China National Energy Strategy and Policy 2020
Subtitle 4: Energy Efficiency and Conservation

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List

Table List

Abbreviation

ASHRAE: American Society of Heating, Refrigeration and Conditioning Engineers
CAFÉ: Corporate average fuel economy
CDQ: coke dry quenching
DLA: Defense Logistics Agency
DOD: Department of Defense
DOE/EIA: Department of Energy/Energy Information Administration
DSM: demand-side management
ECE: Economic Commission for Europe, UN
EJ: Exajoule
EMC: energy management company
EPA: Environmental Protection Agency
ESCO: Energy service company
FEMP: Federal Energy Management Program
gce: gram of coal equivalent
GDP: gross domestic product
GEF: Global Environment Foundation
GJ: gigajoule
GPS: global position system
GSA: General Services Administration
IECC: international energy conservation code
IHVS: intelligent highway vehicle systems
IRP: integrated resource planning
ITS: intellectual transportation system
LCCA: life-cycle cost analysis
LED: light emitting diode
Mtce: million tones of coal equivalent
MJ: megajoule
Mtoe: million tones of oil equivalent
MW: megawatt
OECD: Organization for Economic Cooperation and Development
OMB: Office of Management and Budget
PDF: program development fund
PPP: purchasing power paity
SBC: systems benefit charge
SEER: seasonal energy efficiency ratio
TRT: top recovery turbine
TWh: terawatt-hour
UNDP: United Nations Development Programme
WEC: World Energy Council

Executive Report

Conclusions

1. Strictly enforcing energy conservation is of vital importance to build a well-off society in all way

Energy is the motive force for prosperity of China. China is in the process of industrialization, which requires more energy for economic and social development than developed countries. The total energy cost of China's final user was 1250 billion RMB in 2001, accounting for 13% of GDP. But in America, it only accounted for 7%. Since 1990, China has being into heavy industrial stage, where the percentage of heavy industry output value of total industry increased from 50.6% in 1990 to 64.3% in 2003. Energy intensity of heavy industry output value was 4 times that of light industry. According to scenario analysis for future energy demand, the percentage of heavily industry sector in 2020 will be the same as that of in 2000. Secondly, the quickened pace of urbanization make the per capita energy demand increasing largely because the urban per capita energy consumption is 3.5 times that of the rural (including firewood and crop stalks). Thirdly, the escalation of consumption mix, especially personal cars, increases rapidly and cause energy demand to exceed that of predetermined. Therefore, it is inevitable that the energy demand increases largely. It is estimated that primary energy demand will reach 3500Mtce (in which hydropower, nuclear power and new energy power are calculated according to the gross coal consumption rate for thermal power generation and primary energy is 3300Mtce calculated by equivalent of heat) according BAU scenario, in which coal demand will be 2900Mt and oil will be 610Mt in 2020. Such greatness demand will bring serious issues. Firstly, coal demand will exceed the limit of domestic coal supply capacity (2700Mt). Secondly, the import dependence of oil will reach 70%, making enormous risks for oil security. Thirdly, CO_2 emission from fossil fuel may rank 1st in the world, exceeding that of America in early 1920's. If enforcing energy conservation, the primary energy demand will decrease to 2500Mtce, in which coal to 2100Mtce and oil to 480Mtce. As a result, all the issues will be relieved accordingly ensure to realize target of economic and social development.

In 2000~2020, if enforcing energy conservation, then energy demand will decrease by 900Mtce, of which 65% of industrial sector, 20% of residential and commercial sector, and 15% of transportation sector, which is important to ensure economic growth, reduce oil import, improve environment quality and to strengthen international competition for energy intensive products. The energy of save and reduction usage amounted to 900Mtce, valued at

851 billion RMB, equivalent to 16.3Mt SO_2 and 540Mt CO_2 reduction. Energy conservation may create more employment opportunities, where unit investment of energy conservation creates double employment opportunities of those by oil and gas exploitation, and power generation. It also contributes to building a well-off higher quality human settlements environment and frugal social morals.

2. China has been the second largest energy consumption country, but the per capita energy consumption is far lower than that of the world average.

In 2002, the primary energy output was 1387Mtce, in which 1380 Mt of coal, and 167Mt of oil，ranked 1st and 5th of the world respectively. The electricity generation was 1654TWh, ranked 2nd of the world.

In 2002, the primary commercial energy consumption totaled 1480Mtce, ranked 2nd of the world, of which, 66.1% by coal, 23.4%by oil, 2.7% by hydropower and 0.7% by nuclear power. In addition, the consumption of firewood and crop stalks was 280Mtce in rural area.

In 2000, the per capital primary commercial energy consumption was 1050kgce, equivalent to 9% of America, 16% of OECD countries and 50% of the world average. The annual per capita electricity consumption was 132kWh in both urban and rural households, equivalent to 3.1% of America.

3. Energy conservation has achieved significant results

3.1 Ensure rapid economic growth

From 1980 to 2000, the GDP increased by 9.7% annually, but the primary energy increased by 4.6% annually.

3.2 Energy intensity declines sharply

From 1980 to 2000, the energy intensity dropped by 64%, declined 4.6% annually. In the same period, the energy intensity of OECD and the world dropped by 20% and 19%, respectively.

3.3 Enormous economic benefits from energy conservation

From 1980 to 2000, accumulated saved and reduction usage energy amounted to 1145Mtce, valued at 1082.5 billion RMB (fixed in the price of 1997). The investment saved for energy supply system was 327 billion RMB, calculated by integrated investment from annual saved energy and the newly increased energy supply.

3.4 Make a great contribution to ecological environmental protection

From 1980 to 2000, the accumulated saved energy equals to 20.8Mt SO_2 and 722Mt -C reduction.

3.5 Narrow the gaps between China and foreign countries obviously

In 2000, China’s energy intensity is higher than 60% of non-OECD countries, as well as 1.4 times that of in 1990. The unit product energy consumption gap between China and international advanced level narrowed distinctly, too. For example, the comparative energy consumption for steel was higher than 58.5% of international advanced level in 1990, reducing to 20.9% in 2000.The China energy efficiency of processing, conversion, storage, transportation and end-use was 33.4% in 2000, up by 5.4 percentage points from 1989, decreasing by about 10 percentage points compared to international advanced level.

4. Barriers of energy conservation

4.1 Idea of energy conservation

In developed countries, the idea of energy conservation was conservation and reduction, which was to deal with energy crisis in the early 1970’s, but now it is evolved to increase benefit, reduce pollution, improve living quality and make better public relations. In China, there still has the idea of fill up a deficiency, which is the cognitive source for loosening energy conservation when the energy supply relieves.

4.2 Government energy-saving management

Energy-saving administrative agency is obviously weakened, whose personnel largely ran off, leading to worse energy–saving management.

4.3 Policy and regulation

Energy Conservation Law is worse implemented, where relevant regulations made low progress. It is to establish decision-making system and unified plan with harmonious energy, economy and environment. The ability to make decision and set up regulations for energy conservation is weak.

4.4 Economic incentive

After finance and taxation reform in 1994, it is disadvantage for energy conservation because former incentive policies and measures on energy-saving projects or products, such as tax reduction and loan on favorable terms, have been weakened or cancelled.

4.5 Technological advancement

The investment for research and development of energy-saving technology is so less that it was not listed in the “Tenth Five Year Plan” national key science and technology plan. It is difficult to circulate necessary funds on implementing energy saving technology updating for old equipment in enterprises. Furthermore, the energy-saving equipment quality is poor and some key technology and equipments depend on import excessively.

4.6 Information service

It includes publicity, energy statistics, information network and consulting service, which is very feeble.

5. Energy conservation as the first priority should be the core of the energy strategy

In order to implement market reform and sustainable development strategy, new energy strategy should be drawn up. The basic principles for establishing energy strategy are to give the first priority to meet energy demand for people, especially in poverty, to ensure energy supply security, to utilize energy effectively, and to reduce influence on environment and health with a maximum limit in the process of production and utilization.

The new energy strategy can be described as follows: energy conservation as the first priority, focus of attention on the end-use, service orientation and environment friendly.

- Energy conservation as the first priority. It indicates that when making energy decision, it should give the first priority to provide high quality energy service at minimum cost.
- Focus of attention on the end-use, service orientation. WEC pointed out that the relationship between energy demand and supply is decided by end-use energy service instead of primary energy supply, trade and market. It also indicated that energy system is service orientation and the service quality has more influence on future energy system. This means that it will provide more opportunities for customers, and it will offer different energy service based on end-user demand with acceptable price, and also it will develop energy-efficient, less pollution products for customers. The emphasis of energy management should transfer from energy supply to final consumption.
- Environment friendly: We should uphold coordinated development of energy and environment, develop clean energy and clean utilization technology on energy, and promote national economy electrification.

6. Advance market reform requiring basically changing energy management by government administrative functions

Firstly，Deepen reform must overcome inertia from planned economy. In the energy sector, planned economy has many defects. It can’t optimize resource allocation and separate government functions from enterprises management. Moreover, energy decision and planning is only from energy supply with quantity, but not with quality and benefit. The principle is to produce firstly, living second. Resources are priceless with price distort of energy. Energy conservation is only a tool to make up for deficiency. Energy pricing, finance regime and energy statistics disagree with international prevailing principles.

To some extent, there are also defects because of lagging transitional idea and system reform of energy sector, which are the most barriers in accelerating market reform for energy sector.

In the market economy, energy conservation is different from energy development. The price, quantity and technology is chosen by market in energy supply system, whereas, the government's function is limited in the market malfunction. There are more market defects and barriers for energy conservation than energy development. So energy conservation is a common affair, but the market function is limited. According to study by the World Bank, market made 20% contribution to energy conservation. At the same time, practice of market economy countries indicated that energy conservation is the same as environment protection, where government is a dominant player.

It is necessary to strengthen energy-saving administration for government, and change weakened phase.

7. Readjust emphasis of energy-saving strategy, enforce building energy saving

In 2000, the building energy consumption was 350Mtce, accounting for 26.5% of total national energy consumption.

Building energy conservation makes slow progress. A total of 230Mm^2 energy saving buildings had been built by the end of 2002, only accounting for 2.1% of urban building area. At present, energy consumption for heating per unit floor space of the buildings was triple that in the developed countries because of poor thermal properties of building envelope. Therefore, energy saving has a huge potential in China. Moreover, energy consumption for heating and air conditioning can save over 50% energy in the buildings. Until 2010, the electricity saved from refrigerator, air-conditioner and color TV will be 77.9, 38.5 and 34.2 TWh respectively.

For a long time, the government laid particular stress on industrial energy conservation, neglecting building energy saving, which reflects prominent idea of planned economy, i.e., firstly produce, secondly living. Thus, it makes building energy saving backward so that it becomes the most weakness link and difficult to popularize, which wastes resources. Building energy saving has close relationship with constructing a high quality well-off standard of living and improving environmental quality. So we should readjust energy conservation emphasis, and transfer from industrial energy conservation to building energy saving.

Measures taken include: firstly breaking through reform of heating system, opening up heating market, and promoting energy-saving updating of existing building. The State Council should formulate building energy-saving regulations, strictly executing design standards of building energy saving, implement economical incentives mechanism to encourage to produce and utilize energy saving building materials and energy-saving appliances, establish a special fund on updating energy efficiency of existed buildings, set up and consummate administrative and monitoring mechanism for building energy saving, and draw up energy-efficiency standards and labels on end-use energy equipments.

8. Demand-side management should be implemented in electric power system

In 2002, the total installed capacity reached 353 GW with electricity generation of 1654TWh. It is estimated that it will increase to 900~1000 GW and 4260~4600TWh respectively in 2020.

Until 2010, the saving coal potential is about 110Mt by improving electricity generation and reducing loss from electricity transmission, and the potentials of energy conservation for consumed electric equipments will be 125.3billion TWh.

The electric power system should take measures including: Making efforts in promoting electric power industry reforms, regulating rational power price, implementing DSM, establishing DSM as main body of electric network company, formulating incentive policies and measures for electric enterprises and users, developing technology on clean energy power, consummating electric network, realizing trans-regional network, and drawing up economic incentive policies and mechanism to promote electricity saving and clean energy power.

9. Industrial sector energy saving is principal from structure adjustment

In 2000, final energy consumption of industry sector in China was 497Mtce, making up 55.8% of the total final energy consumption, in which building materials, iron and steel, and chemical industry were the major energy consumption industries.

According to scenario analysis for energy demand, energy saved due to adjustable trade and product structures accounted for 70%~80% of industrial potentials of energy conservation, while energy saved due to depending on technology advancement and reducing unit product energy consumption accounted for 20~30%. In some industries (eg, cements), the energy saved by changing the product structure is equivalent to that by increasing energy efficiency. Therefore, technology advancement should be combined with trade and product structure adjustment to produce more high add-value products in industrial energy conservation.

Industrial sector should revise design code, implement energy audit and reporting/benchmaking management, advance energy-saving technology, build information system on energy management and carry out energy-saving performance contract.

10. Enforce energy conservation by highway transportation in transportation sector

Transportation demand and oil products consumption by highway transportation drastically increase, causing heavily atmospheric pollution. Energy conservation by highway transportation should be emphasized in transportation sector. In 2000, the total energy consumption by transportation (including railway, highway, waterway, civil aviation and pipeline) was 137Mtce, accounting for 15.4% of the total final energy consumption, far less than that of the world, being 29.5%. It is estimated that the energy consumption by transportation will be 210~238Mtce in 2010, reaching 308~440Mtce in 2020.

In China the fuel consumption by different vehicles per 100 t-km is higher than 20% of that in developed countries. The main reasons include: technologies for vehicles lagged for 10~20 years than that of developed countries; old vehicles accounts for 25% of the country; 90% trucks are medium-sized open cars and diesel cars are less; poor quality of oil product; service load rate is only 40%; worse situation of road and lower gasoline price.

The potential of save oil by highway transportation is about 15% in 2010, being more than 30% in 2020.

Measures taken are as follows: imposing taxes on fuel consumption, formulating standards on fuel efficiency and oil product, improving city planning and transportation systems, developing express public transit as the first priority, setting up intellectual transportation system, and encouraging to develop, purchase and utilize alternative fuel vehicles.

Policy recommendation

1. Take saving resources as basic national policy

General–Secretary of the CPC Hu Jintao stressed in the symposium held by the Central Committee on population, resources and environment that it is vital to do better managing the country’s population, resources and environment because it will keep a healthy, fast-growing national economy, increase economy quality and economic efficiency gradually, improve people’s living quality eventually, and promote harmony between human and nature. Resources save，population control and environment protection are of equal importance. Moreover, they have close relationships. Population control and environmental protection have been basic national policies, which have impetus on calling for family planning, enhancing the awareness of environment and strengthening government management. In practice, the status of saving resources is much less than population control and environmental protect so that the response of people at basic levels is intensive. It is recommended to take resources save, population control and environmental protection as the same status, and as our basic national policies.

2. **Strengthen governmental administrative system for energy conservation**

The CPC emphasized many times that Party committees and government at various levels should do better in population, resources and environment by themselves, and responsible for the work. So leaders of Party organizations and governments at various levels should do as treating population and environment to do energy conservation by themselves and responsible for them. It is better to strengthen capacity in integrated decision and coordinate management for leaders at various levels. It is recommended to set up resources-saving office and resume official energy-saving conference institution by the State Council.

Measures taken include: establish special funds for energy conservation administration to organize many activities such as laying down policies and standards, publicity, education, information service and encouragement for energy conservation.

The energy management by government should transfer from energy supply to final energy consumption, and from administrative means to economic means.

3. Formulate auxiliary regulations of Energy Conservation Law

Energy Conservation Law has been put into effect for 6 years, in which except a few regulations, most of them were executed poorly, even unused. Auxiliary regulations were seriously lagging to be laid down.

At present, it is urgent to establish regulations for economic incentive, building energy saving management, energy–efficiency labels of energy consumption equipments, government procurement and energy consumption statistics. In the mean time, we should strengthen enforcement capabilities and supervise on regulations.

4. Improve economic incentive policies on energy conservation

Energy conservation is highly dispersive, second investment. Because the percentage of energy cost is small, highly energy cost can be recovered from product price and energy efficiency is not the determinative factor to choose energy consumption equipments for customers. As a result, economic intensive policies are significant for effect of energy conservation.

The measures taken include: promoting energy pricing by market and scientific management; implementing preferential policies on energy-saving projects such as tax reduction and exemption or accelerating depreciation; adopting preferential tax on enterprises with energy-saving products, and imposing taxes on automotive fuel consumption or increasing tax rate on gasoline and diesel consumption. It is estimated that the percentage of taxes of gasoline and diesel prices will rise about 60%.

5. Increase investment on energy conservation R&D

In 2000, the investment on energy R&D accounted for 6.43% of total R&D investment. In the investment on energy R&D, the investment by enterprises makes up 53.6%, but investment on R&D of energy-saving technology is less, only 2% by enterprises. Furthermore, the technology choice is out of line with energy development strategy and planning, lacking unified management and coordination. The projects on energy R&D were duplicated and intersected, wasting limited resources.

Measures taken include: choosing key technology based on final energy demand, raising the proportion of energy-saving investment in energy R&D sharply, arranging energy-saving R&D projects and expenditure rationally in the national science and technology plan, building unified management and coordinative mechanism, encouraging enterprise to develop energy-saving technology, and promoting commercialization of advancements.

6. Build up energy-efficiency standards and labels on end-use energy equipments

It is one of key measures to make and implement energy-efficiency standards and labels for increasing energy efficiency, which is important to decrease energy consumption, promote market competition, eliminate technology barriers of international trade and reduce pollutants emission. In America, “Energy Star” labels are popularized and the electricity saved was 80TWh annually. Make and implement new energy-efficiency standards for end-use energy equipments (including household electric appliances, lighting appliances, general equipments such as electric motors, air blowers, pumps, compressors and transformers, and industrial boilers). Estimated that until 2020, the potentials of saving electricity will reach 254TWh, and the potentials of saving energy will be 128Mtce (industrial boilers) with net benefit of 506 billion RMB, equivalent to 19.4Mt SO_2 and 97.6Mt-C reduction.

Measures taken include: formulating energy-efficiency standards and labels for end-use energy equipments and relevant polices and measures based on potentials of saving energy of end-use energy equipments, anticipated benefit, capacity of relevant organization (test, manage, supervise, enforcing execute, assess) and international uniform and so on.

7. Take government agency energy saving as the breakthrough cut to advance energy conservation in the country

Government agencies refer to government bodies, institutions, social organizations and public institutions, which run by common financial funds. Government agencies take the lead to save energy, which not only reduce energy consumption and save administrative expenditure, but also dominate energy saving market and promote energy saving mechanism to be popularized. It is important to improve public trust and incorruptness construction.

Energy conservation by government agency has paid more attention by the State Council. Premier Wen Jiabao made comments and instructions that energy saving by government agencies has a huge potential and it is urgent to put on the agenda.

Energy conservation by government agencies is a better breakthrough cut to deepen energy conservation in the country. We should lay down administrative regulations and implementary detailed rules, formulate mandatory energy-saving target, build administrative system (There are 26 full-time persons working for energy conservation in US DOE, and the annual finance is 20M US dollars) and draw up polices and measures such as financing mechanisms, economic incentive, building energy saving and government procurement.

8. Construct energy-saving society by science and technology

Energy supply and energy environment are great challenges for us to build a well-off society in all way. We must rely on science and technology to resolve problems, fully mobilize and advance all the society to strictly enforce energy conservation in all areas, and systematically, deeply and fully improve energy efficiency. Therefore, enormous benefit in economy, environment and society are gained than normal energy conservation. Building a energy-saving society is important to carry out and correspond sustainable development, which is a significant method to improve economic growth way and is a new approach for building spiritual civilization.

We should lay strong emphasis on improving end-use energy efficiency to build a energy-saving society, develop cycle economy and clean production, implement recycling renewable resources and change values and consumption action of wasting resources.

It is vital to renovate technology and policy for building a energy saving society.

9. Introduce new energy saving mechanism.

In the conditions of economic market, the key to implement energy-saving strategy as the first priority is to create equally competitive market environment for energy conservation and development, promoting energy conservation to utilize its own advantages.

The experience from in and abroad indicated that DSM/IRP, energy-service company, life-cycle costs analysis, customers education, market pricing mechanism and externality costs internalization are all effective policy tool for introduce energy conservation as the first priority.

On the basis of demonstration, we should lay down policies and regulations and eliminate barrier, and implement gradually in the country.

Energy Efficiency and Energy Conservation

1. Energy efficiency status and prospect

1.1 Energy conservation and energy efficiency situation

Energy is the motive force for prosperity of China and is the key element of productivity. China is in the process of industrialization, relying on more energy for economic and social development than developed countries. The total energy cost of China's final user was 1250 billion RMB in 2001, accounting for 13% of GDP[1,2]. But in America, it only accounted for 7%[3]. In China, energy demand, especially the rise of oil demand, obviously affects the world market. The GHGs emitted from energy ranked 2nd of the world, only inferior to the USA.

1.1.1 Status of energy supply and demand

In 2002, the primary energy output was 1387Mtce, in which 1380Mt of coal, and 167Mt of oil, ranked 1st and 5th of the world respectively[4,5]. The electricity generation reached 1654TWh, ranked 2nd in the world.

In 2002, the primary energy consumption was 1480Mtce, ranked 2nd of the world, of which 66.1% by coal, 23.4%by oil, 2.7% by hydropower and 0.7% by nuclear power. Table 1-1 and 1-2 shows energy demand and supply.

Table 1-1 Energy output, consumption and mix in China (1980-2002)

	1980	1990	1995	1997	2000	2001	2002
Output							
Coal, Mt	620	1080	1360	1370	1000	1160	1380
Crude oil, Mt	106.0	138.3	150.0	160.7	163.0	164.0	167.0
Natural gas, $10^8 m^3$	142.7	153.0	179.5	227.0	272.0	303.3	326.6
Hydropower, 10^8 kWh	582	1267	1906	1960	2224	2274	2280
Nuclear power, 10^8 kWh	---	---	128	144	167	174	250
Electricity, 10^8 kWh	3006	6212	10070	11356	13556	14808	16540
Primary energy, Mtce	637.4	1039.2	1290.3	1324.1	1069.9	1209.0	1390.0
Mix of primary energy, %							
Coal	69.4	74.2	75.3	74.1	66.6	68.6	70.7
Crude oil	23.8	19.0	16.6	17.3	21.8	19.4	17.2
Natural gas	3.0	2.0	1.9	2.1	3.4	3.3	3.2
Hydropower and nuclear power	3.8	4.8	6.2	6.5	8.2	8.7	8.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Consumption, Mtce	602.8	987.0	1311.8	1378.0	1303.0	1349.1	1480.0
Mix, %							

Coal	72.2	76.2	74.6	71.5	66.1	65.3	66.1
Crude oil	20.7	16.6	17.5	20.4	24.6	24.3	23.4
Natural gas	3.1	2.1	1.8	1.7	2.5	2.7	2.7
Hydropower and nuclear power	4.0	5.1	6.1	6.2	6.8	7.7	7.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: 1. Hydropower and nuclear power is calculated according to the gross coal consumption rate for thermal power generation.

2. Nuclear power was produced in 1991. In 2002 nuclear power accounted for 0.7% of the total energy consumption.

Source: State Statistical Bureau, State Power Network Corporation of China

Table 1-2 China energy output and energy consumption and ranks of the world (1949~2002)

	1949	1980	1990	2000	2001	2002	
	output	output	output	output	output	output	consumption
Primary energy							
Output, Mtce	23.7	637.4	1039.2	1069.9	1170.0	1387.0	1480.0
Rank	13	3	3	3	3	3	2
Coal							
Output, Mt	32.0	620.0	1080.0	1000.0	1160.0	1380.0	1370.0
Rank	10	3	1	1	1	1	1
Crude oil							
Output, Mt	0.12	106.0	138.3	163.0	165.0	167.0	245.7
Rank		6	5	5	7	5	2
Natural gas, $10^8 m^3$							
Output,	0.07	142.7	153.0	272.0	303.4	326.6	301.0
Rank		12	20	19	19	16	18
Hydropower							
Output, TWh	0.7	58.2	126.7	222.4	277.4	288.0	265.0
Rank		6	4	4	3	4	4
Electricity							
Output, TWh	4.3	300.6	621.2	1355.6	1478.0	1654.0	1406.0
Rank	25	6	4	2	2	2	2

Source: State Statistical Bureau, BP Statistical Review of World Energy.

1.1.2 Per capita energy consumption is far lower than that of the world average

In 2000, the per capita commercial energy consumption was 1050kgce, equaling to 9% of America, 16% of OECD and to 50% of the world[6]. The annual per capita electricity consumption was 132kWh for rural and urban residential living, equaling to 3.1% of America[7](Table 1-3).

Table 1-3 International comparison on key energy and economic indicators

	China	America	EU	Japan	OECD	India	world
Population, 10^6	1262	282	376	127	1125	1016	6027
GDP, 10^9 US dollars	1040	9009	9756	5688	27675	482	34199

GDP(calculated by PPP), 10^9 US dollars	4818	9194	8531	3263	25437	2294	
Primary energy consumption, Mtce	1326	3286	2086	750	2086	429	12919
Oil percentage of primary energy consumption, %	22.1	38.3	41.2	50.7	40.7	34.0	37.8
Electricity, TWh	1355	4004	2572	1082	9629	542	15360
Electricity percentage of final energy consumption, %	16.1	20.0	18.3	24.0	19.7	18.7	18.0
Energy intensity, tce/10^6 US dollars GDP	1274	364	214	131	274	891	377
CO_2 emission, Mt-C	881	1580	879	328	3470	266	6422
Per capita indicator							
GDP US dollars	824	31996	25921	44830	24591	474	5675
Primary energy consumption, tce	1.05	11.67	5.54	5.91	6.74	0.42	2.14
Electricity, kWh	1074	14199	6840	8520	8559	533	2549
CO_2 emission, t-C	0.698	5.61	2.34	2.58	3.08	0.262	1.07

Note: 1. Hydropower is calculated by equivalent of heat; nuclear power equivalent conversion rate: 33%.

2. Dollars is calculated by exchange rate in 1995.

3. PPP is purchasing power paity.

4.EU includes to 15 countries.

Source: The Institute of Energy Economics, Japan, Handbook of energy and economic statistics in Japan. 2003.

1.1.3 Massive increase in energy demand

Integrated prediction by the Ministry of Science and Technology, Energy Research Institute of National Development and Reform Commission[8], Chinese Academy of Social Sciences[9], Chinese Academy of Engineering[10], World Energy Council[11] and DOE/IEA [12], the primary energy demand will reach 2500~3300Mtce in 2020, up by 90%~150% from 2000, being 1.7~2.3tce per capita, in which oil demand is 450~610Mt and coal is 2100~2900Mt. Massive increase in energy demand will raise the import dependence of oil and take more pressure to environment(Table 1-4).

The increase rate of electricity demand is faster than that of primary energy. According to research by State Power Network Corporation of China, until 2020, the electricity demand will reach 4200 billion kWh and the installed capacity will be 900GW, 1.8 times that of 2000, which is an arduous task.

Table 1-4 Prediction of primary energy demand in China (2000~2020)

	Total of primary energy	Coal	Oil	Natural gas	Primary electricity	Of which: Nuclear power
	Mtce	Mt	Mt	10^8m^3	Mtce	TWh
2000	1303	1206	224.4	245.0	88.2	16.7
2010						
ERI	1860~2130	1205~1425	322~377	810-865	63~80	48~102

IEA	1860	1320	336	610	80	90
EIA	1985	1630	340	790	230	75
2020						
ERI	2470~3280	2050~2900	480~610	1450~1650	110~145	110~260
IEA	2440	1660	455	1090	130	163
EIA	3040	2350	525	1810	370	130

Note: 1. ERI refers to Energy Research Institute of State Development and Reform Commission; IEA refers to International Energy Agency; EIA refers to US Energy Information Administration;

2.Precis of IEA and EIA are basic case;

3.Primary electricity includes nuclear, hydro and new energy.

Source: Energy Research Institute of National Development and Reform Commission, Scenario analysis for energy demand 2020, July 2003; IEA, China Energy Outlook, Sep.2002; Doe/EIA, International Energy Outlook 2002, March 2002.

1.2 Energy conservation plays an important role in building a well-off society in an all-around way

1.2.1 Ensure economic growth

Energy is a long-term restriction factor to construct a modern country and the key problem is to low of per capita energy consumption and high of energy intensity. To realize the target of GDP reaching four fold the 2000 GDP in 2020 and the increase rate is 7.2% annually, it is a great pressure for increasing energy and electricity demand. We must improve per capita energy consumption to meet energy demand for building a well-off society, at the same time, make efforts to increase energy efficiency and reduce energy intensity.

According to research by Chinese Academy of Social Sciences and Chinese Academy of Engineering, in the available energy development strategy cases, the enforcing energy conservation case has the least investment comparing with other cases such as accelerating to develop clean coal, renewable energy and nuclear power.

1.2.2 Improve environment quality

Many researches showed that energy conservation is a most practical and economic approach to reduce atmospheric pollutants such as SO_2 and CO_2 emission[13].

1.2.3 Strengthen economic competition

The percentages of energy cost in GDP, energy intensity, unit product energy consumption and electricity percentage in final energy consumption are important indicators influencing economic competition, but there is large gap between our country and advanced international level, so energy conservation is a significant tool to promote economic competition.

The percentage of energy intensive products cost in production cost is larger, in which steel and iron industry is more than 25%, petrochemistry 40%, building material 40~50% and chemical fertilizer 60~70%. Energy conservation play a key role in enhancing competition[14].

1.2.4 Improve living quality

The relationship between per capita energy consumption and living quality is close. According to analysis by America Power Research Institute, when the per capita GDP exceeds 3000 US dollars (Chinese target in 2020), the effect on improving living quality by growth of per capita GDP will become weak, but per capita electricity consumption is direct proportion to improving living quality[15].

According to in and abroad experts, the per capita energy consumption is 1.6tce to build a well-off society[16,17].

Energy conservation plays an important role in building a well-off society in an all-around way. To build a well-off society requires that under the moderate of raising per capita energy consumption, it should improve consumption structure, implement impartial allocation, supply low energy consumption, clean civil products and service, and oppose waste, forming sustainable living style and consumption model.

1.2.5 Provide employment

Energy conservation is one of economic movement with quantity and large scale, of which the unit investment is far lower than that of energy exploitation, but the unit investment provides more employment opportunities than exploitation. According to America Key Economy Development Council research, employ opportunities created by energy conservation is double that of by mining oil and gas or building a new power station[18].

1.2.6 Ensure oil security

Ensuring oil security is an important strategy for us. In 2002, the per capita recoverable reserves for oil was only 1.95t, being 8.5% of the world average. According to many researches, in 2020, the net import oil will be 300~420Mt and the import dependence will be

60~70%(Table 1-5). So it is significant to improve efficiency in oil exploitation, processing and end-use, develop alternative products and technology. Researches showed that if we develop saving and alternative technologies and exploit non-conventional oil, then the import dependence of oil will be less than 30%[10].

Table 1-5　Import dependence of oil in China (2000~2020)

	2000	2010	2020
Oil demand, Mt	224		
ERI		335~357	430~475
IEA		377	552
EIA		340	525
Net import (Mt)	69.6		
ERI of NDRC		155~187	240~295
IEA		230	425
EIA		185	380
Import dependence (%)	31.0		
ERI		46~52	59~62
IEA		61	77
EIA		54	72

Source: IEA, China Energy Outlook 2002, Sep.2002; DOE/EIA, International Energy Outlook 2002, March 2002.

1.3 Achieved significant results and experience

Since reform and opening, China has achieved significant results and gained high appraisement.

1.3.1 Great progress in energy efficiency

A. Ensure rapid economic growth.

The annual increase rate of GDP was 9.7% from 1980 to 2000, but the primary energy consumption grew at the rate of 4.6% annually with elasticity of energy consumption of 0.47[1]. It is a great achievement for developing countries in the process of industrialization.

B. Energy intensity declines sharply

From 1980 to 2000, energy intensity in China declined 64% with the annual energy intensity drop rate of 4.6%. In the same period, the energy intensity of OECD declined 20% and of the world dropped 19% [6].

C. Gap of unit product energy consumption between China and international level become smaller

From 1980 to 2000, net fuel consumption for power generation decreased from 448gce/kWh to 392gce/kWh, and the gap decreased from +32.5% to +24.1%. The comparative energy consumption for steel decreased from 1201kgce/t to 781kgce/t and the gap decreased from 70.4% to 20.9%[6,19,20].

D. Enormous economic benefits from energy conservation.

From 1980 to 2000, accumulated saved and reduction usage of energy amounted to 1145Mtce, valued at 1082.5 billion RMB (energy price of 1997). Calculated by annual saved energy and newly energy supply, the saving investment on energy supply system 327 billion RMB [2].

E. Make a great contribution to ecological environmental protection

From1980 to 2000, the accumulated saved energy equals to 20.8Mt SO_2 and 722Mt–C CO_2 reduction.

1.3.2 Basic Experiences

A. Establish government administrative system for energy conversation

In 1980, the government put forward the development strategy on simultaneous development and economization and economization as the first priority. Under this guideline, we should strengthen energy saving management and build up perfect energy saving management system. The State Council set up official energy-saving conference institution, study and checkup energy-saving policies, regulations, plan and measurements, dispose and assort energy-saving tasks. At the same time, ministries and provincial governments set up energy-saving agencies to manage energy conservation. Energy-saving monitoring and services organization were also set up by province and cities at various levels. Until 2003, there are 145 energy-saving service centers, which is unique in the world.

B. Listed in the economic and social development plan

Since 1981, energy conservation is taken as resource to be listed in economic and social development plan.

C. Make policies, regulations and standards.

On November 1.1997, the “Law of Energy Conservation” has been issued and was put into effect on January 1st. 1998. After that auxiliary regulations were formulated by the national, local and sectors. By far there are 45 energy-saving design code and standards, 14 energy-efficiency standards and energy-saving building design code for different climate.

D. Increase funds

From 1981 to 1998, the investment on infrastructure constructing and technology updating was 136.3B RMB, of which 27.2% by the nation, 72.8% by the local and enterprises. The annual saved energy capacity by the nation was 90.42Mtce.

E. Economic incentive

Measures include: setting energy price free, tax reduction and exemption, loan on favorable terms, subsidy, and energy efficiency award for enterprises, which is only in China.

F. Combine energy conservation with improving environment and living quality.

The projects implanted include: Green Lights Project[21], Update rural power networks[22], Clean Production Demonstration Plan, Building Energy Conservation[23,24], Clean Energy Action, Forest Energy Engineering and so on.

G. Introduce energy-saving new mechanism

The new mechanism includes DSM/IRP, energy-service company[25], voluntary agreements, staple procurement and system benefit charge and so on. Some project has gained great results. Take Shengli Oil Field as example. Since DSM was implemented in 1996, electricity consumption decreased from 7.06 billion kWh in 1996 to 6.15 billion kWh in 2000 and the gap between peak and valley decreased from162MW to 60MW[26,27].

1.4 Anticipated benefit of energy conservation

Many researches indicate that, in the future 10~20 years, energy conservation and improving energy efficiency will make great economic, environmental and social benefit.

1.4.1 Enormous economic benefits

According to research by Chinese Academy of Engineering, the accumulated saved energy will be 1040Mtce from 2000 to 2020, valued at 983 billion RMB(final energy price of 1997), being 52Mtce annually. If providing more energy calculated by 1t coal equivalent, then the investment will be 5703 RMB(fixed in the price of 1997), accordingly, 52Mtce energy saved will save investment 296.5billion RMB[2,10].

1.4.2 Alleviate dependence on import oil

Integrated many researches (Energy Research Institutes of National Development and Reform Commission[8], Chinese Academy of Engineering [10], Zhang [28], He[29],World Energy Council[11] and DOE/EIA [12]), the potentials of saving oil will be 22Mt in 2010, reaching 60Mt in 2020 from transportation.

1.4.3 Improve environment quality

Calculated by potential energy of 1040Mtce in 2020, it is equivalent to 18.8Mt SO_2 , equaling to emission in 2002 (19.27Mt), and 656Mt-C CO_2 reduction.

1.4.4 Strengthen economic competition

Energy efficiency plays a key role in energy intensive industries such as metallurgy, petroleum, petrochemstry, chemical fertilizer and building material.

1.4.5 Build a well-off society

Energy conservation and improving energy efficiency are in favor of building a well-off higher quality human settlements environment. In addition, green buildings, green lights, energy-efficiency air conditioner and refrigerator will form high quality residential environment and embody modern human settlements environment.

Promoting clean production, enforcing green certification and energy-efficiency standards and labels will allow users to choose civil products and service with low energy intensity and less pollution. As a result, it will form retainable living style and consumption model.

Developing low energy consumption public transit and making city planning as people the concentration, it will form convenient, comfortable and economic community.

1.4.6 Provide more employment opportunities

Accordingly, employment opportunities created by investment unit energy conservation will double of that by oil and gas exploitation and electricity generation.

2. China energy efficiency and international comparison

2.1 Definition and terms

2.1.1 Energy efficiency and energy conservation

Now energy efficiency is substituted energy conservation created after energy crisis in 1970's.

In fact, according to definitions by international organization, the meaning of energy efficiency and energy conservation is same. In 1979, World Energy Council put forward that energy conservation is to improve energy efficiency by measures, which are available in technology, rational to economy and accepted by environment and society [30], i.e., energy conservation is to reduce energy intensity. We should take measures in all energy system links, such as exploitation, processing, conversion, transportation, allocation and end-use, and eliminate waste by measures, such as economy, technology, law, administration, publicity and education.

In *Energy Efficiency Improvement Utilizing High Technology* pressed by World Energy

Council in 1995, energy efficiency is defined as reducing energy input providing equal energy service. A comprehensive energy efficiency indicator is energy demand for increase unit GDP, i.e., energy intensity. Energy-efficiency indicators of sectors includes economic indicator and physical indicator, in which the former refers to energy intensity and the later refers to unit product energy consumption in industrial sector, but in service sector and buildings it refers to per unit floor space of the buildings and per capita energy consumption, respectively[31,36].

The reason for substituting energy efficiency for energy conservation is conception change. In the early period, energy conservation is to deal with energy crisis by save and reduction, but now it is stressed to improve energy efficiency to increase benefit and protect environment by technology [37].

2.2 Energy intensity

When energy intensity is calculated by exchange rate, Chinese energy intensity is one of the highest of the world, inferior to Russia and East European countries. The gaps between China and foreign countries narrowed in the past 10 years (Table 2-1).

Table 2-1 China energy intensity and international comparison (1990~2000) unit:tce/10^6 US dollars

	1990		2000	
	Calculated		Calculated	
	Exchange rate	PPP	Exchange rate	PPP
China	2417	521	1274	276
America	423	414	364	357
EU	236	270	214	244
Japan	127	221	131	230
Russia	-	-	2422	765
India	924	194	889	187
OECD	296	329	274	299
Non-OECD	1023		816	
World	423		377	

Note: 1. Output value refers to GDP;

2. PPP refers to purchasing power parity

3. Dollars is calculated by exchange rate in 1995.

4. Energy consumption refers to primary energy consumption, in which hydropower is calculated by equivalent of heat, nuclear power is calculated by conversion rate of 33%

Source: Institute of Energy Economics, Japan, Handbook of energy and economic statistics in Japan. 2003.

From Table 2-1, we can see that, in 2000, the energy consumption for 1million US dollars GDP was 1274tce, equaling to 9.7 times of Japan and 3.4 times of the world. In 1990, it was 19.0 times and 5.7 times to Japan and the world respectively.

When energy intensity is calculated by PPP, the gap between China and foreign countries is small. In 2000, it was only higher than 20% of Japan, even lower than 8% of OECD.

In general, energy intensity is highly estimated calculated by exchange rate, but it is lower calculated by PPP. It is impertinent to compare energy intensity with that of international levels calculated by exchange rate and it is suspicious to compare energy intensity calculated by PPP. So it is rational to compare Chinese energy intensity with developing countries with near conditions, instead of with developed countries such as Japan. In 2000, energy intensity calculated by exchange rate was higher than 60% of non-OECD countries and 1.4 times of those countries in 1990.

2.3 Physical energy efficiency[38~42]

According to international prevailing definition and calculated method of energy efficiency and the energy balance table, the China energy efficiency was 33.4% in 2000. Table 2-2 shows energy efficiency change from 1980~2000.

Table 2-2　　Physical energy efficiency in China (1980~2000)

	1980 [42]	1989[38]	1997[38]	2000	Prediction of early 1990's in ECE region[35]
1、Exploitation efficiency	-	31.1	33.0	33.5	59~71
2、Medium links efficiency	74.0	72.4	68.8	67.8	67~75
3、End-use efficiency					
Agriculture	27.7	28.0	30.5	32.0	33~36
Industry	38.7	40.5	46.3	49.6	65
Transportation	21.2	25.4	28.9	28.1	25~30
Residential and commercial	29.1	42.5	54.8	66.2	50~65
Total	34.4	38.7	45.3	49.2	51~55
4、Energy efficiency(2×3)	25.9	28.0	31.2	33.4	34~41
5、Total efficiency (1×4)	—	8.7	10.3	11.2	20~30

Note: 1. Middle links includes energy processing, conversion, storage and transportation;

2. Industry includes construction; residential and commercial includes other sectors

3. ECE refers to European Economic Council, ECE includes West Europe, East Europe and Russia.

From Table2-2, we can see that physical energy efficiency increased by 7.5 percent point compared to 1980, by 5.4 percent point compared to1989.

Energy efficiency in the medium links decreased because the proportion of primary energy transferred to electricity increased. From 1989 to 2000, the end-use efficiency raised 10.5 percent point, mainly attributing to energy intensive industry, especially steel and iron industry, which popularized new techniques and increased industrial concentricity. In transportation sector, the national railway system has gradually been converted to diesel engines and electrified. In residential and commercial sector, demand for high quality energy such as electric power, gas and thermal etc, increased drastically.

Totally, physical energy efficiency increased drastically since 1980's with quicken speed, but the rise rate of energy efficiency increased less; lower than energy intensity drop rate. The main reasons are as follows:

- Coal plays a key role in primary energy and final energy consumption.
- The development of towns and villages industry is quickly.
- Change of industrial structure. The percentage of transportation increased obviously, which had lower end-use energy efficiency, but the percentage of industry decreased with higher end-use energy efficiency (Table 2-3).

Table 2-3 China final energy consumption and structure (1980~2000)

	1980	1989	2000
Final energy consumption, Mtce	452	706	892
Mix, %			
Agriculture	6.9	6.7	5.4
Industry	63.0	56.8	55.8
Transportation	8.0	10.0	15.4
Residential and commercial	22.1	26.5	23.4
Total	100.0	100.0	100.0

Note: Final energy consumption refers to primary energy consumption subtracted energy consumption by energy industry and loss from processing, conversion and transmission and distribution, at last, getting the energy for end-use. The table is emended by international prevailing definition and calculated method of energy efficiency and energy balance table.

In 2000, China energy efficiency level was equal to that of Europe in 1990's and to Japan in 1970's (in 1975 the energy efficiency was 36.5% in Japan). The influencing factors are energy mix, raw material route, enterprise (equipment) scope, efficiency of energy consumption equipments, techniques, fuel quality and utilization of regenerating resources and so on (Table 2-4, 2-5).

Table 2-4 Factors influencing energy efficiency and international comparison (2000) [19,20,39]

	China	Foreign countries	Effect on energy efficiency
Coal percentage of total primary consumption, %	66.1	OECD 20.4	Energy mix changed from coal to oil, end-use efficiency increased by 10% in Japan in 1955~1975.
Coal percentage of total final energy consumption, %	43	World average 9	
Raw material for synthetic ammonia, %	Coal, coke, 62	Natural gas 100 (Japan)	Energy intensity of coal for synthetic ammonia is higher than 70% of natural gas
Raw material for paper pulp,%	Wood pulp, 20	Wood pulp, 100	Bark and black liquor can be used for power generation, self-support ratio is 30% in Japanese paper plant
Thermal power units capacity, MW	60	Public plant has eliminated capacity lower than 100MW in Japan	Designed net fuel consumption for 100MW power generation unit is 390gce/kWh, for 600MW is 320gce/kWh
Output of paper plant, 10^4t/yr	0.25	Developed countries average: 18	
Operation efficiency of industrial boilers, %	60~65	80~85	Annual coal consumption is 380Mt, potential energy-saving ratio is 15%[43,44]
Efficiency of medium and small motors, %	87	92	Annual electricity consumption is 660TWh, potential saving energy is 18TWh[43,45]
Continuous casting ratio of steel	82.5	Japan, 98	When processing 1t steel, fully energy consumption for steel decreased by 200kgce[46]
Unpackaged rate of cement, %	19.1	America, Japan: >95	Saving packing bag of 10^4t cement, it will save 330m^3 high-quality wood, 11700t water, 72000kWh electricity and 80kg coal[47]
Ash in coal for power generation, %	26.0	America: 10.3	
Ash in cleaned coking coal	9.66	America: 7.0	When ash in coking decreases 1%, ash in coke will decreases 1.3% and the output of pig iron will increases 2.7%[48]
Percentage of waste paper of raw material, %	1/3	Japan: 57	Energy consumption by regenerating paper is less than 80% of consumption by wood.

Table 2-5 Energy efficiency and potential energy saving of main equipments (2000)

	Capacity of equipments	Annual energy consumption	Efficiency		Potentials of energy saving
			Average in China	International advanced	
Industrial boiler	0.5263M unit 1256700MW, 90% of coal	Coal: 380Mt	60%~65%	80%~85%	Energy consumption rate: 15%, 60Mtce
Power station	212.8GW	Coal: 528Mt	33.84%	40.63	20~25Mtce

boiler					
Small and medium motors	300GW	Electricity: 660TWh	87%	92%	18TWh
Transformer for electricity distribution	Low efficiency 2.38×10^8KVA	Loss: 41TWh	Off-load loss higher: 90~190% On-load loss higher: 50~60%		9TWh

Source: China Standardization Institute, State Power Company, International Copper Association, China-US clean energy technology forum, August 29th~September 1st 2001, Beijing.

The China energy efficiency is 33%, lower than 10 percent point of the world advanced level. The total energy efficiency is 11.2%, i.e., only 1/10 recoverable reserve was transmitted and used by final energy and 90% was lost and wasted in the process of exploitation, processing, conversion, storage and transportation and end-use.

It is pointed out that most rural residential energy consumption still relies on biomass, and the consumption was 220Mtce in 2000[49], plus these energy, the energy efficiency will decrease to 30%, down by 3.5 percent point.

2.4 Unit product energy consumption

There is great gap of unit product energy consumption between China and international advanced level. In 2000, the indicators of energy consumption of 8 industries (petrochemical industry, power industry, steel and iron industry, nonferrous metal, building materials, chemical industry, light industry and textile industry) are higher than 47% of international advanced level, being more 170Mtce energy use. The energy consumption of 8 industries made up 73% of the total energy consumption of industrial sector. Accordingly, 230Mtce more energy was consumed by industrial sector. Table 2-6 shows energy consumption by energy intensive products from 1990 to 2000.

Table 2-6 International comparison of unit product consumption of energy intensive products (1990~2000)

	1990			2000		
	Average in China	International advanced level	Gap, +%	Average in China	International advanced level	Gap, +%
Net fuel consumption for power generation, gce/kWh	427	332(Japan)	+28.6	392	316(Japan)	+24.1
Comparative energy consumption for steel, kgce/t	997	629(Japan)	+58.5	781	646(Japan)	+20.9
Fully energy consumption for cement, kgce/t	201.1	122.6(Japan)	+64.0	181.0	125.7(Japan)	+44.0
Fully energy consumption for ethylene, kgce/t	1580	857(Japan)	+84.4	1212	714(Japan)	+69.7
Fully energy consumption for synthetic ammonia, kgce/t, (natural gas, large plant), kgce/t	1343	1000(America)	+34.3	1200	970(America)	+23.7

Note: International advance level refers to average value of countries with world advanced level.

Source: Journal of Japan Energy Society, 2001, No.7.

From Table 2-6, we can see that, the gap of energy consumption between China and foreign countries became smaller, especially comparative energy consumption for steel, which was higher than 58.5% of international advanced level in 1990, and decreased to 20.9% in 2000.

It is pointed out that the aim to compare energy consumption of products is to find reasons caused gaps, and indicate direction of energy conservation. The energy consumption of products are influenced by many factors, in which some can't be compared and some are decided by special conditions, which is difficult to change. So potential saving energy can't be calculated by comparing with countries.

3. Energy conservation of electric power system

3.1 Status and prospect of electric power system

3.1.1 Installed capacity

In 2002, the total capacity of power generating equipments was 356.57GW, in which hydro power amounted to 86.08GW, accounting for 24.1%; thermal power amounted to 265.55GW, accounting for 74.5%; and nuclear power amounted to 4.47GW, accounting for 1.3%.

3.1.2 Electricity generation mix

By the end of 2002, 325.71GW of generating units with and unit capacity over 6MW were in operation, in which coal-fired capacity accounted for 75.1%; hydropower capacity accounted for 19.8%; gas-turbine capacity accounted for 2.0%; diesel capacity 1.7%, and nuclear capacity 1.4%.

3.1.3 Electricity generation

In 2002, the total generating electricity was 1654.16TWh, in which hydro electricity was 274.57TWh, accounted for 16.6%; thermal electricity was 1352.20TWh, accounted for 81.7%; nuclear electricity was 26.49TWh, accounted for 1.6%.

3.1.4 Fuel consumption of generating electricity and co-generation of heating

In 2002, fuel consumption of thermal power stations (over 6MW units, including 6MW) was 472.9Mtce, of which coal consumption was 655.9Mt; fuel oil consumption was 10.9Mt; gas consumption was 21.15billion m^3. Fuel consumption of co-generation of heat was 56.3Mtce, of which coal 76.9Mt; fuel oil 1.5Mt; gas 10.42billion m^3.

It is explained that most gas for electricity generation was recycled from industrial waste gas of low calorific value, and the percentage of natural gas was smaller. In 2000, the natural gas consumption was 0.64billion m^3.

3.1.5 Power network

There were 16 large power networks in China by the end of 2002, of which 5 large networks included North China power network, Northeast power network, East China power network, Central China power network and Northwest power network. The installed capacity of power generating equipments was 221.51GW, in which North China system 49.73GW; Northeast system 39.87GW; East China system 60.52GW; Central China 50.56GW; Northwest system 20.83GW. There are 11 provincial networks, in which Guangdong system is the largest with capacity of 35.88GW. The new reform of electric power system will form 6 larger networks, in which Central Tibet network does not belong to larger network. Table 3-1 shows indicators of electric power industry from 1990 to 2002.

3.2 Prediction of installed capacity and generating electricity in 2010 and 2020

It is estimated that the installed capacity of generating electricity equipment will be

600GW and the generating electricity will be 2800TWh in 2010. Prediction of electricity generation mix in 2010 is as follows:

Coal-fired power: 420GW annual generating electricity: 2240TWh

Hydro power: 140GW annual generating electricity: 415TWh

Gas-fired power: 25GW annual generating electricity: 75TWh

Nuclear power: 10GW annual generating electricity: 60TWh

Wind power: 5GW annual generating electricity: 10TWh

Table 3-1 China main indicators of electric power industry (1990~2002)

	1990	2000	2001	2002
Capacity of power generating equipment by year end, GW	137.89	319.32	338.49	356.57
Of which: Thermal	101.8	237.54	2530.12	2655.47
Hydro	36.05	79.35	83.01	86.07
Nuclear	——	2.10	2.10	4.47
Power generation, TWh	621.32	1386.5	1483.8	1654.2
Of which: Thermal	494.92	1107.9	1204.5	1352.2
Hydro	126.40	243.1	261.1	274.6
Nuclear	——	16.7	17.5	26.5
Gross coal consumption rate, gce/kWh	392	363	357	356
Net coal consumption rate, gce/kWh	427	392	385	383
Plant use, %	6.90	6.28	6.24	6.15
Of which: Thermal	8.22	7.31	7.25	7.10
Hydro	0.30	0.49	0.46	0.49
Line loss rate, %	8.06	7.70	7.55	7.52
Generating unit utilization hours	5036	4517	4588	4560
Of which: Thermal	5413	4848	4900	5272
Hydro	3800	3258	3129	3289

Source: State Power Network Corporation of China.

It is estimated that the installed capacity of generating electricity equipment will be 1000GW and the generating electricity will be 4600TWh in 2020. Prediction of electricity generation mix in 2010 is as follows:

Coal-fired power: 650GW annual generating electricity: 3450TWh

Hydro power: 240GW annual generating electricity: 730TWh

Gas-fired power: 70GW annual generating electricity: 220TWh

Nuclear power: 30GW annual generating electricity: 180TWh

Wind power: 10GW annual generating electricity: 20TWh

3.3 Energy efficiency of electric power supply system and international comparison

3.3.1 Gross heat consumption for power generation

According to statistics on plants with individual capacity over 6MW, gross heat consumption rate decreased from 404gce/kWh in 1982 to 356gce/kWh in 2002 and net coal consumption rate decreased from 438gce/kWh in 1982 to 383gce/kWh in 2002 (Table 3-2).

Table 3-2 Gross and net coal consumption rate (1958~2002) unit: gce/kWh

Year	Gross coal consumption rate	Net coal consumption rate
1958	540	601
1960	534	600
1965	458	518
1970	(463)	(502)
1975	450	489
1980	413	448
1985	398	431
1990	392	427
1995	379	412
2000	363	392
2001	357	385
2002	356	383

Note: 1. Net coal consumption rate was the plant with capacity of more than 500kW before 1966, but after 1967 the capacity of plant is more than 6000kW.

2. the number in the brackets is estimation.

Sources: State Power Company

Compared with other countries (German, England and Japan), gross and net coal consumption of rate is higher, up 70gce/kWh[50,51]. Reasons are as follows:

- Small units installed capacity. Average capacity of thermal units was 60MW in 2000;
- Smaller proportion of co-generation;
- Smaller proportion of oil and gas power station. It is less than 4%;
- Poor quality of coal;
- Generating electricity structure. The installed capacity of hydropower only accounted for 24% and generating electricity made up 17%. The percentage of installed capacity of oil and gas power is less than 4%, so coal-fired plant is not only charged with peak load and frequency regulation, but also is alternative to operating on unstable area with low heating efficiency.
- Poor quality of generating electricity equipments. The net coal consumption rate of

domestically large unit is higher than designed because of poor quality.

3.3.2 Plant use rate

The electricity generation mix mainly consists of thermal power, but thermal power was mainly composed of coal-fire plants, which is the main reason for higher plant use rate. Plant use rate will not change for a long time because environment protection, electric dust removing and desulphurization will increase electricity consumption. Table 3-3 shows plant use rate from 1958~2002.

Table 3-3 Plant use rate(1958~2002)

Year	Comprehensive plant use rate	Plant use rate of hydropower	Plant use rate of thermal power
1958	6.31	0.17	7.00
1960	7.12	0.13	7.85
1965	6.98	0.21	7.98
1970	(6.54)	(0.17)	(7.78)
1975	6.23	0.15	7.9l
1980	6.44	0.19	7.65
1985	6.42	0.28	7.78
1990	6.90	0.30	8.22
1995	6.78	0.37	7.95
2000	6.28	0.49	7.31
2001	6.24	0.46	7.25
2002	6.15	0.49	7.10

Note: formulae: plant use rate of generating electricity=electricity consumed by plant÷generating electricity×100%. Number in the brackets is estimated.

Source: State Power Network Corporation of China.

At the beginning of 1990's, the plant use rate of thermal power plants was 4.7~8.1% in most industrial countries. In 1998, the plant use rate of European Unions was 5.07% [50].

Compared with America, France, Canada and Italy, in China, the plant use rate of coal-fired power plant is higher, up by 1 percent point and by 2 percent point than that of Japan. The gaps of plant use rate between China and foreign countries is because of coal-fired power plant and the reasons are as follows:

- Poor quality of coal. Coal ash content of generating electricity was up to 26% in 2000, but in America it was only 10.3%.
- More electricity consumption by cycle water.
- Large electricity consumption by pump.
- Lower efficiency of air drier.

3.3.3 Line loss rate

The power network is weak with higher line loss rate in China. A lot of low voltage distribution loss wasn't taken into account because a quantity of electricity was bulk sale. Since 1998, after construction and updating on urban and rural power networks with investment of 400billion RMB, the line loss rate of rural power networks decreased from 20~30% to 12% (Table 3-4).

Table 3-4 Line loss rate (1958~2002) unit: %

Year	Line loss rate
1958	7.57
1960	7.11
1965	7.3l
1970	(9.22)
1975	10.21
1980	8.93
1985	8.18
1990	8.06
1995	8.77
2000	7.81
2001	7.55
2002	7.52

Source: State Power Network Corporation of China.

Compared with foreign countries, the gap of line loss rate is smaller, in which the line loss rate in America and Japan is 5.5% respectively, France 6.9% and England 7.6%[52].

The problems on transmission and distribution are as follows:

- Construction funds for power networks. Since 2002, because of canceling power construction funds and electricity supply allowance, there are no fixed funds for transmission and distribution, which should be solved by electricity price.
- Policy on power network operation and electricity consumption management. In general the urban power network is better managed than that of rural, where the transmission and distribution equipment is destroyed and electricity is stolen serious.
- Equipments of power network are out of date.

3.4 Potentials of energy conservation analysis for electric power system

3.4.1 Energy saving target

Energy saving target in 2010 and 2020 is as follows:

- Net coal consumption rate. If the net coal consumption rate reduced by 3gce/kWh annually, then it will decrease to 360gce/kWh in 2010, reaching 330gce/kWh in 2020.
- Plant use rate. It is estimated that plant use rate will be 7.0% in 2010, being 6.5% in 2020.
- Line loss rate. The line loss rate will decrease to 6.5% in 2010, reaching 6.0% in 2020.

3.4.2 Estimation of potentials of energy conservation

- Save oil. In 1999, oil consumption by generating electricity and heating was 16.24Mt, in which 3Mt oil was used for ignition and stable combustion. It is estimated that fuel oil will be replaced by coal and natural gas except for 2~3Mt oil for ignition and combustion, which will save oil 13~14Mt in 2020.
- Save coal. Compared to 2000, the coal saved will be 66.6Mtce because of decline of net coal consumption rate and plant use rate in 2010. Compared to 2010, the coal saved will be 96.8Mtce because of reduction of net coal consumption rate and plant use rate until 2020.
- Save energy by reducing line loss rate. Comparing to 2000, the line loss rate will decrease by 34.1TWh in 2010, equaling to 12.28Mtce. In 2020, the line loss rate will decrease by 21.5TWh, equaling to 7.1Mtce.

Combined with above two loss, the energy saved will be 78.9Mtce in 2010 and 103.9Mtce in 2020.

3.5 Increase electricity use efficiency

3.5.1 Final electricity consumption

The final electricity consumption was 1407.6TWh in 2002, in which 5.5% by agriculture, 68.8% by industry, 2.4% by transportation, 14.2% by household and 9.3% by commercial and other sectors (Table 3-5).

Table 3-5 Final electricity consumption and structure (1990~2002)

	2000		2001		2002	
	TWh	%	TWh	%	TWh	%
Agriculture	70.9	6.1	75.9	6.0	77.6	5.5
Industry	791.3	68.3	857.8	68.1	965.7	68.8
Transportation	26.1	2.3	29.1	2.3	33.2	2.4
Residential	167.2	14.4	183.5	14.6	200.1	14.2
Urban	99.7	8.6	106.5	8.5	116.9	8.3
Rural	67.5	5.8	77.0	6.1	83.2	5.9
Commercial	40.2	3.5	45.5	3.6	53.6	3.8
Others	62.7	5.4	68.7	5.4	77.3	5.5

Total	1158.4	100.0	1260.5	100.0	1407.6	100.0

Note: 1. Final electricity consumption=generating electricity-(electricity by plants and line loss);

2. Industry includes construction;

3. Others includes the tertiary industry (education, science and technology, culture and health etc) except commercial, transportation and government agency, social organization and defence.

Source: State Power Network Corporation of China

3.5.2 Potentials of saving electricity analysis

A. Save electricity

Electricity consumption equipments include small and medium motors, pumps, fans, compressors, electric furnace, electric welding, electrolysis, electroplate, transformer, lighting appliances and family appliances. If new technology and energy-efficiency standards and labels were adopted for these equipments, then the potential energy will be 125.3TWh in 2010[43,45,53~58].

B. Shift out the peak-load

After time-of-use electricity tariff by peak and valley was implemented in 1995, 10~12GW peak load was shifted out. If time-of-use electricity tariff system by peak and valley and electricity tariff of discontinued load were popularized, then 40GW peak load will be shifted out in 2020.

Developing cogeneration by small gas turbine can also shift out peak load. It is estimated that cogeneration by gas turbine will substitute for load of 20GW air conditioner.

3.5.3 Electric demand side management (DSM)[53,59]

A. Current status of DSM

DSM was imported in the early 1990’s. In order to implement DSM, the State Planning Commission, State Economic and Trade Commission, Science and Technology Ministry, State Electric Power Corporation and large, medium electricity users, relevant scientific research institutes, colleges and universities and social organizations did a lot of work such as developing foreign cooperation, holding workshops and training, setting up demonstration in enterprises and region power networks and encouraging to develop and utilize energy saving technology by market tools and incentive mechanism, which accumulated effective experiences.

B. Barriers for implementing DSM

- Understand of DSM. DSM include shifting out the peak-load, saving electricity and alternative energy, in which the two formers are widely used and alternative energy is only limited for biomass, coal and oil. In addition, distributed electricity generation is the main part for carrying out DSM.

- No operation mechanism and incentive mechanism for DSM.
- Taking DSM as emergency measure for compensating deficiency, not as resources.
- Irrational power price. Because of irrational power price, users have no interest in DSM.
- Inadequate publicity.
- Insufficient qualified personnel.
- Supply and demand contradiction. It can not be resolved by DSM.

C. Policy and measures

- Take DSM as main body for power network company.
- Formulate incentive policies. Compensate power network company in carrying out DSM, at the same time, it important to take incentive measures for customers, who purchased and utilized high-efficiency energy consumption equipments, and for supply trader, who develop and produce high-efficiency energy consumption equipments.
- Set up public benefit fund for DSM.
- Regulate rational power price structure. It is appropriate to raise basic electricity price, implement generating electricity on network and time-of-use power price, enlarge scope of time-of-use electricity tariff and seasonal price, make the electricity price between peak and valley and seasonal price larger, and popularize electricity tariff of discontinued load.
- Adjust ratio of electricity price to natural gas price

3.6 Barrier analysis

3.6.1 Policy and regulations

There are no suitable legislations and systems for electric power reform and development. Regulatory on power market, power supervision, power price mechanism, DSM and renewable energy generating electricity have not been established.

3.6.2 Management system

At the end of 2002, electric power reform called “divide plant and network, compete price on the network” was carried out. By far, there is still gap between reality and target of restructuring by corporation system, commercial operation and legally management.

3.6.3 Technology

Properties of generation, transmission and distribution equipments are poor. Development of domestically made equipments such as gas-turbine, pumped storage and nuclear units has not been resolved.

3.6.4 Fund

Now because power construction funds and allowance of power supply were cancelled and profit margin was low, there is no way to collect funds.

3.7 Policy and measures

3.7.1 Policy and regulations

Strengthen Electric Power Law and the Law of Energy Conservation; establish regulations on power market, power supervision and DSM.

3.7.2 Management system

Advance electricity reform, set up rational power price mechanism.

3.7.3 Technology

Adjust electricity generation mix, quicken hydropower construction, develop clean coal generating electricity, natural gas generating electricity, nuclear generating electricity and grid connected wind turbines for generating electricity, promote cogeneration by small gas turbine, consummate power network structure, and popularize energy saving technology.

3.7.4 Economic incentive

Set up preferential tax on energy saving project and renewable energy and natural gas generating electricity.

4 Energy conservation of industrial sector

4.1 Energy consumption of industrial sector

Energy consumption by industrial sector makes up 70% of total energy consumption in China. Energy consumption of industry was 390Mtce in 1980, increasing to 896Mtce in 2000. The annual increase rate was 4.2%, which is higher than that of the corresponding period of national energy consumption with increase rate of 3.9% (Table 4-1).

Table 4-1 Energy consumption and increase rate of industrial sector

Year	National energy consumption 10^4tce	Increase rate of national energy consumption, %	Energy consumption by industrial sector, 10^4tce	Increase rate of industry energy consumption, %	Percentage of industry of total, %
1990	98703		67578.0		68.47
1995	131176	5.85	96191.3	7.32	73.33
1996	138948	5.92	100322.29	4.29	72.20
1997	138173	-0.56	100080.34	-0.24	72.43
1998	132214	-4.31	94409.15	-5.67	71.41
1999	130119	-1.58	90797.48	-3.83	69.78
2000	130297	0.14	89633.65	-1.28	68.79

Source: China Statistics Yearbook.

Of the energy consumption mix, coal and coke made up 70%; electric power made up 13~15%; oil products made up 10~11%; natural gas made up 3%. Building materials, steel and iron industry and chemical industry are main energy intensive industries and the total energy consumption of three industries made up 54% of total energy consumption in industrial sector in 2000(Table 4-2).

Table4-2 Energy consumption by building material, steel and iron and chemical industries

unit :10^4 tce

Year	Industrial sector	Of which						Percentage of three industries of total, %
		Steel and iron industry	Percentage	Chemical industry	Percentage	Building material industry	Percentage	
1990	67578.0	10555	15.62	10986	16.26	11907	17.62	49.49
1995	96191.3	11391	11.84	12429	12.92	13611	14.15	38.91
1996	100322.3	12969	12.93	12368	12.33	22459	22.39	47.64
1997	100080.3	12672	12.66	12542	12.53	22380	22.36	47.56
1998	94409.2	12830	13.59	13518	14.32	20634	21.86	49.76
1999	90797.5	12870	14.17	14066	15.49	20765	22.87	52.54
2000	89633.7	12960	14.46	13935	15.55	21054	23.49	53.49

Source: Energy consumption by building material is the data from building material industry and it is great different from data that from China Statistics Yearbook.

Unit product energy consumption of energy intensive products decreased annually in industrial sector and there are 20 types of energy intensive products decreasing in 1990~2000 (Table 4-3). In the same period, the gap of energy intensive products between China and international level narrowed. Table 4-4 shows gaps in 2000. After adjusting structure of enterprises and products, adopting new energy-saving techniques and materials, and updating technology, the results of energy saving was obviously. In 1995~2000, energy saved was 109.1Mtce by 20 types energy intensive products, annual saving energy 21.8Mtce.

Table 4-3 Unit product energy consumption of main energy consumption products in 2000 and prediction in 2005~2020[19]

	1990	2000	2005	2010	2020
Fully energy consumption for steel, kgce/t	1611	1180	1000	860	780
Fully energy consumption for copper, kgce/t	5338	4707	4390	4256	4005
Fully energy consumption for aluminum, kgce/t	11530	9561	8550	8400	8200
Fully energy consumption for lead, kgce/t	1857	1521	1440	1380	1280
Fully energy consumption for zinc, kgce/t	3776	2671	2410	2290	2070
Energy factor consumption for oil refinery, kgce/t	20.58	20.01	18.60	16.90	14.30
Fully energy consumption for ethylene, kgce/t	1580	1212	1000	930	860
Fully energy consumption for synthetic ammonia, kgce/t					
Import plant	1343	1327	1248	1176	990
Domestic large and medium plant	2176	1918	1850	1700	1550
Small plant	2263	1801	1780	1640	1500
Fully energy consumption for caustic soda(diaphragm),kgce/t	1660	1563	1500	1475	1370
Fully energy consumption for cement, kgce/t (Large and medium rotary kilns)	201	181	170	160	130
Fully energy consumption for flat glass, kgce/ wt boxes	34.8	25.0	23.0	20.0	18.0
Fully energy consumption for brick, tce/10^4bricks	1.36	0.95	0.90	0.80	0.70
Fully energy consumption for paper and pasteboard, tce/t	1.55	1.54	1.50	1.45	1.30
Fully energy consumption for sugar, tce/t					
Sugar cane	6.64	6.0	5.5	5.0	4.5
Sugar beet	8.57	8.0	7.0	6.0	5.0

Source: Trade energy conservation plan and prediction by experts.

Table 4-4 International comparison of unit product energy consumption in 2000

	China	Abroad	Gap, %
Electricity consumption for raw coal production*, kWh/t	30.9	30.0	+3.0
Fully energy consumption for oil refinery, kgce/t	117	73	+60.3
Fully energy consumption for ethylene, kgce/t	1212	714	+69.7
Fully energy consumption for synthetic ammonia, kgce/t (large plant, natural gas)	1200	970	+23.7
Gross heat consumption rate for thermal power, gce/kWh	363	303	+19.8
Net heat consumption rate for thermal power, gcee.kWh	392	316	+24.1
Comparative energy consumption of steel, kgce/t	781	646	+20.9
Fully energy consumption for copper smelting*, kgce/t	1352	820	+64.9
Fully energy consumption for cement, kgce/t	181.0	125.7	+44.0
Fully energy consumption for flat glass, kgce/wt boxes	25.0	14.0	+78.6
Fully energy consumption for paper and pasteboard, tce/t	1.54	0.70	+120.0
Fully energy consumption for sugar cane, tce/t	6.0	4.5	+33.3
Electricity consumption for cotton yarn *, kWh/t	2349	2129	+10.3

Oil consumption for truck*, liter/100km	7.55	3.40	+122.1

Note: International advanced level refers to average value of advanced countries.

*represent 1997.

Source: SETC/UNDP/GEF, China final energy efficiency project, PDF-B, Industrial energy efficiency, June 2002; Research groups, Improving energy efficiency potential and measures, October 1999; Relevant trade statistics;: International Petroleum Economy, May 2003; Journal of Japan Energy Society, July 2002; The Institute of Energy Economics, Japan, Handbook of energy and economic statistics in Japan, 2003.

4.1.1 Steel and iron industry

Energy consumption of steel and iron industry was 129.6Mtce in 2000, of which 71% by coal, 26% by electric power, 2.4% by fuel oil and 0.6% by natural gas [60]. From 1990 to 2000, the annual increase rate of output of steel on average was 6.83%, and in the same period, the increase rate of energy consumption was 2.76%. 60% increase output of steel relied on energy conservation. From 1995 to 2000, the comprehensive energy consumption per tonnage steel decreased from 1.44 tce/t to 1.18 tce/t with annual energy-saving rate of 3.9%, saving energy more than 4 Mtce annually.

4.1.2 Chemical Industry

Energy consumption of the chemical industry was 139.4Mtce in 2000, in which 53.6% by coal, 9.8% by coke, 9.8% by oil products, 11.4% by natural gas and 15.5% by electric power.

Major energy intensive products in chemical industry include nitrogenous fertilizer, caustic soda, soda ash, calcium carbide, yellow phosphorous, carbon black and organic chemical, among which nitrogenous fertilizer is the most energy-consumptive product. The energy consumption of nitrogenous fertilizer was 45% of the total consumption in the chemical industry. Energy was also used as the raw material in chemical industry, so the percentage of energy cost in the productive cost is larger, in which energy cost is 60~70% for chemical fertilizer, 75% for calcium carbide, 60% for caustic soda, 60% for yellow phosphorous. Energy consumption decreased in varying degrees because of developing energy conservation. From 1990 to 2000, the imported large installations for synthetic ammonia decreased from 1343kgce/t to 1327kgce/t, the domestically made large and medium size installation decreased from 2176kgce/t to 1985kgce/t, and the small plant decreased from 2263kgce/t to 1801kgce/t (Table 4-3,4-5).

Table 4-5 Output and unit product energy consumption of chemical industry

Product	Output in 2000 Mt	Unit product energy consumption, kgce/t		
			2000	2010 prediction
Synthetic ammonia	31.66			
Import plant	8.32		1327	1176
Large and medium plant	6.78		1985	1623
Small plant	16.56		1801	1700
Caustic soda	6.46	Diaphragm	1563	1500
		Ion-membrane	1090	1050
Soda ash	8.34	Ammonia ash	468	430
		Combined ash	313	280
Calcium carbide	3.40		2153	1950
Yellow phosphor	0.59		7318	7000

Source: SET/UNDP/GEF, China final energy efficiency project, PDF-B, Industrial energy efficiency, June 2002.

4.1.3 Industry of building materials

Building materials are the first energy consumption sector of industry sector and the energy consumption was 210.5Mtce in 2000. Energy consumption by cements product is the most in the building materials and the energy consumption accounted for 70.5% of the total consumption in building materials industry (Table 4-6). Unit product energy consumption by building materials decreased obviously. From 1990 to 2000, coal consumption for cement grog of rotary kiln decreased from 185.6kgce/t to 173.0kgce/t, and for flat glass decreased from 32kgce,wt boxes to 25kgce,wt boxes.

Table 4-6 Output and energy consumption of building materials

Product	Output in 2000	Energy consumption in 2000, Mtce	Unit product energy consumption	2000	2010 prediction
Cement	571.2Mt	148.46	Rotary kiln		
			Heat consumption for cement grog, kgce/t	173.0	150
			Electricity consumption for cement, kWh/t	114.8	116
			Vertical klin		
			Heat consumption for cement grog, kgce/t	154.0	140
			Electricity consumption for cement, kWh/t	98.0	100
Flat glass	201.0 million wt boxes	4.23	Heat consumption, kgce/ wt boxes	25.0	20.0
			Electricity consumption, kWh/wt boxes	8.0	8.5
Architecture ceramic	1738.2 million m^2	21.51	Heat consumption, kgce/m^2	7.20	5.5
			Electricity consumption, kWh/m^2	4.21	3.5
Sanitary ware	57.5 million pieces	0.78	Heat consumption, kgce/per	14.00	12.0
			Electricity consumption, kWh/per	5.15	4.0
Brick	650.6 billion	24.16	Heat consumption, kgce/10^4piece	800.0	700.0

	bricks		Electricity consumption, kWh/10^{4}piece	402.5	400.0
Lime	116.6Mt	8.66	Heat consumption, kgce/t	180.5	160.0
			Electricity consumption, kWh/t	7.8	7.5

Note: output is from statistical data from industry. According to State Statistical Bureau, the output of cement was 597.0Mt in 2000, output of flat glass is 183.5 million wt boxes.

Source: SETC/UNDP/GEF, China final energy efficiency project PDF-B, Industrial energy efficiency, June 2002.

4.2 Gap

Table 4-4 shows gaps of unit product energy consumption of energy intensive products between China and international level.

4.2.1 Steel and iron industry

In 2000, output of steel of large and medium enterprises accounted for 90% of total output and the comparative energy consumption of steel was 781kgce/t, higher than 20.9% that of Japan of 646kgce/t.

Reasons are as follows:

- The iron to steel ratio. The iron to steel ratio is 0.935 in China, higher than 0.174 that of Japan. If the energy consumption per tonnage iron is calculated by 750kgce, then the energy consumption will be 130kgce per tonnage steel.
- Continuous casting ratio. In 2000, the continuous casting ratio was 82.5% in large and medium steel enterprises, while in Japan it was 98%, which saved energy 70kgce by per casting blank.
- Quality of energy and raw materials. Iron-stone consumption for per tonnage steel is 1.8t in large and medium enterprises, while it is 1.64t in Japan. The ash content in coke is 13.4% in China, 11.5% in Japan, and the sulphur content is 0.66% in China, 0.38~0.55% in Japan. Raw materials quality influencing fuel ratio of blast furnace is 15% and 70kgce more energy was consumed by per tonnage steel.
- Recycle of waste heat. The allocation ratio of TRT and CDQ of Japanese blast furnace is 85% and 74% respectively, but in our country the ratio of TRT for blast furnace with volume of more than 1000m^3 is 50% and CDQ is only adopted in Bao Shan Iron and Steel Group Corporation and JiNan Iron and Steel Group Corporation.

4.2.2 Chemical industry

Energy consumption of synthetic ammonia is higher due to following reasons:

Coal and coke is taken as raw materials while in abroad gas as raw materials accounts for

80~90%, but in China it only accounts for 20%, plus raw material of oil, it is up to 35%. In 2000, the energy consumption per tonnage ammonia was 1801kgce in the small size installation with coal and coke as raw materials, higher than 474kgce that of imported installations by gas as raw materials of 1327kgce, higher than 830kgce that of international level of 970kgce. The second reason is because of small size of enterprises and low efficiency of equipments.

4.2.3 Industry of building materials

Comparing to foreign advanced level, the gap of different kilns is 15~65%.
The reasons are as follows:

- Techniques: The technique for cement is by new suspension preheater (NSP) in foreign countries, but in China it is by wet kilns or vertical kilns, which consumed more energy with poor quality products.
- Scope of enterprises: There are more and more cement plants with production of more than 10000t/d in foreign countries, but in our country there are only more than 300 plants with production of 0.3 Mt annually and 7000 plants with production of 0.1~0.2Mt annually.
- Equipment: The equipment for cement is out of date. Refractory materials have poor quality.
- Fuel quality: Fuel for cement is often high-grade coal, natural gas and heavy oil in foreign countries, but in China fuel for cement is often raw coal.

4.3 Potentials of energy conservation analysis

4.3.1 Steel and Iron industry

- Reduce iron to steel ratio;
- Eliminate the open-hearth steel;
- Reduce comprehensive energy consumption per tonnage steel, iron, rolling materials and special steel.

4.3.2 Chemical industry

- Large synthetic ammonia. Compared with advanced technology, the gap of energy consumption is 30% and energy saved is 2.5Mtce. Energy consumption of synthetic ammonia by natural gas will decrease by 700kgce replacing by coal and coke, so improving percentage of natural gas, and reducing percentage of coal and coke will save energy. Compared with coal and coke as raw materials, if increasing 10 billion m^3 natural gas, then it will produce 10 Mt synthetic ammonia, saving energy 4.2Mtce.

- Medium synthetic ammonia. The potentials of energy conservation is 1.2Mtce.
- Small synthetic ammonia. The potentials of energy conservation is 3.3Mtce.

4.3.3 Building materials industry

- Cement. Develop the techniques of new suspension preheater (NSP), replace wet kiln by dry kiln or semi-dry kiln and update old wet kiln, popularize mechanical and vertical kiln, make large productive line for cement. In 2010, the potentials of energy conservation is 10.75Mtce.
- Flat glass. Make glass melt kiln insulation, recycle waste heat, adopt technology of abundant oxygen for float glass furnace and eliminate smaller kilns. The potentials of energy conservation is 1.16Mtce.
- Building ceramics. Update energy-saving kilns for old kilns, popularize roller hearth kiln. The potentials of energy conservation is 12.9Mtce.
- Brick kilns. Popularize hollow bricks, make internal-combustion bricks by industrial cinder and gangue，promote annular kiln, tunnel kiln, and recycle waste heat. The potentials of energy conservation is 13.7Mtce.

Analysis on potentials of energy conservation in industrial sector showed that energy saving has a huge potential by advanced technology to reduce unit energy consumption. According to energy saving plan, until 2010, saving energy for steel will be 24%, building materials 13~22%, synthetic ammonia 6~18% and petrochemistry 10~24%.

According to energy demand prediction by scenario analysis in 2020, from 2000 to 2020, the accumulated energy saved is 310~390Mtce in industrial sector, in which energy-saving volume accounts for 70~80% by adjusting professional structure and product structure, and technological energy-saving volume accounts for 20~30% by reducing unit product energy consumption.

4.4 Barriers analysis

4.4.1 Policies and regulations

Regulation system of energy conservation has not been established and industrial design code is out of date. Energy consumption equipments had no energy efficiency standards and governments at various levels have not effective tools by administrative supervision and economic incentives.

4.4.2 Management System and Organization

Government management structure is not suitable to market economy, and reform of energy saving management system is backward.

4.4.3 Technology

Lack qualified technical personnel, technology extended slowly. Energy saving technology and equipment excessively depends on the import.

4.4.4 Finance

Lack energy-saving investment policies suitable to market economic system.

4.4.5 Information

Lack information on industrial energy consumption, energy consumption of products, and energy efficiency of equipments.

4.4.6 Ability

The ability to establish and implement energy saving policy and regulations is weak for governments.

4.5 Policies and measures

4.5.1 Establish auxiliary regulations for Energy Conservation Law

4.5.2 Revise energy saving design code

4.5.3 Try out energy audit for enterprises

4.5.4 Advance energy-saving new technology

4.5.5 Establish and consummate energy management information system

4.5.6 Carry out reporting/benchmaking management

4.5.7 Implement energy efficiency performance contract

4.5.8 Strengthen enforcement capabilities of energy-saving services

5 Building energy saving

The former 20 years is a period of great of construction in 21st Century. At present, every year the area of buildings built is more than total of developed countries, in which the area of building in 2020 will be double that in 2000. Most new buildings are high-energy consumption buildings, accounting for 95% and 99% existing buildings are highly energy consumption buildings with area of 40 billion square meters. The energy consumption for heating per unit floor space of buildings is three times that of the developed countries. The peak load of air conditioners was up to 45GW, equaling to full load by 2.5 Three Gorges hydropower station. According to current level, the energy consumption of buildings will be 1089Mtce, 3 times that of 2000.If building energy saving standards were enforced to implement and carrying out energy-saving updating for old buildings, then the energy consumption of buildings will decrease by 335 Mtce. Accordingly, building energy saving is main strategy of China and we must pay more attention on it.

5.1 Status of energy consumption of buildings

5.1.1 Range of energy consumption of buildings

According to international prevailing definition and classification, energy consumption of buildings refers to energy consumed by civil buildings. Civil buildings include residential buildings and commercial buildings (service trade and public buildings). The energy consumption of buildings includes that for heating, air conditioning, ventilating, hot water, lighting, cooking, appliance and elevator etc, within which consumption for heating, air conditioning and ventilating accounted for 2/3.

5.1.2 Climate[63]

Climate conditions are a basic factor that influences building energy consumption. China is a vast territory, which spans several climate zones such as cold, temperate and hot zones and the climate types in China differ greatly. The main climate characteristics are cold winters and hot summers. It is certain that these bad climate conditions make energy conservation of buildings more difficult in China.

5.1.3 Building scale

The building scale is enormous in China and in a few years, area of buildings built is 1.6~2.1 billion square meters. Such great building scale is scarcely in the world. By the end of 2002, the area of existing buildings the urban and rural was 38.8 billion square meters, in which the area of the urban buildings was 13.18 billion square meters. It is estimated the area of buildings will be 51.9 billion square meters at the end of 2010 with urban building area of 17.1 billion square meters, reaching 68.6 billion square meters with urban area of 26.1 billion square meters at the end of 2020.

The energy conservation of buildings made slow progress and the area of urban energy-efficiency buildings only accounted for 2.1% of the total area of buildings to this day.

5.1.4 Lighting and family electric appliances

Electricity consumed by lighting and electric appliances is great and increase rapidly. Table 5-1 shows electricity consumed by lighting and appliances.

Table5-1 Electricity consumed by lighting and family electric appliances in urban and rural households (2001)

Item	Number, 10^4	Electricity consumption, 10^8kWh
Lighting		671
Air conditioner	4316	233
Electric fan	50227	90
Refrigerator	12243	264
Washing machine	17365	52
TV set	38825	268
Smoke absorber	6815	59
Electric cooker	11756	116
Microwave oven	2427	27
Hot water shower	1809	52

Source: Electricity by lighting is from Beijing Hua Tongren Market Information Company ”Annual follow up survey for China Green Lights Project”; electricity consumption by family electric appliances is calculated by this program.

5.1.5 Status and prospect of energy consumption of buildings

Energy consumption of buildings in China is enormous because of great population and rising living standards, and the proportion of energy consumption of total energy consumption increased progressively (Table 5-2).

Table 5-2 Energy consumption of buildings (1996~2002)

Year	Energy consumption of nationwide total, Mtce	Building energy consumption, Mtce	Percentage of total, %
1996	1389.5	334.7	24.1
1997	1381.7	341.4	24.7
1998	1322.1	345.7	26.1
1999	1301.2	349.0	26.8
2000	1303.0	350.4	26.9
2001	1349.1	358.0	26.5

In the energy consumption of buildings, the percentage of energy consumption for heating and air conditioning is bigger and the percentage of energy consumption for lighting and family electric appliances increased rapidly. Table 5-3 shows energy consumption by different use (without non-commercial energy such as firewood and crop atalk).

Table 5-3 Energy consumption of buildings by final use (2001)

Use	Energy consumption, Mtce	Percentage of total, %
Heating by urban	134	37.4
Heating by rural	23	6.4
Air conditioning	41	11.5
Light, electric appliances	25	7.0
Cooking, hot water	135	37.7
Total	358	100.0

In the future, the energy consumption of buildings will increase greatly with rising living standards in building a well-off society in all round. Table 5-4 shows prediction of building energy consumption in 2000~2020.

Table 5-4 Prediction of energy conservation of buildings (2000~2020)

Year	GDP, 10^4 billion Yuan	Population, 10^8	Building area, $10^8 m^2$	Total energy consumption, 10^8tce	Per unit of buildings, kgce/m^2	Per GDP consumption of buildings, kgce/Yuan	Per capita consumption of buildings, kgce/per
2000	8.94	12.66	353	3.50	9.92	0.039	276.5
Annual increase rate, %	7.0	0.8		4.5			
2010	17.63	13.71	519	5.61 (6.73)	10.81 (12.97)	0.032 (0.038)	409.2 (490.9)
Annual increase rate %	7.0	0.4		3.0			
2020	34.76	14.27	686	7.54 (10.89)	10.99 (15.87)	0.022 (0.031)	528.4 (763.1)

Note: number in the blackest was energy consumption on condition of non-working.

Source: Science and Technology Department of Ministry of Construction

5.1.6 Peak load of air conditioning and heating

Heating in winter and air conditioning in summer are main factors caused difference of peak and valley of electric power. Because of heating in winter, the proportion of peak load in winter and in summer was 1.4:1.0 in Northeast electric network. In 2002, the load of air-conditioning hit 45GW. It is estimated that in 2010 will be double that of 2002, being 4 times in 2020. The difference of peak and valley of electric power will be seriously. If we stick to energy efficiency for buildings, then the load will decline 50%.

5.2 Gap

5.2.1 Thermal properties of building envelopes

Transmission heat coefficient is the main indicator of building envelopes. After oil crisis in 1973, building standards were revised continuously on improving thermal properties of building envelopes in developed countries [66,67]. As a result, the indicator of thermal properties of building envelopes had increased by 3~8 times.

Table 5-5 shows comparison of limitation of transmission heat coefficients of building envelopes in standard of domestic and abroad. From Table 5-5, we can see that, even if the buildings were constructed on the basis of energy-efficiency standards, the thermal properties of building envelopes is far higher than that of developed countries, in which energy consumption for heating and air conditioning is much higher than those of developed countries. In fact, the gap of buildings between China and developed countries is more than that showing in Table 5-5. Compared to developed countries, the unit area energy consumption for outside walls and roofs is 3~5 times that of developed countries, and for windows is 2~3 times.

Table 5-5 Comparison of limit of transmission heat coefficients of building envelops in standard of domestic and abroad unit: W/m^2℃

Country and region		Roof	Out wall	Window
China	Beijing residential building	0.60 0.80	0.82 1.16	3.50
	Hot-summer and cold-winter zone residential building (medium and lower reaches of Changjiang River)	0.8-1.0	1.0-1.5	2.5-4.7
England		0.16	0.35	2.0
German		0.20	0.20-0.30	1.5
America(equal heating days in Beijing)		0.19	0.32(inner heat preservation) 0.45(outer heat preservation)	2.04
Sweden (in the south)		0.12	0.17	2.00

5.2.2 Energy consumption of buildings

In the recently 30 years, developed countries are working for energy conservation of buildings. Now the energy consumption of buildings in German had decreased to1/4~1/6 of the energy consumption before 20 years. The area of energy saving buildings was 0.23 billion square meters until 2002 in China, only accounting for 2.1% of the total area of urban buildings.

5.3 Potentials of energy conservation of buildings

5.3.1 Potentials of energy conservation by energy-saving design standard for buildings

Due to the poor quality of thermal insulation and airtightness, and low energy efficiency of heating and air conditioning of the urban and rural residential buildings, the gaps between China and developed countries become larger. Compared with developed countries, even saving 50% energy in China, 50% or more potentials of energy still can be saved. Table 5-6 shows prediction of energy saved of buildings in 2010 and 2020.

Table 5-6 Prediction of saving energy (2010, 2020) unit: Mtce

<table>
<tr><th colspan="3">Objects</th><th>2010</th><th>2020</th></tr>
<tr><td rowspan="8">Energy conservation of heating and air conditioning</td><td rowspan="2">Cold region</td><td>New constructive residential building</td><td>9.2</td><td>26.1</td></tr>
<tr><td>Existing residential building</td><td>5.4</td><td>18.8</td></tr>
<tr><td rowspan="2">Hot-summer and cold-winter zone</td><td>New constructive residential building</td><td>7.7</td><td>23.8</td></tr>
<tr><td>Existing residential building</td><td>3.5</td><td>11.8</td></tr>
<tr><td rowspan="2">Hot-summer and warm-winter zone</td><td>New constructive public building</td><td>4.6</td><td>15.2</td></tr>
<tr><td>Existing public building</td><td>3.8</td><td>12.7</td></tr>
<tr><td colspan="2">New constructive public building</td><td>31.0</td><td>103.0</td></tr>
<tr><td colspan="2">Existing public buildings</td><td>9.6</td><td>28.8</td></tr>
<tr><td colspan="2">Energy conservation of lighting, electric appliances and cooking</td><td></td><td>37.2</td><td>94.8</td></tr>
<tr><td colspan="2">Total</td><td></td><td>112.0</td><td>335.0</td></tr>
</table>

It is pointed out that facts proved that if economic and practical measurements are adopted, then energy saving investment of new constructive residential buildings and cost of update buildings is 80~120RMB/m^2, and the investment can be retrieved from energy saving benefit in future 5 years. At the same time, because energy consumption of buildings reduced, i.e., reducing load of heating, air conditioning and lighting, the capacity of equipments decreased, too.

5.3.2 Potentials energy conservation of technology

Energy consumption of buildings includes many final energy services such as heating, air conditioner, cooking, hot water, lighting, refrigerating, washing and entertainment. Population, economy growth, energy service demand, energy saving technology and policies are main factors influencing energy demand of buildings, in which advanced technology play an important role. According to research by United Nations Department for Policy Coordination and Sustainable Development, there is huge potential for energy conservation of buildings in developed and developing countries. The potentials of energy conservation of buildings will be 60% in west European countries in 2020 and 65% for commercial buildings [68].

A. Energy saving technology of buildings and potentials of energy conservation

Energy saving technology of buildings involves building design, building materials, energy consumption equipments and appliances, controlling system and utilization of renewable sources. Potentials of energy conservation of building envelopes makes up 50~80%; heating and air conditioning makes up 30~35%; lighting makes up 50~70%; energy controlling system makes up 10%; advanced solar energy building makes up 85% [21,43,49,68,69].

B. Potentials of energy conservation of family electric appliances

There is obviously gap in energy efficiency of family electric appliances between China and international advanced level, showing great potential energy saving. At present, newly energy efficiency standards for family electric appliances are formulating in our country, which are on the basis of energy saving technology, and regulate the lowest limit of energy efficiency. Accordingly, saving rate and amount of saving energy can be calculated. Table 5-7 shows potentials of saving energy for family electric appliances.

Table 5-7 Potential of saving energy of residential electric appliances

	Retained number in 2001, 10^4	Electricity consumption in 2001, 10^8kWh	Percentage of total electricity use for living, %	Energy-saving rate by implement standards, %	Take effect of standards	Electricity saved in 2010, 10^8kWh
Refrigerator	12243	264.0	14.4	28~34	2004	77.9
Air conditioner	4316	233.1	12.7	12~30	2004	38.5
Color TV	26428	228.3	12.4	15	2004	34.2

Electric cooker	11756	105.8	5.8	10	2005	10.6
Electric fan	50227	90.4	4.9	5	2004	4.5
Washing machine	17365	52.1	2.8	15	2004	7.81
Hot water shower	1809	51.6	2.8	8	2004	4.1

Note: 1. 75% energy efficiency of refrigerators reached the evaluation of energy efficiency of national standard, and 28% energy was saved; 25% energy efficiency of refrigerators reached standard A^+ of EU standard, energy was saved 34%.

2. 75% energy efficiency of air conditioner increased from C grade to A grade of national standard, energy was saved 12%, 25% reached A grade of EU standard, energy was saved 30%.

Source: State Statistics Bureau; State Power Company; Energy Saving Center of Mechanical Industry; China Institute of Family Electric Appliances; International Copper Association; China Institute of Standardization, Potential analysis of energy conservation of major energy consumption product, July, 2003; Motor project team, Energy efficiency and market potential of electric motor system in China, China Machine Press, November 2001; China Energy Strategy Research (2000~2050), Chinese Power Press, May 1997; Beijing Hua Tongren Market Information Limited Company, China Green Light Project annual follow up report, March 2003; China Hardware Products Association, Survey on water heater of urban household, Economy Daily, September 30th, 2002. Huang Ronghua, Wang Yanjia, Hua Shengquan, Discuss on electricity saving plan in 2000, 1993; China Certification Center for Energy Conservation Product, August, 2002.

5.4 Barriers analysis[64,65]

5.4.1 Policies and regulations

Building energy saving is out of order in the market and it must be led by governments. There are no clear regulations on building energy saving in the law and also no incentive policies on construction, sale and utilization of energy-efficiency building.

5.4.2 Management system[70]

Building energy saving has not been listed in the government management function.

5.4.3 Heating system[71,72]

Welfare-style tariffs paid by employer of the planned economy are adopted for district heating in Northern region, which cause more energy waste, environment pollution and payment defaults, which made it difficult for heating continuously.

5.4.4 Idea of energy conservation

Some local officials unilaterally set building efficiency against the construction of more buildings, greatly influencing their achievements in their posts. The public lack knowledge on improving energy efficiency of buildings and become indifferent on energy conservation of buildings.

5.4.5 Technology and products

It lacks qualified technical personnel to research and development on energy saving technology of buildings. Some constructive developers pay no attention on technology and choose cheap products, contusing enthusiasm on developing technology of enterprises.

5.5 Policy approach

5.5.1 Laws and regulations

Establish building energy conservation management rules by State Council is the key to set up and consummate regulation system of building energy conservation.

5.5.2 Economic incentive policies [73]

It is suggested imposing adjustable tax on fixed assets investment or consumption tax on new civil buildings (update, extension) without energy-efficiency standards, where tax rate is 5% of the total investment and zero tax on energy saving buildings. In the northern region, special funds on updating existing buildings were established to improve updating old buildings. Special funds on updating heat network were also set up by the country to lead updating heating system.

To encourage produce and adopt energy-saving windows and insulation materials, tax reduction and exemption were adopted on certified windows and materials. It is necessary to formulate economic incentive mechanism to encourage produce and use energy consumption appliances of buildings.

5.5.3 Organization management

It is urgent to put on the improving energy efficiency of buildings to the agenda, bring into economic and social plan, and strengthen organization by governments at various levels.

5.5.4 Energy-saving technology

Study and develop energy-saving technology for building envelopes, high efficiency system for heating and air conditioning, updating technology for energy saving of old buildings, integrated technology on solar water heater and buildings, heating and air conditioning technology by renewable energy, and analysis software on calculating energy consumption of buildings.

5.5.5 Energy-efficiency standards and labels

Strengthen final energy consumption management to study and set up assessment system on energy efficiency buildings; Organize to establish, revise and carry out forcibly energy-efficiency standards on family electric appliances and lighting appliances; and set up energy-efficiency labels system.

6. Transportation energy saving

6.1 Introduction

Energy consumption by transportation sector involves economic, social and environmental problems, including national oil security, atmospheric pollution, CO_2 emission and loss by casualty accidents and jams.

With the increase growth of economy, the progress of urbanization, and development of tertiary industry, movement of personnel and freight, especially the demand for highway transportation increased drastically in China. In 1990~2002, the turnover volume of highway passenger and freight traffic increased by 198% and 102%, respectively. In 1990~2000, the percentage energy consumption by highway transportation increased from 47.6% in 1990 to 68.4% in 2000 of the total transportation energy consumption, while the percentage energy consumption by railway transportation decreased from 27.7% in 1990 to 13.5% in 2000 .

Highway transportation should be taken as the emphasis in this project. The reasons are as follows:

- Mechanization develops rapidly, especially personal vehicles. The number of personal cars increased from 1.917 million in 1997 to 6.238 million in 2002.
- Atmospheric pollution becomes seriously because of traffic. Take Beijing as an example. Inhalable particles accounted for 45% by the vehicle exhaust, and NOx and CO accounted for 43% and 83% respectively[74].
- Gasoline consumption by highway transportation dramatically increased. The gasoline consumption increased from 24.8Mt in 1990 to 63.8Mt in 2000[90]. The gasoline consumption accounted for 1/3 of final oil consumption, which had more influence on oil security.
- Traffic accidents caused by highway transportation are seriously. 109381 people died in 2002.

6.2 Status energy consumption by transportation sector

The energy consumption by transportation includes railway, highway, waterway, civil aviation and pipeline.

6.2.1 Turnover volume

In 1990~2002, the turnover volume of passenger traffic increased from 562.8 billion person-km in 1990 to 1412.6 billion person-km in 2002, up by 151%, in which the turnover volume of railway passenger traffic increased from 261.3 billion person-km to 496.9 billion person-km, up by 90.2% and the turnover volume of highway passenger traffic increased from 262 billion person-km to 780.6 billion person-km, up by 197.9%. In 1990, the turnover volume of highway passenger traffic was more than that of railway. In the same period, the number of civil vehicles increased from 5.51 million to 20.53 million, up by 272.6%.

From 1990 to 2002, the turnover volume of freight increased from 2620.8 billion t-km in 1990 to 5086.7 billion t-km in 2002, up by 94.1%, in which turnover volume of railway freight decreased by 3.2%, but turnover volume of highway increased by 102.0%.

6.2.2 Energy consumption by transportation sector

According to statistics of transportation sector, the energy consumption by transportation sector increased from 76.46Mtce in 1990 to 137.45Mtce in 2000, up by 79.8%, in which energy consumption by railway transportation decreased from 21.22Mtce to 18.60Mtce. The main reason was that national railway system had gradually been converted to diesel engines and electrified. The energy consumption for highway transportation increased from 36.42Mtce to 93.59Mtce, up by 157.0% (Table 6-1).

Table 6-1 Energy consumption by different transportation type in 1990~2000

	1990	1995	2000
1.Railway			
Total energy consumption, 10^4tce	2385.1	2399.0	1870.6
Of which energy consumption by transportation	2121.6	2007.0	1859.5
Coal, 10^4t	2099.2	1621.9	787.0
Diesel, 10^4t	300.8	448.7	499.0
Electric power, 10^8kWh	71.2	116.8	124.4
2.Highway			
Total energy consumption, 10^4tce	3642.1	5945.6	9359.4
Gasoline, 10^4t	1990	3100	4410
Diesel, 10^4t	490	950	1970
3.Waterway			

Total energy consumption, 10^4tce	1629.6	1660.2	1712.5
Fuel, 10^4t	1118.4	1139.4	1175.3
4.Civil aviation			
Total oil consumption, 10^4t	118.64	271.43	494.14
10^4tce	174.57	387.23	727.10
5.Pipeline			
Total energy consumption, 10^4tce	78.53	82.12	86.45
Electricity by crude oil transportation, 10^8kWh	17.86	16.40	17.26
Oil by crude oil transportation, 10^4t	37.6	40.7	41.2
Electricity by natural gas transportation, 10^8kWh	0.98	1.45	2.73
Gas by crude oil transportation, 10^4m^3	369.1	544.8	1130.0
Total energy consumption by transportation, 10^4tce	7646.34	10082.16	13744.94

Source: Integrated Transportation Institute, State Development and Reform Commission

6.2.3 Proportion of energy consumption by transportation in final energy consumption

The percentage of energy consumption by transportation in final energy consumption in China is the lowest in the world. According to international prevailing definition and calculated method of energy and energy balance table, the final energy consumption was 624Mtoe in 2000, within which transportation made up 15.4%, far lower than the world average percentage of 29.5%. Compared with percentage of 33.7% of OECD, the gaps was greater, showing that transportation was lagged behind economic and social development.

6.3 Per unit energy consumption and international comparison

6.3.1 Per unit energy consumption by different transportation type

Table 6-2 shows per unit energy consumption by different transportation type from 1990 to 2000. From the table we can see that, per unit energy consumption by railway transportation decreased by 35.1%, waterway transportation, down by 48.2%, civil aviation, down by 18.6%, but per unit energy consumption by highway transportation increased by 17.3%. Main reasons were that the percentage of the passenger traffic is bigger and in the cars the average number of seats decrease and comfortable level is improved gradually.

Table 6-2 Unit energy consumption by different transportation type (1990~2000) unit: kgce/10^4t-km

	1990	1995	2000
Railway	160.6	122.7	104.2
Highway	804.6	821.3	943.7
Waterway	138.6	93.7	71.8
Civil aviation	4950	4330	4030

Pipeline	125.4	139.2	138.0

Note: the turnover volume of passenger traffic conversion: railway and highway 1 person-km=1t-km; inland river waterway 3persons-km=1t-m; sea transportation 1 person-km=1t-km, civil aviation domestic flight line adult calculated by 72kg, international flight line, adult calculated by 75kg.

Source: Integrated Transportation Institute, State Development and Reform Commission, 2002.

6.3.2 International comparison of fuel consumption by highway transportation [11,29,68,75,76]

According to prediction of Integrated Transportation Institute of SDRC, IEA and China and abroad experts (He, 2003; O'Rourke and Lawrence, 1995), there is great gap between China and developed countries for fuel consumption by vehicles. In China the fuel consumption of vehicles per 100 t-km is higher than 20% that of developed countries, in which fuel consumption of light trucks is higher than 25%, and medium trucks is 1.1 times, and car is higher than 20~25% that of Japan, 10~15% higher than that of Europe, 5~20% higher than that of America.

6.3.3 Gap analysis[75,76]

Reasons caused differences are as follows:

- Technology. The ability to independent research and develop is weakness. There is no technology for developing a whole car rear to front.
- Condition of vehicles. Old vehicles accounted for 25% of the country and fuel consumption by old vehicles is 5~30% higher than that of normal vehicles.
- Structure of vehicles. 90% trucks are medium-sized open trucks and most of them run by gasoline. Fuel consumption by gasoline trucks is 14% higher than that of diesel trucks.
- Poor quality of oil products.
- Skill of drivers. Career drivers did not accept systemically training, and training system is not perfect. Fuel consumption influenced by skill of drivers is 2~12%.
- Transportation management. Mileage utilization ratio and service load rate are low. The service load rate of social vehicles is only 40%.
- Situation of roads. Off-grade roads account for 20% of mileage by vehicles, where fuel consumption by vehicles in the off-grade roads is higher than 40% that of in the special roads.
- Retail price of gasoline. The retail price of high-quality gasoline was 0.384 US dollar/liter in Beijing on July23rd, 2003, being lower than71% that of London, than 63% that of Tokyo and than 18% that of Washington.
- Policy. There are mistakes and wrong in industrial and professional management.

6.4 Prediction of energy demand and potential analysis on energy saving

6.4.1 Prediction of energy demand

According to prediction by relevant China and abroad agencies, the energy consumption by transportation will increase, especially highway transportation. The number of civil vehicles owed in China will increase from 16.09 million units in 2000 to 36.9~40.1 million units in 2010, reaching 75.2~77 million units in 2020 (Table 6-3).

Table 6-3 Forecast of possession of civil cars (2000~2020) unit: million units

	2000	2010	2020
ERI of SDRC			
Procession of vehicles	1609	4010	7700
Of which: personal cars	365	1580	4150
DOE/EIA			
Procession of vehicles	1609	3688	7519

According to scenario analysis for energy demand in 2020 by transportation sector of the Energy Research Institute, State Development and Reform Commission, the energy demand will be 216~308Mtoe (308~440Mtce) for transportation sector in 2020, up by 144~248% from 2000. If public transit is developed as the first priority, then energy demand will decline 9.4% than that of basic case (as BAU), and energy demand will decline 29.9% when accelerating to develop clean, high-efficiency transportation (Table 6-4).

Table 6-4 Scenario analysis for energy demand by transportation (2000~2020) unit: Mtoe

	Scenario 1	Scenario 2	Scenario 3
2000	88.6	88.6	88.6
2010	167	157	147
2020	308	279	216

Note: Scenario 1 is BAU; scenario 2 is change traffic mode, public transit made great progress, personal cars are main traffic mode, civil aviation increases rapidly; scenario 3 is high-efficiency clean case, accelerate diesel vehicles, alternative fuel vehicles, urban track traffic and railway electrification.

Source: Energy Research Institute, State Development and Reform Commission, China sustainable energy development scenario and carbon emission in transportation sector, October 2002.

6.4.2 Potentials of energy conservation by transportation sector

A. Potentials of energy conservation by transportation sector

The study on "Potentials and measurements of increasing energy efficiency in China"by former State Economic and Trade Commission showed that energy-saving rate would be 15% by highway transportation, among which 4.0% by replace vehicles, 3.2% by development of diesel vehicles, 5.3% by increasing roads quality and grade, and 2.6% by increasing service load rate.

If we take all above measurements, impose taxes on fuel, enforce fuel efficiency standard, and improve quality of oil products, then energy saving rate will be up to 30% in 2020.

B. Energy-saving technology of highway transportation and potentials of energy conservation

Energy-saving technology of highway transportation includes increasing fuel economy of vehicles and quality of oil products, changing constitutes of vehicles, improving situation of roads and bettering transportation management, which have a huge potential (Table 6-5). Cars with fuel consumption of vehicles per 100t-km of 2.1~3.2 liters were made by General Motors Corps, Volkswagen Motors Company, Renault motors Company and Toyota Motor Company.

Table 6-5 Energy saving technology and energy saving potential of highway transportation

Measures	Energy saving potential by technology, %
1. Improve vehicle fuel economy	20~50
1.1 Increase engine efficiency	5~20
1.2 Improve transmission system	10~15
1.3 Electron control	5~20
1.4 Lighten whole vehicle	15~20
1.5 Decrease wind resistance and rolling resistance	5~10
1.6 Improve of system	5~20
2. Change vehicle constitute	
2.1 Develop diesel vehicle	23~32
2.2 Large tonnage truck	60
2.3 Add trail car	30
3 Improve situation of road	6~10
4 Improve transportation management	-

Source: Ernst Worrell, Mark Levine, et al, Potentials and policy implications of energy and material efficiency improvement, UN, 1997; Helga Steeg, Energy efficiency and environment, IEA; Energy Efficiency Center of Energy Research Institute, State Development and Reform Commission, China sustainable energy development scenario and carbon emission in transportation sector, October 2002; SETC/UNDP/GEF, China final energy efficiency project, PDF-B, Energy efficiency of transportation, June 2002; Guo Yanjie, Potential energy saving analysis and technological policy of transportation, Energy Policy Research Bulletin, 1993,No.6,11~16.

6.5 Barriers for highway transportation

6.5.1 fuel efficiency of vehicles

- Policies and regulations. At present the policies and regulations are lacking auxiliary, making it difficulty to execute the law. The standards are not perfect and there are no energy-efficiency standards.
- Institution. There lacks coordination between relevant departments.
- Technology. The ability to innovate technology is weak and there lacks new technology to improve energy efficiency.
- Finance. State enterprises of vehicles are absent of fund.
- Information. Decision-maker and drivers has short of information on fuel efficiency.

6.5.2 Alternative fuel and technology

- Policies. Absence of policies on supporting research and development, and encouraging buying and utilizing.
- Institution. Absent of alternative-fuel vehicles system.
- Technology. The key technology is backward.
- Finance. Expensive price for alternative-fuel vehicles such as electric vehicles

6.5.3 Public transit

- Policies. Investment focuses on constructing expressway, absent effective measurements to take public transit as first priority.
- Institution. There lacks coordination between local governments and relevant departments and the operating right is not open to the public.
- Finance. Lower price of ticket; absent funds for state enterprises; expensive cost of constructing subways and light rail transit.
- Information. Lack relevant measurements and benefit information for decision-maker; lack information service for the public.

6.5.4 Synthetic transportation system

- Policy. Lack unified regulations.

- Institution. Lack coordination among departments of transportation optimization and region layout.
- Technology. Engineering technology of transportation is dropped behind, especially on intellectual transportation system.
- Finance. Absent funds for transportation infrastructure construction and transportation management.
- Information. Lack relevant measurements and benefit information for decision-maker; weak public traffic consciousness.

6.6 Policies and measurements for highway transportation

6.6.1 Impose taxes on fuel

Many researches showed that the rise of price of oil products greatly influenced fuel efficiency of vehicles[77]. In America, Long-term price elasticity (15 years) was up to 0.4[78]. Analysis on relationship between gasoline end-use price and fuel efficiency of new vehicles (IEA, 2001) from 1970 to 1995 in America showed that both of they changed simultaneously[32,79].

6.6.2 Formulate standards of fuel efficiency[80,81]

In 1978, according to Energy Policy and Energy Conservation Act, CAFÉ standard was made and carried out forcibly in America. It was estimated by Office of Technology Assessment, US Congress that the contribution to energy conservation for CAFÉ was about 15~50%[68]. In Japan, Fuel efficiency of vehicles was made on the basis of Top-runner. In EU, fuel efficiency standard of vehicles is also voluntary.

In China, the design of fuel efficiency standards focus on cars, mini-bus and light bus, and the fuel consumption of these types vehicles are 12%, 3% and 8% respectively in 2000. It is estimated that it will be 22%, 2% and 3% in 2020.

According to research of Environmental Science and Engineering Department of Tsinghua University and China Automobile Industry Technology Research Center, implementation of the fuel efficiency, the fuel saved will be 50~70Mt in 2030.

6.6.3 Make better urban traffic system

- Draw up regional traffic integrated plan, optimize traffic flow;

- Consummate and unify traffic regulations;
- Public transit as the first priority;
- Improve parking management system(limit parking, increase fees) and technology;
- Consummate energy conservation management system of transportation, study and try out DSM;
- Set up intellectual transportation system;
- Improve driver management system and training mechanism.

6.6.4 Support R&D for high-efficiency and alternative fuel vehicles

Research emphases are as follows:

- High-efficiency engine;
- Advanced transmission system;
- Electron technology vehicles;
- Technology for vehicles from rear to front;
- New dynamics and alternative fuel technology;
- Examination and appraisement technology.

7. Energy conservation of government agency

7.1 Overview

7.1.1 Aim and significance

Energy consumption by government agency is largest in the every government of world, where the percentage of energy cost is larger in administrative expenditure. Energy waste is still serious because of lack of save motivation and effective restriction.

Strictly enforcing energy conservation of government agency is of vital importance. The advantages are as follows:

- Save energy and resource and reduce energy consumption. The energy-saving target of government agencies in developed country is more than 20% in the period of 10 years.
- Save administrative expenditure. If investment on energy consumption is 1US dollar, then it can save 4 US dollars. Government procurement can save 10% expenditure.
- Reduce pollutants and GHGs emission. After the United Nations Environment and Development Conference in 1992, CO_2 reduction is the major target of government agencies by improving energy efficiency.
- Lead high-efficiency products market.

Government procurement plays an important role in reducing production risks and also encourages to produce and sale energy-efficiency products.

- Promote energy-saving new mechanism. It includes life-cycle costs analysis, energy audit, energy-efficiency standards and labels, energy efficiency building, energy-efficiency contract, energy service company and renewable portfolio standard(RPS) of electricity from renewable energy. Leading role and demonstration of government promote new strategy and mechanism to be put into effect [82~87].
- Improve public reliance on government. Energy conservation of government agency will set an example for the country, which is of vital importance to improve reliance of energy-efficiency policy. Sunny procurement of government contributes to incorruptness.

7.1.2 Current status of energy conservation of government agency

Energy conservation of governments began in 1970’s after the first oil crisis in the developed countries. Now many countries, such as America, Europe Unions, Japan, Canada, New Zealand, Russia, Ukraine, Bulgaria, Hungary, Rumania, Korea, Mexico, Brazil, Argentina, Columbia, India, Thailand, Indonesia and the Philippines, implement energy conservation of government agency.

7.1.3 Definition of government agency

According to Government Procurement Law, “government” refer to government body, institution, social organization and public institution, which run by financial funds. Final energy consumption includes defense, government body, social organization, public service, education, culture and broadcast and television, health and sports and social welfare and scientific research.

7.2 Energy consumption and potential energy saving of government agency

7.2.1 Present situation of energy consumption of government agency[88]

Energy consumption by government agency is larger in China. In 2000, the energy consumption by government agency amounted to 57.2Mtce in nationwide, of which oil was 18.6Mt and electric power was 63.4TWh (Tables 7-1 and 7-2). The energy consumption by government agency was equivalent to consumption by agriculture sector (57.9Mtce). The electricity use by government agency is close to electricity consumed by 800 million rural residents (67.5TWh). The expenditure of energy consumption by government agency was up to 100.8 billion RMB (Table 7-3). Moreover, the increase speed of energy consumption by government agency far exceeded that of national energy consumption. Energy consumption increased by 65% from 1990 to 2000, in which electric power increased by 210%. In the same period, national energy consumption increased by 32%, in which electric power increased by 132%.

Table 7-1 Energy consumption and energy cost of China government agency(2000)

Energy	Consumption	Unit price	Energy cost, 10^4 Yuan
Coal	7.612Mt	257.0 Yuan/t	195,628
Coke	0.122Mt	559.0 Yuan /t	6,792
Crude oil	14000t	2064.0 Yuan /t	2,890
Gasoline	8.777Mt	3612.0 Yuan /t	3,170,144
Kerosene	1.601Mt	2936.0 Yuan /t	470,024
Diesel	8.037 Mt	3281.0 Yuan /t	2,636,940
Fuel oil	0.19 Mt	1562.0 Yuan /t	29,678
Natural gas	$64Mm^3$	2.0 Yuan /m^3	12,800
Electricity	6.342TWh	0.56 Yuan /kWh	3,551,520
Total			10,076,416

Source: State Statistical Bureau, SINOPEC

Table 7-2 Electricity consumption by government agency(2000)

user	Electricity consumption, GWh
Public service of house management and consultant	17201
Of which: public transits in the city	3564
street lamp	1344
Health and sports and social welfare projects	6468
Education, culture and broadcast, TV	10237
Science research and technology service	4113
Government bodies and social organization	11210
Others	13517
Total	62747

Source: State Power Company.

7.2.2 Seriously waste of energy consumption by government agency

According to preliminary investigation by the State Economy and Trade Commission in China, the per capita energy consumption and the per unit floor space of government agency, especially administrative organ, not only exceeded that of urban residents but also exceeded that of developed countries such as Australia (Table 7-3)。

Table 7-3 Unit energy consumption by government agency and international comparison

	Government agency average (2001)	Administrative organ average (2001)	Highest of administrative organ average (2001)	Urban household average (2001)	Official buildings average in New South Wales in Australia (1999/2000)
Per capita floor space of buildings, m^2	27.9	31.3	44.4	14.9	
Per capita energy use, kgce/year	682	1497	1958	197	669
Per capita electricity use, kWh/year	1057	2371	3972	217	
Per unit floor space energy use of the buildings, kgce/m^2	24.5	47.8	66.8	20.6	22.4
Electricity use per unit floor space, kWh/m^2	37.9	75.8	184.1	22.6	
Per capita energy cost, Yuan/year	1113	317l	8929	331	

Note: 1.Per capita energy consumption, energy consumption per unit floor space of the buildings, per capita energy cost didn't include fuel consumption of vehicles. 2. Area of buildings of urban household refers to usable floor area; 3. Per capita energy consumption and energy consumption per unit floor space of buildings in China, electric power is calculated according to the gross coal consumption rate for thermal power generation of 0.363kgc/kWh.

Source: State Economic and Trade Commission, "Investigation on energy consumption by government agencies"; State Statistical Bureau; New South Wales Government, Energy use in government operations 1999~2000.

Another investigation on 106 central government units by the Ministry of Finance showed that the per capita floor space of official buildings was 46m^2, above 53%~77% of the regulated standard of 26~30 m^2. The number of official vehicles was more than 77000, exceeding more than 40000 that of regulated standard.

It is estimated that there are more than 3.5 million official vehicles in the country with cost of 300 billion RMB per year (including expenditure for drivers and servants).

All the above suggests that buildings of government agency, especially administrative organ, were greedy for bigness, pursuing modern and luxury. In addition, luxury and waste was serious with excess of official vehicles.

7.2.3 Potentials of energy conservation analysis

Preliminary analysis showed, if we update existing public buildings for energy conservation, improving quality of thermal insulation of the building envelopes, adopt heating and air conditioning equipments with higher energy-efficient ratio and reform charge on heating, meanwhile, the new constructive public buildings are implemented the energy-saving standards, then 50% energy can be saved for heating and air conditioning.

In the lighting energy conservation, the energy-saving rate will be 18%.

In addition, the standby power consumption of office equipments is considerable, when 50% electricity is reduced.

From above analysis, the total energy-saving rate is 27%, in which electricity-saving rate is 30%.

7.3 Energy-saving target and policies

7.3.1 Energy-saving target

In 2007, the energy consumption per floor space of buildings by government agency shall decreased by 15% comparing to 2000, and by 20% in 2012.

The government also should lay down energy-saving targets on oil and water.

7.3.2 Policies and measurements

- Set up organization;
- Energy-saving management. Each government agency should develop an annual energy-saving plan, putting forward energy-saving goal and corresponding measurements such as energy measuring and statistics, energy audit, contract energy management, energy-efficiency incentive, education and training.
- Government procurement.
- Building energy saving.

8 Barriers of energy conservation

Improving energy efficiency and energy conservation rely on changes of economic system, innovation of structure and advancement of technology. It also has relationship with national culture quality. So it is a long progress. At present, there is a serious of barriers for taking energy conservation as the first priority.

8.1 Idea of energy conservation

Idea of energy conservation of decision-maker is of great significance to influence orientation and methods of energy-saving policies, effectiveness and creation of energy conservation. In developed countries, the idea of energy conservation was conservation and reduction, which was to deal with energy crisis in the 1970's, but now it is evolved to increase benefit, reduce pollution, improve living quality, and make better public relations. In China, there still had idea of fill up a deficiency and reduction of energy conservation, which goes against polices of energy conservation and system innovation.

8.2 Energy conservation management by government

In 1990's, energy-saving administration was weakened and reform of energy-saving management was lagged because of overplus of energy supply and administration reform. Some sectors and local governments loosed energy-saving management following by reduction of energy-saving officer, leading to worse energy–saving management.

8.3 Energy price

Energy price is a footstone for energy-saving policies. It is the crux for optimizing resource allocation when energy price cannot reflect cost of supply and demand and give distorted signal to enterprises and consumers and lead up to waste energy. A great progress has been gained in the energy price reform since 1993, but there still has some problems to be solved by deepen reform. In addition, externality costs has not been brought into energy price.

8.4 Economic incentive

Incentive policies and measures on energy-saving projects or products, such as tax credit, loan on favorable terms, are important policy tools to inducing energy conservation. After the reform in finance and taxation system in 1994, the policy was weakened, even cancelled, which is disadvantage for energy conservation.

8.5 Technological advancement

There are many barriers for energy-saving creation and diffusion on institution, fund and management, of which the main problem is that it is absent funds for new energy-saving technology commercialize; difficult financing for energy–saving technology updating for old-equipments; poor quality of energy-saving equipments; key technology and equipments depend on export excessively; lack unified plan and effective management.

8.6 Information service

Information is a footstone for laying down and carrying out energy-saving policies, which includes publicity, energy statistics, information network, consulting service and energy efficiency labels. It is very feeble in the work.

9 Policy recommendations

9.1 Take resources saving as basic national policy

After the United Nations Environment and Development Conference in 1992, the CPC and the State Council paid more attention on population, resource and environment. Sustainable strategy, economic development and correspondence of population, resource and environment have been taken as key measures in the socialist modernization construction. Resource conservation, population control and environmental protection are of equal importance. Moreover, they have close relationships. Population control and environmental protection have been basic national policies, which have impetus on calling for family planning, enhancing the awareness of environment and strengthening government management. In practice, the status of saving resources is much less than population control and environmental protect. It is recommended to take resources conservation, population control and environmental protection as the same status, and bring forward basic national policies as population control, resource conservation and environment protection.

9.2 Strengthen governmental administrative system for energy conservation

The CPC emphasized many times that Party committees and government at various levels should do better in population, resource and environment by themselves, and be responsible for the work. So leaders of Party organizations and governments at various levels should do as treating population and environment to do resources conservation by themselves and be responsible for them.

In order to strengthen energy-saving management system of government, it is recommended to set up resource-saving office and resume official energy-saving conference institution by the State Council. Resource-saving bureau is set up under the National Development and Reform Committee, which is the resource-saving office for the State Council.

Establish special funds for energy conservation administration, which is to lay down policies and standards, publicity, education, information service and encouragement for energy conservation.

9.3 Improve economic incentive policies on energy conservation

- Continuously promote market-oriented energy price reform and scientific control by government.
- Take energy conservation as main parts of adjusting tax polices. Preferential polices, such as tax reduction, exemption and accelerating depreciation, should be adopted in energy-saving projects. Enterprises of producing energy-saving products, should be given tax reduction and exemption as high technological enterprises.
- Oil price is adjusted by tax leverage, which changes from lower tax and low price to moderately higher tax and high price. In the near 3~5 years, the percentage of taxes of gasoline and diesel will rise about 60%.

9.4 Formulate auxiliary regulations of Energy Conservation Law

Auxiliary regulations, standards and policies must be laid down to ensure that Energy

Conservation Law is to be put into effect. Energy-saving management system also should be reconstructed fitting for market economy, forming energy-saving mechanism to consumed energy in the whole society.

9.5 Build up energy-efficiency standards and labels on final energy consumption equipments

Energy-efficiency standards for equipments include household electric appliances, lighting appliances, general equipments (such as electric motors, transformers, medium or small boilers and pumps), buildings (including doors and windows), automobiles and equipments by renewable energy.

It is a complex work to decide whether energy-efficiency standards and labels were built up for energy consumption equipments, which should investigate institution, cultural and political factor, existing energy management system, existing administrative ability and international consistency and choosing preferential equipments and products. Meanwhile, auxiliary policy tool should also be studied.

9.6 Take energy conservation of government agencies as the breakthrough cut to advance energy conservation in the country

Energy conservation of government agencies has been paid more attention by the State Council. Premier Wen Jiabao made comments and instructions that the potential of energy conservation of government agency is so huge that it is urgent to put on the agenda and regulations and rules should be systematically laid down by some sectors.

Energy conservation of government agency includes organization and management, government procurement, building energy efficiency, popularization of new energy-saving technology and incentive policies. So energy conservation of government agency is a better breakthrough cut to deepen energy conservation in the country. We should lay down administrative regulations and implementary detailed rules on the basis of investigation and use international experience, and have a plan to carry out them in the country.

9.7 Construct energy-saving society by science and technology

Energy supply and energy environment are great challenges for us to build a well-off society in all-around way. We must rely on science and technology to resolve problems, fully mobilize and advance all the society to strictly enforce energy conservation in all areas, and systematically, deeply and fully improve energy efficiency. Therefore, More benefit in economy, environment and society are gained than normal energy conservation. Building an energy-saving society is important to carry out and correspond sustainable development, which is a significant method to improve economic growth way and is a new approach to build spiritual civilization.

We should lay strong emphasis on improving final energy efficiency to build an energy-saving society, develop cycle economy and clean production, implement recycling renewable resources and change values and consumption action of wasting resources.

It is vital to renovate technology and policy for building a energy saving society.

9.8 Introduce energy saving new mechanism

- DSM/IRP;
- Energy service company;
- Energy audit;
- Industrial energy efficiency networks;
- System benefit charge;
- Voluntary agreement;
- Government procurement.

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