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China's Energy Industry Case Study Report

A Component of the Study Project of Sustainable Industrial Development in China Commission by the United Nations Industrial Development Organization

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SUMMARY

As a basic industry and one of the major industrial sectors, China's energy industry has been encouraged and supported by national policies and has achieved remarkable development. However, the energy industry has based itself on the development and production of domestic resources in the long time but it has been restricted by insufficient financial investment and influenced by the shortage of energy supply over a long period. As a result, the energy structure is somewhat inappropriate, the energy utilization rate is low and the environmental pollution caused is very serious. Therefore, the policies relating to the energy industry should be appraised and adjusted from the angle of the sustainable development strategy.

The major reasons for appraising and adjusting the policies on the energy industry are as follows:

1. In the process of economic transformation, structural adjustment needs to be made to the energy industry to significantly increase the funding and resource utilization rate. Since the energy industry has been operated and monopolized by the state under a highly planned system for a long time, the market-oriented transformation and adjustment of the energy industry will not only involve the adjustment of the energy production and consumption structure, but will also involve the adjustment of the organizational form, organization structure and scale of energy enterprises, and the reallocation of various resources including human resources. These adjustment need to be carried out under market conditions. At the same time, in the environment of market economy, China's energy industry will not achieve healthy development unless it accepts fierce competition and meets the challenges by carrying out profound reform and adjustment.

2. As an industry primarily related to the allocation of resources, the energy industry is very important for the implementation of the sustainable development strategy. First, as one industrial sector, the energy industry itself needs sustainable development. Second, as a resource-based basic industry, the effective future development of the energy industry is necessary to support the whole of society's sustainable development. Consequently, the sustainable development of the energy industry has become an important part of China's sustainable development strategy. At present, the problem of environmental pollution arising out of energy development and utilization is one of the major factors influencing the energy industry's sustainable development. In order to reduce the emissions of such harmful gases as SO_2, CO_2 and NOx, fly dust and other pollutants, we should shift our focus to the development and utilization of quality energy sources characterized by high efficiency and low pollution. However, resources, financing and technology are the main barriers restricting the utilization of quality energy sources.

3. The proportion of quality energy sources in China's energy resources is low. The total reserve of traditional energy resources proved by the end of 1990 was over 790 billion ton, with coal accounting for 88% and petroleum, natural gas, water

energy and other resources accounting for only 12%. Therefore, the future supply of quality energy sources in China will inevitably be internationalized and the sources need to be diversified in view of supply safety. After China's accession to the WTO, low-cost energy sources in the international market will certainly enter the Chinese market and more new technologies and advanced management methods in the field of energy production and development will be introduced into China. This means transnational energy corporations will certainly launch competition with the domestic energy enterprises in funding, technology, equipment, management and the marketing of energy commodities.

According to the study of our research team, the focuses of China's adjustment of her energy policies in the near term should be as follows:

1. To promote the development of various quality and alternate energy sources

From the angle of making up the shortage of petroleum supply and diversifying the supply of quality energy sources, we should make great efforts to develop various alternate energy sources for relieving the inequality between supply and demand arising from the year-by-year reduction of petroleum reserve and the continuous growth of demand. The alternate energy sources of top priority include gas energy sources (natural gas and coal bed gas), primary electric power (hydropower and nuclear power), renewable energy sources (solar energy and wind energy) and other clean fuels.

Natural gas is both a quality clean energy source and a quality industrial chemical. Natural gas is the most realistic energy source for replacing petroleum at present and for a quite long period into the future. Electricity generation with natural gas can replace oil-fired, and part of coal-fired, power stations and achieve positive environmental effects. The development of natural gas-driven transportation tools can replace gasoline, diesel and other fuel oils for transportation. A Gas chemical industry can replace part of the petrochemical industry. Hence, the development and utilization of natural gas can directly replace a large amount of petroleum. China has rich natural gas resources and the potential is quite huge, but the progress of natural gas development and utilization is slow.

Besides natural gas, China also has abundant coal bed gas resources. The regional distribution of coal bed gas resources can form a complementary relationship with the distribution of natural gas resources in some regions.

At the current stage, natural gas development and utilization needs to be accelerated by the urgent adoption of special policies in order to meet the goal of sustainable development.

The scientific and rational utilization of China's rich coal resources is also dependent on sustainable development-oriented policies within the energy industry. In the past, China has implemented a policy of rash coal development and utilization which has led to certain environmental problems. In the future, under the constraint of sustainable development-oriented policies, the coal industry needs to take a road of protecting resources and vigorously developing clean coal utilization technology.

2. To continuously strengthen energy conservation, increase energy efficiency and promote environmental protection

To increase energy efficiency and save energy has an important position in the energy strategies of all countries. Since the 1980s, due to the potential shortage of energy supply, China has formulated corresponding energy conservation plans mainly through administrative measures as well as economic measures. These plans have seen significant achievements, effectively relieving the pressure of energy shortage and successfully enabled China to realize sustainable and rapid economic growth while maintaining a low growth in energy consumption. The sustainable development-oriented energy strategy requires us to increase energy efficiency and implement energy conservation in all aspects and, at the same time, demands us to mainly rely on market system for promoting energy conservation and increasing energy efficiency.

3. To push forward the development of the western China region

The ongoing development of the western China region has resulted in good opportunities and challenges for implementing the sustainable development-oriented energy strategy in the whole western region and even the whole country. On one hand, the western region has one of the richest energy resources in our country but with a low per capita energy consumption level. The development and utilization of energy sources in the western region can make realistic contributions to the local social and economic development and the improvement of the local people's living standard On the other hand, the slow economic development and the vulnerable ecological environment in the western region limit the development and utilization of energy sources, and any development and utilization of energy sources will bring about new pressures on the local ecosystem. In such a situation, only through implementing a set of successful and sustainable development-oriented energy policies can we enable the development of energy resources in the western region that make real contributions to the local social and economic development and improvements to local people's living standards.

1. INTRODUCTION

Since the 1980s, the state has formulated a series of policies for encouraging and supporting the development of the energy industry. The general policy on energy development put forth by the Chinese Government at that time was to lay equal stress on development and conservation, with conservation taking the first priority. In respect of energy development, the policy is to take coal as the basis, electric power as the center, give the priority to the development of hydropower, actively develop nuclear power and exploit rural energy sources and new energy sources according to local conditions.

The implementation of this policy has led to a major increase in energy supply capability and has raised the energy utilization rate, thereby enabling China to realize her phased targets of social and economic development on the basis of a low energy growth rate. China has built the second largest energy system in the world. In 2000, China's primary energy output was 1,080Mtce. Of this, coal output dropped from the peak of 1,400Mt in 1996 to 998Mt due to the closing of coal mines and restriction of production; petroleum output was 163Mt; and the output of natural gas was 27.73 billion cubic meters. However, China's per capita energy consumption is still very low. China's total consumption of primary energy in 1999 was 1,244Mtce and the per capita consumption was only 998kg, while the world per capita level was 2,039kg.

China has a huge rural population and there is a large amount of non-commodity energy sources in domestic energy consumption. In the total amount of commodity and non-commodity energy sources consumed in 1998, the percentages of coal, petroleum, natural gas, nuclear power, hydropower from large and medium-sized hydropower stations and renewable energy sources were respectively 61.6%, 17%, 1.8%, 0.3%, 3.6% and 1.6%, but the percentage of biological energy sources and other non-commodity energy sources was up to 14%. These biological and non-commodity energy was primarily used in rural areas (source: Study on Energy Policies—2001 Energy Data, January 2001). The underdeveloped infrastructure and inferior energy sources used in rural areas, combined with the relatively backward energy development and end use technologies have led to a low energy utilization rate of about 32%.

Because of the low energy utilization rate, the environmental problems caused by energy are also one of the main challenges for the future development of China. According to Japan Energy Economy Research Institute's estimation, the quantity of China's CO_2 emission in 1997 was 853Mt of carbon, taking the second place in the world. As announced by the State Environmental Protection Administration, the quantities of China's SO_2 and fly ash emissions in 1999 were respectively 18.58Mt and 11.59Mt. In order to improve environmental quality and actively take pollution control measures China has emphasized energy conservation in her energy policies, formulated the Energy Conservation Law, encouraged the development of renewable energy sources and put forth the Essentials for the Development of Renewable Energy Sources in the 9th Five-Year Plan period. Through these actions, 400Mtce of energy was saved during the 9th Five-Year Plan period with an annual average conservation rate of 5.6%. This resulted in reductions in emissions of SO_2 and CO_2 of 8Mt and

180Mt of carbon respectively. Recently, the Chinese Government has proposed to further optimize the energy structure, increase the energy utilization rate, promote energy conservation and comprehensive utilization technologies, actively develop new energy and renewable energy sources (wind energy, solar energy and geothermal energy) and strengthen environmental protection.

In view of the opportunities and challenges confronted by China's energy industry, and under the guidance of the state's new energy policies, the main aim of this research is to appropriately adjust current policies to formulate a framework of relevant, sustainable and development-oriented policies to guide and drive the restructuring of the energy industry and market-oriented reform to realise the harmonious development of energy, economy and environment. Within these policies solving the problems of labor redeployment during the transfer to sustainable development of the energy industry; significantly increasing energy utilization rate and the economic benefits of energy enterprises; ensuring a basic balance between total demand and supply of energy; and safeguarding the safety of energy supply are all basic considerations to be addressed.

2. GOALS OF THE SUSTAINABLE ENERGY INDUSTRY AND PRINCIPLES OF FORMULATING POLICIES

2.1 Optimize the Structure of Energy Supply, Increase Energy Efficiency and Improve the Environment

According to the geological and mineral sector's survey and prospecting, the total volume of China's energy resources is equal to 4,001.7 billion ton of standard coal, more than 90% of which is coal. Since the reserve of coal is huge and the cost of coal exploitation is relatively low (compared with than that for the exploitation of such quality energy sources as petroleum and natural gas), a coal-focused primary energy production and consumption structure has been in place in China for a long time.

2.1.1 The Structure of Energy Supply with Coal as the Mainstay is the Direct Reason of Low Energy Efficiency

(1) At present, China's energy efficiency is only about 32%, which is about ten percent lower than the foreign advanced level. The excessive proportion of coal in industrial energy consumption and the leading position of coal in electricity-generation are the major reasons of the low efficiency. In 1998, China's total primary energy consumption was equal to 1.322 billion ton of standard coal. Of this, the proportion of industrial energy consumption was 71.4% with coal consumption accounted for 89.1% of the industrial energy consumption. In the same year, the industrial sector's total coal consumption was 1.15 billion ton, accounting for 88.8% of China's total coal consumption of 1.295 billion ton; 32.3% of the coal consumed was used as fuel and raw material in industrial terminal utilization and 56.4% of the coal was used for the processing and conversion of secondary energy sources; more than 94% of the fuels used by the power sector was coal; and the amount of coal used for power generation accounted for 39.8% of the total coal consumption.

(2) The volume of domestic energy consumption is only second to that of industrial energy consumption. In 1998, the amount of commodity energy sources used for domestic consumptions accounted for 10.9% of the total energy consumption. However, coal accounted for 38.4% of the urban domestic energy consumption and most of the coal was directly used as fuel for such terminal consumptions as coking and heating.

(3) The low energy efficiency is also closely related to the low technological standard of coal-fired equipment. The average efficiency of industrial boilers whose coal consumption accounts for 30% of the total coal consumption is only 65%. This efficiency is 15-20% lower than the world advanced level. The average heat efficiency of thermal power sets is 32.8% and the average energy consumption for power supply is 400g of standard coal/kWh, which is about 20% higher than the advanced level. The heat efficiency of urban domestic coal consumption is only 15-25%. The rate of gas popularization in a considerable number of large and mid-sized cities is no more than

70%.

(4) Coal is still used as a main raw material in China's chemical industry, especially in the coal chemical industry. In the domestic coal chemical products, the proportion of synthetic ammonia that uses coal and fire coal as raw materials is more than 65%. In particular, small-scale synthetic ammonia processors, whose output accounts for a half of the total output entirely use coal as raw material. However, 95% of the raw materials for the US's synthetic ammonia are natural gas. The energy consumed by each ton of synthetic ammonia that use coal as raw material is 40-70% more than that consumed when natural gas is used.

(5) The proportion of coal in the structure of terminal energy consumptions in China is far higher than those in the developed countries. Large-scale direct coal burning not only reduces the efficiency of utilization but also directly pollutes the environment. The structures of terminal energy consumptions of China, the US and Japan are compared in Table 1.

Table 1: Comparison of Some Energy Sources in the Structures of Terminal Energy Consumptions of China, the US and Japan (1997)

	China	US	Japan
Coal	45.5	1.8	6.4
Petroleum	16.9	53.9	63.2
Gas fuel	6.0	23.3	6.1
Electricity	9.2	18.8	23.1

Source: Wang Qingyi, Energy Data in 1998, Energy Policy Research, Issue 1 of 2000

2.1.2 The Influences of Coal Burning on the Environment

In 1997, the volumes of SO_2 and fly ash discharged in China were respectively 23.2 million ton and 17.44 million ton. According to rough assessment, about 90% of the SO_2 and 70% of the fly dust came from coal burning. The serious air pollution attributable to SO_2 has led to acid rain. At present, in China's total territory the proportion, of the areas suffering from acid rain has reached 30%. Further, coal is the mineral fuel with the highest CO_2 discharge coefficient. In 1995, the discharge volume of the greenhouse gas CO_2 was equal to 8.34 million ton of carbon, 80% of which was from coal burning.

2.1.3 Optimize the Structure of Energy Supply through Diversified Channels

The rapid development of China's economy since the implementation of reform and opening up has not only increased China's aggregate economic volume and the per-capita GNP, but has also promoted the adjustment of China's industrial structure and the upgrading of energy consumption. In particular, the implementation of the strategy of sustainable development has further strengthened the trend of China's adjustment of its structure of energy supply and the upgrading of its energy consumption. At present, China's domestic supply of quality energy sources is still

greatly constrained by the degree of resources verification and funding. Since the relative costs of quality energy sources are high and the investment required for building petroleum and natural gas transmission networks is quite large, the expansion of demand for quality energy sources are greatly restricted at present. Therefore, the evolution of China's primary energy structure will be a gradual process of advancement. However, the structure of terminal energy consumption can be changed, the energy efficiency can be increased and the environment can be improved in a short term through both expanding the import of quality energy sources and increasing the level of electricity consumption. The structure of energy supply will be correspondingly adjusted with the expansion of petroleum and natural gas import and the enhancement of efforts in exploiting such quality energy sources as nuclear power and hydropower. Therefore, policy support should be enhanced, the prospecting and exploitation of petroleum and natural gas should be promoted, the rate of resources verification should be increased and the reserve of back-up resources should be raised to make the domestic petroleum and natural gas resources fully exploited and utilized. At the same time, policies should be formulated to support the exploitation, industrialization and commercialization of the coal bed gas that has potential value for exploitation for making up the shortage of natural gas output.

In addition, super-critical electricity generation technology and integrated gasification and composite circulation (IGCC) technology can be used to convert more coal into electricity to attain the coal-electricity ratio of 50-60% of the developed big coal producing countries. To explore the gasification and liquidation of coal, and especially to look for appropriate coal sources and directly liquidate them into finished oil products, would promote the structure changes of energy supply, releasing the pressure arising out of China's insufficient petroleum supply, reduce the costs of oil import and consequently create huge economic benefits. China should also vigorously develop hydropower and wind power and appropriately develop nuclear power. In the southeast coastal areas (characterized by deficient energy resources and rapid economic development), liquid natural gas (LNG) may be imported and petroleum and gas resources from neighboring countries such as Russia may be imported to make up China's shortage of quality energy sources.

In short, to get reliable energy supply from the domestic and international energy markets and realize the strategic development of China's energy structure is an important premise for China's formulation of policies on the sustainable development of the energy industry.

2.2 Use both Domestic and International Markets and Resources to Ensure the Safety of Energy Supply

2.2.1 Economically and Reasonably Use Energy Resources from Both the Domestic and International Markets

China's demand for energy will inevitably grow with the continuous growth of China's economy, the increase of China's total population and China's social and economic modernization. According to the development strategy proposed by Deng Xiaoping, by the middle of the 21st century, China will have reached the level of moderately developed countries at that time. According to prediction, China's

per-capita energy consumption will probably reach the level of 2.5-3.0t of standard coal by 2050 and, on this basis, China's total energy consumption will reach about four billion ton of standard coal and account for more than 15% of the world's total energy consumption at that time. However, restrictions in the domestic energy resources and energy sources exploitation technology, China's future energy supply will be constrained by serious shortage of domestic resources. Such a constraint is an important restrictive factor for the sustainable development of China's society and economy. Therefore, the only way to overcome the restriction of domestic resources is to develop and utilize foreign resources while effectively using domestic resources.

2.2.2 Lay Particular Stress on the Quality Energy Resources of Foreign Countries When Using Foreign Markets and Resources

According to the result of the second assessment of petroleum and natural gas resources, China's total reserve of petroleum resources is 94 billion ton, exclusive of the reserves in Taiwan Provinces and the southern part of South China Sea. Though the long-term reserve of China's petroleum resources is large, the natural conditions of the areas where the resources are located are quite harsh and 46.3% of the resources are distributed in such inaccessible areas as plateaus, mountains, loess tablelands, deserts, marshes, beaches and sea areas where petroleum cannot be easily explored and exploited. By the end of 1998, China's accumulative proved petroleum reserve was 19.8 billion ton and the remaining proved reserve was only 2.4 billion ton. According to prediction, China's petroleum demands in 2005, 2010 and 2020 will respectively reach 248 million ton, 296 million ton and 380 million ton, but China's crude oil outputs in 2005, 2010 and 2020 respectively can only reach 160-170 million ton, 170-180 million ton and 180-190 million ton. Consequently, the shortfall of crude oil supply in the said three years will respectively reach 78-88 million ton, 116-126 million ton and 190-200 million ton. It means that one-third of China's petroleum consumption will have to rely on foreign resources by 2010 and about 50% of China's petroleum consumption will have to rely on foreign resources by 2020. Therefore, to speed up the exploitation and utilization of foreign petroleum and natural gas resources is a strategic focus for China to ensure its long-term stable petroleum and natural gas supply.

There are mainly two channels for using international petroleum and natural gas resources. The first channel is direct import through international trade and the second channel is to develop petroleum and natural gas resources in foreign countries and establish overseas production bases. To carry out resources exploration and exploitation in foreign countries and establish overseas petroleum and natural gas production bases is the only way for China to ensure the safety of its future petroleum and natural gas supply and the Chinese petroleum enterprises to participate in international competition and implement transnational operation. After more than 50 years of development, China has established a complete petroleum industry and built up technical and personnel skills. While, China's petroleum exploration and exploitation technologies are generally inferior to those of the large foreign petroleum companies, China's technologies in some fields (e.g. in increasing the recovery ratio of old oil fields) are quite advanced, which is very beneficial for the Chinese enterprises to actively participate in the development of some exhausted oil fields and old fields in foreign countries. The Chinese petroleum enterprises must develop overall advantage of complete production and service functions in geological research,

prospecting, exploitation, processing and survey, design, drilling, logging, equipment manufacturing and logistic service to enhance their competitive power in overseas development, speed up the progress of overseas development and get more allotted petroleum and natural gas resources for China.

2.2.3 Ensure the Safety of Energy Supply

As China exploits and utilizes foreign markets and foreign resources for globalizing its sourcing of energy supply, the risk of supply suspension will also be globalization, which will inevitably produce great impacts on China's social and economic development and national security. A corresponding safety strategy must be formulated to ensure the safety of China's future energy supply.

With the gradual increase of China's dependence on international petroleum and natural gas resources, the focus for China to ensure the safety of its future energy supply will be to strategically guarantee the safety of China's stable petroleum and natural gas supply in the medium and long terms. The purpose should be to ensure China's stable, economical and safe obtainment of the necessary petroleum and natural gas resources, guarantee the stable supply of foreign petroleum and natural gas so far as possible, and reduce the risk of supply suspension. Therefore, China should adopt a strategy of diversification and an appropriate safety strategy and formulate the corresponding policies, laws, rules and measures.

The strategy of diversification covers four aspects. The first aspect is the diversification of the sources of import. China should decentralize the sources of imported petroleum and avoid excessive dependence on petroleum supply from unstable regions (e.g. the Middle East) and through the unstable zones (e.g. the Strait of Malacca). The second aspect is the diversification of petroleum types. From a long-term point of view, especially after China's accession to the WTO, the finished oil market will be gradually opened up. Therefore, China should manage it consumption of various crude oil, finished oil and chemical raw material resources on the basis of the long and medium term strategies. Consequently, China should establish a mechanism and environment to facilitate its flexible import of crude oil, finished oil and chemical raw materials. The third aspect is the diversification of the means for obtaining petroleum. Besides petroleum trade, obtaining overseas allotted petroleum and establishing petroleum processing enterprises through joint ventures with petroleum producing countries are both effective means for obtaining petroleum resources. The mutual development of these various aspects is beneficially for realizing the maximum economic benefits and safe supply. China should gradually increase the proportion of overseas allotted petroleum in its total petroleum import. In respect of the selection of regions for overseas development, China should give priority to neighboring countries and the countries from where the distance of transportation is short and work together with Middle Asia, Russia and the developing countries with friendly relationship with China first. In terms of procedure, China should develop the existing oil fields first, and carry out risk prospecting after accumulating experience and funds through cooperation with big foreign petroleum companies. In the short term, China should lay particular stress on forming relations with four strategic regions, including Middle East—Northwest Africa, Middle Asia—Russia, North America and Southeast Asia. The long-term strategic stress should be laid on the regions of Middle East—Africa and Middle Asia—Russia. The

Chinese petroleum companies should try to enter the regions where big international petroleum companies have not or cannot enter for various reasons, or adopt cooperate with big international petroleum companies and avoid direct competition with these companies. In terms of technology, China should make full use of its own advantages in technology and experience in the development of foreign oil fields with proved reserves or the projects for increasing the recovery ratio of old oil fields. The fourth aspect is the diversification of the channels and means of transportation. For example, China may establish its own ocean fleet, open up new marine channels and build transnational petroleum pipelines.

The safety strategy mainly covers two aspects. The first aspect is the development of petroleum reserves, including the building of a national strategic reserve, and to formulate preferential policies for encouraging the petroleum-linked enterprises to increase commercial reserves besides their normal working reserves. The second aspect is ensuring the safety of petroleum supply by enhancing China's national strength, establishing good political and economic relations with the major petroleum producing nations through diplomatic work and economic cooperation, and to adopt some escort measures in special conditions. To establish an all-round petroleum supply safety guarantee system is also very necessary.

2.3 Conservation first is Still the Basic Strategy for the Sustainable Development of the Energy Industry

Over the 20 years since China's energy supply began falling short of demand, China has always insisted on the policy of "laying equal stress on exploitation and conservation and giving the priority to conservation" for the development of the energy industry. This policy has supported the rapid growth of China's aggregate economic volume with low energy consumption. Since the 8th and the 9th Five-Year Plan periods, China's energy conservation rate (calculated on the basis of reduced energy consumption per unit amount of GDP) has been up to 4-5%. Energy conservation has not only played a part in releasing the shortage of energy supply and maintaining the balance between energy supply and demand, but also reduced the energy consumption of China's energy system that is characterized by the use of large amounts of fossil fuels. Consequently the emission of harmful gases and granulates has been reduced making an important contribution to the improvement of the environment and a reduction of greenhouse gas.

The most direct effect of energy conservation is to increase the economic benefits of energy utilization, so energy conservation is an important measure for China to change the form of its economic growth from extensive to intensive. Its indirect effect is to benefit the ecological environment through reducing energy consumption, especially the consumption of such mineral fuels as coal and petroleum that can produce many pollutants. In the 21st century, both China and the whole world will be confronted with huge pressures arising out of economic and social development and the further growth of energy demand. However, because fossil energy sources cannot retire from the stage of history in a short term, the environment will be worsened with the increase of energy consumption. Therefore, all countries still need to insist on and enhance energy conservation and inhibit the excessively rapid growth of energy consumption.

In the period of the planned economy, China mainly carried out energy conservation through implementing mandatory plans to reduce energy consumption. These mandatory activities include planned energy consumption (power consumption), quota-based energy consumption (power consumption), penalties for excessive consumption and reward for conservation and administrative implementation of energy conservation management and technological advancement. All those measures played their historical role in reducing the waste of resources, increasing energy efficiency and maintaining the balance of energy supply and demand during times of energy deficiency. However, the achievements of energy conservation in that period were mainly achieved through administration. When there is serious waste and extensive energy utilization, it was relatively easy to carry out energy conservation through administrative measures.

In the 1990s, China set up a framework for a market economy system, demanding that government functions should be separated from enterprise management, administrative powers in enterprise management should be weakened and mandatory plans should be given up at the beginning of the next century. After experiencing extensive operation, the Chinese enterprises and society have turned to the track of intensive economic development that increases the difficulty of energy conservation. In such a situation, the energy conservation system must be correspondingly modified in accordance with the market economy and more market-based measures such as price, tax, finance, policies, rules and regulations should be adopted for carrying out all-round coordination and operation. As the country carries out macro-regulation, enterprises and citizens may voluntarily choose the forms of energy conservation. The state's goal of energy conservation has to engender spontaneous actions by enterprises and all members of the society.

In this new period, making use of the mature international experience, China is carrying out integrated resources planning (IRP), demand side management (DSM) and green light program, which are successful attempts for promoting energy conservation in the whole society by using market mechanism. The Energy Conservation Law that was implemented as of Jan. 1, 1998 has pushed China's energy conservation work forward to a new level. The Law clarifies the purpose and means of energy conservation and the corresponding legal responsibilities, thereby institutionalizing the work of energy conservation and directing the formulation and improvement of the supporting policies, rules and regulations within the market economy. At present, some new energy conservation management systems (e.g. energy conservation standard and identification, energy conservation product certification system and mandatory energy conservation management) specified in the Energy Conservation law are under tentative implementation. However, energy conservation will be mainly dependent on the advancement of energy conservation technologies and the support of market-oriented energy conservation mechanisms and policies.

2.4 Promote the Development of Substitute Energy Sources and the Clean Utilization of Coal

To replace fossil energy sources such as coal and petroleum with renewable and clean energy sources (e.g. solar energy source, wind energy source, subterranean heat, nuclear power and hydropower) and avoid the air pollution of SO_2, NO_x and

granulates discharged during energy exploitation and utilization, is a developing industry that China and the world are vigorously encouraging. The clean utilization of coal is realized through adopting advanced clean coal technology, effectively increasing the efficiency of energy conservation, reducing the emission of SO_2, NO_x and dust, ultimately reducing the influence of coal utilization on the environment and the effect of greenhouse gas. Confronted with the severe challenges arising from energy development, all nations, especially the developed countries, have devoted a lot of funds and advanced technologies to the development of substitute energy sources and clean coal technologies, trying to effectively reduce the costs of substitute energy sources and clean coal utilization, speeding up the transformation of the structure of energy supply, increasing energy efficiency and realizing the sustainable development of the energy industry. This is a realistic way for the energy industry to maintain sustainable development in the new century.

The environmental benefits of clean utilization of coal and substitute energy sources are very obvious and it presents the prospect of harmonious development between human's energy utilization and the environment. Because substitute energy sources are of many types, available in large volume, easily obtainable and reproducible, concern about the exhaustion of energy sources is thereby removed. The secondary energy sources conversion technologies for most substitute energy sources and clean coal utilization technologies have become mature, left the laboratory and entered commercial development. The most serious problem at present is that the economic costs of the existing exploitation and utilization technologies are high, mainly because of the characteristics of the substitute energy sources (e.g. low density, strong seasonality or time limitation of energy sources), the low efficiency of energy conversion or technological equipment's high requirements on the quality of materials. These reasons make the investment in substitute energy sources higher than that in conventional fossil energy sources, reduce the competitiveness of operating cost and lead to certain market barriers. Especially in developing countries, though such countries want to develop substitute energy sources and clean coal utilization for improving the environment, they are short of the funds necessary for importing advanced technological equipment. Furthermore, these countries' supportive policies cannot be fully implemented for the lack of funds. China is no exception.

China has rich new and renewable energy sources. For example, the volumes of such resources as wind, subterranean heat, solar energy and hydropower that have large-scale exploitation in other areas of the world are quite big in China. The exploitable volume of wind energy is 253 million KW; the proved reserve of subterranean heat is equal to 3.16 billion ton of standard coal; the annual sunshine time in more than two-third of China's territory is more than 2,000h and the total radiation quantity of solar energy is 3.3×103~8.4×106KJ/m2/year; and the energy of the exploitable hydraulic resources is equal to 378 million kWh. In order to ensure China's long-term energy supply and improve the environment via the strategy of sustainable development for the energy industry, China has formulated the "Essentials for the Development of New Energy Sources and Renewable Energy Sources" (1996-2000), requiring that the total volume of the new and renewable energy sources exploited and utilized by 2010 reach about 390 million ton of standard coal. With the gradual exploitation in the future, new and renewable energy sources' substitution of traditional energy sources will be more obvious and will become the foundation of the future structure of energy supply.

Coal is China's richest energy resource and China's coal reserve is the third largest in the world. Because of low exploitation costs and extensive applications, the proportion of coal in China's primary energy structure will remain high at the beginning of the new century, even though coal exploitation and utilization always lead to serious environmental pollution. Such a situation is consistent with China's national conditions and strength. Through developing and utilizing clean coal technology, China may improve the environment of coal utilization and allow coal to continue contributing to China's economic growth and social prosperity before new and renewable energy sources become the dominant energy sources.

It's inevitable that China will make great efforts to develop substitute energy sources and clean coal utilization in the new century. To overcome the market barriers, China should reduce costs and increase efficiency first, then realize commercialized and industrialized exploitation and utilization, which is a long-term and arduous task. We should enhance the efforts of policy support and guidance immediately.

The World Energy Council has researched the prospects for global energy supply and demand to 2050, concluding that the global energy consumption in 1990 to 2020 will grow by 55-70% from the current level; two-third of the additional energy consumption will come from developing countries; and 50% of the growth of consumption will be contributed by countries and regions such as China, India, Indonesia, Brazil, Pakistan, Thailand and Malaysia Peninsular. Thus we can see the future energy demand places huge pressure on energy supply and the environment. To realize sustainable development, more and more countries are developing new and renewable energy sources and promoting their industrialization through making financial investment and formulating the corresponding supportive policies and incentive rules. The US formulated a government level sunshine electricity generation program as early as 1977. In 1980, it included photovoltaic electricity generation into its public power development plan and has cumulatively invested more than USD800 million. In 1992, the US formulated a new photovoltaic electricity generation plan, aiming at increasing the total quantity of photovoltaic electricity to 1,450MW in 2000, equal to 10 times of the world's total volume of photovoltaic electricity at present, and the Clinton Administration's financial budget for photovoltaic battery development was USD87 million in 1994. Because of the US's implementation of a photovoltaic battery industrialization plan in 1990, the US has increased the efficiency of battery by two percent and greatly reduced the cost through implementing a policy that combines scientific research institutions with industrial enterprises.

According to prediction by a world authoritative body, the proportion of new and renewable energy sources in the structure of energy supply will be more than 50% in the middle of the 21st century and new and renewable energy sources will become one of human's basic energy sources. Thus it can be forecasted that the global energy structure will inevitably see essential changes in the next 20-30 years. After hosting the World Environmental Development Conference in 1992, the Chinese Government has put forth an Agenda for the 21st Century, emphasizing that "renewable energy sources are the foundation of the future energy structure", "the national development strategy should give the first priority to the development of renewable energy sources" and "energy conservation should be extensively carried out and new and renewable energy sources should be actively developed". The Agenda indicates that China's

strategic choice of not only satisfying the energy demand of the current social development but also ensuring energy supply for the descendants is entirely consistent with the general trend of global energy development.

2.5 Promote the Energy Industry's Healthy Development through Reform, Reorganization and Transformation

China's energy industry is confronted with severe challenges at the beginning of the new century. First, the implementation of the strategy of sustainable development and environmental management has brought about more and more restrictions on the energy industry. Second, after China's accession to the WTO, the opened market will surely lead to the entry of foreign energy products and foreign energy enterprises, thereby increasing the competitive pressures on China's energy industry. Third, China's social and economic development has put forth higher qualitative requirements on energy service. When analyzing and appraising the current situation of China's energy industry, we may find that there is a big gap between the domestic level and the international level not just in the standard of technological equipment, but also the efficiency of production and management or product quality and service.

China's energy industry had been monopolized by the state for a long period under the planned economy system. Confronted with the shortage of energy supply, China adopted a series of supporting policies, including such measures as raising money to run energy enterprises, providing subsidies for losses, tax exemption for profit and collection of charges not included in the calculated prices, which made the situation of energy supply see huge changes in a short period and even the supply exceed demand when the market system was changed. Though these supporting policies aimed at increasing supply enabled energy supply to realize rapid growth, the negative effects of the short-term and quick-effecting policies are profound and need to be controlled. Disorderly distribution and duplicated construction has created the problem for the entire energy industry of failure to reach optimum economic scale. The shortage of coal supply had been one of the greatest concerns of China. However, under the guidance of the policy of "building coal mines of any sizes", the output rapidly reached the peak amount of 1.39 billion ton in 1996. However, the unexpected drop of market demand forced the coalmines to reduce production and increase stock. One of the results of the policy adopted at that time is that township and small private coal pits (whose total output is already more than that of the national key coal mines) are spread in all parts of the country. In 1998, there were more than 50 thousand coal production enterprises in the country with annual average output of only 25 thousand ton; and there were more than 69.8 thousand township and small private coal mining points with annual average output of less than 7,500t. This duplicated structure has led to not only low return on investment, waste of resources and aggravated environmental pollution, but also excessive market competition. According to statistics, at the end of 1998, there were 111 key state-owned coal mine enterprises; the average amount of coal sold by each enterprise was only 4.2 million ton/year; and the average market share of these key enterprises was less than 0.4% of the total market capacity; the annual output and annual sales volume of Datong Mineral Administration Bureau, China's biggest power coal enterprise, were respectively 30 million ton and 29.14 million ton and its market share was 2.9%; the annual output and sales volume of Kailuan Co., Ltd., China's biggest coking enterprise, was 18.8 million ton and 16.8 million ton and its market share was 1.7%. However, the

situations of the other coal producing countries are different from that of China. For example, in 1996, the US's coal output was 958 million ton, in which the top four companies' output accounted for 36%; Germany's coal output was 235 million ton, in which the output of the top two companies accounted for 93%; South Africa's coal output was 207 million ton, in which the biggest company's output accounted for 30%; and Australia's coal output was 250 million ton, in which one company's output accounted for 19%. The same phenomenon also exists in the power and petrochemical industries. In 1998, the total installed capacity of power sets in all parts of China was 299 million KW, already taking the second place in the world, but the average capacity/set was only 52.1 thousand KW; and the total capacity of small thermal power sets, each with a capacity under 50 thousand KW, was more than 30 million KW, accounting for more than 15% of the total capacity of all thermal power sets. In 1998, the number of power plants each with a capacity above 6,000KW was 2,733, including 1,764 small power plants each with a capacity under 30,000KW (accounting for 64.6%); and the proportion of large power plants each with a capacity above 300 thousand KW was less than 8%. As for petrochemical enterprises and refineries, the number of enterprises each with an oil refining capacity above one million ton is 42 and their annual average production capacity is 3.46 million ton. However, the annual average production capacity of the 708 refineries in the world already reached 5.24 million ton in 1994. The annual production capacity of the ethylene equipment of big foreign companies is generally 0.6-1 million ton, but the annual production capacity of China's large ethylene equipment is generally 0.3 million ton.

The energy industry is a relatively investment and technology intensive industry. Large modernized energy enterprises always invest billions of dollars for the installation of modern technological equipment. Because of the decentralized use of funds, though output growth can be achieved with small investment but high consumption and low quality, both economic and social benefits will not be so good. The following figures prompt deep thought: in 1998, the number of China's coal workers was 4.61 million, while China's coal output was 1.25 billion ton and the per-capita productivity was 26.7t/year; the US's coal output was 927 million ton, while the number of workers was only 78 thousand and the per-capita output was 11,885t/year; Australia's coal output was 219 million ton, while the number of workers was less than 30 thousand and the per-capita output was 10,800t/year. At present, China's coal production cost is already higher than the market price of coal. In 1996-1998, the central financial authority of China provided RMB1 million of subsidies for loss to the key state-owned coalmines and separately returned all the VAT to the mines at a rate of 13%. However, in Australia, coal export has made huge contributions to the growth of its gross GNP. As for the power industry, because of low capital investment for immediate success, a lot of small-capacity and low-voltage power sets have been established for power generation; the heat efficiency of these small power sets is only about 30%, which is 7-10 percent lower than that of super-critical large power sets; and the coal consumption of the small power sets for power supply is up to more than 600g of standard coal per kWh, which is over 200g more than the national average coal consumption for power supply. Stimulated by profits, many investors are enthusiastic for the construction of power source points, thereby leading to poorly designed and constructed power grid. After the appearance of buyer's market, the weak power transmission and distribution capability of power grids has become a barrier restricting the exploitation of the power market. On one hand, the power supply capability of power grids is generally excessive; on the other

hand, the power transmission capability of rural power grids is insufficient. There are seven counties without power supply in west China and the number of households without power supply is about seven million.

Energy enterprises' poor economic benefits are certainly closely related with their production and management. However, the standard of technological equipment is directly related to the high consumption of energy sources and raw materials, inflated cost and low technical and economic indicators arising from their small scale. Therefore, the inherent defect of the energy industry is can be expressed as a very low risk-resisting ability in the great tide of market economy. Besides market factors, an enterprise should also be able to control and reduce its costs to cater for the fluctuation of price for maintaining its stable profit. Unfortunately, what the domestic enterprises lack is just this ability. In the period of planned economy, the government decided the prices of products and it was the government who decided the profit and loss of an enterprise through promulgating government decrees and policies. However, in market economy, the prices of commodities are the products of the adjustment of market supply and demand. The market may eliminate an enterprise if it lacks the ability to control cost. As the international petroleum price rises and falls sharply, the profit indexes of the Chinese petroleum and petrochemical enterprises also rise and fall with the international petroleum price. Though the price of coal has not come in line with the international price, the domestic market has been opened up, so it's very difficult for the state-owned coalmines to reduce losses and increase profits under the fierce impacts of price. Due to the high entry cost to the power industry it is not so sensitive to market and price. However, under increasing demands from many areas of society, the power industry (which is more obviously monopolistic in the energy industry) will also have to confront competition and challenges in the world power market.

China's energy industry needs to be reformed, reorganized and transformed and strategic restructuring should be implemented. Through the reorganization of assets, China should implement an enterprise bankruptcy and merger system, adjust the sizes of enterprises and concentrate capital for realizing the upgrading of the industry and the essential transformation of technological equipment. Through reorganization and restructuring, China should activate the domestic enterprises' operating mechanisms in accordance with the law of the operation of market economy. Through market-oriented structural reform, China should separate government functions from enterprise management, release the flow of capital, increase the domestic enterprises' risk-resisting ability for confronting the WTO's challenges against the energy industry. The energy industry has basically got rid of the restrictions of the planned economy system and is also internally stimulated and pressed to implement reform. However, the task of reform, reorganization and transformation is so arduous that the state should formulate the corresponding guiding policies for achieving the strategic goal of healthy development.

2.6 Make Full Use of the Market Mechanism in Resources Allocation

The supply and distribution of energy sources, the country's important strategic materials, obviously showed the characteristics of mandatory plan in the period of planned economy. The energy industry played the role of both a basic industry and a

cause of the public good in that period. While being encouraged, supported and even protected by the state's industrial policies, it became an industry with stable profit and rich benefits for the staff and workers. In the period of the macroeconomic system's transition towards market economy, the energy industry showed a strong inability top adapt its inherent structural characteristics, reacted against the market-oriented operation of the energy industry and greatly restricted the function of market in optimizing the distribution of resources.

Seemingly the small scale of energy enterprises has been caused by the expedient measures adopted for satisfying the need for rapid growth in supply. The real reasons behind the phenomenon are the narrow-minded policy sentiment of self-balanced energy supply and demand and the territorial division caused by a feudal economy. As big tax payers for the local governments, small refineries, small coking plants, small coal pits and small thermal power plants that are spread everywhere have made historical contributions to the development of local economies but, at the same time, they have become a barrier for the interregional flow and reasonable allocation of essential productive factors. A big aggregate volume is the most essential characteristic of China's energy sources. However, the structure of resources is non-sensual; there are less quality resources but more inferior ones; and most resources are located far away from the consumption centers.

More than 70% of China's exploitable hydropower resources and 39% of China's proved coal reserves are located in west China. However, the degree of energy self-sufficiency in the developed areas in east China is very low and more than 70% of the energy required needs to be supplied from the other areas through long-distance railway or marine transportation, thereby tightening China's transportation capacity and making the final prices of energy abnormally high. China has launched the strategy of western development and implemented west-east power transmission to create conditions for optimizing the allocation of resources in a larger range and forming a unified power grid across China. However, besides the long-term construction and the implementation of preferential policies for increasing economic benefits, another important thing for the implementation of the project is that the eastern market can accept the clean hydropower transmitted to the eastern areas. Therefore, the power market in east China needs to install capacity and provide convenience in price for realizing west-east power transmission. The situation of the coal industry is also quite worrying. Now that the power to administer the key state-owned coal enterprises has been transferred to local governments, these enterprises may still become the accessory of local economies if they do not insist on the separation of government functions from enterprise management, carry out market-oriented reorganization and restructuring and become real business entities. Confronted with the present weakening of market demand, if a local government implements market protection, monopolizes the local market and does not allow the quality coal from the other areas to enter the local market, survival of the fittest among coal enterprises (and the associated removal of inferior coal production) will not be realized. When the market demand becomes strong, a local government may take measures to protect the outflow of coal, so the reasonable flow of resources will again become no realizable. As for the petroleum and petrochemical industry, through the reorganization of the resources and assets of the relevant enterprises, two big companies (based in the south and the north) with integrated operation from the upper to the lower stream have been formed. However, whether the territorially divided

operating mode will lead to regional market monopoly is still a subject pending studies.

One of the goals of the market-oriented reform of the energy industry is to make full use of the market mechanism for optimizing the allocation of resources and maximizing the benefits of allocation. To realize this goal, we must insist on market-oriented structural reform, get rid of the old sense of territorial self-balance in energy supply and demand (local self-balance) and establishing coal mines, power plants and refineries in the local places, base ourselves on the overall situation of China and use the laws and means of market operation for realizing the circulation and flow of resources and funds on the larger perspective. To reach this goal, we must provide correct policy guidance and promote the implementation of the two important resources allocation projects in the energy industry—west-east gas transmission project and west-east power transmission project; and the optimized utilization of coal and petroleum resources.

2.7 The Policies on Energy Consumption must be Consistent with the National Conditions

Different people always have a different understanding of national conditions. Large population, poor foundation and weak economic basis are one part of the national conditions, according to which, China has formulated the policy of plain living, hard struggle and building the country with industry and thrift. Under the guidance of this policy, the whole nation has worked hard, practiced austerity, carried out socialist construction and rapidly lifted China out of the state of "poverty and blankness". The cream of this policy should still play a guiding role in our construction of a socialist country and fighting against duplicated construction and inferior projects. On the other hand, China is advancing towards the third strategic goal for realizing modernization; the overall strength of China has greatly increased; the people's economic lives have seen great changes; the whole nation has basically reached the standard of relatively comfortable life; and the per-capita GDP of some provinces and cities (e.g. Shanghai, Guangzhou, Shenzhen, Beijing and Zhejiang) has reached or approached the level of moderately developed countries. The national per-capita GNP topped USD800 at the end of 2000 and will certainly exceed USD1,000 in the 10^{th} Five-Year Plan period. Foreign experience has proved that at such a stage of economic development a country's economic structure, especially industrial structure, will see fierce changes; the speed of industrial upgrading and the rise of the standard of technological equipment will be very rapid; and information industry and high and new technology will become new growth points. China's accession to the WTO will further integrate China's economy into the global economy, which may make China's economy realize advancement by leaps. At the same time, the people's personal demands for consumption will also see new changes. They will no longer be satisfied with fine foods, low-grade recreational consumption and comfortable living environment. The demands of residents in different economic situations for cultural consumption, travel and a warm environment will be stronger. Therefore, to improve the environment and realize sustainable economic and social development will become a new goal that the people will strive for. Such a situation will lead to new changes in respect of the modes, types and needs of energy consumption. Therefore, to fully understand the new characteristics of China's national conditions and timely adjust the policies restricting and inhibiting energy consumption is necessary for

supporting the adjustment of China's energy strategy and promoting the energy industry's sustainable development.

It should be admitted that some of the policies adopted to restrict excessive energy consumption and inhibit too rapid energy growth in the period when China's aggregate economic volume was small, and rapid growth was needed to achieve the effect of relieving the shortage of energy supply, reducing the waste of energy sources and supporting the effective growth of economy. At present, the energy market has seen great changes; the supply exceeds demand; and the market is in urgent need of structural adjustment. In such a situation, market exploration becomes more important. Demand is one of the three major factors stimulating economic growth. The energy industry's development also needs sufficient demand that can activate the market. By now, the market has been basically activated through the adjustment of some policies, especially the power industry's cancellation of its power to sell the electricity use right, the formulation of some preferential policies for encouraging consumption and the transformation of urban and agricultural power grids. However, the structural adjustment of demand in the whole energy market is still very slow. Our policies on energy consumption should be the policies that encourage appropriate consumption on the basis of opposing waste, insisting on energy conservation and increasing energy efficiency. This is a reorientation under the new national conditions, according to which, we should formulate a set of policies that can guide market demand and is beneficial for the structural adjustment and sustainable development of the energy industry.

3. ANALYSIS OF ENERGY DEMAND AND SUPPLY IN 2010 AND THE TENTATIVE PLANS

3.1 The Situation of Social and Economic Development

According to the predictions made in the Chinese Government's 10th Five-Year Plan and ten-year plan, China's GDP in 2010 will double that in 2000 and the annual average growth rate will be 7.18%. In the 9th Five-Year Plan period, though China's economy experienced the remaining impacts of high inflation in early 1990s, the influence of Asia Financial Crisis in 1997 and the impacts of the extraordinarily serious flood in 1998, China's GDP in 2000 still reached RMB8,900 billion; according to the RMB-USD exchange rate in that year, China's GDP topped USD1,000 billion and the annual average growth rate was 8.3%; the per-capita GDP was nearly USD850; the GDP in 2000 doubled that in 1980 in advance; and the people's living standard basically reached the level of relatively comfortable life. After China's economy reached the peak growth rate of 14.2% in 1992, the growth rates in the following years had dropped year by year by about one percent every year and the growth rate in 1999 was only 7.2%. However, the annual economic growth rate in 2000 rallied to 8% for China's overcoming of the influences of the financial crisis, successful implementation of its financial policy and monetary policy, active expansion of export, increase of investment and stimulation of domestic demand. China's economy has stepped on a track of sustainable development. Because of China's implementation of the policy of coordinated development of regional economies for reducing the gap between east China, west China and central China, especially the implementation of the strategy of west development, there is a very broad space for China's economic development in the next ten years. At the same time, since the persons with low incomes in both rural and urban areas will need to improve their living quality and economic situation, economic development will continuously stimulate the growth of demand. Therefore, according to the trends of China's economic development, though China's aggregate economic volume has reached a certain level, the per-capita level is still very low and the factors that can stimulate rapid economic growth are still very strong. Recently, many domestic and foreign economists and authoritative research institutions have used various methods to predict China's mid-term or long-term development. Most of their conclusions hold that China's annual average growth rate may reach 6-8% in the next ten years. Therefore, the Chinese Government's plan of economic development at an average growth rate of 7.18% may be realized and there is also some leeway left. China's population in 1995 was 1.211 billion. The too rapid growth of population will be effectively controlled. According to the speed of population growth consistent with the country's social and economic development, China's population is expected to reach 1.37 billion in 2010. As for the adjustment of industrial structure, the increase of the proportion of the tertiary industry and the drop of the proportion of the primary industry will lead to the move of rural labor forces towards cities and towns, thereby raising the degree of urbanization and enhancing the strength of energy consumption, especially the consumption of quality energy sources.

3.2 Prediction of Energy Demand

According to the abovementioned situation of social and economic development, this

report puts forth two different energy demand plans to probe into the possible effect of the implementation of the policy of sustainable development for qualifying and analyzing the feasibility of the implementation of the policy.

3.2.1 Conventional Plan (BAU)

The so-called conventional plan is a prediction of energy demand on the basis of the existing technical and economic levels, with no important changes made to the current energy conservation policy and the energy consumption structure remaining consistent with the structure of China's energy resources. It means this plan is based on the domestic energy consumption and the restriction of environmental protection is basically not considered. Generally called as BAU plan in the international fields of energy, this is a basic plan used to compare the energy demands resulting from the implementation of the policy of sustainable development. For this purpose, we need to select the results of energy prediction made in the early period. Therefore, this report adopts the basic results of prediction of energy demands in 2000 and 2001 made by the Energy Research Institute (ERI) with Medee-s model (developed by France Resources Research Institute) for the technical aid program of Asia Development Bank (ADB) in 1994. China's economy was in a period of rapid growth and energy consumption also showed a trend of continuous rise at that time. However, restricted by the people's improper sense, energy consumption was still based on the domestic inferior energy sources, so the energy policy basically saw no changes and especially the sense of environmental protection was weak. The base period of the original report was 1990. The author of this report adopts the actual data in 1995 and has recalculated some data (see Table 2).

Table 2: Conventional Plan of Energy Demand Prediction (BAU)

	Unit	1995 (actual)	2000 (actual)	2010
Annual average growth of GDP	%		9	8
Population	100 million	12.11	13	14
Total energy demand	Gtce	1.31	1.41	2.07
Composition	%	100	100	100
Raw coal	%	74.6	71	64
Crude oil	%	17.5	19.1	21.8
Natural gas	%	1.8	4.1	6.6
Hydropower	%	6.02	5.5	6.7
Nuclear power and others	%	0.08	0.4	0.9
Structure of terminal energy consumption	%	100	100	100
Coal	%	65.6	57	46
Petroleum	%	20.1	19.8	17.6
Natural gas	%	2.6	5.4	7.8
Electric power	%	11.7	17.8	28.6

3.2.2 Comprehensive plan

The comprehensive plan is a prediction of energy demand that can ensure social and economic development in the condition of sustainable development. Through strengthening energy conservation, greatly increasing energy efficiency, reducing the emission of greenhouse gas for environmental protection, making more use of foreign and domestic quality energy sources to improve and optimize the structure of energy supply, this plan predicts the optimized structure of terminal energy consumption.

Table 3: Prediction of energy demand (comprehensive plan)

	Unit	1995 (actual)	2000 (actual)	2010
Annual average growth of GDP	%	8.7		7.18
Population	100 million	12.11	12.48	13.7
Total energy demand	Gtce	1.31	1.32	1.75
Composition	%	74.6	69.6	60.5
Raw coal	%	17.5	21.5	22.2
Crude oil	%	1.8	2.2	7.6
Natural gas	%	6.02	6.6	9.7
Hydropower	%	0.08	0.1	1.3
Nuclear power and others	%	100	100	100
Structure of terminal energy consumption	%	58.3	52.3	35.6
Coal	%	20.1	26.4	23.9
Petroleum	%	2.24	2.5	7.8
Natural gas	%	11.62	13.9	29.6
Electric power	%	7.74	4.9	3.1

3.3 Planning of Energy Development

Prediction of energy output

Table 4 indicates the domestic energy supplies according to the two energy demand plans.

Table 4: Prediction of Energy Demand and Output in 2010

		BAU		Comprehensive	
	Unit	Demand	Output	Demand	Output
Total energy supply	Gtce	2.07	1.82	1.75	1.67
Coal	Gt	1.94	1.89	1.48	1.55
Petroleum	Gt	0.33	0.17	2.74	0.18
Natural gas		1036	595	1000	800
Hydropower	Twh	420	420	575	575
Nuclear power and others	Twh	55	55	75	75
Composition	%	100	100	100	100
Coal	%	64	74.2	60.5	66.4
Petroleum	%	21.8	13.2	22.2	15.6
Natural gas	%	6.6	4.4	7.6	6
Hydropower	%	6.7	7.1	9.7	10.8
Nuclear power and others	%	0.9	1.1	1.3	1.2

3.4 Comparison of the Balance of Supply and Demand

One common point between the BAU plan and the comprehensive plan is that the domestic energy production will be unable to satisfy demand and both petroleum and natural gas will be short of supply and need to be imported. The shortages in the BAU plan are bigger. In the BAU plan, the shortage of petroleum will be 160 million ton and the shortage of natural gas will be 44.1 billion cubic meters, while the shortages of petroleum and natural gas will be respectively 90 million ton and 20 billion cubic meters in the comprehensive plan. The BAU plan is unfavorable for the environment in the aspect that it needs to exploit and utilize about 300-500 million ton of coal, while the comprehensive plan needs less coal. Furthermore, because the coal output is expected to be larger than demand, the excessive part may be used for export. Since the comprehensive plan lays more stress on energy conservation and the substitutive role of hydropower and nuclear power, the demand for petroleum will drop. Though China will still need to purchase petroleum from the international market, the pressure from mass import will be relieved.

From the structure of energy demand and supply indicated in Table 4 we may obviously see that the structure will be optimized to a certain extent, the proportion of coal will drop and the proportion of quality energy sources will rise ten years later. However, when comparing Table 3 with Table 4 we may find that the degree of the optimization of the terminal structure is higher than that of the primary energy structure.

3.5 Conclusion

1. According to the State Statistics Bureau's preliminary statistics, the total energy consumption in 2000 was equal to 1.22 billion ton of standard coal. On the basis of the said figure, the annual average growth rate of energy consumption in 2001-2010 is expected to be 3.67%; the annual average growth rate of GDP will be 7.18%; and the elasticity coefficient of energy supply will be 0.51%; and the elasticity coefficient indicated in the conventional plan (BAU) made in 1994 is 0.49. Thus it can be seen that the

relationship between energy supply and demand in the comprehensive plan is quite flexible. Especially the demand will decide production and supply in the coal market.

2. The comprehensive plan will need to consume 3.2tce more energy sources (including 460 million ton of coal and 600 million ton of petroleum) in 2010 in comparison with the BAU plan. Only the two types of fossil fuels will additionally discharge 248 million ton of carbon dioxide and 50 million ton of carbon (total 298 million ton of carbon). In 1995, the volume of carbon dioxide discharged by China in 1995 was equal to 819 million ton of carbon (determined by APEC in September 1998). According to the comprehensive plan, the volume of carbon dioxide discharged for the utilization of fossil fuels will be equal to 1.105 billion ton of carbon in 2010, which means the volume will rise only by 293 million ton in 15 years; however, according to the BAU plan, the volume will rise by 591 million ton and reach 1.491 billion ton of carbon. APEC predicted (September 1998) predicted that the volume of carbon dioxide discharged by China in 2010 would reach 1.7 billion ton of carbon, while the US Energy Agency and the International Energy Organization (1999) predicted the volume would be 1.39 billion ton of carbon. Both of their predicted figures are higher than that predicted in the comprehensive plan. Therefore, if the energy plan can be really implemented under the guidance of the policy of sustainable development, the influences of energy exploitation and utilization on the environment will be reduced and the development of China and the change of global climate will be benefited.

3. As for the main policy measures to be adopted for implementing the plan, we must strengthen energy conservation and the development of domestic quality energy sources. For the restriction of the conditions of resources, it's difficult to greatly increase the output of petroleum. However, the exploitation of natural gas is just unfolding. We should speed up the development of gas fields in west China and offshore gas fields. We should also vigorously develop hydropower and nuclear power and use renewable energy sources to generate electricity and safely and stably increase the volume of petroleum import. According to the comprehensive plan, China is expected to import about 90 million ton of petroleum in 2010, accounting for 33.3% of China's petroleum consumption in the same year. According to the BAU plan, China will need to import 160 million ton of petroleum, accounting for almost a half of the total petroleum consumption. The huge import will inevitable increase China's economic burden and is also very unsafe. To reduce the volume of petroleum import, we must actively promote the conservation of petroleum and use electricity and gas to substitute petroleum.

4. China's exploitation and utilization of coal will play an important role in energy consumption and supply in a considerably long term. To change coal into electric power and implement clean coal utilization is an important choice for the sustainable development of the coal industry. Therefore, the output of coal rises rather than drops in the plan, which is necessary for China to give full play to its advantage in coal resources and expand export for promoting economic growth.

4. SUGGESTIONS ON THE ADJUSTMENT OF THE POLICY ON THE SUSTAINABLE DEVELOPMENT OF THE ENERGY INDUSTRY

When researching and formulating the plan of energy development in the 10th Five-Year Plan period, China has made extensive and in-depth studies on the policies related to the energy industry. On the basis of the goal of energy development decided by the government, we put forth the following suggestions on the further implementation of the sustainable development-oriented energy policy.

4.1 Enhance the Adjustment and Reform of the Traditional Energy Industry

China should give the first priority to the reform and adjustment of the traditional energy industry in the 10th Five-Year Plan period, with the focus laid on increasing the energy sector's efficiency in energy exploitation and utilization and further adjusting the orientation of the use of coal. While laying particular stress on energy conservation, China should transform the low-efficiency and high-consumption equipment, increase the productivity and quality of the industry and reduce the consumption of materials and energy sources. As a major energy source, coal will still be developed in the future. However, the emissions of such pollutants as SO_2 and NO_x should be minimized and such clean energy sources as natural gas and coal bed gas should be used as fuel or raw material in partial replacement of coal. The key policy suggestions are as follows:

(1) The standard of economic scale should be formulated for newly built energy projects. For example, the unit capacity of thermal power sets should be no lower than 300 thousand KW and sub-critical and super-critical power sets should be adopted so far as possible; the capacity of each set of ethylene equipment should be more than 600 thousand ton; and no coal mines that cannot reach the standard of economic yield and whose coal has high sulfur content should be built. The progress of using big production units to replace small ones should be accelerated and the policy of closing down small thermal plants and small coal mines and building big thermal power plants and big coal mines at the same time should be strengthened. The small enterprises to be closed down should be sold through auction, so these enterprises can use the incomes to make shift in production and arrange the laid-off workers.

(2) The existing energy enterprises should be encouraged to enhance the efforts of technological transformation, transform the old equipment and processes, increase technology content and add environmental protection facilities, with the focus laid on energy conservation and increasing energy efficiency.

(3) Coal should be mostly used for thermal power generation. The coal industry should unceasingly increase the quality of the coal used for power generation and reduce sulfur content. In respect of clean coal utilization, the country should mainly propel coal liquidation to advance from demonstration to

industrialized production and operation. The subsidies for the coal industry and the refunded VAT may be used to support coal liquidation.

(4) Using natural gas and coal bed gas as fuel and chemical raw material in replacement of coal should be encouraged.

(5) Post transfer and training of employees from the traditional energy enterprises should be supported.

4.2 Enhance the Efforts of Support the Exploitation and Utilization of Domestic Quality Energy Resources

The existing structural barriers should be broken to enable various quality energy sources to participate in fair competition in the market. In this aspect, China should promote the structural reform of the energy industry in conformity with the requirements of market economy and formulate investment and finance policies that can promote the optimization of the structure of energy supply. For example, China may sell some state-owned energy enterprises and use the income as the fund for adjusting its structure of energy supply, supporting the development of clean coal technology and new energy sources, the construction of environmental facilities for power stations, the import substitution of advanced energy equipment, the popularization of important energy conservation technologies, the development of hydropower and energy construction in the central and western parts of China. China should strengthen the policy of internalizing environmental cost, encourage the production of quality energy sources and guide the use of quality and efficient energy sources and the adoption of advanced production equipment. In respect of petroleum and natural gas, China may implement preferential tax policies on the old oil fields that are in the later period of development and reform the policy on the pricing of natural gas according to the need of the development of market economy.

4.3 Actively Introduce and Use Foreign Petroleum and Natural Gas Resources

China should carry out macro-regulation to the use of foreign petroleum and natural gas resource, amend the policies on the petroleum and natural gas industry and, by such policy means as financial control and taxation, guide petroleum enterprises to economically and reasonably develop the domestic petroleum and natural gas resources. China should also encourage the expanded use of international resources through establishing an overseas petroleum prospecting and exploitation fund and an investment-encouraging system and formulating policies on insurance for overseas investment in petroleum exploitation.

The existing petroleum product import management method should be reformed and the three major petroleum companies should be allowed to independently decide the method, type and time of petroleum import. China should also speed up the domestic petroleum companies' transition towards a transnational operating mode that integrates the upper stream with the lower stream and combines domestic trade with foreign trade.

4.4 Enhance the Efforts of Policy Support and Promote the Development of Renewable Energy Sources by Leaps

(1) The policy of clarifying the goals of the development of new and renewable energy sources and expanding market shares. Whether new energy and renewable energy sources can be industrialized is dependent on the government's goals and policy environment to a great extent.

(2) The policy of promoting the industrialization of new energy sources. When formulating policies on the development of new and renewable energy sources in the past, China has only regarded new and renewable energy sources as supplementary energy sources used to make up the shortage of commodity energy supply in rural areas and the remote areas with backward economy. To promote the development of new and renewable energy sources, China must adjust its concept and treat new and renewable energy sources as follow-up energy sources and one of the basic energy sources in China's diversified energy structure. The main measures include the following: China should include the industrialization of new and renewable energy sources into the future social and economic development plan and the country should offer support in finance; China should launch new and renewable energy sources industrialization projects at the appropriate time; and hydropower generation, subterranean power generation and localized production of solar photovoltaic batteries and solar heat collectors should be encouraged to reduce costs and expand market shares.

(3) The regional priority order for the development of new and renewable energy sources should be changed. It means that the policy of encouraging the development of new and renewable energy sources for making up the energy shortage in rural areas and remote areas should be changed into the policy of formulating mandatory rules and regulations to promote the development of new and renewable energy sources in the selected areas with good conditions of resources and developed or moderately developed economies. For example, a quota system for power generation with renewable energy sources may be implemented by means of making experiment or demonstration first and expanding the range of experiment then.

(4) For the popularization and utilization of new and renewable energy products featured by big volume, large areas of distribution and certain commercial foundations, the government should encourage the establishment of non-profit-oriented consultation organization for providing the users with intermediary consultation service. In addition, China should establish and perfect the standard and service system, strengthen information and talent training, encourage international cooperation and the introduction of advanced technologies and funds from foreign countries.

4.5 Establish an Energy Conservation Policy System under the Market Mechanism

The government should guide energy conservation in policy and provide excellent

service to enterprises and the public for realizing the essential improvement of the energy conservation system. The particular measures that may be adopted include to strengthen propaganda on energy conservation for increasing the citizens' sense of energy conservation, to carry out macro-regulation of energy conservation by means of price control and taxation, to strengthen the spreading of information about energy conservation and the popularization of energy conservation products, to propel the establishment of energy conservation service companies for serving enterprises and the public in respect of energy conservation through leasing, consultation and intermediary service and to do a good job of the improvement and amendment of the laws, rules and regulations supplementary to the Energy Conservation Law for making the law more consistent with the market operation system.

4.6 Make the Relevant Polices Standardized and Institutionalized

Energy policies should be divided into guiding policies and mandatory policies according to their effects.

The standardization and institutionalization of policies are very important for strengthening the country's implementation of the policy on the sustainable development of the energy industry. The strategic restructuring and reform of the energy industry should be carried out under market environment. However, only guidance by the market is insufficient and normative documents and even laws and rules must be available for adjusting the social and economic relations among various parties. Second, the legal status of the implementer and the rules of market operation must be clarified and standardized for realizing orderly operation according to law. Third, the relations and ranges of many adjustments must be clearly defined. For example, what is big and what is small concerning the issue of "using bit to replace small" and what is the range of the energy efficiency indexes of some equipment? If such questions are not clearly answered, the range involved will be unclear and one will be unable to check the effect of implementation.

The position of new energy sources and renewable energy sources should be legally defined at present. They should be treated as one of the follow-up energy sources and basic energy sources in the 21st century rather than only supplementary energy sources. The relevant legislation should be taken into account and, like treating coal, electric power, petroleum and energy conservation, we should clarify the legal position of new and renewable energy sources and the relevant legal relations.

Mandatory policies are also necessary for the country to eliminate small thermal power plants and to close down the small coal pits that carry out mining in a disorderly way and the small refineries and small coking plants that incur damage to both resources and the environment.

In addition, as to the quota system for power generation with new and renewable energy sources and the policies on the sales of the small enterprises to be closed down, normative documents are also necessary for guiding the particular market operation.

Of course, administrative laws, rules and normative documents are even more necessary for the policies on the energy industry's structural reform.

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