arabia, Oman, Angola, Vietnam, Indonesia, Yemen, and Equatorial Guinea. The social instability in these regions and the recent sky-rocketing oil prices oil make oil supply security a major concern in China.

Table 15: Energy Supply, Imports and Exports of China in Selected Years, Mtoe (1990-2004Mtoe)

Item	1990	1995	2000	2003	2004[1]
Total Energy Available for Consumption	672.966	906.745	806.05	1196.601	1379
Primary Energy Output	727.454	903.238	748.916	1119.384	1292.2
Recovery of Energy5		16.184	12.32	14.301	
Total Imports	9.17	38.192	100.317	140.336	
Total Exports (-)	41.125	47.432	63.182	88.907	
Coal Imports	140.21	114.45	152.53	7.77	

Source: CNSB, 2005

China is still a net exporter of coal and coke. In 2004, it reported a net export of 80 million tons of coal and coke. China mainly imports coal from Indonesia, Australia, Vietnam, New Zealand, Russia, South Africa, and North Korea. Simultaneously, South Korea, Japan, and Taiwan import coal and coke from China. A net oil importer since 1993, China's petroleum industry is focused on meeting domestic demand. Most Chinese oil production capacity, which is close to 85%, is located onshore. In April 2004, Chinese authorities

[5] Recovery of Energy includes the recovery of gas from furnace blast and waste heat recovery.

announced several new finds in the area of the existing Shengli field located in the northeast. It is expected to extend oil production in the area.

Government priorities focus on stabilizing production in the country's eastern regions at current levels, increasing production in new fields in the west, and developing the infrastructure required to deliver western oil and gas to consumers in the east. The latter remains a major obstacle, given the long Retail distances involved. Offshore oil development also is a high priority.

In China, prices for petroleum products are regulated, with variations based on location and the type of consumer. Recently, there has been substantial pressure to raise domestic prices in the face of high world oil prices. A series of increases in the state-mandated prices, however, has still not been sufficient to keep pace with the world market. This led, in the first half of 2005, to increases in exports of some petroleum products, particularly diesel, as the gap between domestic prices and world prices widened. The eventual goal is to eliminate subsidized prices, but given the dependency of vulnerable segments of the Chinese population on cheap fuels, particularly in agriculture, it will likely take at least several years to accomplish this goal.

Table 16: Gasoline Retail Price in 2004

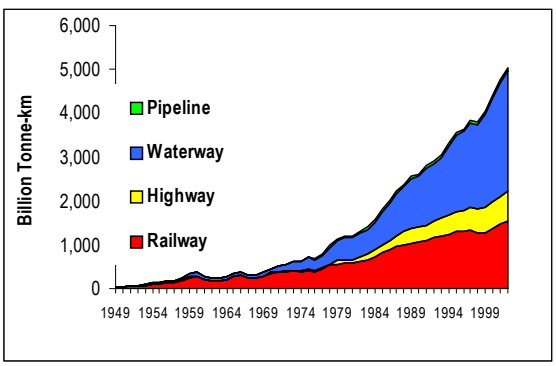
China	US	Japan
0.41	0.50	1.00

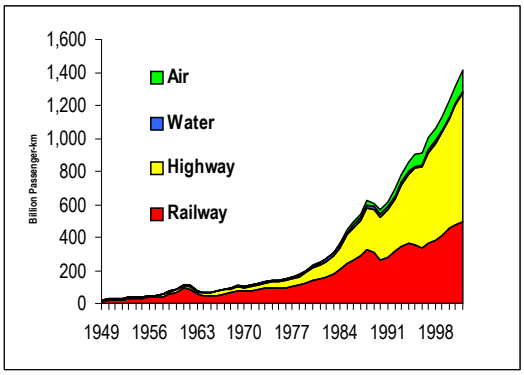
Source: Chinese National Development and Reform Commission, 2005, IEA, 2005

The driving force behind China's oil demand increase is the rapid increase of automobile ownership and the freight and passenger transportation (See Figures 8 and 9). As petroleum's dominant role as the fuel for automobiles will not change in the years to come, the prosperity of the transportation sector means greater oil demand and more imports.

Figure 8: Freight Transport by Mode **Figure 9: Passenger Travel by Mode**

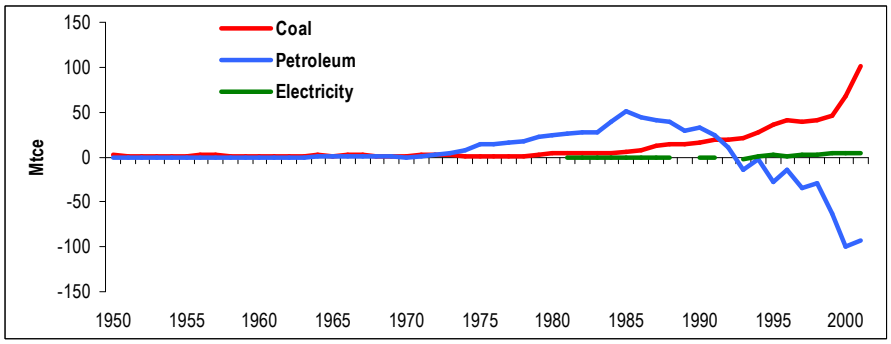
Source: LBNL, 2004





From 1990 to 2004, due to economic and energy structural adjustments, China's dependence on external energy supply, especially oil supply, dramatically increased (see Figure 10). However, the Chinese government has reiterated that China's per capita primary energy consumption is only 1.08 toe, equivalent to 66% of the world average and 13.4% of the level of the United States. Moreover, China's crude oil import only account for 6.31% of the world total crude oil trade, much lower than the 26.9% lion share of the United States and the 11.3% share of Japan.

Figure 10: China's Net Energy Exports



Source: LBNL, (2004)

From 1997 to 2000, China's energy consumption declined and there existed some extent of energy oversupply. But since 2001, the Chinese economy has gained momentum and due to the rapid increase in energy-intensive product demand and production, energy shortages have become a roadblock to China's economic development. From 2003 to 2005, over half of the Chinese provinces experienced some blackouts; coal and oil products were of short of supply and it is expected that the current transition of Chinese economy from labor to capital-intensive industrialization (characterized by large demand for energy) will continue for a long time. As a result, coal and coke export is no longer encouraged by the government; an increasing share of the country's growing demand for oil and more natural gas has to be imported, meaning even greater reliance on international oil import and greater exposure to the risks on international energy market.

As China is a large country with little electricity exchange with other countries, all other renewable energy (except large hydro) is used on local and small scale basis, China has little renewable energy trade with other countries.

The HELIO Manuel provides two ways of calculating Indicator 5, one for countries that are net importer of energy and another for those that are net exporter of energy. In the first case, the aim of indicator 5 is to check if the

country is very dependent on energy imports (units in Joule). The indicator is estimated by the ratio between non-renewable energy imports and non-renewable energy consumption. The second case, the aim of the indicator 5 is to verify if the economy is not dependent on non-renewable energy exports. In this case, the indicator is estimated (in monetary value) by the ratio between non-renewable energy exports and total value of all exports.

As indicated in Table 15, China is a net energy exporter in 1990 and a net energy importer in 2004. If the above approach is followed:

Table 17: China's Energy Import and Export, as well as Total Export (million US$)

Year	Fossil Fuels, Lubricants and Related Materials			Total export
	Import	Export	Net export	
1990	1272	5237	3965	62091
2004	44047.6	13044.9	- 31002.7	593320

Source: CNSB, 2005

Calculated in the above Approach 2, China's reliance on energy trade in 1990 should be:

X= 5237/62091 x100% = 8.4%;

China's dependency on non-renewable energy can be roughly estimated in 2004 in the following way:

- In 2004, China's total primary energy consumption was 1970 Mtce, of which 93% is non-renewable (1832.1Mtce), hydro is 137.8 Mtce.
- In the year China produced 1845 Mtce of primary energy (Zhang, 2005), of which hydro also 137.8 Mtce, which means the country's non-renewable energy production in the year was 1707.1 Mtce.

If we neglect the changes in energy stock, then,
For 2004, X= (1832.1-1707.1)/1832.1x100%=6.8%

It can be seen that the above indicator design does not fully reflect the China's energy transition from an energy exporter to importer.

To solve the problem, the following approaches have been suggested by some international experts: examine the energy resilience degree through using both types of indicators:

(a) indicator based on net import (or net export as the case may be) of

non-renewable energy as percentage of total exports;
(b) indicator based on import of nonrenewable energy as percentage of total exports for both years (1990 and 2004); and,
(c) the ratio of non-renewable energy imports to total non-renewable energy consumption.

Based on data in Table 17, the values of indicator 5 are calculated according to Approach (a) and (b) (as indicated in Table 18).

For Approach (c), in 1990, China's non-renewable energy import was 8.95 Mtoe, and its total non-renewable energy consumption was 639.85 Mtoe, the share of non-renewable energy imports in total non-renewable energy consumption was 1.4% in 1990. Similarly, in 2003, the ratio between non-renewable energy import and total non-renewable energy consumption was 12.3% in 2003(CNSB, 2005).

Table 18: HELIO Indicator Result (a)

Resilience to External Impacts: Energy Trade

Approach (a): net non-renewable energy export/total export		**Approach (b): non-renewable energy import/total exports**		**Approach (c) non-renewable energy imports /total non-renewable energy consumption**	
1990	2004	1990	2004	1990	2003
6.4%	-5.2%	2.0%	7.4%	1.4%	12.3%

The existing HELIO Star does not account for negative values. Moreover China's situation is unique in that it transitioned from an energy exporting country into an energy importing country in a relatively short period of time. To solve this problem, the results of Approach (c) can be used in the HELIO Energy start.

Table 19: HELIO Indicator Result (b)

Vulnerability

Description		**Data Points**		**Parameters**		**Z**	**Results**	
Indicator	Unit	X (2003)	X (1990)	W (reference)	Y (goal)		I (current)	I (1990)
5)Vulnerability	%	12.3	1.4	100	-	100	0.123	0.014

Indicator 6: Burden of Energy Investments

In 2003, the fixed asset investment of the energy sector was RMB 500 billion (US$ 60.46 billion), accounting for approximately 15% of total fixed investment in China during the year (CNSB, 2004).

Energy is a significant pillar industry in China and under the traditional planned economy, investments in the energy industry used to be almost financed with government grants; investment decision-making was highly centralized. The projects were approved by the central government, and the government through complicated procedures managed the project construction. Local governments, especially enterprises were little involved in investment decision-making.

The increasingly important role of the private sector in the Chinese economy is also reflected in public energy investment. As can be seen from Table 20, the share of State-owned investment in the energy industry has declined enormously since 1990. Over this period, although the amount of state-owned investment has increased, compared with total fixed asset investment in the country, the share of state-owned fixed asset investment has been shrinking.

Table 20: China's Total Fixed Asset Investment and State-owned Investment in Energy Industry, 1991-2003, US$ bn

	1991	1995	2000	2001	2002	2003
GDP	261.4	706.3	1080.5	1175.3	1270.2	1417.8
Total fixed asset investment	66.6	242.1	398.0	450.0	526.0	671.9
Fixed asset investment in the energy industry(state-owned)	11.6	24.5	34.3	31.7	31.8	34.8
Share of state-owned investment in energy sector in GDP	4.4%	3.5%	3.2%	2.7%	2.5%	2.5%

Source: CNSB, 2005b, CNSB, 2005a

In Chinese statistics, the energy sector is defined as consisting of 5 sub-sectors: coal mining and processing; petroleum and natural gas extraction; electricity; steam production and supply; petroleum processing and coking; and, gas production and supply.

Since 1991, electricity, steam production and supply is the sub-sector that

has received the lion share of state-owned fixed asset investment in energy industry. Simultaneously the proportion of state-owned investment has increased from less than 43% in 1991 to 75% in 2003. Another sub-sector that has seen an increasing share of state-owned investment is gas production and supply, but its share is still small, only 2.9% in 2003. The increases in the share of state investment is accompanied by shrinking shares in the other 3 sub-sectors, coal mining and processing, petroleum and natural gas extraction, and petroleum processing and coking.

Table 21: The Direction of State-owned Fixed Asset Investment in Energy Industry

	1991	1995	2000	2001	2002	2003
Coal mining and processing	18.5%	13.9%	7.0%	7.6%	8.9%	10.8%
Petroleum and natural gas extraction	28.5%	24.7%	12.9%	14.3%	6.0%	8.2%
Electricity, steam production and supply	42.8%	51.5%	75.0%	71.0%	79.3%	75.0%
Petroleum processing and coking	10.0%	8.0%	3.3%	4.8%	3.5%	3.1%
Gas production and supply		1.9%	2.1%	2.2%	2.3%	2.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: CNSB, 2005b

These changes can be explained by the following developments in the Chinese energy sector. To boost the energy development, the Chinese government has taken a series of measures to attract foreign and domestic investment. As a result of these reform policies and measures, the sources of investment have been increased and the fund channels have been widened. Today, energy investment is active and most energy projects are mainly financed with enterprise investments.

In the coal industry, there coexist major state-owned coal mines, local state-owned coal mines, collectively-owned, as well as private coal mines.

In the electricity sector, the monopoly rate is high and as a result of the 2002 power corporation restructuring, there are now five major power generation groups and two grid corporations. In addition to these giant companies, there also power stations invested and rum by state-owned, collective-owned, and

private Chinese enterprises as well as major international electricity investors, including EDF from France, the US International Electricity Corporation, Enron, and Siemens.

In the early years of wind power development in China, some major wind farms were financed with foreign government loans. As government offer higher grid-connection tariffs from renewable sources, wind power projects have successfully attracted the market entry of some foreign and domestic enterprises. In addition, numerous small hydropower projects are invested in and operated by private enterprises.

During the 1998 government streamlining, the Ministry of Coal and the Ministry of Electricity was dissolved. Now the Energy Bureau under the National Development and Reform Commission is the government agency in charge of energy.

2004 is another milestone in the development of Chinese energy industry. In July, the State Council issued the "Decision about Investment Regime Reform", which established enterprises' role as major players and independence in investment activities under the principle that "whomever makes the investment shall be the decision-maker, the beneficiary, and the risk undertaker of the investment". The Decision was intended to put to an end the practice that all investment projects need permission from the government. Projects invested by enterprises and involving no government investment will no longer need government permission. Such projects, if they are on the Catalog of Investment Projects Subject to Government Authorization, will be authorized from the public administration perspective.

By the end of 2002, the installed capacity of wind power had reached760 MW. A key obstacle in the development of wind power is low wind turbine localization rate. The high costs of imported equipment increased the investment costs and narrowed the profit margin of wind farms. To solve this problem, on 4th July 2005, the National State Council issued a notice and stipulated that for any future wind farm to get permission by the government, they must have an equipment localization rate of no less than 70%; the importers are required to pay tariffs for wind turbine import. This measure is designed to boost the technology transfer to local wind manufacturers and reduce the cost of wind turbines.

It should be noted that in China, government budget is only used as a supplementary instrument for boosting the energy sector's development. As the energy sector is still highly dominated by large state-owned enterprises, even among the corporations that have made initial public offering on the domestic and international stock exchanges, the majority of the shares are

still held by the State. Therefore, for China the energy investment of State-owned enterprises is taken as a substitute of the government's burden of energy investment.

Table 22: Burden of Energy Investment

	1991	2003
State-owned investment in Energy industry/GDP	4.4%	2.5%

Source: CNSB, (2004)

Table 23: HELIO Indicator Result

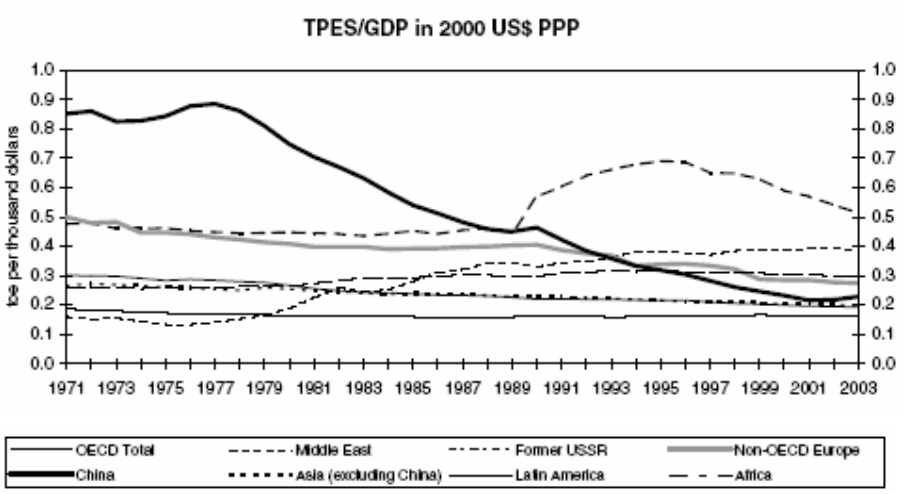
Description		**Data Points**		**Parameters**		**Z**	**Results**	
Indicator	Unit	X (2003)	X 1991)	W (reference)	Y (goal)		I (2003)	I (1991)
6) Public sector investment	%	2.5	4.4	10	-	10	0.25	0.44

Technological Sustainability

Indicator 7: Energy Intensity

For a long time, the Government of China has adhered to the principle of "developing and conserving energy simultaneously, with conservation put in the first place". After the 1980s, the State Council and relevant government departments formulated and implemented a series of energy conservation rules and regulations, set up a three-tier energy conservation management system at the central, local/industrial and enterprise levels and implemented a series of policies on energy-conservation technologies. They launched the national "energy-conservation publicity week", established and applied standards, labeling and certification of energy efficiency and effectively boosted the work on energy conservation and raising energy efficiency. From 1980 to 2000, China's energy intensity went down by an average annual rate of 5.32% (IEA, 2005a).

Figure 11: Energy Intensity Trends of Selected Countries



Source: IEA, 2005

The Government of China has also consistently focused on energy conservation in the energy intensive industries. From 1990 to 2000, the output of iron and steel doubled, yet its total energy consumption increased by only 34%. During the same period, the energy consumption for each RMB10, 000 of production output in the chemical industry declined by an annual rate of 5.15%. The building material industry has also undertaken a series of measures and has lowered the per unit energy consumption of its products.

Since the 1980s, the State Council and its relevant departments successively promulgated and implemented a series of policies and regulations to direct and standardize the energy conservation work of the construction sector, such as the Circular on Opinions on Accelerating Innovation in Wall Materials and Popularizing Energy conservation Buildings, the Policies on Energy-conservation Technologies in Buildings and the Regulations on Management of Energy Conservation in Civil Buildings. The released standards for energy conservation in buildings mainly include the Design Standards for Energy Conservation in Civil buildings (the part of heated residential buildings), the Grading of Insulation of the Outside Windows of Buildings and Its Testing Method, the Design Standards for Lighting in Civil Buildings, the Design Standards for Thermal Engineering in Civil Buildings, the Design Standards for Energy Conservation in Thermal Engineering and Air Ventilation in Tourist Hotel Buildings, the Technical Directive Rules on Energy Conservation Renovation of the Existing Residential Buildings and the Design Standards for Energy Conservation in the Residential Buildings in Areas Unusually Hot in Summer and Cold in Winter.

Starting in 1992, the Ministry of Construction began a pilot program for energy conservation in buildings. By the end of 2000 around 180 million square meters of energy-conservation buildings had been built. During the period of 1996 to 1998, the China Green Lighting Program popularized a total of 267 million high-efficiency lighting products and saved 17.2 billion kWh of electricity.

As a result of technological progress and technology renovation for energy conservation, the average energy consumption major energy-intensive products dramatically lowered and significantly contributed to the decline in GDP energy intensity. However, compared with international advanced levels, China still lags behind.

Table 24: Changes in the Average Energy Consumption of Major Energy-intensive Products in China and Comparison with the International Advanced Level

Energy-intensive products	1990	2000	2002	Int'l Advanced Level
Coal-fired power generation (gce/kWh)	427	392	383	316
Steel production (large and medium-sized enterprises) (kgce/t)	997	766	715	646
Cement production (large and medium-sized enterprises) (kgce/t)	201.1	193.8	172(est.)	127.7
Ammonia (large enterprises with natural gas as feed stock) kgce/t	1343	1273	1215	970

Source: Tsinghua University (2005)

In 2004, China issued the Medium and Long-term Plan for Energy Conservation (2020), which further stipulates that by 2010, China's GDP energy intensity should fall by 14.5% to 2002 levels, with an annual average decrease of 2.2%. By 2020, intensity should fall by 41% based on 2002 levels and have an average annual decrease rate of 3% from 2002 to 2020. The plan, if realized, will reduce the energy consumption in 2020 by 980 Mtoe, equivalent to 111% of the 882 Mtoe of planned energy production increase over the same period (Zhou et al, 2005).

In 1990, the world total primary energy supply was 365,994 PJ (8,741.6 Mtoe), and the world total GDP (billion 2000 US$ using PPPs) 33,014.8 (IEA, 2005 b), the energy intensity was 11.09 MJ per 2000 US$ PPP.

In the HELIO Report Manual, it is indicated that the average work

consumption of primary energy per unit of GDP in 1990 was 10.64 MJ/euros. Therefore, the exchange ratio between MJ/euros and MJ/US$ 2000 PPP should be 0.96.

Table 25: Energy Intensity of the Chinese Economy

MJ per 2000 US$ PPP		MJ per euro	
1990	2003	1990	2003
20.52	9.63	19.70	9.24

Source: IEA (2005b)

Table 26: HELIO Indicator Result

Description		Data Points		Parameters		Z	Results	
Indicator	Unit	X (2003)	X (1990)	W (reference)	Y (goal)		I (current)	I (1990)
7) Energy productivity	MJ/euro	9.24	19.70	10.64	1.06	9.58	0.854	1.946

Indicator 8: Renewable Energy Deployment

With the progress and development and energy science and technology, in China the renewable energy industry has experienced some e development. In 2003, new renewable energy contributed 36.4 Mtoe of energy, equivalent to 2.6% of China's total primary energy consumption, see Table 27.

Table 27: Share of Primary Energy Consumption in China by Fuel Types

Item	1990		2000		2003	
	Mtoe	%	Mtoe	%	Mtoe	%
Coal	526.5	60.2	602.9	56.3%	788.4	56.7
Petroleum	114.7	13.1	224.4	21.0	266.8	19.2
Natural gas	14.5	1.6	22.8	2.1	33.1	2.4
Nuclear power	0	0	4.4	0.4	10.5	0.8
Renewables	219.3	25.0	216.6	20.2	292.7	21
Of which: (1)Large and medium hydro	24.0	2.7	37.2	3.5	60.4	4.3
(2)Traditional use of biomass energy	253.4	21.0	153.4	14.3	195.9	14.1
(3)New renewable energy	11.9	1.4	26.2	2.4	36.4	2.6
Total	875	100.0	1071.1	100.0	1391.5	100.0

Source: Zhou et al.., (2005)

In China, around 60% of the country's 1.3 billion people are still living in rural areas. A large share of the rural families still rely on non-commercial biomass, mainly firewood and agricultural waste as fuel for cooking and heating. According to the Energy Research Institute of China National Development and Reform Commission, biomass used in this way is 195.6 Mtoe per year, accounting for 69% of the renewable energy use in China. It should be noted that in China, the statistics of new renewable energy tends to exclude large and medium-sized hydropower and traditional use of biomass. Instead, new renewables consist of small hydropower, biomass energy, solar energy, geothermic energy, and wind power. With the ongoing rapid urbanization in China, it is estimated that each year, around 20 million farmers become urban residents, which will lead to their shifting from traditional biomass to commercial energy for heating and cooking. The current trends of shrinking traditional use of biomass will decline further.

Unlike other countries, small hydro, in China, is witnessing the fastest growth and is the biggest contribution to economy. By the end of 2003, the installed capacity of small hydropower had reached 31GW, with over 20000 enterprises and nearly 0.52 million employees. Small hydro is now providing electricity supply to 300 million people, around 1/3rd of Chinese countries, and ½ of China's territory (Zhou etc., 2005). The rapid development of small hydro is due to government support and preferential policies. The government has deregulated small hydro investment and operation and offers RMB 150 of subsidy for per kW of installed capacity during the investment. In grid connection, the government secures the grid connection rights of small hydropower. In 1998, the Chinese government initiated the rural electricity system reform and rural grid renovation program and trial unification of rural and urban electricity charges of a same grid. Under the government support, three phases of small-hydro-based rural electrification county countries, which respectively involve 100, 200, and 300 counties, was carried out, further boosting small hydro development.

Table 28: Renewable Energy Exploitation and Utilization in China, 2003

	Utilization	**Mtoe**
Large and medium-sized hydro	236.8TWh	60.41
Traditional use of biomass	195.86 Mtoe	195.86
New Renewables		
Small hydro	31.0 GW, 103.7TWh	26.46
Biomass energy		
Family biogas	1.3 million households, gas output: 4.6 billion m3	0.60
Large and medium-sized biogas	Over 2500 facilities, gas output: 1.2 billion m3	
Straw gasification	525 facilities, gas output:175 million m3	
Electricity generation with bagasse	1700MW, 4000GWh	0.99
Electricity generation with forest and agricultural waste	50MW	0.05
Electricity generation with municipal waste incineration	100MW	0.13
Electricity generation with landfill gas	10MW	0.01
Solar Energy		
Solar-thermal heaters	50 million m2	4.20
Passive solar house	26.60 million m2	0.56
Solar oven	0.478 million m2	0.17
Photovoltaic cell	50 MW, 100 GWh	0.03
Geothermic energy		
Direct utilization	0.49 Mtoe	0.49
Electricity Generation	32MW, 160GWh	0.04
Wind Power		
Grid-connection turbines	567MW, 1535GWh	0.38
Mini-turbines	33MW, 34GWh	0.01
Total		292.81

Source: Zhou etc., (2005)

The sales and supply of solar thermal heaters has seen a 30% annual growth in recent years. In 2005, there were over 1000 enterprises engaged in the research and development, production, sales, and installation of solar thermal heaters and the annual production is estimated at more than 10 million m^2(CREIA, 2005). China is the country with the biggest solar thermal heater production in the world.

Wind power is also reporting rapid growth. By the end of 2003, 40 wind farms had been built in China, with a total installed capacity of 567 MW (Zhou etc., 2005). To stimulate the development of wind power, the Chinese government has implemented the wind power concession program. The grid-connecting tariff offered to wind power is much higher than that to thermal power. To improve the localization of wind turbines, in 2005, the Chinese government made a decision that any new wind power project must make the localization rate of its equipment no less than 70%(NDRC, 2005) if it is to get government approval,

Biogas is widely use among rural households for cooking and heating. In 2003, there were more than 13 million household biogas facilities in use in China. Annual biogas generation is 4.63 billion m^3. On the basis of small biogas facilities for household uses, China has developed large and medium-sized biogas facilities for animal farms; over 2500 such facilities have been built in China. The annual biogas output is 1.2 billion m^3 (Zhou etc., 2005).

In 2004, the Chinese government issued the Law of Renewable Energy Promotion and the Medium and Long-term (2020) Plan for Renewable Energy Development, which stipulates that the share of renewable energy to 10% of China's total primary energy consumption by 2010 and 15% by 2020.

Table 29: Share of Renewables in Total Primary Energy Consumption

1990	2003
25.0%	21.2%

Source: Zhou et al, (2005)

Table 30: HELIO Indicator Result

Description		Data Points		Parameters		Z	Results	
Indicator	Unit	X (current)	X (1990)	W (reference)	Y (goal)		I (current)	I (1990)
8) Renewables	%	21.2	25.0	8.64	95	-86.36	0.855	0.811

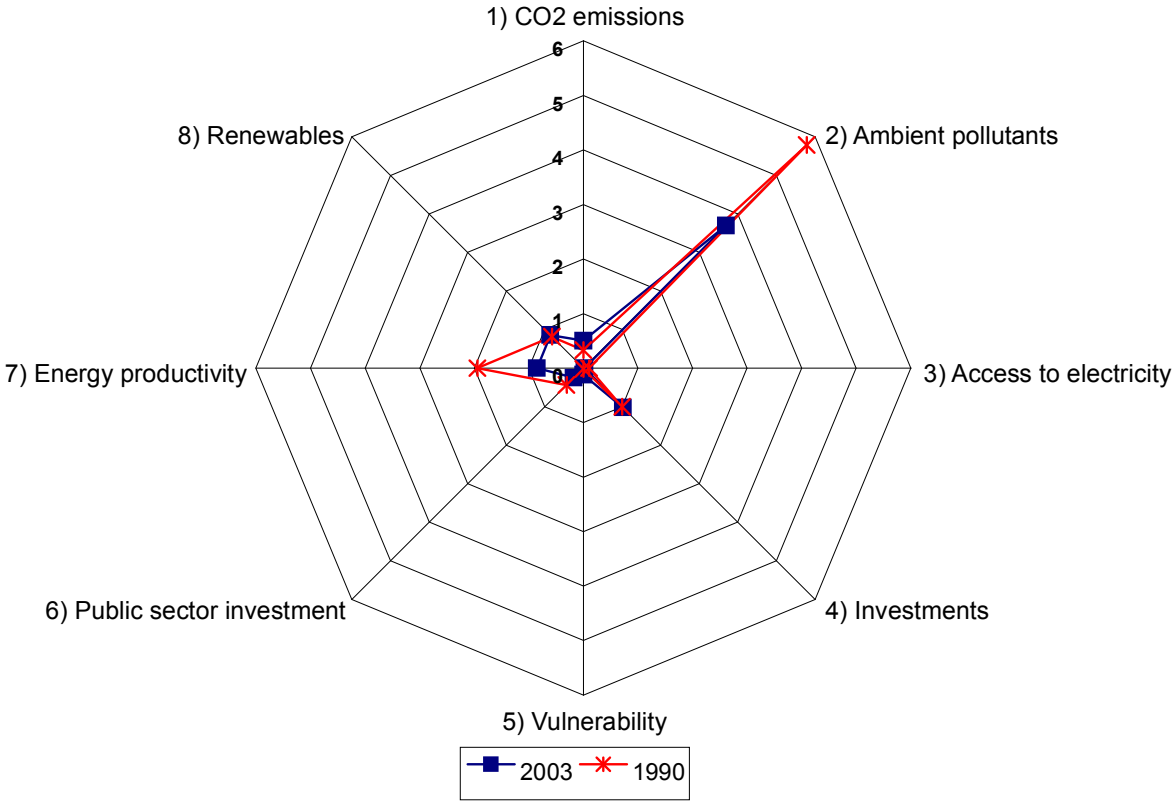
Presentation of Country Star

Table 31: HELIO Indicators-Summary Table

Description		Data Points		Parameters			Results	
Indicator Name	Unit	X(2003)	X(1990)	W(ref)	Y(goal)	Z	I(2003)	I(1990)
1) CO2 emissions	kgC/cap	736.0	600.0	1,130	339	791	0.502	0.330
2a) Particulates	µgr/m3	275a	387a	50	10	40	6.625	9.425
2b) SO2	µgr/m3	49a	115a	60	12	48	0.771	2.146
2) Ambient pollutants	-						3.698a	5.785a
3) Access to electricity	%	98.0	89.6b	-	100	-100	0.020b	0.104
4) Investments	%	4.6	6.6	6.6	95	-88.4	1.022	1.0
5) Vulnerability	%	12.3	1.4	100	-	100	0.123	0.014
6) Public sector investment	%	2.5	4.4c	10	-	10	0.25	0.44c
7) Energy productivity	MJ/euro	9.24	19.70	10.64	1.06	9.58	0.854	1.946
8) Renewables	%	21.2	25.0	9	95	-86.36	0.855	0.811

a: data of 2004 b: data of 1993 c: data of 1991

Figure 12: China's HELIO Star, 1990 vs 2003



Conclusions and Policy Recommendations

Among the 8 HELIO indicators, China has witnessed a shrinking in the value of four indicators, meaning that its energy sustainability has improved in those four aspects: ambient pollution; access to electricity; public energy investment; and energy productivity. The improvement has been especially strong with regards to ambient pollution and energy productivity. Meanwhile, the other four indicators show an increase over the same period, meaning deterioration in its energy sustainability with regards to: CO2 emissions; investment in renewables; vulnerability to the fluctuations and risks on the international energy market; and the use of renewables.

It should be noted however that although the HELIO indicator value shows much improvement in ambient pollution, the reality is that ambient pollution is only monitored in approximately half of the Chinese cities, the majority of which are bigger cities. In order to attract investment and create a good image, these cities have been targets of local and central governments' air pollution control efforts. And the clean up is often realized through prohibiting the use of coal in these cities and the relocation of large polluting industrial enterprises which merely shifts rather than reduces the pollution. China's total emissions of SO2 and suspended particulates have increased significantly since 1990 demonstrating that the country's overall age ambient pollution has worsen, instead of improving.

Another indicator illustrated by the HELIO star that may fail to reflect the actual change is the vulnerability to risks on the international energy market. Since 1990, China has shifted from a net energy exporter to a major energy importer. However, the HELIO indicator can not reflect this dramatic change because it only considers the share of non-renewable energy trade and does not distinguish import and export. However, the reality is that in the current international energy market, an importer faces greater risks and is more vulnerable than an exporter: this is especially true because of the recent dramatic increases in international oil prices. In China, a large share of oil is used as fuel for vehicles, which cannot be readily replaced with other forms of energy in the near future. With the strong momentum of increases in passenger transportation and freight transportation, it is expected that China's reliance on oil imports will further increase, and correspondingly, the country will face greater exposure to energy security risks.

Another important fact is that since 1990, the share of renewables in China's energy mix has shrunk from 25% to 21.2%. Two thirds of the renewables used in China are traditional use of firewood and stalk. In the past few years, urbanization has been increasing at an annual rate of over 1 percentage point

per year, meaning that each year, over 13 million Chinese farmers become urban residents. Most of these new urban residents will shift to commercial energy, mainly in the form of coal, LNG, LPG, or natural gas. This trend will continue in the years to come, posing additional challenges to the country's initiative for energy mix optimization.

Policy Recommendations

Greater support and more effective incentives for energy conservation and efficiency improvement

To maintain the robust growth of Chinese economy and support the continual improvement of the 1.3 billion Chinese people's living standard, reliable and sustainable energy support is key. The overall energy intensity of the Chinese economy is still much higher than most developed countries and there exist a huge potential for energy efficiency improvement, both in terms of energy supply and industrial and household energy use. Clear policy signals and incentives need to be created to stimulate energy saving and efficiency improvement by families and enterprises alike. A typical example is that water shortages have become a serious problem in many Chinese cities. In 2004 the Shanghai municipal government implemented a project: changing the flush toilet water tanks of all families in Shanghai from the previous 13-liter to 9-liter ones, it is estimated that this effort has led to over 4 m^3 of water savings by each resident, and 70 million m^3 for the 17 million local residents. Such wide ranging measures, including encouraging the use of energy efficient household appliances, lights, and cars, though seeming negligible on per capita basis, can lead to enormous improvement in energy efficiency.

Cleaner use of coal

Because of China's coal-dominated energy resource endowment, it is widely recognized that even if China realizes its ambitious targets of increasing the share of hydropower, solar, wind, and biogas from the current 7% to 15% by 2020 and the share of nuclear power from the current level of less than 1% to 4%, coal will still contribute to half of the total primary energy supply in China. The progress in coal liquefaction and gasification technologies can contribute to the burn of coal in a cleaner way.

Making use of coal mine methane, coal bed methane, and gas from oil fields

Each year, large amounts of coal mine methane, coal bed methane, and gas from oil fields are flared or directly emitted into the air, causing global warming and endangering the life of coalminers. These gases are also clean energy and valuable resources. The commercial use of these gases should be

increased through compulsory legislation, positive policy incentives, and effective capacity building.

Greater support to renewable energy development

Currently, renewable energy is still not competitive due to its higher unit cost. Renewable energy development needs the support of government. China has very good resource conditions for the development of solar energy, wind power, and power generation with agricultural waste. Additional fiscal and taxation supports however are needed to attract greater participation by enterprises and investors.

Annex 1 – Indicator Calculation Formula

The generic formula used to calculate the eight indicators is:

$I = (X - Y) / (W - Y)$

Where:
I = the value of the vector (in relative terms)

X = the value (in absolute terms) of the environmental, economic social or technological parameter

Y = the objective of sustainability in absolute terms and corresponds to the value 0 of the vector

W = the value (in absolute terms) which corresponds to value 1 of the vector

It can be seen only three variables are used to calculate each indicator with the definitions of these variables remaining the same for each indicator. The X value varies over the long-term while values W and Y are constant. Therefore, the denominator is the same for all countries and remains constant during the calculation of the base year and the current year I values. The smaller the difference between X and Y, the smaller the value of I will be, indicating that smaller I value indicating better sustainability performance.

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