# Overview of the National Energy Strategy

Energy is a key component of China's overall economic development and must not be overlooked as the country implements coordinated and sustainable policies geared at fostering that development. The fact that energy governs the majority of economic developmental trends is the biggest challenge facing China in the short and long terms. The first two decades of this century will be an important strategic period resplendent with opportunities for the Chinese nation to realize a great resurgence. Many unexpected changes will likely take place in the world's economic and social spheres, while the energy realm itself also faces many challenges; such as whether China's energy supply can meet the needs of its economic growth and social progress, and whether China can blaze a trail for energy's sustainable development with Chinese characteristics, which, to some extent, depends on the formulation and implementation of a correct medium to long term energy developmental strategy aimed at the year 2020.

Under market economy conditions, the function of a medium to long term strategy for China's energy development should embody the following four goals: (1) Coordinate energy resource projects; (2) Work out government fiscal budgets based on these projects; (3) Use them on a legislative basis; and (4) Improve the executive administration related to the energy industry.

## I. China's Energy Development

Over the last 20 years, China's achievements in the energy realm have caught the attention of the world, and laid a strong foundation for its energy industry. China's industrial aggregates of coal, electricity, and petroleum currently rank first, second, and fifth, respectively, in the world. To secure the needs of future economic development, address the energy use for farmers in rural areas, reduce the dependence of the economy on energy, and improve energy efficiency and environmental protection, China has realized the following achievements:

### A. Energy consumption has only doubled while gross domestic product (GDP) has quadrupled.

Consumption of primary energy amounted to 1,480 Mtce in 2002, ranking second in the world. While China's GDP increased by 9.7 percent in the period from 1980 to 2000, average annual energy consumption only rose by 4.6 percent, far below the economic growth rate in the corresponding period. All together, about 1,260 Mtce was saved between 1981 and 2002, which met the country's goal of supplying enough energy to sustain healthy economic growth: half through exploitation and half by saving. China's elasticity coefficient of energy consumption was only up to 0.47 (see Table 1).Such a low coefficient is rare, not only in developing countries and but in developed countries as well.

### B. The energy utilization rate has been greatly improved.

Energy consumption per unit GDP has continuously decreased. Energy consumption per ten thousand RMB, calculated in the prices of 2000, decreased from 4.28 TCE in 1980 to 1.45 TCE in 2000 (see Fig. 1 attached for details). Accordingly, GDP per ton of coal equivalent rose from 2,335 RMB in 1980 (according to the year 2000's prices) to 6,880 RMB in 2000. The energy consumption per unit output was reduced by 64 percent with an average annual conservation rate of 4.6 percent during the 20 years (1980-2000). The world

average energy consumption per unit output fell by 19 percent in the corresponding period. OECD member countries saw an average drop of 20 percent. Furthermore, energy consumption per unit product has dropped considerably in major high energy-consuming sectors (such as metallurgy, chemicals, building materials, petrochemicals, and power). General energy consumption per ton of steel, copper metallurgy, compound ammonia and oil consumption of internal-combustion engines fell by more than 30 percent; narrowing China's energy consumption gap for major energy-consuming products within the international advanced level. For example, coal consumption for thermal power generation has decreased from 32.5 percent in 1980 to around 20 percent[1] today, while the comparable energy consumption per ton of steel has also dropped from 70.4 percent in 1980 to approximately 10 percent today[2].

**C. Great achievements have been made in environmental conservation.**

During the period from 1981 to 2002, China saw its carbon dioxide emissions and sulfur dioxide drop by 770 million tons, and 19 million tons, respectively, due to energy conservation and an overall reduction in energy use. Since the 1980s, energy projects (gas, small hydropower) and energy-saving technologies have been established in rural areas according to their local characteristics. Energy efficient buildings in urban areas have been erected. New types of energy such as solar, wind and geothermal are being developed and utilized. These energy-saving measures have resulted in a reduction of 30 Mtce of conventional commodity energy, which is roughly equivalent to 20 million tons of carbon dioxide emissions each year. China is definitely on the sustainable development path.

Basic experiences that brought about China's energy development progress are:

Industrial structure reform has resulted in structural changes.

Phenomenal changes have taken place in China's industrial structure in the past twenty years, especially in the industrial sectors consuming mostly primary energy (the proportion of energy consumption by industrial sectors to the nation's total energy consumption remained at about 70 percent in the 1990s). These structural changes have produced obvious energy-saving results. The proportion of low value-added and energy-intensive industries has dropped, while the proportion of high value-added and energy-saving industries has increased. For example, the metallurgy industry has decreased in proportion while the proportion of electronics and communications equipment manufacturing has risen. Product and technical structures have been upgraded. According to calculations, more than the 70 percent of the saved or reduced energy came from this restructuring of industries and products.

Economic institutional reforms have triggered significant systematic changes.

New waves of economic reforms have changed the resource allocation approach adopted during the planned economy. The market mechanism has played a fundamental role in resource allocation. Extensive economic growth has gradually evolved. The efficiency of energy production and utilization has been improved by market incentives which accelerate the elimination of high energy-consuming and material-consuming enterprises, products and technologies. A significant example is the reform of the energy pricing system. Energy pricing reform evolves from **(1)** mandatory pricing by the government, to a **(2)** combination of the government pricing and market pricing, then **(3)** gradually deregulating pricing in the

[1] In 2002, China's coal consumption for power supply by thermal plants was 383g of coal equivalent

[2] Comparative energy consumption per ton of steel in key iron and steel enterprises is 709kg of coal equivalent.

market so that prices are determined by supply and demand, and the pricing mechanism plays an adjusting role in the supply and demand matrix for the energy products.

The implementation of energy-specific energy policies has brought about significant policy changes.

China's government has employed laws, policies, standards, and economic and administrative tools to promote energy conservation and optimize the energy mix. The guideline for energy development in 1980 "emphasizes both development and savings derived from energy and saving as the priority in the short term." Along with other laws and regulations, China has promulgated and implemented The Law of Coal, and the Law of Electricity. As for energy supply, China carried out such policies as "doing what is appropriate in the light of local circumstances; comprehensive and multipurpose use; mutually complementary in many kinds of energy resources;" and "pursuing energy efficiency". As to energy supply, the government adopted the projects of "Generating Power by Pooling Capital" and "Managing Mines by Non-Government Entities" to boost energy supply and alleviate severe energy shortages. Efforts were made to supply rural areas with electricity by establishing small hydropower projects to reduce the number of people who had no power to consume from 450 million in 1978 to 28 million in 2000.

Yet, that still leaves two billion people in the world without electricity. On the other hand, the Chinese government has integrated energy conservation into our national economy and social development plan, while creating a relatively complete system of managing these energy-savings. The Energy Conservation Law was passed in 1997, and has since formulated and implemented 164 state standards for energy-savings. Since the 1990's the government has set a series of new development goals such as improving the ecological environment, achieving sustainable development, and realizing a new type of industrialization. A series of plans and pilot projects have been organized and carried out (e.g. developing green energy, and promoting energy-saving products and techniques).

These were the result of industrial policies that limited and eliminated high materials-consuming, energy-consuming, and polluting products, technologies, or enterprises, while establishing emissions fees and capital control systems to improve the country's environmental quality. New mechanisms and methods that fit into the market economy have recently been under discussion. New concepts and methods have been gradually introduced through demonstration and promotion. These include the "Integrated Resources Planning (IRP)", "Demand Side Management (DSM)", and "Energy Services Company (ESCO)".

Yet, in China, energy efficiency still has a long way to go. Environmental pollution has not been fundamentally controlled. The irrational energy structure, which exists in the long term, has not been improved. The extensive growth of the economy will be difficult to sustain. If things go on like this, China's heavy economic dependence on energy will result in unsustainable economic development.

## II. Challenges to China's Energy Demand

The first 20 years of this century will be a strategically important period posing both opportunities for and challenges to China's economic and social development. The 16$^{th}$ National Congress of the CPC has made the quadrupling of GDP by 2020 a national goal; stating that it wants to "build a well-off society in an all-round way." Calculated on the basis of purchasing power parity (PPP), China's per capita GDP will surpass USD $10,000 by then. According to international experience, these 20 years are a key period for realizing

industrialization and comprise an important phase in which significant changes could take place in the economic structure, urbanization level, and the population's consumption structure. In recent years, these changes have been foreshadowed to various extents.

First, China's economy has expanded into an era characterized by heavy chemical industries. Since 2002, China's economy has entered a new phase of high-growth, while increasingly displaying the characteristics of its heavy chemical industries. The ratio of heavy industries in the entire industrial sector has been growing over the years and has already exceeded 60 percent (this figure reached 60.9 percent and 64.3 percent in the years 2002 and 2003, respectively). The formation mechanism in this heavy chemical industry stage is mainly due to medium and long term factors such as the upgrading of residential consumption structure and the speeding up of both the urbanization process and infrastructure construction, which means that the heavy chemical industry era will continue for quite a long period. Furthermore, future economic growth will have a higher demand for energy than the period dominated by light and textile industries. If energy efficiency levels in these industries are not significantly improved, economic growth will depend too highly on energy supply.

Secondly, the urbanization process is accelerating. In 2003, China's urbanization rate was 40.3 percent; 10 percent lower than the global average and 15 percent lower than other countries with the same income level. In the future, the urbanization process will quicken in China and reach about 55-60 percent in 2020. At the present, annual energy consumption per capita in cities is 3.5 times that of rural areas. Even if the urbanization level increases by 1 percent every year in the first twenty years of this new century, China will still see its urban residents increase by at least 13 million every year, signaling a significant newly-added demand on energy.

Finally, China is becoming a major manufacturing base for the world. Since China is at the lower end of the international division of labor, the majority of the country's imports are high value-added products and services, while exports are mostly products by common manufacturing industries. Energy consumption per unit value of imports is different from that of exports, which actually causes international transfer of energy demand. Under such an import and export structure and along with the inevitable increase of import and export volume, it is difficult to buck the trend that energy demand is transferred toward China in the short term.

This economic trend has medium and long term implications which will continue into the first twenty years of this century. Like many developed countries, China must go through the process of its energy consumption per capita increasing quite quickly (especially when GDP per capita is between USD $1,000 to USD $6,000), and its energy structure changing rapidly (e.g. the ratio of petroleum demand picks up). Seeing as how China is a populous country with an insufficient resource possession per capita, and is in the midst of economic globalization coupled with stringent environmental protection, China's situation is more complex than the challenges faced by other developed countries. Moreover, rapid growth of energy demand in China will exert increasingly greater influence on the international energy market. As a result, China's energy issues have become hot issues in international political and diplomatic realms.

How much energy does China need in building its well-off society while supporting its economic and social development objectives? And the challenges and pressures China must face will depend on both the laws of economics and social development, as well as the types of economic, energy and environmental policies the government adopts. To illustrate the demand for energy and its social effects by adopting different policies, we set up three scenarios.

In Scenario A, the Business as Usual Scenario, no special policy measures are taken to greatly affect energy demand and bring about social benefits.

In Scenario B, the related policies will be adjusted accordingly.

In Scenario C, the Advanced Policy Scenario, a greater policy adjustment will highlight the influence of economic, energy and environmental policies under the prerequisite that these policy adjustments are feasible.

What should be explained here is that existing policies cannot be used even under Scenario A. Consideration should be given to both the sophistication of relevant policies in force in the sectors of industry, transportation, construction, and energy transformation, and the implementation of the policies in contemplation (see Table 1 for detailed policies). The only difference between Scenario A and the other two Scenarios is the time taken to implement the policies under consideration. Please see the attached Table 2 for the difference in policies adopted by different Scenarios.

Table 1 shows the total demand for primary energy, and the energy mix under the three scenarios. Table 2 gives the demand for coal, oil, and natural gas under the three scenarios.

Table 1. Comparison of total demand for primary energy and its composition

| **Scenarios** | **Type** | **Total Demand for Energy（Mtce）** | | | **Annual Growth Rate** | **Composition (%)** | | |
|---|---|---|---|---|---|---|---|---|
| | | 2000 | 2010 | 2020 | 2000~2020 | 2000 | 2010 | 2020 |
| **A** | Coal | 907 | 1425 | 2074 | 4.22% | 69.9% | 66.7% | 63.2% |
| | Oil | 324 | 538 | 877 | 5.10% | 25.0% | 25.2% | 26.7% |
| | Gas | 36 | 112 | 220 | 9.44% | 2.8% | 5.2% | 6.7% |
| | Primary power | 29 | 63 | 109 | 6.77% | 2.3% | 2.9% | 3.3% |
| | Total | 1297 | 2137 | 3280 | 4.75% | 100.0% | 100.0% | 100.0% |
| **B** | Coal | 907 | 1365 | 1788 | 3.45% | 69.9% | 66.0% | 61.7% |
| | Oil | 324 | 524 | 795 | 4.58% | 25.0% | 25.3% | 27.5% |
| | Gas | 36 | 108 | 193 | 8.74% | 2.8% | 5.2% | 6.7% |
| | Primary power | 29 | 70 | 120 | 7.28% | 2.3% | 3.4% | 4.1% |
| | Total | 1297 | 2068 | 2896 | 4.10% | 100% | 100% | 100% |
| | Coal | 907 | 1205 | 1466 | 2.43% | 69.9% | 64.8% | 59.4% |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **C** | Coal | 907 | 1205 | 1466 | 2.43% | 69.9% | 64.8% | 59.4% |
| | Oil | 324 | 460 | 638 | 3.44% | 25.0% | 24.7% | 25.9% |
| | Gas | 36 | 115 | 219 | 9.41% | 2.8% | 6.2% | 8.9% |
| | Primary power | 29 | 79 | 144 | 8.26% | 2.3% | 4.3% | 5.8% |
| | Total | 1297 | 1859 | 2466 | 3.26% | 100% | 100% | 100% |

Note: Power is calculated by electrothermal equivalent, Mtce means million tons of coal equivalent.

Table 2. Demand for coal, oil, and natural gas under the three scenarios

| | **Scenario** | **2000** | **2005** | **2010** | **2020** |
|---|---|---|---|---|---|
| **Coal** （100 million tons） | **A** | 12.7 | 16.2 | 20.0 | 29.0 |
| | **B** | 12.7 | 16.2 | 19.1 | 25.0 |
| | **C** | 12.7 | 15.2 | 16.9 | 20.5 |
| **Oil** （100 million tons） | **A** | 2.3 | 2.9 | 3.8 | 6.1 |
| | **B** | 2.3 | 2.9 | 3.7 | 5.6 |
| | **C** | 2.3 | 2.7 | 3.2 | 4.5 |
| **Natural gas** （100 million cubic meters） | **A** | 272 | 399 | 840 | 1654 |
| | **B** | 272 | 406 | 811 | 1453 |
| | **C** | 272 | 445 | 863 | 1645 |

We may draw the following conclusions from the above forecasts:

1. **China can keep energy demand growth at a relatively lower rate for the next 20 years if the right energy strategies and related policies and measures are taken.**

The demand for primary energy will reach 2,500-3,300 Mtce by 2020, with an average of 2,900 Mtce; 2.2 times that of the year 2000. This means that China may achieve sustainable rapid growth with relatively less use of energy, while further improving people's living standards by using less energy consumption per capita than that of existing developed countries.

2. **While maintaining the same economic growth, there would be difference in energy mix and energy efficiency improvements, due to different policy**

**measures adopted, resulting in a different amount of demand for primary energy, possibly as low as 800 Mtce by 2020.**

That is to say, although all scenarios meet the economic development objectives, different energy development strategies may produce completely different results in the energy supply, energy security, and environmental protection arenas.

**3. With the improvement in living standards and improvements in the consumption structure, significant changes will occur in the energy demand mix, especially in the transportation and industrial sectors.**

The growth rate of energy demand for construction will be higher than that of the industrial sector and all of society in the corresponding period. The proportion of energy consumption by these two sectors will increase from less than 35 percent at present to 57-75 percent of the total by 2020, gradually becoming the major factors demanding energy growth. Therefore, more attention should be given to the energy supply and energy efficiency of these two energy-consuming sectors with rapid growth, as well as the problems of oil security and environmental protection.

On its road to building a well-off society, China will face a series of challenges in the energy realm:

**First, a sustainable supply of resources faces increasing pressure.** China is one of the few countries (including South Africa and India) in the world that mainly depend on coal. Coal comprised 67.9 percent of China's primary energy consumption structure in 2003, 41.5 percent higher than the global average, and 46.5 percent higher than OECD member countries. Viewed from a global perspective, especially pertaining to developed countries' energy development processes, secondary energy reform (replacing fire wood with coal and coal with petroleum) has been completed, and now the third stage of reform involving the diversification of a country's energy supply mix is underway. The future trend is the substitution of fossil energy with renewable energy. China has just completed its primary energy reforms and is evolving into the second stage where petroleum and natural gas develop rapidly. A diversified energy structure has yet to take shape.

Looking at the country's reserves of fossil fuel, exploitable reserves per capita in China is far below the global average. China currently has 2.48 tons of petroleum, 1408m$^3$ of natural gas and 89 tons of coal per capita, which only accounts for 10, 5, and 57 percent of the global averages, respectively. China's petroleum output will not increase considerably, and is estimated to be around 180~200 million tons by the year 2020, after which time it will drop gradually. Although China boasts rich reserves of coal, they are not all verified. At the present, China has exploitable coal reserves of 188.6 billion tons and untouched scrutinized reserves of 61.8 billion tons; among which 90 percent are distributed in the central and western regions under severe natural conditions, vulnerable ecologies and far away from consumption centers, which implicates aggravated difficulties in development, transportation and utilization. Moreover, there are only 30 billion tons[3] among the untouched scrutinized reserves suitable for building large and medium sized mines. If China's authorities want to build new mining facilities with annual output capacities of up to 1 billion tons by 2020, they still need scrutinized reserves of 100 billion tons, hence, a huge plausibility gap.

**Second, while economic and social development depends heavily on energy, it is more difficult today than 20 years ago to improve energy efficiency, despite a huge potential.**

[3] Coal Industry Association, China Coal, Feb. 2004

China's economic and social development depends more heavily on energy than developed countries. End use energy consumers in China spent 12,500 RMB on energy consumption in 2001, comprising 13 percent of total GDP, while consumption in the U.S. was only 7 percent. From the perspective of energy utilization efficiency, the energy consumption per unit product in China is relatively high[2]. At present, the energy consumption per unit product in eight high energy-consuming sectors, where energy consumption makes up 73 percent of the total energy consumption of industrial sectors, is 47 percent higher than that of the world average advanced level. Compared to the international advanced level, China's industrial sectors consume an additional 230 Mtce.

From the above scenario analysis we can see that **the possibility exists to reduce consumption by 800 Mtce by 2020.** Yet, it will be more difficult than it was in the past 20 years to achieve this goal in the future. The positive results in energy conservation achieved by economic system reform and restructuring in the past 20 years mean there is great potential to tap in the future. However, with the arrival of heavy chemical industries and the transferring of international manufacturing; workable policies and measures must be carried out that address the economy, energy, and environment to achieve a remarkable success.

**Third, China faces relatively bigger pressures and more challenges to maintain sustainable economic development, especially in meeting environmental demands for a well-off society.** China cannot avoid implementing control over pollution. Take air pollution as an example. China's emissions of carbon dioxide and sulfur dioxide rank first and second in the world, respectively. Although the carbon dioxide emissions per unit GDP is obviously declining, (a drop of 52 percent from the year 1990 to 2001), total $CO_2$ emissions increased from 349 million tons in 1980 to 832 million tons in 2001. Sulfur dioxide emitted by coal burning is the main cause for acid rain. Acid rain in the mid 1990's affected over one million square kilometers more than it did in the 1980s. Regions with an annual average rainfall registering a PH value below 5.6 make up 30 percent of the nations total number of areas. Serious environmental pollution has caused high economic and environmental costs, and brought about great damage to public health. Statistics by domestic and foreign research institutes show that the losses caused by air pollution comprise 3 to 7 percent of the GDP. The main reason for such serious air pollution lies in the fact that China uses coal as a major fuel in its energy mix, and no effective measures have been taken to protect the environment. 70 percent of CO2 emissions, 90 percent of $SO_2$ emissions, and 67 percent of NOx emissions come from coal. In addition, pollution is becoming even more serious due to the increasing number of vehicles. According to the analysis of the energy demand scenarios, the estimated sulfur dioxide and NOx emissions by 2020 is shown in Table 3 based on the present levels.

[4] Comparing energy intensity (energy consumption per unit GDP) between countries, there will be great deviation due to the currency conversion. If calculated with nominal exchange rate, China's energy intensity in 2000 was 9.7 times that of Japan, and 3.4 times the world average level, which shows that China's energy intensity was overestimated. If calculated with purchasing power parity, China's energy intensity was just 20% higher than that of Japan and even 8% lower than the average level of OECD member countries, which shows obvious underestimate. Therefore, we choose energy consumption per unit product as the base for comparison.

Table 3. Estimated Sulfur Dioxide and NOx Emissions

| | **Scenarios** | **2000** | **2010** | **2020** |
|---|---|---|---|---|
| Sulfur dioxide (10 thousand tons) | A | 1995 | 3174 | 3945 |
| | B | 1995 | 3040 | 3401 |
| | C | 1995 | 2680 | 2789 |
| NOx (10 thousand tons) | A | 1890 | 2846 | 4061 |
| | B | 1890 | 2727 | 3501 |
| | C | 1890 | 2467 | 2870 |

From the perspective of environmental capacity, the air quality in most cities across the country should be up to state Class 2 standards, $SO_2$ emissions must be kept under 12 million tons or so[5]; NOx emissions should be under 18 million tons by 2010 and 16 million tons by 2020, respectively. And these citerion are the lowest standards required by the "environmental well-off standard." However, as shown in Table 3, an environmental "deficit" already exists. **$SO_2$ and NOx emissions have exceeded environmental capacity, even under Scenario C with the least amount of emissions pollutants. To meet today's requirements, the two pollutants should be reduced respectively by 15.89 million tons and 12.70 million tons, decreases of 57 and 44.3 percent, respectively.** Furthermore, if we look at Scenario A, which teems with much more pollutants, then there would be an even more serious air pollution problem. In addition, carbon dioxide emissions will increase considerably. China is under increased pressure from international circles to limit its greenhouse gas emissions. In light of international experience and China's potential, it is not impossible to reduce environmental pollution considerably and meet the environmental requirements for a "well-off" society while maintaining economic growth and energy development. However, this will be a great challenge.

**Fourth, it is imperative to maintain energy security, especially in the oil industry. Serious issues may arise if improper measures are taken.** With the rise of income per capita, China will inevitably face two issues: **(1)** The evident increase in oil consumption; and **(2)** the large quantity of imported oil to meet domestic needs due to limited domestic oil resources. These problems have already emerged. China has been a net import country of oil since 1993, and its dependence on foreign oil had risen from 7.6 percent in 1995 to 31 percent in 2000. **Oil consumption will reach at least 450 million tons by 2020, at which time China's dependence on imported oil might be close to 60 percent, equal to the level of the U.S. today (In 2003, U.S. dependence on foreign oil was 66.2 percent).** The fact that most of China's oil supplies come from international sources will influence the supply and demand in the international oil market, and will make China's oil supply a prominent security issue. Chinese government and enterprises will need to learn: **(1)** how world events impact oil security, **(2)** how to fully utilize domestic and foreign resources, **(3)** how to establish early warning and contingency plans, **(4)** how to take part in an

[3] Only the capacity of sulfur dioxide was taken into consideration here based on the control of acid rain.

international cooperative framework that may facilitate the safeguarding of China's oil security, and **(5)** how to improve the competitive strength of Chinese oil enterprises to compete in the international markets. In addition, the Chinese government also needs to guarantee the supply security of power and natural gas, another facet of energy security.

## III. A sustainable energy development strategy is critical in this period

The goal of building an overall well-off society requires high demands on energy supply and its supply quality. Adopting the right energy strategy ensures energy supply, solves outstanding problems, and can meet challenges in the future. Two strategic issues for China's future development exist: (1) from the perspective of energy development trends in the world, especially developed countries, there is no doubt that the energy supply will shift from the current age of diversified energy to that of renewable energy; gradually realizing the substitution of fossil fuel. It is estimated that by 2060 the percentage of renewable energy taking up the primary energy consumption will reach 50 percent. Though the realization of this objective will take a considerably long time, this development trend has shown its first indications and will become a strategic problem that must be solved by developed countries. We can learn by watching this global energy development trend whether China will be able to incorporate it and implement a leapfrog strategy in the energy realm. (2) From the perspective of China's future development in the long term---although it is still possible to achieve the goal of quadrupling the GDP in the first 20 years of this century while only doubling energy consumption--- excessive dependence on fossil fuels (especially coal[6]) over time will severely weaken China's sustainable energy development.

In the first half of this century, China will strive to realize its target of sustainable development in its energy sector within three 15-year periods. Specifically, energy consumption will double by the year 2020 (the first 15 years) to support quadrupled economic growth, while changing the status quo of extensive growth, realizing basically intensive use of energy, and trying to blaze a trail for coal development and utilization with Chinese characteristics.
Diversified energy development will roughly take shape by 2035 (the second 15 years) as China significantly changes its energy structure by ending its excessive dependence on coal and laying the foundation for renewable energy to realize full-scale development.

Sustainable energy development is roughly achieved by 2050 (the third 15 years). Newly added energy demand is mainly quenched by new resources, such as renewable and nuclear energy. Their overall utilization in the energy mix will rise above 30 percent as far as possible. Hydrogen fueled vehicles will constitute an integral part of the transportation sector. In order to realize the government's long-term energy development targets, the first twenty years of this century are a crucial period when China's energy strategy must focus on realizing and developing its long-term targets to truly achieve the "transformation" of the development mode. China will try to establish a new development mechanism in the next twenty years to pave the way for future development.

This transformation should include the following four aspects:

**First,** achieving the goal of building an overall well-off society requires a shift from simply meeting the basic requirements of economic development to meeting the dual purpose of

[6] China's coal consumption takes up 32.6% of the global consumption in 2003.

achieving environmental benefits while satisfying the basic needs of realizing the coordinated development of China's economy, society and environment, so as to embody a human-oriented, coordinated, sustained, scientific conception of this development. **Energy development should shift its focus from "quantity" to "quality," making environmental protection an integral policy-making element of its energy development strategy.**

**Second,** government policy must shift from security capability on the supply-side to the interaction between improving supply capacity and improving energy efficiency on the demand-side, and therefore, pay the latter more attention.

**Third,** the development mode of the energy industry will shift from the government's mandatory control to a market oriented mechanism under governmental guidance to overcome the drawbacks of a planned economy in light of the current energy realm. This move should further bring into play institutional reform to secure energy supply, improve energy efficiency, and optimize the energy consumption structure.

**Fourth,** with the advent of globalization and China's imminent entry into the World Trade Organization, **energy development should shift from relying on the "self-balance" of domestic resources to pursing an international strategy which fully utilizes domestic and international resources and markets.** That is, China's energy strategy in this new era should incorporate an international perspective.

To meet the challenges of energy development according to the above principles, China should bring its sustainable energy development strategy in line with the criterion of "securing supply, keeping energy-saving as a priority, a diverse energy mix, and with environmentally friendly, and market-driven features" in the next 20 years. "Securing supply" means that as China develops its economy and energy mix, it must **1)** provide its citizens with reliable, low cost energy service, **2)** focus on meeting the public's energy needs, especially those of the impoverished population, and **3)** effectively ensure our national energy security. "Keeping energy-saving as a priority" refers to the dual focus on both "development" and, "giving priority to energy-saving" in developing the country's long-term energy guidelines. To change the current status in order to utilize energy more extensively, China must constantly cut down its level of energy consumption per unit GDP and strive to realize the objective of quadrupling our GDP by 2020 while only doubling our energy consumption. "Optimizing structure" means we must gradually change the current situation, in which the energy mix too heavily relies on coal; and at the same time, speed up the development of clean and optimum energy. Thus, primarily realizing the diversification of the energy mix and also making a breakthrough in the clean utilization of coal; "Being environmentally friendly" refers to minimizing the effects on the environment and public health during the course of production and utilization of energy, so as to promote the common development of energy resources and a clean environment. "Market-driven refers to bringing into full play the fundamental role of resource allocation based on market forces. Letting the market decide on energy price, quantity and technology, accompanied with selective intervention by the government will guarantee that energy security, environmental quality, and energy research can be properly combined.

**By 2020, the main objective of sustainable energy development in China is to keep the demand for primary energy between 2,500 and 2,900 Mtce.** The proportion of coal consumption must be kept under 60 percent while the amount of renewable energy should reach 525 Mtce (among which new renewable energy generation will be up to 100 million KW). Dependence on imported oil should stay approximately under 60 percent as the rate of reduction of major pollutants levels off between 35 to 40 percent. By 2020 a diverse

energy mix coupled with a clean and secure energy supply system will have developed alongside a sustainable system of energy development, thus laying a foundation for long-term development in the future.

## IV. Ensure energy supply and guarantee oil security

1. Have our feet firmly planted in domestic resources, make good use of international resources and form a new mechanism so that the energy sector develops steadily and continuously.

*The status of energy resources is as follows:*
**I)** Looking at the total volume of pure resources, China's coal resources could guarantee medium and long-term development. At present, China has exploitable coal reserves of 188.6 billion tons, which can sustain development for more than 100 years based on current output. Although the amount of resources is theoretically guaranteed, the actual verified rate is low with untouched scrutinized reserves being far less than the predicted amount. If constraints by water resources and environmental capacity are considered, China could attain a maximum annual coal output of 2.8 billion tons. The key to coal supply is the increase of output capacity and construction of infrastructures, such as transportation. If based on the scheme with the highest coal demand, coal demand will reach 2 billion and 2.9 billion tons in 2010 and 2020, respectively. However, if we consider the supply capacity of currently registered mines and state-owned mines under construction; annual output capacity is estimated to reach 710 million tons[7] by 2020. If township mines still maintain their output capacity of 350 million tons, 1.8 billion tons of coal output capacity will be added by 2020 with an annual net increase in output capacity of at least 80 million tons[8]. Apparently, coalmine prospecting and construction is an onerous and expensive task. China should pay more attention to these three issues in development of its coal sector. First**,** change the current situation of "restricting to a designated area" in the coal sector and build a grand coal base. Second, boost the yield rate of coal and reduce the serious waste of resources. Third, coordinate and foster relationships between the coal, power, and transportation sectors.

**II)** It is also inevitable that China will obtain almost 60 percent of its petroleum from outside the country by 2020. Viewing gross petroleum reserves, countries of the world could be classified into five classes; extremely rich, very rich, relatively rich, not rich and poor. In 2001, China had geological petroleum reserves of 21.759 billion tons, exploitable reserves of 6.204 billion tons and remaining exploitable reserves[9] of 2.408 billion tons. Based on the above classifications, China falls into the "relatively rich" category. Meanwhile, its resource possession per capita is only 12.1 percent of the global average (10 percent in 2003) while remaining exploitable reserves per capita are only 8.4 percent of the global average. Examining the supply capacity of domestic petroleum resources in the first twenty years of the century, as well as the future prospects, we could draw the following

[7] The production capacity for decommissioned mines has been deducted.

[8] Though the problem of coal supply in southeastern coastal areas can be addressed through import

[9] The (verified) exploitable reserves are the geological reserves multiplied by yield rate %, and accumulated exploitable reserves minus accumulated yield output (production output) is the left over exploitable reserves.

conclusions: **first**, China's petroleum reserves are still in their "mature stage" and haven't receded into the senescent stage yet. The future trend depends on the strategic interplay between old oilfields in the east and two newer oilfields in the west and offshore areas. If China invests hugely and prospects painstakingly, the pattern of "balanced output and consumption with a slight shortage" will sustain for about ten years. **Second**, newly added reserves grow slowly with deteriorating quality. China's geological petroleum reserves in the 1990's grew annually by 640 million tons, showing an annual average growth rate 3.66 percent lower than the 770 million tons and annual growth rate of 7.6 percent in the 1980s. Interestingly enough, the years from 1996 to 2000 witnessed an overall trend of reserves growing slowly.

The yield rate was 32.6 percent in 1980, 29.1 percent in 1990 and 28.6 percent in 2000, with a decreasing trend over the years. **Third**, with no surprise expected in newly detected reserves, China's petroleum output will stay stable or grow mildly for a certain period, or even drop after 2010. China's petroleum output has been stable and growing mildly since the end of the 1980s, increasing at an annual average of 1.23 percent from 1990 to 2001; much lower than GDP's growth speed in the same period. From region to region, output in old eastern oilfields has been dropping over the years. While, increased output in the northwest and middle (mainly the Ordos Basin) has roughly made up for this decrease in the east. Output increase comes mainly from the coast. In light of future trends, it is estimated that China will welcome a petroleum output peak around the year 2015 with maximum output possibly reaching 200 million tons. In 2020 output will drop slightly to 180 to 200 million tons. If calculated based on a low petroleum consumption scheme (i.e. 450 million tons), China will need to import 140 million tons and 250-270 million tons of petroleum respectively in 2010 and 2020; making outward dependence on petroleum hit 44 percent and 56-60 percent.

Looking at global petroleum resources and the supply and demand situation, the world is still in a relatively safe period for petroleum early on in this century. There are four reasons: **first**, in the past twenty years, global petroleum output and remaining exploitable reserves climbed up steadily, as remaining exploitable reserves grew by an annual growth rate of 2.2 percent to reach a status of "balanced output and consumption with slight excess". Petroleum reserves and the production ratio have stayed above 40. **Second**, after the later part of the 1980s, global petroleum production has been restricted as a whole. OPEC resorted to an overall strategy of limiting output to maintain prices and acted as a reservoir for the globe's petroleum supply. Members of the Commonwealth of Independent States have reduced their petroleum output significantly due to political and economic reasons. **Third**, global petroleum reserves may double within 30 years (by 2025). **Fourth**, petroleum output will see an upward trend before 2020, and may drop slightly due to the development of substitute energies after that. The "post-petroleum era" will be a time of diversified energy mixes, as the ratio of petroleum in primary energy formation inevitably decreases. On a whole, both petroleum consuming and exporting countries will enjoy a relatively safe period in the first twenty or thirty years of this century. Global petroleum demand (including that of China) will be satiated.

**III)** China's natural gas development is still in its infancy, hence it has great potential. However, providence will prove necessary in the future. Looking at the capacity of domestic resources supply, China has total geological natural gas reserves of 4.1 trillion $m^3$, exploitable reserves of 2.35 trillion m,$^3$ and remaining exploitable reserves of 1.84 trillion $m^3$. The natural gas industry saw rapid growth due to protracted lingering. Compared with 1990's figure, geological natural gas reserves in 2000 was 425.6 percent higher, while remaining exploitable gas reserves were 558.1 percent greater. The increase in prospected

reserves mainly comes from the exploration of new areas and discovery of brand new gas fields. While old oil fields in the Sichuan basin continue to grow, new fields are being explored to provide future uninterrupted strategic relay. We can see that China's natural gas reserves have developed from their juvenile age to a youthful stage. Natural gas reserve production ratio was 62.2 in 2001; much higher than petroleum's 15.4 ratio(global average reserve production ratio for petroleum and natural gas was respectively 41.0 and 67.1 in 2003). It is estimated that accumulated detected reserves of natural gas will reach, respectively, 4.9 trillion $m^3$ and 7.5 trillion $m^3$ in 2010 and 2020, which indicates that China's natural gas reserves will stay in there youthful stage at least until 2020.

Yet, various comparative values related to natural gas are even lower than the percentage of petroleum to the global average. Both possession per capita and unit area abundance values are smaller than 20 percent. Unit area abundance average was 1.006 million $m^3/km^2$ , only 32.6 percent of the global average, which means that China has mostly low-yield gas fields. This calls special attention to China's volume of natural gas resources being smaller than that of petroleum. If calculated by the equivalent value, natural gas reserves are 72.9 percent that of petroleum reserves. Moreover, China is plagued by "innate defects" such as long transportation distances and low abundance, as well as the problem that natural gas prices are too high, which has constrained the widespread usage of natural gas. We should spend more efforts in solving these "dilemmas" in the development of natural gas, and find a solution that complies with China's practical situation. Hence, we should be enthusiastic, yet prudent in developing our natural gas sector. Working out short and medium term development policies that integrate natural gas must first and foremost have resources as the foundation. Also, introduce and implement a market oriented pricing mechanism and let market forces guide production and sales. Next, maintain domestic resources as the main source for the country's fuel consumption, and keep foreign resources in a supplementary capacity. Obviously, planning beforehand is the key to realizing these goals and properly executing the appropriate policies.

To ensure the needs of economic development and social progress by 2020, China should stick to the following two principles in energy supply:

**First**, have our feet firmly planted in domestic resources and make good use of international resources. A foreign resource-oriented economy will be a conspicuous feature (not only reflected in energy resource field) of future economic development in China. Actually, not one industrialized country (even big powers such as the U.S.) in the world today can depend completely on their own resources. China, when transforming from a domestic resource-oriented to a foreign resource-oriented economy, must resolve two problems. The first is to establish a new mechanism that supplies resources continuously and safely suits an outward resource-oriented economy as it opens up to foreign competition (we will discuss petroleum issues emphatically in the following sections). The second is to balance and make good use of the relationship between domestic and foreign resources. Namely, we should clarify the principle of "having our feet firmly planted in domestic resources and making good use of international resources" while facing the challenge of the energy supply in 2020. We should then identify the state's overall energy volume and the direction of structure development. More importantly, we should make good use of international resources from a global resource outlook.

**Second**, we should carefully handle the relationship between the government, market and enterprise by establishing a new market-based mechanism that nourishes the energy sector's stable and sustainable development. We should give full reign to the fundamental role of the market mechanism in configuring resources; allowing the government to

correctly exert its guidance only to avoid the more violent ups and downs in the energy sector. Particularly, we should apply our experience (solving the problem of supply shortages rapidly by deregulating the coal and power sectors) accumulated in the 1980's and study the carefully learned lessons from energy shortages (especially power) in the recent period. We will ensure stable and sustainable energy supply by promoting market-oriented reform in the energy sector, transforming the government's functions, establishing a government control approach that agrees with market-oriented reform and resorts to institutional innovation.

2. Adopt comprehensive measures to ensure petroleum security

**(1)** Domestic and foreign petroleum resources, demand and supply conditions and petroleum security countermeasures are jointly combined into three factors that affect China's petroleum security

Viewed from a long-term and global perspective, the so-called "energy issues" can be more correctly termed as "petroleum issues"[10]. Petroleum is the key factor that creates social fortune and the most important commodity that affects global diplomacy, economic order, and military activities. Almost all countries have placed petroleum at the core of their energy strategies.

So-called "petroleum security" entails guaranteeing that the petroleum demand necessary for the sustainable development of both economy and society is satiated in regards to both quality and price. So-called "petroleum insecurity" mainly reflects the damages on a country's economy by temporary and abrupt cutoffs, or shortages in petroleum supply, or prices shooting up. The extent of this damage rests mainly with the economy's reliance on petroleum, magnitude of oil price fluctuation and the ability of the authorities to deal with emergency situations, which includes strategic reserves, standby output capacity, alternative energies and a precautionary mechanism.

Three major factors that contribute to China's petroleum security are: **1)** condition of China's oil and gas fields, **2)** domestic output, and **3)** import demand. Whether the global petroleum supply, demand conditions, and price fluctuations can match up with China's actual demand involves having the proper petroleum security countermeasures already established..

**(2)** To establish the correct outlook on "petroleum security," we must first accurately understand the modern international petroleum market and corresponding geopolitics.

Today's petroleum market and geopolitics are tinted with the following features: **First**, the relationship between a petroleum exporter and consumer has taken on wholly new dimensions. It is now very difficult for either OPEC or OECD to unilaterally decide petroleum prices and control the international market in the long term. Both parties fight over interests but at the same time depend on and cooperate with each other. **Second**, the supply and demand pattern is complicated. Non-OPEC petroleum exporters have strengthened their role while more and more hot spots for petroleum prospecting are appearing. A new consumer hot spot is forming in Asia. Global petroleum trade and flow direction are also complicated. Both petroleum consuming and exporting states are diversifying their export (import) channels to stabilize supply and demand and obtain better economic benefits. **Third**, multinationals are becoming a major power in controlling the

[10] Energy in Limited World, Study Report of International System Analysis Research Institute, 1981

international petroleum market. The trend of privatizing petroleum companies is greatly influencing exporting and importing nations to different extents. A new batch of grand multinationals has mushroomed in the world's major exporting/importing countries via mergers and acquisitions and the development of upstream and downstream supply channels. These multinational giants have allied with international financial consortiums to emerge as major players, influencing the international market.

The above changes in the global petroleum market and petroleum geopolitics present both favorable conditions and new challenges to China. Major factors that affect China's petroleum security are described as follows. **First**, the international petroleum supply may have temporary shortages. Increasing dependence on imported petroleum aggravates the risk to the petroleum supply. Short-term local shortages are now possible in a global context. These antagonistic forces threaten the petroleum supply. **Second**, petroleum prices may suffer short-term violent fluctuations in a global context. Petroleum prices, if too high, may reduce a nation's GDP's growth rate, and if too low, may result in losses for the domestic petroleum sector. **Third**, in the domestic sphere, domestic petroleum and gas production are somewhat uncertain. Natural disasters may have grave impacts on production and transportation (especially for the conveyance of natural gas). **Fourth**, China's petroleum companies are not strong enough and lack experience in international operation. **Fifth**, China doesn't have a petroleum security response system.

**(3)** Adopt comprehensive measures and establish a petroleum security guarantee system.

The problems that derive from petroleum insecurity could be weakened or reduced by comprehensive measures. Besides the implementation of a sustainable development energy strategy (as emphasized above) and the placement of energy conservation at the top of the priority list, comprehensive measures still include:

**First**, speed up prospecting and development of domestic petroleum and gas resources. The state needs to increase its investment in fundamental and preliminary petroleum geological work to create better conditions for exploring new areas and fields, and encourage large domestic petroleum companies by favorable policies to strengthen their efforts in upstream prospecting. Investment priorities in the global petroleum industry have been transferred upstream since the 1980's. The investment ratio in the upstream has increased gradually from 40-60 percent to 78.5 percent in 1995 and 82.9 percent in 1998. The state should execute practical and regional petroleum development strategies to speed up the development of petroleum technology.

**Second**, strengthen petroleum production and increase the yield ratio. At present, China's oil fields have an average yield ratio of 34 percent, which could be lifted above 50 percent by intensified mining with tertiary oil extraction technology to highly boost exploitable reserves. According to the "Global Petroleum and Gas Resource Appraisal" report published by the U.S. Geological Survey and World Petroleum Association in 2000, China could expand its exploitable reserves more than 80 percent by 1.96 billion tons by adopting measures such as intensified mining to boost yield rates.

**Third**, develop alternative fuel technologies. In the global context, a wave of technical innovation is washing over the vehicle sector due to the replacement of traditional gasoline or diesel-fueled vehicles with those fueled by new energies. Moreover, the new generation of automobile and alternative fuel technology has made major progress. Achievements have been made in fuel cell, hybrid power cars, advanced diesel technology, coal, natural gas and

biomass liquefaction. Some are already available for preliminary commercialized application. China's government should work out its development plan for a new generation of vehicles, coordinate domestic and foreign resources, establish an open and coordinated problem-tackling mechanism with efforts exerted from "government, industry, universities and R&D institutions", to guarantee abundant capital investment and obtain breakthroughs in these fields.

**Fourth**, incorporate into the international cooperation framework and integrate with the international market in all aspects. As a big emerging petroleum consumer in the world, China should align itself with the well-established international pattern for petroleum interests, carry on energy diplomacy, actively participate in the different global and regional energy cooperation organizations, fully engage in the futures and spots hedging markets, resort to the market to acquire petroleum products, stick to petroleum quotas implemented from abroad, open up the domestic petroleum futures market to foreign investors, and establish a legal and regulatory system that is helpful and compatible to the international market.

**Fifth**, gradually establish and perfect the petroleum strategic reserves and precautionary system. China is expected to build a diversified and reasonably configured petroleum strategic reserve system to adapt to the security needs at all levels, while at the same time trying to accomplish a strategic reserve equivalent to 40 days' demand by 2010 and 55 days' demand by 2015. China must also establish an oilfield reserves and output capacity reserves system, and set up a security precautionary response mechanism. It is advised to establish a precautionary response program based on five levels (i.e. the petroleum shortage reaches 3, 5, 7, 10, and 15 percent of the import volume).

## V. Improve the system as government facilitates the implementation of a strategy with energy conservation as a priority

1. China has huge a potential for energy conservation.

Since the 1990's, China has been adjusting industrial and product structure, strengthening energy management and promoting new processes, technologies and equipment in energy-saving. Unit consumption indicators for 33 types of products in 11 major energy-consuming industries examined by the state have dropped in different degrees (Please refer to table 4). Although the gap between the unit consumption of major high-energy-consuming products in China and the international advanced level is dwindling, unit consumption of major industrial products as a whole is still 30 percent above that of the international level. One should note that every single product's energy consumption level is decided by many factors (including incomparable ones) and a country's potential in energy-saving is not calculated simply by the comparison between internal and external energy consumption.

Table 4. Comparison of gap in unit consumption for major energy-consuming products with international advanced level

| Name | Unit | 1980 | | | 2000 | | |
|---|---|---|---|---|---|---|---|
| | | Domestic average level | International advanced level | Gap between domestic and international (%) | Domestic average level | International advanced level | Gap between domestic and international (%) |
| Coal consumption for thermal generation | Gram standard coal/kwh | 448 | 338 | +32.5 | 392 | 316 | +24.1 |
| Comparable energy consumption/ per ton steel | Kilogram standard coal/ton | 1201 | 705 | +70.4 | 781 | 646 | +20.9 |
| Cement comprehensive energy consumption | Kilogram standard coal/ton | 203.8 | 135.7 | +50.2 | 181 | 125.7 | +44.0 |
| Ethylene energy consumption | Kilogram standard coal/ton | 2013 | 1100 | +83 | 1212 | 714 | +69.7 |
| Truck fuel oil consumption | Liter/100 ton km | 8.7 | 3.4 | +155.9 | 7.6 | 3.4 | +123.5 |

Note: The data are cited from the China Energy Development Report (2001) and Energy Research Institute Research Report; a coal-fired power station is above 6,000KW, the average comparable energy consumption is sampled from 75 large and medium scale enterprises in the steel sector; the cement indicators refer to those from large and medium scale rotary kilns.

Major reasons causing the overall backward level of energy efficiency in China include: **first**, outdated technical equipment; **second**, smaller equipment scale which results in a difficult decrease of unit energy consumption per product; **third**, gap in raw materials and processing course. Compared with the international advanced level, we lag far behind, which, however, does not mean that China will tap all these potentials in future. This is explained by two major reasons: **first**, the country is in a different economic development stage; **second**, China's energy consumption structure with its focus on coal is difficult to change in the short term. Differences in energy efficiency caused by energy quality make it difficult to reduce the gap between unit consumption and systematic efficiency level.

China will tap its energy-saving potential via two channels. One is brought along by structural change and strengthened management; i.e., indirect energy-saving. The other is formed by the reduction in unit consumption; i.e., direct (technical) energy-saving.

Major energy consuming industries in China have the energy-saving potential of 86.42 Mtce in 2005. As estimated, the entire industry has an energy-saving potential of about 130 Mtce. Considering the energy-saving potential in transportation and buildings, China, as a whole, will have an energy-saving potential of 180~200 Mtce during the 10$^{th}$Five-Year Plan period. By 2020, major energy consuming industries will have an energy-saving potential of 190 Mtce while the entire industry can save 250 Mtce. Considering the energy-saving potential in transportation and buildings, China, as a whole, will have an energy-saving potential of 400~450 Mtce. If such potential is tapped, unit GDP energy consumption in the first twenty years of this century will drop by 2.3-3.7 percent annually. Although the possible decrease extent is milder than the last twenty years, it will be still far above global annual decrease rate of 1.1 percent[11] by then.

It is thus clear, that huge potential and possibility exists for energy conservation and boosting energy efficiency. Whether less energy input can realize China's target of economic growth depends largely on the effective tapping of this energy-saving potential. Energy conservation will also exert visible benefits in guaranteeing energy security and reducing environmental pollution caused by energy production and use.

Looking at industrial sectors with the most energy consumption; although the overall ratio of energy demand by sector will drop gradually to 56.7-58.7 percent (Please refer to table 5) from 72.7 percent in 2000, transportation and buildings remain the largest consumers. Energy consumed by these two sectors grows quite fast. Ratio of energy consumed by transportation will increase from 11.1 percent in 2000 to 16.3-17.1 percent in 2020 while that by buildings will grow from 16.2 percent in 2000 to 25.0-26.7 percent in 2020.

This shows, we should save energy in every possible sector. Effective measures must be applied to the three big consumers. Industrial sectors that will always consume more than half of the total energy consumption within the next twenty years must remain the focus of energy-saving efforts. China should change its current patter, where efforts are spent in energy conservation in other industries, while the transportation and buildings sectors are overlooked. One problem is that these two energy-consuming heavyweights have entered a rapid growth period and will only have higher demand ratios. Therefore, we must adopt effective measures as soon as possible. If China issues fuel taxes, adopts a fuel efficiency standard, and attains gradual progress in optimizing the transportation sector structure, then transportation will decrease its oil consumption by 87 million tons by 2020; comprising

[11] World Energy Outlook---Comment Today's Supply for Promoting Tomorrow's Development, IEA, 2001, Geology Press

almost half of domestic crude oil output at that time. Huge energy-saving potential exists also in buildings. At present, only 2.1 percent of urban housing and buildings in China have reached the design standards for heating and proper energy conservation. Compared with countries in similar climates and latitudes, energy consumption by heating and air conditioning in unit floor area in China is twice as high. In 2020, a decrease of 160 Mtce of energy consumption by dwelling, office, and industrial spaces will be seen by 2020.

Table 5. Sub-sector's demand for primary energy

| Scenario | | Total Energy Consumption (Mtce) | | | Average annual growth rate |
|---|---|---|---|---|---|
| | | 2000 | 2010 | 2020 | 2000~2020 |
| C | Industrial sector | 943 | 1239 | 1398 | 2.0% |
| | Transportations | 145 | 246 | 409 | 5.3% |
| | Commercial/civil | 210 | 374 | 659 | 5.9% |
| | Total | 1297 | 1859 | 2466 | 3.3% |
| B | Industrial sector | 943 | 1384 | 1664 | 2.9% |
| | Transportations | 145 | 275 | 494 | 6.3% |
| | Commercial/civil | 210 | 409 | 738 | 6.5% |
| | Total | 1297 | 2068 | 2896 | 4.1% |
| A | Industrial sector | 943 | 1429 | 1924 | 3.6% |
| | Transportations | 145 | 282 | 535 | 6.8% |
| | Commercial/civil | 210 | 426 | 821 | 7.1% |
| | Total | 1297 | 2137 | 3280 | 4.7% |

Note: End-use energy demand by the three sectors is converted into primary energy.

## 2. Bigger obstacles still exist in current energy conservation work

China's first obstacle is a backward concept of energy conservation. In developed countries, awareness in saving energy has transformed from just saving and reducing energy usage (in response to the energy crisis in the early 1970's) to a target of boosting benefits, reducing pollution, improving quality of life and ameliorating the public relationship. Meanwhile in China, making up for shortages and curtailing energy use still prevails, which shows a

reactive mindset that revolves around energy supply tension. The focus on energy conservation only heats up when energy supply is threatened.

The second obstacle is China's energy conservation departments in the government are obviously weak. Also, the brain drain of energy conservation administrators has resulted in deteriorating the energy-saving management pool. The U.S., Japan and other countries are currently beefing up their energy conserving administrative departments.

The third obstacle is the obvious ineffectiveness of China's legislation to pass and enforce energy conservation law. The so called, "Energy-saving Law", has not been enforced effectively while the arrival of supplementary regulations proceeds too slowly. A comprehensive plan and decision-making system that coordinates energy, economic, and environmental concerns has yet to be established. Energy-saving decision and lawmaking abilities are weak.

The fourth obstacle is the lack of an effective economic incentive system. After fiscal and tax system reform in 1994, former incentive policies and measures such as tax credits and concession loans were weakened or even abolished, which does not bode well for energy conservation efforts.

The fifth obstacle is a weak capacity for technical innovation. Scant investment in R&D for energy-saving technologies is the problem. Furthermore, energy conservation was excluded from the 10th Five-Year plan, and totally left out of crucial scientific and technological plans. Enterprises are experiencing difficulties in financing their technical reform to energy conservation. Energy conserving equipment is of poor quality. China relies too much on imports for some key technologies and equipment.

3. The key links in energy conservation work is the government's promotion via an effective economic incentive system

The first is to regard resource saving as the basic state policy in the new era.

China should place energy conservation at the top of its energy strategy. Namely, in order to meet the growth of energy demand, energy conserving should be given top priority, over simply increasing the energy supply. In order to ensure strategic significance of energy conservation, it is advised to uplift resource saving to the plane of national policy and regard "controlling population, saving resources and protecting environment" as China's basic policy[12] in the new area to form the policy environment and social atmosphere that is integral to establishing an energy conserving society.

China must raise the whole nation's awareness of resources, actually change the economic growth mode, adjust its economic structure, speed up technical progress, and build a resource conserving society within or around three years.

Several aspects must be addressed while building a resource conserving society. **First** of all, energy conservation should be incorporated into fundamental state policy, and an indicator system that reflects economic and scientific development, social progress, resource utilization, and environmental protection should be established. **Second**, China should rein in the present extensive economic growth mode characterized by high consumption and pollution while gradually establishing a resource conserving national economic system. Reforming traditional industry and promoting structural upgrades through technical progress will build a well-structured international industrial division pattern,

12 At present, resource saving has not been taken as a basic state policy.

which is helpful to the sustainable use of resources and environmental protection. **Third**, China should resort to legal and economic means to promote the effective development and use of resources. The new administrative framework should revolve around setting up an energy and resources auditing system, combined with the current environmental assessing system. Allowing the market to play the fundamental role in configuring resources while, at the same time, establishing a scientific resource price-forming mechanism and price structure must be the priorities of this new administration. **Fourth**, a resource-saving consumption mode is advocated while resource conserving products should be provided to satisfy the people's demand.

The second is to beef up the government's energy conservation administrative system that actually enacts the government's policies.

Market defects and obstacles in energy-saving fields are unavoidable, and mainly consist of the following: the market price does not represent long-term benefits; the investor prefers energy-development projects; environmental costs in energy production are not incorporated into energy price; consumers have limited access to sufficient energy conservation information and techniques, improper fiscal, tax and regulatory policies adopted by the government hinder adequate tapping of the energy-saving potential. Energy conservation is tinted with the feature of public affairs resulting in the market mechanism having a limited role. According to a study by the World Bank, the contribution rate by market power to tapping energy-saving potential is only 20 percent. Experience in market economy countries has shown that the government must take a leading role in energy conservation, just like environmental protection.

In order to buck the trend that the government's administrative function in energy conservation is weak, it is advised that the State Council set up a resource-saving office, restore the State Council Energy Conservation Office Meeting System and earmark a fund dedicated to energy-saving management, and used in stipulation of sound energy-saving policy and standards, propaganda, training, information service, awards.

The government's role should be changed, and the government's major function in energy conservation is specified as such: **1)** stipulating energy price and economic policies such as taxation, intensifying market signals; **2)** formulating energy conservation regulations and standards; **3)** providing information service, including public propaganda, energy auditing, energy efficiency labeling, education and training; **4)** assisting and encouraging research, development and demonstration of energy conservation technologies; **5)** facilitating and coordinating activities conducted by different energy-saving organizations; **6)** the government strives to conserve energy within its institutions. Energy management by the government should transfer its focus from the energy supply to end use consumption and from administrative means to economic means. At present, we should begin energy conservation in the government departments, one by one, as a breakthrough to the nationwide energy-saving work.

The third is to establish and improve energy-saving economic incentive policy.

Energy conservation is a highly scattered unorganized secondary investment activity. Since energy consumption in most enterprises is only a small part of the production cost with higher energy costs getting passed on to the consumer through adjustments in product price, consumers don't regard energy efficiency as the decisive factor in choosing energy-consuming equipment, the government's economic incentive is quite important to effective energy-saving work.

We recommend that China further its market-oriented reforms and end energy and scientific price controls by the government; adopt preferential policy in energy-saving investment projects such as tax credits or accelerated depreciation; apply tax credits to enterprises that produce new energy conservation products, collect fuel oil taxes or increase the consumption tax rate for gasoline and diesel.

The fourth is to align the focus of energy conservation strategy and strengthen energy-saving in buildings and transportation while furthering the energy conservation work in other industries.

In energy management, historically, the government has emphasized energy conservation in industries and overlooked that of buildings, which points to the fact that the government's economic plan for the energy sector emphasizes production over daily life. As a result, China has progressed little in the field of energy conservation, while some go as far as saying it is the most vulnerable link in the country's energy-saving work. Moreover, the quickly growing transportation sector has not received adequate attention either. In order to reverse this situation and accept the fact that energy consumption by buildings and transportation grows rapidly in the process of building a well-off society in an all round way, China should adjust its energy conservation strategy and strengthen its energy-saving efforts in buildings and transportation while continuing to work hard in all other industries. Compared with the currently rapid growth of buildings and transportation, energy conservation lags far behind. We must have tight control on energy conservation in the above two fast-growing sectors. Time waits for no man. Otherwise, it will be difficult to rectify.

Energy-saving in industries: The two industries mentioned above will still be the largest energy consumers in 2020, but they will also be the sectors that see the biggest gains in energy conservation during that time. Assuming that energy conservation is achieved on a grand scale by adjusting industrial and product structure, implies that the industrial sector could achieve 70 to 80 percent of its energy-saving potential. Additionally, reducing unit product energy consumption through technical advancements takes another 20 to 30 percent Hence,to best conserve energy in the industrial sector, technical progress should be combined with the adjustment of industrial and product structure. China should revise its energy-saving design specifications, implement corporate energy audits and report/compliance management, promote technical progress in energy-saving, establish an energy management information system and push forward policies and measures that are based on performance to promote energy conservation in the industrial sector.

**Saving energy in buildings**: By the end of 2002, China had only 230 million $m^2$ worth of energy efficient buildings. This figure represents only 2.1 percent of the urban floor area. To save energy consumed by buildings, China has to find an alternative to its heating system, open the heating market and boost the renovation of existing buildings from the aspect of energy efficiency. The State Council should stipulate energy-saving ordinances, enforce strict standards for energy-saving designs, offer economic incentives to production and use more energy efficient construction materials. Meanwhile, the administrative and regulatory mechanism must adopt a better energy conservation attitude.

**Transportation energy-saving**: At present, average oil consumption per hundred kilometers for all types of vehicles in China is 20 percent higher than that in developed countries. If the proper policy is in place, the potential for oil savings in road transportation could be about 15 percent by 2010 and above 30 percent by 2020. It is recommended that China collect fuel oil taxes, stipulate fuel efficiency and oil quality standards, improve

urban planning and traffic systems, give priority to the development of express public transportation, design smart traffic systems and encourage the development, purchase and use of cars driven by alternative fuels to facilitate energy savings in transportation.

Moreover, in the power system, China should strongly encourage demand-side management and adopt a ceiling on power prices. To accomplish these goals, China must first identify grid operators as the key players in implementing demand-side management and developing incentive policies and measures to influence both power companies and users.

The fifth is to establish an end use energy efficiency standard and labeling system for high energy consuming equipment.

One key measure to improve energy efficiency is stipulating and implementing end use energy-consuming equipment efficiency standards and labeling, which has great implications in reducing energy consumption, boosting market competition, removing technical barriers in international trade and cutting down pollution emissions. Factors to understand when developing these standards for end use energy-consuming equipment are as follows; energy-saving potential, projected benefits, capacity of related organizations (testing, management, monitoring, enforcement and appraisal) and international consistency. China should also work out supplementary policies and measures (such as household appliances, light fixtures, motors, fans, water pumps, transformers and other general equipment and industrial boilers).

**The sixth is to establish a new energy-saving mechanism under a market economy**

Under a market economy, the key in giving priority to energy conservation strategy is to create a market environment that allows equal competition for energy-saving and development. Domestic and international experience has shown that Demand-Side Management and Integrated Resource Planning (DSM/IRP), energy service provider, life cost analysis, consumer education, market-driven pricing mechanism and internalized external costs are effective policy tools that give priority to energy conservation. With these new energy-saving mechanisms, China should work out policies and regulations that can be easily and gradually implemented nationwide based on pilot projects and demonstrations.

## VI. Exert best efforts to realize the optimization of the energy mix

Looking at China's energy production structure, the proportion of coal in primary energy consumption has declined significantly since 1990 (see the attached table). The proportion of coal in the total primary energy consumption fell from 76.2 percent in 1990 to 66.1 percent in 2002. However, the heavy dependence on coal in China's energy mix has not been addressed for such a long period of time. The main reason for this is that, currently, no energy strategy and policy for optimizing the energy mix exists. China's existing energy mix has caused serious environmental pollution and threatens the sustainable energy supply because of its unlimited consumption of fossil fuels. In addition, such an energy mix may impede energy efficiency. China's average utilization efficiency of natural gas is 30 percent higher than that of coal, which is 23 pecent lower than that of oil[13].

[13] NIRA granted research project, Research of Northeast Asia Energy and Security Guarantee II: China Energy Environmental Issue and the Necessity of its International Cooperation with Northeastern Asian Countries, Executive Summary

**The course to optimize the energy mix may have a great effect on the total demand for energy. According to sensitivity analysis, a drop of 1 percent in the proportion of coal in the energy consumption mix can cause the total demand for energy to decrease by 20 Mtce. According to energy supply analysis, structural adjustments may save 128 Mtce by 2020.**

In light of present trends, we can forecast that the consumption of superior energies such as oil and natural gas will increase rapidly, causing demand motivated structural changes. Structural changes have taken place in public energy consumption and in developed areas and have laid a good foundation for the adjustment and improvement of energy mix. **The following principles should be embodied in making policies for energy structural adjustment: 1) The energy mix should be optimized to the fullest under conditions that international resources should be fully exploited based on domestic resources under the prerequisite of energy supply and economic acceptability; 2) The state's energy security should be guaranteed; and 3) Environmental quality should be improved and the capability of sustainable development should be strengthened**

**Recommendations for energy structural adjustment and improvement include: gradually decreasing the proportion of coal consumption, speeding up natural gas development, satisfying the basic domestic demand for oil by using both domestic and foreign resources, aggressively develop hydropower, nuclear power and renewable resources. Twenty years will be spent creating an initial diverse energy mix, making the proportion of superior energy increase.** Lay a foundation for the realization of the goal of the second 15-years diverse energy mix. **The details are as follows:**

**Efforts should be made to gradually reduce the proportion of coal in primary energy consumption and keep the proportion of coal under 60 percent by 2020,** blaze a path to intensify development and use of clean coal with Chinese characteristics. Coal still plays a critical role in China's energy mix because it is more abundant than oil; this situation may remain for a long time. But it is imperative to speed up technological innovation, make inroads in the development and utilization of clean coal technology, develop the advanced multi-cogeneration, super-super critical coal power generation technology and implement the correct policies to promote and utilize clean coal technology.

**The development of natural gas should be accelerated; it can play an important role in reducing coal consumption. As to oil, international resources and markets should be fully exploited to meet domestic oil needs.** Efforts should be made to improve the slow development of natural gas. The proportion of natural gas in the energy mix should increase from 2.8 percent in 2000 to 5-6 percent by 2010 and 6.7 -8.9 percent by 2020. The average annual consumption of natural gas should increase by 9 percent from 2000 to 2020. The development of natural gas should be based on domestic resources and supplemented with imports. The total demand for natural gas should amount to 160 billion cubic meters[14] by 2020, and assuming natural gas imports of up to 50-60 billion cubic meters, means that the dependence on foreign resources will be about 34 percent. The three key uses of natural gas are: (1) Power generation; (2) Civil and commercial use; (3) Industry. In order to maintain fast development and realize the above-mentioned goals, China must exploit and utilize natural gas. By 2020 the domestic natural gas yield should have multiplied by 3 to 4 times that of 2002. At the same time, China must also expand its gas transmission infrastructure to fully utilize imported natural gas. Another factor affecting whether natural gas can truly

[14] Data on natural gas of base year was converted into heat value of 9310K/km3. According to such calculation, the total demand for natural gas is 160 billion cubic meters.

substitute coal depends on whether its price is competitive in the market. Due to high prices, the current natural gas market is not developing smoothly. Therefore, the problems existing in the current pricing system must be dealt with as soon as possible.

The demands for oil by 2020 will amount to 450-600 million tons, which is 2-2.6 times that of the year 2000. Considering natural resources limitations, the country's heavy dependence on imported oil, and present pressures on oil security, China should strive to meet the basic needs of its domestic markets, rather than replace coal as its main energy resource. Efforts should be made to keep the consumption of oil below 450 million tons by 2020.

**Efforts should be made to aggressively develop hydropower, nuclear power, and renewable resources.** It is estimated that by 2020 the needed installation capacity will be up to 860-950 million KW (see table 5). That means about 29-33 million KW should be added to the existing installation capacity within the next 20 years. **China should accelerate the construction and development of hydropower with an installation capacity of no less than 200 million KW, even striving to reach 240 million KW.** The proportion of hydro in the country's total power supply shall increase from 16.4 percent in 2000 to 19-22 percent by 2020. This would require increasing annual hydropower installation capacity by 6.4-9 million KW. As far as hydro resources are concerned, reserves that could be recovered in terms of technology amount to 521 million KW. However, the present rate of development of only 15 percent is much lower than the world average level[15], which includes developing countries such as India, Vietnam, and Brazil. According to the above tentative plan, hydropower development will reach 38-45 percent. In addition, great interregional differences exist in hydropower development. The degree of development in the eastern region is 68 percent, leaving little room to develop massive hydropower. It is only 8 percent, however, in western regions. From the above analysis, we can see that there is great potential for hydropower development in western regions, but the difficulty and costs will be very high.

Table 6. Comparison of demand for power generation and different power mixes under three scenarios

| Scenario | | Installation Capacity （GW） | | | |
|---|---|---|---|---|---|
| | | 2000 | 2005 | 2010 | 2020 |
| C | Total installation capacity | 319 | 398 | 543 | 865 |
| | Coal power | 228 | 272 | 338 | 509 |
| | Oil power | 9 | 9 | 3 | 1 |
| | Gas power | 1 | 5 | 25 | 43 |
| | Hydropower | 79 | 107 | 154 | 240 |

15 China's development rate is only 10% on the basis of power quantity, lower than the world average level 18.4%, ranking about 80th in the world.

| | | | | | |
|---|---|---|---|---|---|
| | Nuclear power | 2 | 4 | 15 | 40 |
| | New energy | 0 | 1 | 7 | 30 |
| B | Total installation capacity | 319 | 407 | 551 | 867 |
| | Coal power | 228 | 281 | 361 | 568 |
| | Oil power | 9 | 10 | 4 | 3 |
| | Gas power | 1 | 3 | 26 | 39 |
| | Hydropower | 79 | 108 | 146 | 211 |
| | Nuclear power | 2 | 5 | 10 | 34 |
| | New energy | 0 | 1 | 3 | 13 |
| A | Total installation capacity | 319 | 402 | 559 | 947 |
| | Coal power | 228 | 285 | 384 | 661 |
| | Oil power | 9 | 10 | 4 | 6 |
| | Gas power | 1 | 3 | 28 | 46 |
| | Hydropower | 6795 | 100 | 132 | 191 |
| | Nuclear power | 22 | 4 | 9 | 31 |
| | New energy | 0 | 1 | 3 | 11 |

**Efforts should be made to increase nuclear power installation capacity, through actively developing nuclear power, to 40 million KW by 2020 with an annual growth rate of 15.9 percent.** The proportion of nuclear power in total power generation should increase from 1.2 percent in 2000 to 5 percent by 2020. China's uranium resources are abundant in the short term and have much potential for the long-term development of nuclear power. Input, technology, and the environment are the key factors in developing nuclear power. Emphasis should be put on increasing the proportion of domestic production and realizing massive production, considerably strengthening the competitive strength of nuclear power.

**Great efforts should be made to actively develop renewable resources and lay a foundation for the future replacement of fossil fuels.** The utilization of renewable resources may reach 525 Mtce by 2020, doubling the amount of 309 Mtce in 2000, while the proportion of the advanced utilization of renewable resources in the total utilization of new renewable resources will rise from 15 percent in 2000 to 73.5 percent by 2020.

Installation capacity of renewable resources generation shall reach 100 million KW by 2000, in which hydropower comprises 80 million KW, wind power 20 million KW, and biomass power 5 million KW. Looking at overall quantity of resources, China has 7300 Mtce of new energy resources and renewable resources available for utilization. The quantity under development is not more than 50 Mtce, leaving sufficient resources for utilization. During the 9th Five-Year Plan period, the development and new utilization of renewable resources had reached an average annual rate of 11.2 percent. If this figure could be raised to 15 percent, the development goals set for 2020 could be realized. Despite its long-term objectives to replace fossil fuels with renewable resources, the short-term objectives should be taken into consideration to solve energy use problems in the remote rural areas that may arise in building a "well-off" society.

## VII. Implementing an environmentally friendly energy strategy by means of governmental impetus, participation of the general public, caps control and emissions trading

### 1. The environmental status may be worrisome.

Outstanding environmental problems are: the aggregate of pollutant emissions is far beyond the environmental loading capacity; the deteriorating trend of the ecological environment remains fundamentally unchanged; atmospheric pollution in many cities is affecting the local residents' health; shortage of water resources and the questionable security of drinking water in some areas; land desertification and prairie desert encroachment in some areas.

Environmental restrictions influence energy strategy, supply and demand, and economic and social development. Under many circumstances, environmental factors have a more decisive meaning than actual resources. Environmental restrictions on energy development are as follows.

(1) *The amount of sulfur dioxide based on the requirement of air quality.* A study of the China Environmental Scientific Research Institute shows that the $SO_2$ concentration in most cities across the country can only meet a Class 2 standard (where total $SO_2$ emissions is restricted to around 12 million tons). At present, the capacity resources of the atmospheric environment have been used up in most cities in China. Coastal and urban areas with fast growing economies are suffering seriously from acid rain and $SO_2$ emissions, while only western regions (except medium and large cities) still have some atmospheric environmental capacity.

(2) *The amount of sulfur dioxide based on acid rain control.* The National Plan of Acid Rain Control researched by the China Environmental Scientific Research Institute shows that the maximum capacity in our entire country for SO2 emissions is around 16.20 million; keeping in mind the critical load of sulfur settlement (keeping $SO_2$ emissions within the degradable capability that the ecology can handle). Unfortunately, according to the forecasts, by 2010 and 2020, based on the minimum emissions scenario, $SO_2$ emissions will reach 34.43 million tons and 40.56 million tons, respectively. If based on the maximum emissions scenario, it will reach 40.72 million tons and 57.38 million tons, respectively, which are both far beyond the environmental capacity.

(3) *The environmental capacity of NOx.* According to conditions of the past ten years, the environmental capacity of NOx has already reached a saturation point. The environmental capacity of nationwide NOx cannot exceed 18.90 million tons which happens to be the exct

amount of nationwide NOx emissions in 2000. If we do not control NOx emissions produced in the course of energy activities, according to the forecast of minimum scenario, the NOx produced only by burning coal may increase from 19.80 million tons in 2000 to 28.89 million tons in 2010 and 35.21 million tons in 2020. Adding the NOx emitted from vehicle pollution, the NOx emissions in the next 20 years will double.

(4) *Environmental standards are increasingly tight*. Through building our environment for 30 years, China has established relatively sound legal and environmental governance systems. Caps controls, concentration compliance, and caps requirements of emissions units together comprise the backbone of Chinese environmental administration. According to this requirement, sulfur dioxide in the "$10^{th}$ Five-Year Plan" period in China will decrease from 19.95 million tons to 18.20 million tons in 2005. As far as the electricity sector is concerned, the total amount of electricity generation in China will reach over 2 trillion kwh in 2005, increasing by 48.4 percent as compared with that in 2000. The amount of thermal power generation will increase by 45.6 percent, while coal consumption will only decrease by 3.1 percent. Thus, all newly built thermal power generation units must be required to install sweet devices. In order to fulfill 2005 caps targets, sweet generation units should at least make up 19 percent of the thermal power generation units. This is a big challenge.

(5) *Restriction of greenhouse gas emissions*. According to the forecasts, the amount of CO2 emissions will range from 1.3 billion tons to 2 billion tons in China by 2020, which is 1.5-2.2 times larger than that in 1998. The level of CO2 emissions per capita will range from 0.9-1.3 tons by 2020. After 2020, it will be difficult for China to avoid its commitment to restricting greenhouse gas emissions. In terms of CO2 emissions control, the energy sector has unshirkable responsibilities and duties. Therefore, China will subject her energy resources to global environmental pressure and ensure its future energy development. The economic input required by restricting emissions of greenhouse gas will force China's energy sector to reposition its energy development goals.

(6) *The restrictions imposed by the environment must be compatible with the objective of a well-off society.* An environment compatible with a well-off society is important for China to realize a well-off society in an all-round way. The environment is also an important indicator to measure when building a well-off society in an all-round way. According to the examination indicators of the nationwide model of environmental protection, state of provincial and city ecologies, and the experience of developed countries, the environmental requirements for the next 20 years are shown in Table 7.

Table 7. China's environmental requirement targets in the next 20 years

| Indicator | | Unit | 2000 | 2010 | 2020 |
|---|---|---|---|---|---|
| Air pollutants caps | Target of emissions cap of $SO_2$ | Ten thousand tons | 1995 | 1600 | 1300 |
| | Target of smog emissions cap | Ten thousand tons | 2257 | 1600 | 1000 |
| | Target of emissions cap $NO_x$ | Ten thousand tons | 1890 | 1800 | 1600 |
| Air pollution control | Rate of industrial smog elimination | % | 91.41 | 100 | 100 |
| | Rate of smog reduction | % | 91.8 | 95 | 97 |
| | Rate of reduction in $SO_2$ (burning) | % | 10.3 | 50 | 70 |

| | | | | | |
|---|---|---|---|---|---|
| | Rate of reduction in industrial powder | % | 82.1 | 90 | 95 |
| | Proportion of desulphurizing units in coal fired units | % | 2.1 | 38.4 | 80.2 |
| | Emissions compliance of industrial boilers' smog | % | 91.0 | 94.0 | 97.0 |
| | Emissions compliance of industrial kilns' smog | % | 70.3 | 80.0 | 90.0 |
| Input to environmental protection | The proportion of environmental input in GDP | % | 1.1 | 1.5 | 2 |
| Air environmental quality | Days with air quality index better than grade 2 | Day | | 200 | 300 |
| | Average daily density of $SO_2$ | $\mu g/m^3$ | 150 | 150 | 150 |
| | Average daily density of in-breathing particulates | $\mu g/m^3$ | 150 | 150 | 150 |
| Living environment in towns | Popularity of gas in urban areas | % | 39.0 | 60.0 | 75.0 |

**2. Implement environmentally friendly strategies and measures**

A balance between energy and the environment is the basis of environmentally friendly policy. Energy is the core of environmental matters; energy production and use significantly influences local, regional and global atmospheric environments. Environment is key for energy policy-making and environmental assessment should be the precondition for the approval of all the energy projects. The environment should be incorporated into integrated resources planning. Energy is also at the center of environmental diplomacy because energy-consuming products are the objects of international trade green barriers. Energy production (particularly nuclear and hydroelectric power) and utilization (in the range of green lighting, green construction materials, energy-saving air conditioners and refrigerators, green computers) are the principal goals of a green campaign. A healthy environment restricts the development of energy resources, so these energy resources should be regarded more as a driving force for the sustainable development of the energy sector. Considering the fact that the China's environment has been seriously damaged, and that the main cause of this damage is the production and utilization of energy, it is recommended that environmental protection be taken as the integral factor when deciding energy strategy. Therefore, the environmental capacity needed by a well-off society for a healthy environment must be one of the important variables in the energy policy decision-making process.

The implementation of environmentally friendly strategies must involve these four aspects: government driven, public participation , caps control and emissions trading.

**Government-driven:** Environmental protection will fail if left to the market to decide; the government must play a stronger role. The government's role is not only to direct investment in environmental protection but also to formulate and execute laws, regulations,

and standards. The government should also establish an economic incentive system to accelerate the development of clean energy and the elimination of highly consuming and heavily polluting industries.

**Caps control:** Environmental quality has severely worsened. Cap controls on emissions are necessary to realize the balanced development of the economy, energy mix and the environment.

**Emissions trading:** Trading is a low cost and highly effective way to protect the environment. It is also the most effective way to utilize environmental resources. International experience has shown impressive results and should be referred to when applying emissions trading in China.

**Public participation:** Bringing NGO's into full play is an important approach to promote the healthy development of the environmental protection cause in our country. Public education is needed to increase knowledge on environmental protection and improve public awareness of the relationship to their local surroundings. Its main aim is ensuring that the government executes its authority fairly and legally.

The following are policy recommendations:

**(1) Develop environmentally friendly energy and energy technology.**

The development of clean energy and clean energy utilization technology should be the central goal of sustainable development energy strategy. In 2020, coal will still occupy about 60 percent of primary energy consumption; the development of clean coal technology is critical. By 2020, accelerating the promotion and use of clean coal technology can cut coal demand by 200 million tons and decrease emissions accordingly. It is recommended that the national clean coal technology commission, established in 1995, be resumed. The government should revise its promotion plan of national clean coal technology, strengthen the link between environmental protection and the development of clean coal technology. In addition, incentive policies for technical research, development, promotion and utilization of clean coal technology should be formulated, while restraint policy should be carried out for highly polluting technology and products.

**(2) Stricter caps control will be carried out against principal pollutant emissions.**

Strict cap controls over $SO_2$ emissions have been carried out but in the next stage, great attention must be paid to the inhaled particulates since they have become the major pollutant in many cities. Significant increases in NOx make it necessary to gradually put them under cap controls. At the same time, still stricter cap controls against the smoke dust and powder emissions must be implemented.

**(3) Increase emissions fee standards and carry out emissions trading.**

The emissions fee standards should not be lower than the cost of pollution control, which should be incorporated into production costs. Pollutant emissions trading can reduce pollution emissions at a minimal cost. The SO2 emissions trading system should be carried out nationwide. The current absence of laws, regulations, and on-line automatic inspection should be rectified; supervision and management must be enhanced.

**(4) Implement environmental protection buy-downs and internalize the external costs of environmental pollution.**

Under the new power system of “separation from grid and bidding for access”, to encourage clean power supply, more power generation from renewable resources and priority access should be implemented. As to price competition, not only the financial cost but also the external costs of environmental pollution should be incorporated into the total cost.

**(5) Control the environmental pollution of urban transportation in the early stages.**

Environmentally friendly transportation policies that give priority to public transportation, fuel consumption reductions, tailpipe exhaust controls and clean fuel vehicle development should be implemented. Reductions in vehicle exhaust emissions should take into consideration: type and number of vehicles, fuel, and regulations. Fuel improvement measures include: prohibition of leaded gasoline, fuel improvements, alternative fuel and fuel quality improvement. The improvement measures for vehicles emissions include: engine improvements, tailpipe purification, particulate collector, and motor vehicle maintenance. Developed countries have shown that total pollution emissions can be reduced by 30 to 40 percent by carrying out good service and maintenance. As far as rules and regulations are concerned, traffic demand management policy, special laws and regulations to control gasoline and vehicle emissions and fuel efficiency standards should be finalized. In addition, gas tax reforms should be put into practice in the short term.

**(6) Respond to global warming**

It is predicted that by around 2030, the total amount of CO2 emissions in China is likely to surpass that of the U.S. ( currently ranking first globally), which means China’s advantage of emitting less greenhouse gas per capita will no longer exist. Our country will likely face much more pressure in international negotiations on global climate warming. Shortly before or after the year 2020, international climate change conventions aimed at the reduction of greenhouse gas emissions will exert great pressure on our economic and social development. We should take precautions now and respond earlier. We should fully understand the importance of the global warning problem and develop a sustainable development strategy; working out the best medium and long term strategies to deal with the problem and promote China’s sustainable development as soon as possible. The Chinese ideological guidelines for the national strategy to deal with global climate warming under the framework of sustainable development are: **1)** Insist on promoting short-term goals in the context of long-term goals; **2)** put the security of economic development at the core, **3)** (with sustainable development as the fundamental starting point), improve energy efficiency and intensify ecological construction; **4)** unswervingly push forward Chinese sustainable development strategy in an all-round way; **5)** constantly improve China’s ability to ease and adapt to climate change so as to lay a solid foundation for protecting the global climate. The overall objectives of the national strategy for China to deal with climate change are: **1)** achieve remarkable success in decreasing the growth rate of net emissions of greenhouse gas; **2)** continue to strengthen the ability of adapting to climate change; **3)** improve the general

public awareness of climate change; **4)** develop the scientific research level in the field of climate change to the international advanced level.

## VII. Institutional reform and technical innovation is the core for finalizing sustainable development strategy

In the next 20 years, China will confront numerous changes; some of which will impede sustainable energy development. To realize the goal of doubling energy consumption while only quadrupling GDP, we must continue to build on our successes in the past 20 years, and make breakthroughs in institutional reform and technical innovation. This is the key to the success of our sustainable development strategy.

### 1. Accelerate the market-oriented reforms in the energy realm

Generally speaking, the energy sector was the last to go through the reform process. To a certain extent, it has restricted the development of the economy and hindered further reforms. Market-oriented reform in the energy realm has made some achievements, but it still remains in its initial phase and the reform process has proven arduous. Moreover, a series of fundamental conflicts and problems have not been completely addressed, which in turn impede further reforms and long-term development in the energy sector. **(1)** The coal price has not been completely market-oriented; **(2)** The reform process of "separation from the grid and bidding for access" has just begun; **(3)** Fairly strong regional monopolies still exist in the oil sector; **(4)** Although the competition framework is slowly being established; the main players of competition, the market order, the market function and the pricing mechanism have not yet been put in place.

Experiences in the past 20 years indicate that economic institutional reform plays a very important role in the country's fairly rapid economic development. In the next 20 years, China must further deepen institutional reforms, especially focusing on the relatively slow arrival of market-oriented reform in the energy realm.

The overall goal of our reform is: to ensure that China's overall energy strategy is carried out and that full market competition is allowed to efficiently allocate resources. China also needs to improve the international competitive strength of its energy sector and satisfy society's daily increasing demand for energy. Additionally, it must meet all challenges in the energy realm and supply high quality, stable, sufficient, and clean energy products at a low price for the relevant industries and users.

The following are issues that still need to be addressed:

(1) Reform the setup of the government's energy administration, and establish both a comprehensive energy administrative department and a professional energy regulatory agency.

As far as the setup of an energy administrative institution in our government is concerned, there are two outstanding problems:

**First**, the current institutional setup has three distinct drawbacks in three aspects: **1)** poor ability in multi-goal comprehensive decision-making and transdepartmental comprehensive coordination; **2)** relative weakness of the administration in various sectors dealing with the

energy realm, and the asymmetric situation of "strong enterprises and weak government"[16] exists. Most enterprises in the energy sector are massive, state-owned enterprises and, accordingly, power is being consolidated into a series of oligopolies in some sectors. Some enterprises used to be the original government departments responsible for certain industries, (petroleum and petrochemical sectors, and electric power sector), and in the light of their favorable positions in the sectors and the government, they not only possess very strong market control but also the stronger capability of influencing policy and decision-making. As a result, the power of the current government energy administrative agency is weak; **3)** the manpower currently allocated to the energy administration is inadequate, which is not in line with the strategic position of energy, the ever-severe energy supply situation, and the various fields covered by the administration.

**Second**, greater drawbacks still exist in the corporate governance mechanism. As the energy sector becomes more and more market-oriented, the regulatory system, which must create and protect a fairly competitive market environment and eliminate the natural monopolostic atmosphere from days past, is still in the initially beginning stage. Fortunately, an independent Electric Power Regulatory Commission has been recently established to watch over the electric power sector. However, the energy administrative system is still in a period of transition; from mandatory and direct intervention in enterprise to the establishment of a modern control system. There is still sharp friction between the new and old systems, which brings up two major issues: **1)** The current energy control system can only cover the electric power sector and a vast control vacuum still exists, especially in natural gas. As China struggles to transmit natural gas from western China to eastern China, the country must implement effective control over this energy network, which still resembles a natural monopoly. **2)** The electric power control agency recently established is in an awkward position of "having an agency, but lacking functions" because it lacks the necessary authorization and power, which are innate features of a modern control system. As a result, the old system still plays a leading role, which not only undermines the establishment of the new energy administrative system currently under trial, but also subjects the market-oriented reform of the electric power system to greater risks.

Thus, it can be seen that the current governmental administrative institutional setup does not adapt itself to the needs of energy development and reform under the new economic situation. It cannot properly deal with the shortages in energy supply and energy security. It cannot formulate and implement strategies based on energy's long-term, sustainable development. Even if a good strategy was worked out, the current energy administration lacks the ability and the power to properly carry it out.

In order to eliminate the outstanding drawbacks of the energy administrative system, it is recommended that, according to the principle of "separating the function of governmental administration from that of regulatory agency", China adopts a two-tier structure while establishing a comprehensive energy administrative institution (Ministry of Energy) and a separate, legitimate energy control agency.

With regard to restructuring and improving the current energy administrative institutions, the main work should be concentrated in the following two aspects: **1)** Finalize, as soon as possible, the electric power control agency's functions. Furthermore, the electric power regulatory commission should be entrusted with the right to control prices and access,

[16] The above mentioned "strong enterprises, weak government" does not refer to the implication that we advocate limited government under a market economy

outright. Simply transferring the control rights and powers to different departments does not accomplish this goal. A wholly new system must successfully replace the old one in the energy realm. Such a “drastic” action will set an important precedent for the reform of other administration systems in other monopoly sectors (telecommunications and railway). Due to the complete lack of independent anti-monopolistic agencies in China, this wholly new control system must be entrusted with the policing and regulating of potential monopolostic conduct, and be given the right to restructure entire, monopoly-prone industries. It is a matter of special importance to entrust these rights. **2)** Implement effective control over the natural gas sector, especially over the natural gas pipeline networks, which currently have all the characteristics of a monopoly. The two related aspects are the equitable interconnection and price of the main pipelines. Restructuring could be carried out by the electric power control agency by giving it full reign over the natural gas sector, and the ability to appoint appropriate control personnel. The agency’s current name, Electric Power Control Commission, could easily be changed to Energy Control Commission.

The difference between a comprehensive energy administrative agency and a professional energy control agency are as follows: the former draws up the national energy strategy, medium and long-term energy development planning, annual development plans and energy policy, arranges and coordinates the interdepartmental relations and the development of different categories of energies. The latter carries out the national energy plans and policies, and implements proper independent control over the two particular sectors of electric power and natural gas.

With regard to the sustainable development of energy, resources and environment, there still exists the problem that while the central government does make it a priority, the local governments give it little or no attention. In addition to comprehensive countermeasures such as linking achievements in one’s political career with scientific development, and a tougher management system, organizational safeguards are also needed in local energy administrative institutions. Specifically, the professional energy control agencies should set up their central and local divisions in a perpendicular way. Meanwhile, comprehensive energy administrative institutions also need to be established at the local level, so as to formulate and implement local energy policies under the unified leadership of the national energy plan, while keeping local conditions in mind.

(2) Clearly spell out the government’s functions and establish a government administrative system suitable for the market-oriented reform of the energy sector

Although we have seen several rounds of reform in the energy sector, no clear distinction between the functions of the government and those of enterprises has yet appeared, except on paper. The government is still directly intervening in enterprise and the problems of “unused functions” and “overstepping functions” in the government are still serious. This problem of “overstepping functions” has severely beset the foundational function of the market mechanism which is trying to play its proper role of resource allocation. Furthermore, many enterprises find themselves stuck in a world of “mandatory binding”, where the market’s supply and demand signals are obstructed by the malpractice of the government administrative mode.

A new round of power shortages has recently appeared, as well as the ever-sharpening price competition of coal used for electricity in the past two years. These problems are the manifestation of the malpractice by the conventionally planned administrative mode. At present, the biggest obstacles facing electric power system reform are the lagging

governmental reform and the ineffectual modern electric power control system. Allowing competition to legitimize power prices would be preferable to the current situation with its half plan and half market approach, which is proving to be a most disadvantageous state. These cases clearly indicate that the government has reached the point where reform can not be delayed any further, otherwise, the domestic energy supply will not be in a position to meet the energy demand by 2020, and also avoid the sharp price fluctuations.

True reform is not merely a matter of raising executive efficiency, but a matter of making a thorough transformation of the government's functions. That is, to resolutely delegate authority to lower levels where one ought not to manage is not the answer. Specifically speaking, reform the access control system established on the basis of project examination and approval, make greater efforts to carry out the reform of the investment administrative system (price system reform is to be discussed later). The objective of the reform is to "relax economy-related control and strengthen social control" so as to push forward the revolution of control and the transformation of function. "Relax economy-related control" is the core content and main direction of attack for reforming the current investment system. Its implications are: **1)** to relax the access control, **2)** give back the rights to investors to make their own operational and investment decisions in enterprise, **3)** establish an investment administrative system where those who invest will benefit and bear the risks, **4)** no longer regard the financial evaluation of a project as the principal criterion in the government's examination and approval, **5)** cancel the current project examination and approval system, and **6)** confine the extent of economy-related control to the matter of judging whether an enterprise is a monopoly or not. "Strengthening social control" means that according to the medium and long-term development strategy and objectives of the national energy plan, the government should: **1)** control such social objectives as the sustainable utilization of resources, environmental protection and energy security, **2)** establish an evaluation system that can reflect the above-mentioned social objectives scientifically, and can be conveniently and quickly handled and taken as the basis for future decision making, **3)** set up a lowest access threshold so as to establish an approval system for projects with the social control as the core content. Throughout the above-said function transformation of the control system, relax the economy-related control and establish an incentive system that fully brings into play a varied pool of investors, such as state-owned, non-government and foreign-capital. To strengthen social control, the government must realize the following social objectives, **1)** orderly and high-efficiency utilization of resources and **2)** effective control of environmental pollution.

The essentials of above-said reform of the governmental administrative mode have four respects: **1)** The examination and approval system for projects based upon the rational concept of economy-related control is transformed into an approval system for projects with strengthening social control as the objective, thus realizing the transformation of control functions. **2)** The basis for an effective and well operating approval system for projects with social control as the core content lies in the institutionalized social access to criterion, i.e., an open, transparent and foreseeable process of government decision making. Otherwise, it is hard to solve the problem of random decision-making, and realize a logically sound market system. **3)** To quickly as possible establish and improve the relevant laws and regulations so as to solve the ever-worsening problem of lagging legislation in the current energy realm. This means to make full use of the rule of law to standardize and restrain the competitive and trading behaviors of different sorts of enterprises, the rights and decision-making of the government's control agencies. The standardization of law ensures that the enterprises abide by law in operation and the government administers according to law. **4)** Establish a system capable of effectively raising administrative efficiency and binding

relevant organizations. It is recommended to legislate or set rules to prescribe a time limit for decision making to speed up the overall lagging process. Furthermore, according to "Administrative Licensing Law" and "Administrative Review Law", it is imperative to establish the appeal and administrative review systems. Through the systematic institutional arrangement, an open, competitive, orderly and coordinated energy market will be created.

In addition, it is necessary to carry forward the market-oriented reform in terms of the urban public utilities (including water supply, gas supply and heating) and introduce an equitable and legally guaranteed licensing rights business system geared to various investors so as to increase supply, raise efficiency and improve overall services accordingly.

(3) Expedite the readjustment of ownership structure in various energy sectors, optimize industrial institutional structure, put into effect the common development of multiple economic sectors, and establish a unified, open, competitive and orderly energy market.

At present, a very common phenomenon known as "closed competition" or better known as industrial monopoly is prevalent in different energy sectors and needs to be radically addressed. "Closed competition" means the competition is enclosed within the state-owned economic circle. Because of this hardly surmountable obstacle, nongovernmental capital and foreign funds are loathe to enter the market. These are the drawbacks (especially in the property rights system) innate in the corporate governance structure of state-owned enterprises. What is more, some state-owned enterprises which have subsisted on government resources for many years (particularly those ultra large state-owned enterprises) have recently transformed into a competent department of the government in charge of some sectors under the system. This situation allows for little or no separation between governmental functions and enterprise management. Furthermore, these giant state-owned companies have not learned how to compete in a market economy, as the "closed competition" has resulted in a great deduction of their effectiveness and ability to utilitize a market mechanism. Recently the problems of "Enclosing Fields in a large scale" have appeared in some sectors. This is directly related to the softening or loosening of government control on the budget of state-owned enterprises.

Establishing "open competition" to replace "closed competition", has four main points:

**1)** Relax access policy to encourage the new enterprises (especially the private-run and foreign-capital companies) to accede and utilize new technologies (the policy applicable to all the energy sectors with the exception of electric power transmission networks and upstream sectors of petroleum natural gas). Eliminate binding policies that restrict the accession of the non-state-owned enterprises. Establish a business environment with different types of ownership where enterprises can smoothly accede and secede, merge and acquire, to solve the problem unitary structure of ownership. Establish a new-type access system which encourages the development of renewable energy resources, promotion of energy conservation and improvement of energy efficiency. With regard to renewable energy and energy conservation, it is advisable to create a environment which promotes the accession of new enterprises by establishing policies and systems like a mandatory market share system.

**2)** Reform the property rights system. In order to reform state-owned energy enterprises, it is necessary to take property rights system reform most seriously. The large state-owned enterprises should welcome and invite privately-run and foreign-capital strategic investors so as to form a property rights structure with mixed ownership, and encourage the public

listing of state-owned large-scale energy enterprises. The state should retain ownership in only the smallest number of state-owned enterprises at key links (e.g. electric power transmission grid enterprises). It is also practicable to implement on a trial basis, the "golden share" ( one-vote voter power) for the state-owned funds in the smallest number of enterprises at key links. Furthermore, we know from our experiences in property rights system reform of the small-scale state-owned enterprises among the other competitive industries that there is a need to adopt multiple forms ( auction, assignment, lease and bankruptcy, etc.) to put into effect the integral withdrawal of state-owned capital. The funds gained from these withdrawals, under the prerequisite of solving the issues left over in the original enterprises, will be used to replenish the registered capital of state-owned large-scale enterprises so as to really ensure the advancement, withdrawal, and optimization of deployment of the state-owned economy.

**3)** Optimize industrial organizational structure. While monopolies still exist to a certain degree in the electric power and petroleum sectors, the government should conditionally relax its control over the market access for the downstream sectors of power generation, petroleum wholesale and retail, and the midstream sector of oil refining. The five major state-owned power generating companies should strictly abide by the limits to their ownership of market shares (regional power generators are not permitted to own more than 20 percent of their shares). The control agency should assess and influence the market so as to strengthen its antimonopoly control. The coal sector, for example, must thoroughly change its current situation of "restricting their activities to a designated area" and the resulting excessive decentralization. The coal industry can use regional integration as the breakthrough point and gradually consolidate several nationwide interregional, trans-ownership and trans-sector (coal power and coal chemical industries) large-scale coal corporate groups. Also, more attention should be paid to the access of the new enterprises (particularly the privately-run and foreign-capital ones), which would relieve the pressure on the coal supply that currently exists and make it sustainable in the long term.

**4)** Establish a unified domestic energy market which will gradually integrate with the international market. First, solve the problems related to the local partitioning of the energy market, and establish a unified and open energy market, which would promote the optimal allocation of resources. Then, effectively open up trading and gradually integrate the domestic and foreign markets, which are of double significance when solving our country's energy supply problems and standardizing domestic markets. Finally, with China's accession into the WTO, we should implement a two-way opening up to investment and trade, which will foster a good external environment for petroleum energy enterprises to "blaze a new path in the world" and make good use of the domestic and foreign markets. Also, it is necessary to actively initiate the opening up of China's markets to the outside world. Doing so will not supplement the insufficient domestic supply, but also solve the problem of "closed competition". A market environment established on the basis of the interplay between the domestic and foreign aggregate supply and demand will significantly normalize the competitive behaviors of China's enterprises.

(4) Reform the price formation mechanism and establish a price system committed to the readjustment of the energy sector's structure and sustainable development.

In terms of the price structure and formation mechanism of China's energy products, there exist the following problems: **1)** The prices for many energy products (especially electric power products) are classified as controlled, lack flexibility, and are divorced from the supply and demand forces in a real market. **2)** The duality of energy pricing used to swing

between commodity attributes and social attributes and therefore lacked the stability of an actual pricing mechanism. With a view to attracting investment and protecting the interests of the producers, the price formation mechanism of “cost plus payback of investment” was established in the field of power generation and natural gas pipelines, however, since it is not easy to supervise the costs, a sharp price perverse mechanism formed, thus causing the continuous rise of prices. If China wants to keep social objectives in mind, the administration must implement price controls on electric power end users, and exert governmental guidance on prices of coal for electricity, The authorities must strike a balance by first relaxing control and then executing control to solve the monopoly problem in the petroleum sector, always referring to the international petroleum market. **3)** The price structure does not contribute to the readjustment of energy structure and the accomplishment of sustainable development. Ignoring the environmental costs and encouraging the excessive low price of coal used for electricity, has severely restricted the development of other types of energy. For example, the price formation mechanism used for natural gas resulted in excessively high prices of natural gas, which, in turn, the market had trouble accepting. As a result, the market deviated from its energy development objective of expediting the development of natural gas. Another example is the lack of a fuel oil tax, which has caused the low combustion efficiency of automobiles to actually worsen and not improve.

Under the conditions of a market economy, the key to effectively readjusting the energy market structure to encompass a strategy for sustainable development ultimately lies in the reform of the price formation mechanism and price structure, for which the following problems should be addressed emphatically:

**First**, adopt the price formation mechanism of market pricing, to create effective competition for energy products. This move will truly and sensitively reflect the relationship between supply and demand in the energy market, and accurately transfer the transaction costs to the end users who can then save energy on their own initiative. Next, unswervingly continue to reform the electric power system by employing “bidding for grid access” and establishing a price formation mechanism that is truly market-oriented. To curtail shortages in the electric power supply, which appear today, use price ceilings for the price of grid access. As for coal, its influence and ability to affect the overall energy plan should be cancelled out by establishing an interlocking mechanism between coal and power prices (except in cases that might trigger off severe currency inflation). As to reforming the pricing mechanism for petroleum, **1)** The price should reflect the relationship between supply and demand in China’s petroleum market, rather than the direct relay of international petroleum prices, which does not reflect the genuine relationship between supply and demand. Also, the present system of lagging oil prices needs to be updated to reflect the real time oil price. In addition to all this, China should strive to open all circulation links and establish risk guarding and effective regulatory systems, which will prove to be major factors determining the progress of reform.

**Second**, effective price regulation should be enforced in China’s industries that have serious monopolistic characteristics. Because power transmission, distribution networks, and natural gas pipeline networks are all currently controlled by monopolies, price controls must be implemented to their grid fees. With regard to the today’s power transmission and distribution networks, a cost mark-up method can be adopted to address the severely lagging development of the power grids, and help them make the transition to a maximum upper limit method. For natural gas networks, simply using market-side acceptable prices to determine price control should be sufficient.

**Third**, formulate energy price structure in favor of energy structure readjustment and the accomplishment of the nation's sustainable development objectives. **1)** Implement environmental protection, and internalize environmental losses, caused by the combustion of coal, into the prices of coal-fired power, so as to change the current situation with its excessively low coal prices; **2)** Price reform is desperately needed in the natural gas sector, where the biggest issue is the currently used "cost mark up method", which only protects producer's interests without taking into consideration the consumers' will or ability to pay. The resulting high price of natural gas handicaps its ability to get a foothold in the overall energy market. Price reform efforts should consider the substitute price of natural gas, as opposed to the other kinds of fuel, and determine the price of natural gas in light of the consumer's likelihood to pay. **3)** Establish the energy sustainable development funds which will provide the appropriate subsidies necessary for the development of renewable energy and new technologies.

**Fourth**, discriminate the duality of energy prices, and establish a scientific price mechanism capable of protecting the low-income population and ensuring the people's basic standard of life. On the one hand, follow the example of the gradient price method for water prices that has already been tried out in some cities. This method takes into account the demand rigidity resulting from residents' basic life demands, and would therefore apply to electricity, implementing lower prices where necessary. For consumers who go beyond their limit, higher prices accumulate stage by stage. On the other hand, the extra income accrued by the implementation of gradient prices can be used to subsidize the use of electricity by the low-income population and agricultural production.

(5) Conduct market-oriented pilot projects in small areas, and gradually establish a new, open, and competitive market mechanism of resource allocation.

The current mode of resource allocation in our country is not market-oriented and the prices of resources are far lower than their market value. The present resource allocation mode has not only brought about the unfair allocation of resources, but has also given more power to employers. A market-oriented system is a better solution for this problem. It should solve the following three problems as well:

**First**, establish a market-oriented allocation system of resources through public bidding and auction, in which there are four main points: **1)** Fix prices based on the quantity of resources, instead of production output. Enterprises will have to pay a fairer price for their resources and will accordingly be urged to cherish said resources, reduce their lavishness and raise efficiency; **2)** Take into account the overall scale of resources, quality of resources, and mining conditions. Put into effect the public bidding and auction system, fix prices throughout market, and prevent the prices of resources from severely deviating from their market value; **3)** The course of auction should be open and transparent. Transparency will alleviate the unfair allocation of resources and power seeking by employers; **4)** Help offset the high costs involved with prospecting by reducing early-phase mining costs. This will encourage enterprises to prospect for ore and try harder to find ore deposits.

**Technical innovation should play a bigger role**.

As viewed from the current circumstances, there is a serious lack of input into energy research and development. In 2000, the funds used in energy research and development for our country amounted to 69.7 billion RMB (only equal to 1.8 percent of Japan's input), which occupied 6.43 percent of the nation's total expenditure on research and development

and 0.0068 percent of GDP (in Japan 15.73 percent and 0.088 percent, respectively). As far the money put into energy research and development, enterprises contributed 53.6 percent, while the percentage of funds used for energy conservation research and development was only 2 percent of the total amount invested. In addition, evident drawbacks exist in the technical innovation mechanism, which results in a lower contribution by technical innovation to improve energy conservation or energy efficiency. If this situation does not change, the future energy sustainable development objective will be extremely difficult to be realize. In order to upgrade the energy technology from an introductory stage to an innovative one, China must meet the needs of its future energy development. Recommended proposals are as follows:

**First**, intensify efforts to increase investment in energy research and development. Raise the overall government budget and actual proportion of investment in energy research and development. Determine the proper objectives, concentrate superior resources, and address the key technologies in energy research and development. When selecting the projects to fund, the scientific and technological plans should be in line with the needs of state energy research and development strategy, and emphatically support the research and development of the priority fields and state key technologies.

**Second**, improve the governmental administration in respect to research and development. It is recommended that the government should, on the basis of demand forecasts; work out the state energy supply and consumption strategies, and the energy research and development strategy that can best satisfy the national economic development. At the same time, the formulation of energy strategy should be based on technological prediction research, when determining the state's priority fields and key technologies. In the administration's scientific and technological plans, the government should transfer its present function of directly operating its scientific and technological plans, to being the decision maker on projects and simply appropriating the correct funds. The government's role should be only to check, accept, and assess current projects, trusting that the expert intermediary agency will implement as it sees fit. In this way, the adjustment and control functions of the government can better implement strategy, while avoiding the negligence inherent in the macro administration of energy. A unified and coordinated mechanism should be established among the governmental departments and inside the department for the energy research and development, which would: **1)** formulate scientific, technological, and industrial development plans, **2)** exchange and share information, and **3)** promote achievements.

**Third**, form an effective innovation encouraging mechanism. The key lies in the system of reform, especially the much needed market-oriented reform in the energy realm. The establishment of both a competitive market structure and a corporate governance structure constitutes an effective mechanism capable of constantly pushing forward the innovation of private enterprise, so as to make technical innovation step a permanent feature of China's economic development. The reform of energy science and research organizations must continue in a classified way while market-orientation and the industrialization of research development achievements comes into full swing. Bringing the market into play will only develop the rational energy consumption market and consequently enable energy research and development that is both compatible with the market and encouraged by the market. The government should work out economic incentive policies that relate to clean energy consumption, and encourage the research and development by organizations and enterprises in the energy sector. Such policies will increase their input into the research and development of clean energy and energy conserving technologies.

**Fourth**, promote the close cooperation of various kinds of domestic and foreign resources. Taking the state scientific and technological plan projects as the link, establish cooperative partnerships between the government and enterprises. On the enterprise level, put into effect a mode of research and development that jointly bears the risks and achievements for the research and development projects. Necessary characteristics include a large amount of investment, long term development cycles and high risks. Also, to foster the full use of the international research and development resources, the scientific research personnel and institutions of our country should be encouraged to participate in the international arena of energy research and development. China's scientific and technological plans should include special funds for international scientific and technological cooperation. It is also necessary to actively attract overseas transnational companies to establish their energy research and development organizations in China, which can promote the cooperation, research and development of energy technology.

## VIII. Promote massive development of renewable energy through legislation

### 1. Strategic status of renewable energy

Internationally, renewable energy is classified into two categories: conventional renewable energy and new renewable energy. Conventional renewable energy mainly includes large-sized hydropower and biomass energy produced through conventional technology. New renewable energy mainly includes small-sized hydropower generated through modern technology, solar energy, wind, biomass, geothermal, ocean energy, and solid wastes.

In 2000, global consumed renewable energy was 1,960 Mtce[17], occupying approximately 13.6 percent of the world's supply of primary energy. Electric power generated by renewable energy accounts for 19 percent of the total, which is only second to power generated by coal.

The improvement of energy efficiency and development of renewable energy are essential to energy's sustainable development. **Strategically, the world will finally shift to renewable energy. Therefore, all countries around the world should promote renewable energy development as their basic option of energy development in the 21st century.** The European Union (EU) stipulates that the percentage of renewable energy in primary energy needs to be increased from 6 percent in 1997 to 12 percent in 2010 and will reach 50 percent in 2050.

China develops renewable energy vigorously for the following reasons: **1) Sustainable development; 2) Energy mix adjustment; 3) Environmental protection; 4) Development of western regions; 5) To supply energy and power for rural and remote areas as well as promote ecological construction; 6) Enhance energy supply security; 7) Find new growth factors for our economy.**

### 2. The reasons for slow renewable energy development and its related international experience

17 The world Energy Survey, 2002 IEA, big hydropower included in the data

In 2000, China consumed 309 Mtce[18] of renewable energy, which occupied 20.2 percent of the total primary energy consumption, among which new renewable energy reached 37.4 Mtce, occupying 12.1 percent of the total. Meanwhile small-sized hydropower occupied 78 percent of the new renewable energy. New renewable energy generated 8.3 billion KWH power, occupying 6.17 percent of the total. The development of new renewable energy in our country has been lingering for a long time.

The reasons are: **The technical costs for power generation by renewable energy is too high and the market is too small.** Up to now, the cost of power generation by renewable energy is much higher than that of power generation by conventional energy, with small-sized hydropower being the exception. Obviously, high costs will restrict the renewable energy market, and plus, a narrow market will handicap firms' ability to reduce costs. A vicious circle is created where the development of renewable energy gets more difficult.

International experience in renewable energy development can be summed up as follows: **Compete with the cost of conventional energy by; adopting economic incentive policies, mandatory market policies, and new technology.**

The competition with the conventional energy mainly means to reduce the subsidies for fossil energy and internalize its environmental cost.

Economical incentive policies include awarding subsidies to renewable energy and tax credit policies.

**Mandatory market policy means to require renewable energy to occupy a certain proportion of the market through laws, regulations, and governmental decrees, while transferring the incremental costs to consumers in a fair approach. The following are suggested policies.**

**(1) Renewable energy portfolio standard (RPS, Renewable Portfolio Standard):** This is a quantity-based policy mechanism, which requires the power generated by renewable energy to occupy a certain proportion in the total power, and leave its price to be determined by the market. Generally, it is accompanied by issuing green energy certificates to generators and establishing a green energy certificate trading mechanism.

**(2) Feed in Law:** This is a price-based policy mechanism, which requires an electric company to buy the power of generators using renewable energy at a set price. The actual quantity of renewable power will be subject to the market.

**(3) Competitive solicitation mechanism (NFFO, Non Fossil Fuel Obligation):** The government issues a tender and controls the whole process of competitive solicitation and realizes its goal by signing a long-term power purchase agreement with the generators using renewable energy. This is also a quantity-based policy and concession belongs to this mechanism.

18 Big hydropower not included, but includes the conventional use of biomass.

Adoption of new technology: Many renewable energy technologies are still in their primary, immature phases, therefore, we need to tackle key problems by developing pilot projects, reducing the cost and enlarging the market to realize their massive production.

## 3. The strategy of renewable energy development

The overall development goal of renewable energy by 2020: **1) develop renewable energy on a large scale; 2) have most renewable energy technologies comply with international standards; 3) reduce the costs by realizing its commercialization; 4) promote the transfer of rural fuel mix and optimize the energy quality in the rural areas; 5) Solve the power supply problem in remote areas.** Strive to achieve 525 Mtce's worth of renewable energy use by 2020, with an installation capacity reaching 100 million kw.

Realize the goal of renewable energy development by these basic ideas and measures; (1) Government support, (2) Legal guarantee, (3) Introduction of competition, and (4) Reliance on science and technology

**Governmental support**: Domestic and foreign experiences indicate that renewable energy will not develop rapidly without the governmental support. The government's support includes carrying out mandatory market policies and economic incentive policies to promote renewable energy development.

**Legal guarantee**: In the early stage, in order to develop renewable energy, all countries first develop their own technology. Once the technology becomes mature, they then shift the focus to reducing costs as well as the opening up of the market. In recent years, some countries require electricity companies to supply or purchase renewable power through legislation. Thus, they need not to follow the old sequence and can leapfrog to the phase of creating markets directly.

**Introduction of competition**: Costs can be reduced only by competition; there is the need to enlarge the market further to finally realize its commercialization value.

**Reliance on science and technology**: Fundamentally, renewable energy development relies on the advancement of science and technology.

## 4. Policy recommendations

**First**, strengthen legislation, and strive to approve and promulgate the Law of Promotion of Utilization of Renewable Energy Resources.

**Second**, intensify building-up and innovation in policy formulation: At present, **1)** It is imperative to speed up pilot projects for renewable energy (wind power ) **2)** It is imperative to improve the investment and financing environment to attract overseas and private capital; **3)** A good job should be done when designing and implementing the plans that benefit the public; **4)** It is necessary to accelerate the research and development of pilot projects through mandatory market share.

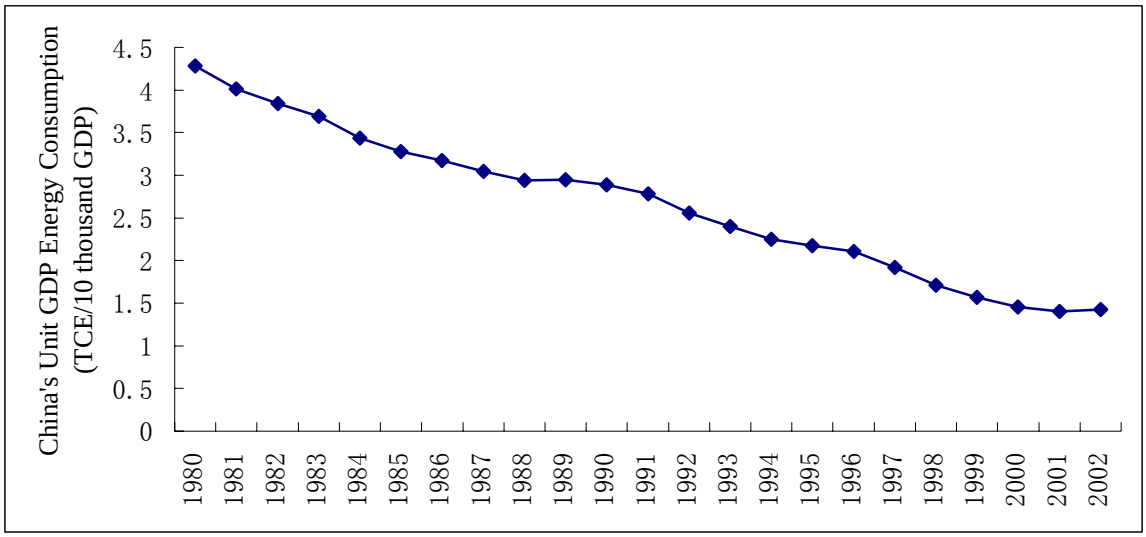
**Third**, adopt suitable economic incentive policies. Since tax credits are not included in China's system of power generation using renewable energy, it is recommended that value-added tax rates for renewable power generators be as much as 6 percent. Custom duties and income taxes could also be reduced.

**Fourth**, increase investment in renewable energy. It is recommended that the development of renewable energy resources be included into the sector development. And the plans to tackle key scientific problems by various levels of governments should also be integrated into fiscal budgets.

**Fifth**, localize the equipment manufacturing of renewable energy power generation. It is imperative when encouraging overseas and private investment in the renewable energy sector, that equipment manufacturing be localized to cut down costs.

## Appendix

Fig. 1 1980~2001 China's unit GDP energy consumption evolution




Source: China Statistics Abstract 2003, calculated on the basis of constant price in 2000

Table 1: China's potential policy initiatives based on the three scenarios

| **Transportation** | **Buildings** | **Industry** | **Energy shifting sectors** |
|---|---|---|---|
| ● Charge gas tax on vehicles<br>● Develop the public transportation mode, and set up intelligent traffic systems (ITS) in the large and medium sized cities<br>● Work out measures to promote clean fuel automobile development<br>● Make relevant policies, encourage the international manufacturers with energy-saving environmental protection type vehicles to enter the Chinese market<br>● Advance the formulation of the fuel efficiency standard | ● Formulate building energy-saving standards and implement heating price reform, to promote energy-conservation<br>● Formulate and implement energy efficiency standards and labels for household appliances<br>● Implement new-type energy-saving walls for buildings<br>● Promote and demonstrate large-scale projects such as green illumination projects, etc. | ● Demonstrate and popularize voluntary energy-saving agreements<br>● Revise the sector's energy-saving design specifications<br>● Set up industrial products labeling and classification of energy consumption system<br>● Make the complementary codes of the energy-saving law, and launch pilots for promotion | ● Continue to push forward the system reform of electric power system<br>● National Electricity Co. eliminates overall the units under 100,000 kilowatts<br>● Generally install desulphurizing devices for newly-built thermal plants<br>● Develop energies with low carbon or no carbon, such as hydropower, etc.,<br>● Encourage the research, development, and application of fuel cell, solar photovoltaic cell, etc. |

Table 2 Factors included in the three scenarios and main differences among the three scenarios

| | **Scenario A** | **Scenario B** | **Scenario C** |
|---|---|---|---|
| **Population** | The family planning policy has slightly been relaxed, the rate of natural growth of population is relatively high, national population is up to 1.485 billion by 2020. | Continue to carry out the state basic policy of the family planning, the rate of natural growth keeps relatively low-level, National population is up to 1.470 billion by 2020. | Carry out the family planning policy strictly, birth rate shows a trend to drop year by year, with 1.445 billion national populations by 2020. |
| **Urbanization** | Household register policy, resources and economic development level restrict urbanizing progress. The urbanization rate is 52.86% by 2020. | Giving priority to the development of small towns, give consideration to the mode of coordinated development of different kinds of cities. The urbanization rate is 55.78% by 2020. | Suitable for the needs of the development of western regions, all the small and medium-sized cities, big cities see rapid development. The urbanization rate is 58.29% by 2020. |
| **Consumption trend** | ● The city builds houses fast, but energy efficiency level is not improved very fast.<br>● Rural housing construction will increase very fast.<br>● The popularity of the rural resident's ordinary household appliances will improve by a relatively large margin.<br>● The rural automobile upgrades, the motorcycle and automobile increase more.<br>● In leading civilians to choose the consumption pattern of high-efficient, environmental protection, the government's influence is relatively weak. | ● The housing and car consumption increase by a fairly big margin.<br>● Energy-consumption in big cities is mainly electric power and gas; communities rely mainly on electric power, coal, LPG in small cities.<br>● The demand potential of household electrical appliances is relatively great in small towns; the sales volume of ordinary home appliances increases remarkably.<br>● Natural gas is widely used in the eastern area. | ● Purchases of homes, automobiles will increase very fast.<br>● Residents use high-quality energy, such as gas fuel and electric power, etc. Natural gas consumption increases by large margin in the city.<br>● Home appliances improvements accelerate; home appliances products' energy efficiency is improved.<br>● The proportion of rural electric power and LPG use is raised, the renewable energy is commercialized and gets certain development |
| **Adaptation degree to global economy** | It is difficult for China to meet the challenges brought by global economic changes. | The global economic changes have little effect on Chinese economic development. | The adverse effect of global economy is totally digested. |

| | | | |
|---|---|---|---|
| **Industrial sector** | • Small enterprise is difficult to implement close, stop, merge and shift, their competitive strength is relatively weak. | • The size and structure of the enterprise shift to economical size, tending to be rational. | • Enterprises seek to have large-sized corporate development, their international competitiveness is strengthened. |
| **Transportation** | • The small and medium-sized cities lack public transit mode of rational planning. Travel relies mainly on private vehicles; the urban public transit cannot meet the requirement.<br>• Vehicle energy efficiency raise relatively slower | • Focus on public transport and motorcycle for development.<br>• From 2005 to 2008, big cities and some coastal areas will implement Europe II standards mainly. After 2010, Euro-II implemented in small and medium-sized cities.<br>• Some taxis for urban public transit will promote LPG in step by 2005-2010. | • Large and medium cities residents' trips rely mainly on public transport, large and medium cities set up intelligent traffic system (ITS)<br>• The technological progress of the automobile trade is remarkable. Alternate techniques of clean fuel will be generally adopted for public transport and private cars. Euro III standard in the key cities. |
| **Electricity generation** | • Thermal power plants adopt desulphurizing device in step, the thermal power plants without desulphurizing devices occupy sizable proportion by 2020.<br>• Hydropower, nuclear power, natural gas cogeneration and wind develop generation relatively more steady. | • For the newly- built thermal power plant, the proportion of the power plants with desulphurizing devices increases as soon as possible. The desulphurizing devices will be generalized by 2020. Begin and adopt clean coal generate electricity technology after 2010.<br>• Hydropower, nuclear power, natural gas cogeneration and wind generation accelerate | • Thermal power plants adopt desuphurizing devices, with generally. More applications of the clean energy technology, ultra critical high-efficient generating set, IGCC, etc.<br>• Hydropower develops smoothly, nuclear power, natural gas cogeneration develops on a large scale relatively, and Wind electricity increases rapidly. |

| | | | |
|---|---|---|---|
| **Energy-saving policies** | • Enhance the complementary codes *Energy Conservation Law*<br>• Lack valid policy means to guide the market. The implementation of energy-saving goal is obstructed. | • Refine the complementary codes of *Energy Conservation Law*<br>• Energy-saving policy, measures can be implemented more smoothly | • Refine the price mechanism of energy, and fiscal and taxation system that encourage energy-saving.<br>• Energy-saving policy and measures are successful. |
| **Environmental protection policies** | • Continue to use the current environmental protection standards<br>• Before 2005, implement atmosphere pollution control for "two control regions" and key cities.<br>• Before 2010, $SO_2$ emissions cap and density will be in compliance in “two control regions”. | • Continue to use the current environmental protection standard<br>• PM10, PM2.5 are the focus of control measures<br>• Improve air quality by increasing the supply of gas in the big cities.<br>• Before 2005, implement atmosphere pollution control in “two control regions” and key cities.<br>• Before 2010, $SO_2$ emissions caps and density will be in compliance in “two control regions”.<br>• Before 2020, “two control regions” policy will be carried out effectively, acid rain and $SO_2$ area will be controlled. | • Make efforts to implement emissions standards in big cities.<br>• Make stringent standard for NOx emissions.<br>• The substitution of coal not only takes place in the big cities but also happens in the rich medium-sized cities<br>• Set up a stringent system of environment enforcement<br>• Adopt the stricter $SO_2$ emissions standards for power plants, force power plants to adopt desulphurizing technology |
| **Energy resources** | • The international oil resources will not be restrained over the next 20-30 years.<br>• Chinese oil output has limited ability to increase production, but imported oil can satisfy oil demand growth<br>• It is difficult for user to bear natural gas price; with slow exploration, and development of natural gas, slow | • The international oil resources will not bec restrained over the next 20-30 years.<br>• Chinese oil output has limited ability to increase production, but imported oil can satisfy oil demand growth<br>• The exploration and infrastructure construction of domestic natural gas is developed smoothly, | • The international oil resources will not bec restrained over the next 20-30 years.<br>• Chinese oil output limited ability to increase production, but imported oil can satisfy oil demand growth<br>• Natural gas price mechanism will improve, natural |

| | | | |
|---|---|---|---|
| | construction of pipeline network, LNG and pipeline natural gas import are limited.<br>● The output of domestic natural gas is 80 billion cubic meters by 2020, import 40 billion cubic meters. | the development of the natural gas market is good<br>● The output of domestic natural gas is 120 billion cubic meters by 2020, import 50 billion cubic meters | gas demand increases rapidly, import volume of natural gas increases.<br>● The output of domestic natural gas is 120 billion cubic meters by 2020, import 80 billion cubic meters |
| **Energy security** | ● Based on domestic energy resources | ● Utilize foreign high-quality energy, set up diversified energy import system. | ● Diversify energy imports, pay attention to energy security problem |
| **Energy sector reform** | Progress of reform lags behind other sectors, monopoly continues to exist in some aspects. | Carry on restructure of the energy enterprises.<br>Monopoly is broken. | The reform makes relatively fast progress. Energy enterprises have improved their international competitive strength |
| **Energy efficiency level** | ● Because the objective condition obstructs the development of some technologies, and due to some policy oriented disputes choose other options to comply with the objectives of international average level difficult to realize for technical equipment and the equipment operational performance. | ● Assume that the technology, the energy efficiency of unit products and equipment efficiency competence of unit product of trade of every department in China, reach the international average level when the time comes in 2030 | ● Assume the technology and energy efficiency, equipment efficiency level of different sectors and trades in China can reach the international average level by 2030 |
| **Public's awareness of energy-saving and environmental protection** | ● Better | ● Better | ● Good |

Table 3 The relationship between the newly-increased GDPs and the newly-increased energy demands among three scenarios

| | | **Unit** | **2000~2005** | **2005~2010** | **2010~2020** |
|---|---|---|---|---|---|
| **Scenario C** | Newly-increased GDP | 100 million RMB | 39274 | 54798 | 174335 |

| | | | | | |
|---|---|---|---|---|---|
| | Newly-increased energy demand | Mtce | 277 | 285 | 607 |
| | Newly-increased energy demand / newly-increased GDP | Tce /10, 000RMB GDP | 0.704 | 0.520 | 0.348 |
| **Scenario B** | Newly-increased GDP | Hundred million RMB | 39274 | 54798 | 174335 |
| | Newly-increased energy demand | Mtce | 375 | 396 | 828 |
| | Newly-increased energy demand / newly-increased GDP | Tce /10, 000RMB GDP | 0.954 | 0.723 | 0.475 |
| **Scenario A** | Newly-increased GDP | Hundred million RMB | 39274 | 54798 | 174335 |
| | Newly-increased energy demand | Mtce | 374 | 466 | 1143 |
| | Newly-increased energy demand / newly-increased GDP | Tce /ten thousand RMB GDP | 0.952 | 0.851 | 0.655 |

Table 4: Energy consumption mix and its volatile trends

| | Total energy consumption（0.01 Mtce） | Proportion % | | | |
|---|---|---|---|---|---|
| | | Coal | Oil | Natural gas | Hydropower |
| **1980** | 60275 | 72.2 | 20.7 | 3.1 | 4.0 |
| **1981** | 59447 | 72.74 | 19.96 | 2.79 | 4.51 |
| **1982** | 62067 | 73.67 | 18.91 | 2.56 | 4.86 |
| **1983** | 66040 | 74.16 | 18.14 | 2.44 | 5.26 |
| **1984** | 70904 | 75.27 | 17.45 | 2.37 | 4.91 |
| **1985** | 76682 | 75.8 | 17.1 | 2.2 | 4.9 |
| **1986** | 80850 | 75.8 | 17.2 | 2.3 | 4.7 |
| **1987** | 86632 | 76.2 | 17.0 | 2.1 | 4.7 |
| **1988** | 92997 | 76.2 | 17.0 | 2.1 | 4.7 |
| **1989** | 96934 | 76.0 | 17.1 | 2.0 | 4.9 |

| | | | | | |
|---|---|---|---|---|---|
| **1990** | 98703 | 76.2 | 16.6 | 2.1 | 5.1 |
| **1991** | 103783 | 76.1 | 17.1 | 2.0 | 4.8 |
| **1992** | 109170 | 75.7 | 17.5 | 1.9 | 4.9 |
| **1993** | 115993 | 74.7 | 18.2 | 1.9 | 5.2 |
| **1994** | 122737 | 75.0 | 17.4 | 1.9 | 5.7 |
| **1995** | 131176 | 74.6 | 17.5 | 1.8 | 6.1 |
| **1996** | 138948 | 74.7 | 18.0 | 1.8 | 5.5 |
| **1997** | 137798 | 71.5 | 20.4 | 1.9 | 6.2 |
| **1998** | 132214 | 69.6 | 21.5 | 2.2 | 6.7 |
| **1999** | 130119 | 68.0 | 23.2 | 2.2 | 6.6 |
| **2000** | 130297 | 66.1 | 24.6 | 2.5 | 6.8 |
| **2001** | 134914 | 65.3 | 24.3 | 2.7 | 7.7 |
| **2002** | 148000 | 66.1 | 23.4 | 2.7 | 7.8 |