CHAPTER

7

Energy Policies and Strategies

The PRC is the second largest energy consumer after the United States, and holds top rank in the production and consumption of coal, its dominant fuel. Rising demand for energy is a very significant factor in the economic development of the PRC, especially the Western Region.

National energy profile

The Western Region has substantial deposits of coal, oil, and gas. Over the past few decades, the Government has invested considerable capital in developing energy sources in the region.

COAL

The Western Region holds most of the PRC's coal reserves of 1,000,000 Mt (Table 7-1).

Table 7-1 Coal Resources in the Western Region, 1999

Province	Coal Reserves (Mt)	Share of National Total (%)
Inner Mongolia	225,600	22.6
Guangxi	2,100	0.2
Five provinces in southwest	89,000	8.9
Gansu, Ningxia, Qinghai, and Xinjiang	139,900	14.0
Shaanxi	162,100	16.2
Western Region total	**618,700**	**61.9**

Source: State Development Planning Commission (1999a); State Development Planning Commission, n.d., *Report on Strategy Study of Tenth Five-Year Plan.*

Coal production in 1998 was 1,350 Mt, or roughly one-third of the world total. That same year, the PRC had net coal exports of 35 Mt, primarily to the Republic of Korea and Japan.[1] However, the Western Region accounts for only about a quarter of the PRC's coal production (Table 7-2).

The coal industry is suffering from oversupply. Large State-owned coalmines have built up inventories, and many are operating at a financial loss. A large number of small, unlicensed mines add to the oversupply, and in 1998 the Government launched a major program to close them down. As of early 2000, more than 30,000 small coalmines had closed, and more are closing. Local coal prices have started to recover, but supply still outpaces demand.

OIL

The PRC's total oil reserves are estimated at over 100,000 Mt. The economically exploitable oil deposits amount to 11,000 Mt, priced internationally at $18 a barrel. Of the total oil reserves, 27.6 percent are in the Western Region (Table 7-3).

Table 7-2 Energy Production in the Western Region, 1999

Province	Coal (Mt)	Oil (Mt)	Natural Gas (GL)	Total Power (TWh)	Hydropower (TWh)
PRC	**1,045.0**	**160.0**	**25.2**	**1,239.3**	**196.6**
Inner Mongolia	70.7			38.0	0.2
Guangxi	8.2	0.0		25.3	15.4
Chongqing	11.8		0.3	15.8	3.2
Sichuan	20.9	0.2	8.2	44.4	26.0
Guizhou	40.3		0.1	33.5	13.4
Yunnan	26.6	0.0	0.1	29.8	18.5
Tibet				0.6	0.5
Shaanxi	24.3	6.4	1.3	25.5	2.0
Gansu	18.9	0.4	0.0	26.2	11.8
Qinghai	2.1	1.9	0.4	11.4	8.8
Ningxia	15.3	1.3	0.0	11.2	0.9
Xinjiang	27.8	17.4	3.1	16.7	3.0
Western Region total	**267.0**	**27.7**	**13.4**	**278.6**	**103.6**
Western Region as % of PRC	25.5%	17.3%	53.2%	22.5%	52.7%
Gansu as % of PRC	1.8%	0.3%	0.0%	2.1%	6.0%
Xinjiang as % of PRC	2.7%	10.9%	12.3%	1.3%	1.5%

Source: State Development Planning Commission (2001c).

Table 7-3 Oil and Natural Gas Resources in the Western Region, 1999

Basin	Oil Reserves		Gas Reserves		
	Oil Reserves (Mt)	Share of National Total (%)	Theoretical Reserve (GL)	Discovered Exploitable Gas (GL)	Rate of Discovery (%)
Sichuan	-	-	7,360	687	9.3
Tarim (Xinjiang)	10,700	10.5	8,390	515	6.1
Jungar (Xinjiang)	8,600	8.4	-	-	-
Shaanxi, Gansu, Ningxia	6,600	6.5	10,700	750	7.0
Qaidam (Qinghai)	2,200	2.2	1,920	147	7.7
Western Region	**28,100**	**27.6**	**28,370**	**2,099**	**7.4**

Source: China Natural Gas and Petroleum Company (1994); State Development Planning Commission (1999a).

The PRC ranks fifth among the world's oil-producing countries. Of its 160 Mt of oil production, 17.3 percent is from the Western Region, and 10.9 percent from Xinjiang. However, the country has been a net oil importer since 1993. Production and consumption are projected to be 160 Mt and 215 Mt respectively in 2000, leaving a gap for imports of 55 Mt. Domestic oil supplies will come mainly from Xinjiang, and imports mainly from the Middle East and Central Asia. Consequently, the oil industry is likely to be important in the Western Region.

The PRC's oil industry is undergoing major changes. In 1998, the Government reorganized most of its oil and gas assets into three vertically integrated firms: the China National Petroleum Corporation (CNPC, or PetroChina), the China Petrochemical Corporation (Sinopec), and the China National Offshore Oil Corporation (CNOOC). Originally, CNPC was engaged primarily in upstream production and exploration activities, while Sinopec focused on downstream refining and distribution and CNOOC developed oil and gas fields offshore. Sinopec is Asia's largest oil refiner; the Government owns 80 percent of this listed company. The Government has also deregulated the price of gasoline, Sinopec's main product. Making the industry competitive in the international market will require further reforms.

NATURAL GAS

In contrast to its coal reserves, the PRC's reserves of natural gas are very small. The low natural gas endowment places the PRC at a disadvantage for two main reasons:

- Natural gas is the most convenient and cleanest fuel for a range of uses from space heating to electricity generation during demand peaks.
- Natural gas is the best feedstock for numerous chemical syntheses, including nitrogenous fertilizers (of which the PRC is the world's largest producer).

The largest reserves of natural gas are in the Western Region, where discovered exploitable reserves total 2,090 GL (Table 7-3). More than half of the natural gas production is from the Western Region, and one-third comes from Sichuan. Xinjiang ranks second in gas production, with 12.3 percent of the PRC's total.

ELECTRICITY

Like the coal industry, the electric power industry is experiencing oversupply because of slower economic growth, the effects of the Asian economic crisis, and excessive investment. The Government has responded by closing down small thermal plants and by imposing a moratorium on power plant construction (with a few exceptions). Most small plants are diesel or coal-fired plants that local governments constructed when

demand grew in the 1980s. Generally, they are relatively inefficient and polluting.

Oversupply and a lack of adherence to negotiated contracts discourage foreign investment. However, the State Development Planning Commission's Energy Research Institute projects electricity consumption to grow at 5.54 percent per year. If a real competitive market for electric power develops, the PRC market may once again become attractive to foreign investors. New regulations will be necessary to attract foreign investment in power transmission, distribution, and retail.

HYDROPOWER

The PRC's hydropower resources rank first in the world. There are 378.5 GW of exploitable reserves, nearly 80 percent of which are in the Western Region.[2] However, the rates of exploitation and utilization are low, especially in the Western Region. By the end of 1999, the country's total installed generating capacity was about 73.0 GW, only a fifth of the potential generating capacity. Considering the parts of the Western Region with the greatest reserves, actual generation was an especially low percentage of potential generation in Tibet (Table 7-4).

The Western Region accounts for 52.7 percent of the PRC's hydropower generation, but 81.5 percent of the potential generation (Table 7-4). Gansu province alone generated 117.47 TWh of hydroelectric power in 1999, or 6 percent of the country's total.

Table 7-4 Hydropower Resources in the Western Region, 1999

Province	Exploitable Reserves (GW)	Yearly Power Generation			
		Potential		Actual	
		(TWh	%	TWh	%
Inner Mongolia	2.4	8.4	0.4	0.1	0.1
Guangxi	14.2	63.9	3.3	5.7	7.8
Chongqing/Sichuan	91.7	515.3	26.8	10.8	14.9
Guizhou	12.9	65.2	3.4	5.0	6.8
Yunnan	71.2	394.5	20.5	6.9	9.4
Tibet	56.6	330.0	17.1	0.2	0.3
Shaanxi	5.5	21.7	1.1	0.7	1.0
Gansu	9.1	42.4	2.2	4.4	6.0
Qinghai	18.0	77.2	4.0	3.3	4.5
Ninxia	0.8	3.2	0.2	0.3	0.5
Xinjiang	8.5	46.0	2.4	1.1	1.5
Western Region	**290.9**	**1,567.8**	**81.5**	**38.4**	**52.7**
PRC	**378.5**	**1,923.3**	**100.0**	**73.0**	**100.0**

Source: State Development Planning Commission (1999b).

Table 7-5 Installed Wind Power Capacity in the Western Region, December 1998

Wind Farm	Unit Capacity (kW)	Units	Total Capacity (MW)
Xinjiang	100, 150, 300, 450, 500, 600	144	67.1
Inner Mongolia	55, 100, 120, 250, 300, 550, 600	110	45.2
Gansu	300	4	1.2
Western Region		258	113.4
PRC total		**529**	**223.6**

Source: SDPC (2000a), p. 15.

WIND POWER AND SOLAR ENERGY

The Government has made an effort to promote renewable energy. However, further policy, regulatory pricing institutional reforms are needed to create an enabling environment to fully develop the potential for renewable energy development. By the end of 2000, the PRC had installed 268 MW of wind power, 15 MW of photovoltaic solar power, 35 MW of solar thermal power, and 76 MW of geothermal power.

Across the Western Region, from Xinjiang through Gansu to Inner Mongolia, there are considerable wind power resources. The winds across the plateaus in these regions are generally steady, with little turbulence and few gales. Much of the land is grassland, and suitable for wind power development. The Ministry of Electrical Power has estimated the exploitable wind energy in the PRC at 253 GW.[3] The Western Region ranks second in wind resources after the Eastern Region, but accounts for only half of the country's installed capacity (Table 7-5).

The PRC is rich in solar energy resources with total radiation of 3.3×10^6 kJ/m^2 to 8.4×10^6 kJ/m^2. Two-thirds of the country has more than 2,000 hours of sunshine a year. Western provinces enjoy the highest annual solar radiation and sunshine hours, which are very high by world standards (Table 7-6).

In Tibet, by the end of 1999, seven solar photovoltaic stations had been set up in remote and isolated rural counties with unit capacities varying between 25 kW and 100 kW.

Table 7-6 Solar Energy in the Western Region, 1999

Type	Province	Sunny Hours per Year	Annual Energy Radiation (kJ/m²)
1	West Tibet, Southeast Xinjiang, West Qinghai, and West Gansu	2,800–3,300	670–840
2	Southeast Tibet, South Xinjiang, East Qinghai, Central Ningxia, Central Gansu, and Inner Mongolia	3,000–3,200	590–670
3	North Xinjiang, Southeast Gansu, and North Shaanxi	2,200–3,000	500–670
4	Guangxi and Southern Shaanxi	1,400–2,200	420–500
5	Sichuan and Guizhou	1,000–1,400	330–420

Source: State Development Planning Commission (1999b).

PROJECTED ENERGY SUPPLY IN THE WESTERN REGION BY 2020

The PRC's projected energy supply and sources for the next two decades, based on the Western Region's energy supply in 2000 and the PRC's development strategy for the region, are shown in Table 7-7 and Table 7-8.

On average, the annual growth rates of energy supply in the PRC are between 2.6 percent and 3.1 percent. Coal will still be the dominant energy source in the PRC throughout the next two decades although its share is likely to decrease from 68.3 percent in 2000 to 57.4 percent in 2020. Oil supply is likely to increase but will account for a declining proportion of total supply. Gas, hydro, nuclear, new, and renewable energy sources are forecast to increase their shares very quickly.

In the Western Region, projected annual energy supply growth rates are between 5.0 percent and 5.6 percent, much higher than those in eastern PRC. In the next 20 years, all kinds of energy supply are likely to increase dramatically. The output of coal and oil is likely to more than double, gas output to increase more than five times, hydro and nuclear energy output to more than quadruple, and renewable energy output to increase about 200 times. By 2020, renewable energy supply in the Western Region will amount to 7.12 percent of the total (Table 7-9 and Table 7-10).

Table 7-11 shows the electricity supply trend in the PRC and in the Western Region. The available data suggest that, on average, the power supply will

Table 7-7 Projected Supply of Primary Energy in the PRC, 2000–2020

Fuel	2000	2005	2010	2015	2020
Coal (Mt of raw coal)	1,045.0	1,167.0	1,305.0	1,468.0	1,620.0
Oil (Mt)	160.0	174.5	185.2	196.6	206.7
Gas (billion cu m)	25.2	54.7	80.4	107.6	130.9
Hydro and nuclear power (TWh)	227.8	320.2	435.1	544.1	682.0
Renewable (Mt, coal equivalent)	1.0	5.0	18.6	56.6	140.9
Total (Mt, coal equivalent)	**1,092.7**	**1,277.6**	**1,481.1**	**1,727.9**	**2,016.4**
Average annual growth (%)		2.6	3.0	3.1	3.1

Source: Energy Research Institute, State Development Planning Commission.

Table 7-8 Share of National Primary Energy Supply, 2000–2020

Fuel	2000 (%)	2005 (%)	2010 (%)	2015 (%)	2020 (%)
Coal	68.3	65.3	62.9	60.7	57.4
Oil	20.9	19.5	17.9	16.3	14.6
Gas	3.1	5.7	7.2	8.3	8.6
Hydro and nuclear power	7.6	9.2	10.7	11.5	12.4
Renewable	0.1	0.4	1.3	3.3	7.0
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Energy Research Institute, State Development Planning Commission.

Table 7-9 Projected Supply of Primary Energy in the Western Region, 2000–2020

Fuel	2000	2005	2010	2015	2020
Coal (Mt of raw coal)	267.0	326.8	417.6	513.8	615.6
Oil (Mt)	27.7	34.9	44.5	58.0	77.5
Gas (billion cu m)	13.4	35.6	56.3	73.2	85.1
Hydro and nuclear (TWh)	104.0	165.0	260.0	342.0	446.0
Renewable (Mt, coal equivalent)	0.4	1.9	7.4	24.0	63.3
Total (Mt, coal equivalent)	**286.4**	**392.7**	**539.0**	**696.0**	**889.7**
Average annual growth (%)		5.4	6.6	5.2	5.0

Source: Energy Research Institute, State Development Planning Commission.

Table 7-10 Shares of Primary Energy Supply in the Western Region, 2000–2020

Fuel	2000 (%)	2005 (%)	2010 (%)	2015 (%)	2020 (%)
Coal	66.6	59.4	55.3	52.7	49.4
Oil	13.8	12.7	11.8	11.9	12.4
Gas	6.2	12.1	14.0	14.0	12.7
Hydro and nuclear power	13.3	15.3	17.9	17.9	18.3
Renewable	0.1	0.4	1.4	3.5	7.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Energy Research Institute, State Development Planning Commission.

Table 7-11 Projected Electricity Supply, 1999–2020

Region	1999 (TWh)	2005 (TWh)	2010 (TWh)	2015 (TWh)	2020 (TWh)
PRC	**1,233.1**	**1,729.3**	**2,292.4**	**2,995.5**	**3,822.5**
Average annual growth (%)		5.8	5.8	5.5	5.0
Average growth (%)					5.5
Western Region	281.1	495.0	693.0	956.3	1,242.2
Average annual growth (%)		9.9	7.0	6.7	5.4
Gansu	26.2	35.0	47.8	65.0	86.0
Xinjiang	16.9	24.5	36.5	52.5	72.5
Western Region as % of PRC	22.8	28.6	30.2	31.9	32.5
Gansu as % of PRC	2.1	2.0	2.1	2.2	2.3
Xinjiang as % of PRC	1.4	1.4	1.6	1.8	1.9

Source: Energy Research Institute, State Development Planning Commission.

Table 7-12 Natural Gas Consumption in the PRC, 1997

	Quantity (GL)	%
Industrial feedstock	14,500	76.6
Power and heating	2,190	11.6
Household	2,120	11.2
Transport and commercial	120	0.6
Total	**18,930**	**100.0**

Source: Han (1999).

increase by 5.5 percent each year over the next two decades PRC's, and by 7.3 percent in the Western Region.

Energy consumption in the Western Region

Energy consumption in the Western Region is much lower than elsewhere in the PRC. On average, a person in the Western Region consumes about 80 percent of the energy that a person in the Eastern Region does.

ELECTRICITY CONSUMPTION

Electricity consumption per capita per year is higher in parts of the northwest than the national average of 918 kWh. The need for space heating in winter pushes consumption per capita above the national average in Inner Mongolia, Gansu, Qinghai, and Ningxia.

In contrast, electricity consumption per capita in the southwest is well below the national average. Reasons include high density of population and an underdeveloped power industry.

OIL CONSUMPTION

The dramatic growth of oil consumption has made the PRC a net oil importer. Between 1985 and 1998, oil consumption increased by 116 percent. In the same period, domestic oil production increased by only 29 percent. Oil imports increased from 0.9 Mt in 1985 to 57.4 Mt in 1998, for an annual growth rate of 37.7 percent.

GAS CONSUMPTION

Gas accounts for a very small share of total energy consumption in the PRC, about 2.2 percent, whereas the world average is 23.2 percent. In addition, natural gas in the PRC is mainly used in industry (Table 7-12).

Because of an underdeveloped gas network, natural gas is consumed locally. In 1997, gas consumption in Sichuan, Xinjiang, Heilongjiang, and Liaoning amounted to 81 percent of the PRC's total.

ENERGY CONSUMPTION OF RURAL HOUSEHOLDS

Biomass energy consists of wood and forest industry residue, agricultural residue, animal manure, hydrophytes, municipal and industrial organic wastes, and oil crops. In this report, biomass energy is taken to include the first three types, and refers to rural energy consumption in the Western Region. Optimal use of biomass energy is of great significance in poverty reduction and environmental protection. In 2000, 64 percent of the population lived in rural areas; the rural population derived 57 percent of its domestic energy supply from biomass.[4]

In 1997, the rural population consumed about 365 Mt (coal equivalent) of biomass; the Western Region accounted for 25.3 percent of this consumption (Table 7-13).

Energy efficiency is only about 5 percent, and the use of wood has huge environmental impact. Over the past 20 years, local governments, with the assistance of the private sector and international organizations, have developed many small hydropower plants, coalmines, solar energy systems, and wind power plants. These projects have brought electricity to many rural households, but many others still cannot afford commercial energy.

A new strategy is necessary to cater to the rural poor. Since 1999, the Government has required local governments to protect forests and grasslands along the upper reaches of the Yangtze River and the Yellow River. Cutting trees and bushes in those areas is now prohibited. This policy makes it difficult for households to access biomass energy. There is a need to find alternatives; one possible solution may be to provide rural households with a minimum amount of coal, free of charge.

Biomass energy consumption by rural households leaves plenty of room to improve energy efficiency and environment. To collect biomass for cooking, a typical rural household in Sichuan needs to spend 100 to 150 person-days a year.[5] Using biomass gas instead of collecting biomass will save time. As well as the collection time, a household needs to spend about 3 person-hours cooking if using biomass directly. Moreover, the energy efficiency of direct-burning biomass is only 5–8 percent.[6]

Table 7-13 Biomass Energy Consumption in the Western Region, 1997

Region	Rural Population (million)	Consumption per Capita (t, coal equivalent)	Biomass Energy (Mt, coal equivalent)
PRC	**880.0**	**0.76**	**364.56**
Guangxi	39.2	0.63	12.93
Chongqing	15.3	0.74	8.13
Sichuan	70.3	0.53	20.71
Guizhou	31.0	0.51	12.91
Yunnan	25.0	0.58	10.08
Tibet	n/a	n/a	n/a
Shaanxi	26.9	0.82	10.55
Gansu	19.8	0.56	7.32
Qinghai	3.4	0.44	1.40
Ningxia	3.7	0.45	1.39
Xinjiang	8.7	0.79	6.69
Western Region	**243.4**	**0.60**	**92.11**
Western Region as % of PRC	**27.7%**	**79.00%**	**25.30%**

Source: *China Rural Energy Statistical Yearbook 1998–1999.*

Biomass gasification is technically and economically viable. By 1997, the PRC had built 164 biomass gasification plants. Gas production amounted to 45 ML, and about 27,600 rural households were using biomass gas for cooking. Unfortunately, all the gas plants are in the Eastern Region.

Three kinds of gasification technologies are available (Table 7-14).

The individual household plants require only a small capital investment and are therefore well suited to the Western Region, where population density is low.

TOTAL SHARE OF NEW AND RENEWABLE ENERGY

New and renewable (biomass) energy is the main energy source for rural households. In 1999, the PRC consumed 1,220 Mt (coal equivalent) of commercial energy, and 2.73 Mt (coal equivalent) of renewable energy (biomass). Table 7-15 shows the PRC's commercial and renewable energy consumption in 1999.

In 1999, new and renewable energy accounted for over 18 percent of total energy consumption in the

Table 7-14 Comparison of Capital Investment in Biomass Gasification Plants

Technology	Type of Machine	Output	Capital Investment	Investment per Household
Gas for power generation	Demo model	1,200 kW	3.8 million yuan	3,167 yuan per kW
Centralized gasification	XFF-2000	Supply 200 households	384,500 yuan	1,945 yuan
Individual household	FUDE-50	Supply 1–2 households	1,300 yuan	1,300 yuan

Source: Qin (2000).

Table 7-15 Consumption of Primary Commercial Energy and New and Renewable Energy in the PRC, 1999

Type of Energy	Consumption (Mt, coal equivalent)	Share (%)	
Total primary energy	1,492.7	100	
Commercial energy	1,220	82	
Total new and renewables	272.4	18	100
Traditional biomass	242.4		89
New energy	30.3		11

Source: Li and Han (2000).

PROJECTED ENERGY DEMAND OF THE WESTERN REGION UP TO 2020

The Energy Research Institute of the State Development Planning Commission has projected energy demand from a base year of 2000 using various assumptions about GDP growth and the elasticity of energy demand with respect to GDP (Tables 7-16 and 7-17).

The GDP growth assumptions for regions are consistent with the discussion in Chapter 1. Coal will continue to dominate energy demand over the next 20 years, increasing by more than 50 percent over the period. However, its share of total energy demand will decrease from 62.9 percent in 2000 to 47.5 percent in 2020. Similarly, oil demand will increase, but its share will decrease. The demand for natural gas, hydropower, nuclear power, and renewable energy will increase both in absolute terms and as a

Table 7-16 Projected Energy Demand, 2000–2020

	PRC					Western Region				
Fuel	**2000**	**2005**	**2010**	**2015**	**2020**	**2000**	**2005**	**2010**	**2015**	**2020**
Coal (Mt)	1,020	1,127	1,245	1,408	1,554	254	282	311	352	389
Oil (Mt)	215	245	296	335	380	26	31	38	45	53
Gas (GL)	29	65	116	174	220	14	18	25	33	45
Hydro and nuclear power (TWh)	228	320	435	544	682	104	165	260	342	446
Renewable (Mt, coal equivalent)	1	5	19	57	141	0	2	7	24	63
Total (Mt, oil equivalent)	**1,159**	**1,363**	**1,644**	**1,971**	**2,335**	**275**	**332**	**411**	**509**	**639**
Average annual growth, %		2.7	3.8	3.7	3.5		3.8	4.4	4.4	4.7

Source: Energy Research Institute, State Development Planning Commission.

Table 7-17 Shares of Primary Energy Demand, 2000–2020

	PRC					Western Region				
Fuel	**2000**	**2005**	**2010**	**2015**	**2020**	**2000**	**2005**	**2010**	**2015**	**2020**
Coal	62.9	59.1	54.1	51.0	47.5	66.1	60.6	54.1	49.4	43.4
Oil	26.5	25.7	25.7	24.3	23.3	13.4	13.4	13.1	12.7	11.9
Gas	3.4	6.3	9.4	11.7	12.5	6.5	7.3	8.0	8.7	9.3
Hydro and nuclear power	7.2	8.6	9.7	10.1	10.7	13.8	18.1	23.1	24.5	25.5
Renewables	0.1	0.4	1.1	2.9	6.0	0.1	0.6	1.8	4.7	9.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: Energy Research Institute, State Development Planning Commission.

Western Region. Small hydropower plants, coalmines, and biomass energy, solar, and wind power systems are the main sources of energy supply for small towns and villages. New and renewable energy sources could meet 30 percent of the Western Region's needs and 50 percent of rural needs by 2020.

share of total energy demand. For instance, the demand for gas is likely to expand more than seven times in volume and four times in share.

Energy demand in the Western Region will exhibit the same pattern of change as that of the PRC as a whole, except that the growth rate is likely to be higher. Coal will be the main energy source with a volume of 388.5 Mt and 43.4 percent share. Oil demand will double but its share will decrease slightly from 13.4 percent in 2000 to 11.9 percent in 2020. Gas, hydropower, nuclear power, and renewable energy will increase in both volume and share. For more details, see Table 7-18 and Table 7-1.

Energy balance analysis for the PRC and the Western Region

The PRC will remain a net importer of energy. In 2020, total energy imports will probably amount to 319 Mt (coal equivalent). The country will mainly import oil and gas and export a small amount of coal. Table 7-19 shows the balance of total energy, coal, gas, and oil for the PRC up to 2020.

The Western Region will become the PRC's domestic energy supplier. Although both energy demand and supply will increase, supply is forecast to grow more rapidly than demand. Total energy exports from the Western Region to the Eastern Region will reach 250 Mt (coal equivalent) in 2020, more than four times the 2000 level. Coal will account for 91 percent of energy exports. The balance of exportable energy will include oil, gas, and electricity (Table 7-20).

Energy policies and related issues

Since the 1980s, the Government has adopted a range of policies to guide the development of the energy industry.

Table 7-18 Projected Electricity Demand, 1999–2020

Region	1999	2005	2010	2015	2020
PRC	**1,233.1**	**1,729.3**	**2,292.4**	**2,995.5**	**3,822.5**
Average annual growth (%)		**5.8**	**5.8**	**5.5**	**5.0**
Western Region	281.1	393.5	523.4	685.6	877.6
Average annual growth (%)		5.8	5.8	5.6	5.0
Gansu	26.2	36.7	48.9	64.0	81.9
Xinjiang	16.9	23.7	31.5	41.3	52.9
Western Region as % of PRC	22.8	22.8	22.8	22.9	23.0
Gansu as % of PRC	2.1	2.1	2.1	2.1	2.1
Xinjiang as % of PRC	1.4	1.4	1.4	1.4	1.4

Source: Based on data from the Energy Research Institute, State Development Planning Commission.

Table 7-19 National Primary Energy Balance, 2005–2020

	2005	2010	2015	2020
Primary energy balance (Mt, coal equivalent)				
Energy supply	1,278	1,481	1,728	2,016
Energy demand	1,362	1,644	1,971	2,335
Import	85	162	243	319
Coal balance (Mt, coal equivalent)				
Coal supply	1,167	1,305	1,468	1,620
Coal demand	1,127	1,245	1,408	1,554
Export	43	60	60	66
Oil balance (Mt, coal equivalent)				
Oil supply	175	185	197	207
Oil demand	245	296	335	380
Net imports	70	111	138	173
Import dependence (%)	29	37	41	46
Natural gas balance (GL)				
Gas supply	55	80	108	131
Gas demand	65	116	174	220
Net imports	10	36	66	89
Import dependence (%)	15	31	38	40

Source: Energy Research Institute, State Development Planning Commission.

Table 7-20 Primary Energy Balance of the Western Region, 2005–2020

	2005	2010	2015	2020
Primary energy balance (Mt, coal equivalent)				
Energy supply	393	539	696	890
Energy demand	332	411	509	639
Export	60	128	187	251
Coal balance (Mt, coal equivalent)				
Coal supply	327	418	514	616
Coal demand	282	311	352	389
Exportable	45	106	162	227
Oil balance (Mt, coal equivalent)				
Oil supply	35	44	58	77
Oil demand	31	38	45	53
Exportable	4	7	13	24
Natural gas balance (GL)				
Gas supply	36	56	73	85
Gas demand	18	25	33	45
Exportable	17	32	40	40
Electricity balance (TWh)				
Electricity supply	495	693	956	1,242
Electricity demand	394	523	686	878
Exportable	102	170	271	365

Source: Energy Research Institute, State Development Planning Commission.
Note: Primary energy sources include hydropower, nuclear energy, and geothermal electricity. Energy conversion factors to 1 ton (coal equivalent): crude oil, 1 t; oil products, 1 t; bituminous coal, 0.6945 t; natural gas, 1074 m^3; primary energy, 3.67 MWh). The conversion factors are based on the average efficiency of converting fuel oil to electricity in various countries.

COAL DEVELOPMENT

In the 1970s, the Government set a production target for coal of 1,400 Mt of coal by 2000. Given the shortage of capital and primary energy, small-scale production was encouraged. By 1985, local governments and the private sector had developed about 80,000 small coalmines, many of them in the Western Region. This overcame the energy shortage, but it also led to frequent accidents, negative effects on the environment, and inefficient use of natural resources.

Small coalmines face numerous problems. Because of energy substitution and conservation, national coal stocks are increasing. In 1999, the PRC produced 1,390 Mt of coal but consumed only about 900 Mt. The Government decided[7] in 1998 to close inefficient and dangerous coalmines. In addition, it has announced a range of policies relating to environmental conservation, including the Environmental Protection Law, the Environment Protection Management Regulations for New Project Development, the Utilization and Management Regulations for Coal Ash of 1989, and the Utilization and Management Regulations for Stone Coal. These policies have had considerable impact on the small and private-funded coalmines in the Western Region.

The Government has introduced various policies relating to coal conversion and consumption. Among these are China's Clean Coal Technology in the Ninth FYP and 2010 Development Outlines (June 1997) and a series of energy conservation policies (Energy Conservation Development Outlines, China's Energy Conservation Technology Outlines, Management and Evaluation Methods for Energy Conservation Equipment). Under these policies, clean coal and energy conservation technologies have developed quickly. For example, the share of washed coal in the PRC's total coal consumption increased from 24 percent in 1998 to 28 percent in 2000.

OIL DEVELOPMENT

The PRC's oil production is likely to continue to be less than demand. It could reach 160–170 Mt in 2005 and 180–190 Mt in 2015, as against demand of 269 Mt in 2005 and 370–395 Mt in 2020.[8] Given the supply-demand imbalance, the PRC's strategy is to promote energy conservation, find alternative fuels, use renewable energy, explore foreign oil reserves, and diversify sources. The Government is trying to stabilize oil output in the Eastern Region and further develop fields in the Western Region. The use of advanced technology may make it possible to maintain the output of the Eastern Region oilfields, but the resources of the Western Region may attract all available domestic capital and technologies. The oil companies may have to cut down capital investment in the Eastern oilfields, close unproductive wells, and transfer personnel and equipment to the Western Region.

Other policies include diversifying sources of supply and enlarging storage capacity. In addition to imports by sea, the Government is negotiating long-term import-export agreements with Russia and Central Asian countries. The PRC's oil stocks are equivalent to only 20 days' consumption. Now that imports have increased, some argue that the PRC must increase its storage capacity.

In relation to oil supply, the Government should promote energy substitution policies. For example, promoting and using natural gas to substitute for oil and oil products will benefit environmental conservation, reduce oil imports, and spur the development of natural gas in the Western Region.

Oil imports from Kazakhstan and Russia via Xinjiang would stimulate the development of the energy sector in the Western Region, but would be expensive. If the PRC imports oil and gas from Russia via the northeast (Daqing), it may affect the economic and energy development in the Western Region in the short term. However, in the long run (20 to 50 years), the PRC will require imports of oil and gas not only from Xinjiang but also from Russia.

GAS DEVELOPMENT

The development of gas resources requires major investment in pipeline networks and distillation networks. The extension of the gas distribution

system will allow gas to replace coal for power and heat generation. These projects are designed to form a nationwide network of natural gas supplies based on three major natural gas producing areas in the west: Sichuan, Shaanxi, and Xinjiang. The network will also cover most developed areas in the east.

Gas transport from Xinjiang to the Eastern Region

Recent statistics show that the Western Region has natural gas reserves of 1,500 GL. Natural gas has a huge market potential, and is likely to become a major form of clean energy in the 21st century. The Xinjiang gas pipeline will start from Lunnan and finish in Shanghai (Figure 7-1). The total length of the pipeline will be about 4,200 km. The capital cost is estimated at 38,400 million yuan. The planned diameter of the pipeline is 1,118 mm and the annual gas transmission capability is 12 GL.

The Super Gas Transport Project aims to transport natural gas from Central Asia via Xinjiang to Shanghai. It is a key component of the Government strategy to

Figure 7-1 Gas Pipelines

develop the west. The Government has mobilized foreign investment in the project, which at a cost of 120,000 million yuan is second only to the Three Gorges Project in investment size. A careful analysis of the social and environmental impacts of this project is required.

The eastern provinces have also shown interest in the project since it would help ease their energy shortages. Gas pipeline projects could make areas along their routes magnets for capital, technology, and skills, facilitating economic development in the route regions.

Another proposed gas project would link the Russian gas grid in Siberia to the PRC and possibly the Republic of Korea via a pipeline from Irkutsk. The estimated cost of the project is $10,000 million, and a feasibility study is under way. The PRC would like the pipeline to go directly to northeast PRC. However, Russia is suggesting that the line should enter the PRC via Mongolia because this route is shorter. About $12,500 million is required to extend the 4,000-km pipeline from the Irkutsk basin gas fields in Eastern Siberia to northern PRC. The PRC expects the pipeline to transport 20,000–25,000 GL of gas a year to the PRC, while the Republic of Korea expects to receive 10,000 GL a year.

Gas transport from Inner Mongolia to Beijing

There are plans for a pipeline to carry natural gas to major markets in northern PRC and the coastal areas including Beijing, Tianjin, Hebei, and Shandong provinces. PetroChina has signed contracts with the Royal Dutch Shell Group for the construction of the gas pipeline.[9]

Gas transport from Sichuan to Hubei

The governments of Sichuan and Chongqing prefer not to export their natural gas. The results of gas reserve surveys are not encouraging as they suggest that there is no certainty that available reserves will be adequate to meet future local demand from a population of 115 million (1999). Additionally, gas prices are so high (1.09 yuan/m^3 per household) that customers in central PRC may not be able to afford the gas. After transport to Wuhan (Hubei province), the price may increase by 0.1 yuan/m^3 (given the cost of gas transport from Ningxia to Gansu).[10] Customers may not be able to afford the gas since purchasing power in Hubei is not much better than in Sichuan and Chongqing. Consequently, gas transport from Sichuan and Chongqing may not be feasible.

POWER DEVELOPMENT

The Government has introduced many reforms in the power industry. Among others, the reforms involve restructuring institutions, converting provincial electricity bureaus into companies, reforming tariffs, encouraging private sector investment, and splitting the vertically integrated power system into individual generation, transmission, distribution, and retail companies. The Electric Power Law of 1996 requires reform toward the creation of vertically separated power producers and retailers in a competitive market.

Thermal power

In 1997, when power was in surplus, the policy of optimizing elements of thermal power plants attempted to restrain further development of small thermal units. Power supply still exceeds demand, the surplus being equivalent to about 10 percent of installed capacity. Consequently, a new policy, the substitution of large and highly efficient power technologies for small and inefficient power technologies, requires either 300 MW or 600 MW power units. In addition, the Government has approved the development of cogeneration.

Hydropower

The Government has made efforts to develop hydropower in the Western Region, particularly the large hydropower projects on the Yellow and Yangtze rivers. It aims to increase hydropower output to 30 percent of total power production by 2010. To promote hydropower, the Government has introduced various incentives for development: a

poverty reduction policy for remote rural hydropower development, low interest rates for hydropower investment, tax exemptions and preferential tariff policies, and special policies for resettling displaced people.

Power transmission

SDPC proposes to transmit power from Guizhou, Yunnan, and Guangxi to Guangdong. Guizhou, for example, would send Guangdong 4 GW of power by 2005.

Hydropower transmission is seen as having multiple benefits. It will have a positive impact on rural electrification, poverty reduction, and tourism. The hydropower will meet increasing power demand in Guangdong, where consumption increased by 11 percent in 1999 and 20 percent in 2000. In the past, Guangdong installed many small, inefficient, expensive, and dirty coal and diesel power plants. Transmitting power to Guangdong will mitigate pollution, reduce electricity tariffs, and ease power shortages.[11]

Yunnan has also initiated power projects in line with the national plan of sending power from the west to the east. These projects include the Xiaowan hydropower plant on the middle reaches of the Lancang River, the 600 MW Qujing power plant, the technology upgrade for Kaiyuan power plant designed to generate 600 MW, and the enlargement production project for Xuanwei power plant. The projects will enable the province to supply a total of 8 GW to Guangdong by 2015. Development of dams in the Lancang River should reflect the downstream impacts of such dams.

In addition, the Government welcomes foreign investment in hydropower plants and power transmission. Hong Kong China Electric Power Ltd. is negotiating with the Guizhou government and power company for an investment in hydropower plants. Hong Kong, China needs strategic power supplies.[12]

There is also a proposal for further thermal power development in Inner Mongolia and Shanxi and the transmission of power to Beijing, Tianjin, and Tangshan.

Renewable power

In 1996, the Government introduced a Brightness Program, which called for the use of solar and wind energy to power remote and rural households. The Program combines poverty reduction, environment conservation, and development of renewable power sources. In March 1996, SDPC promulgated its Developing Program with the Wind policy, which aims to develop wind power technology in two steps: (i) entering into joint ventures with foreign firms in 1996–2000; and (ii) developing the PRC's wind power technology after 2000 on the basis of the experience in joint-venture production. However, further policy reforms are needed to provide incentives to develop wind power.

Domestic power tariffs

The Government has implemented several policies to help poor households reach a minimum level of energy consumption. Firstly, it has a detailed subsidy policy for the poor in cities. Table 7-21 shows the subsidy standards of the PRC Government for poor households in the 10 capital cities of the Western Region and Beijing.

In urban areas, electricity tariffs are less than 0.4 yuan/kWh. Household tariffs in Guangzhou, Beijing; and Lanzhou, for example, are 0.38 yuan/kWh, 0.39 yuan/kWh and 0.32 yuan/kWh, respectively. Hence, a poor household in Lanzhou would pay 12.8 yuan per month for 40 kWh of electricity. That is about 2.8 percent of the 458 yuan minimum monthly income of a three-member household in Lanzhou—an acceptable rate.

Table 7-21 Government Lifeline Subsidy Standards, 2000

City	Subsidy (yuan per capita per month)
Beijing	280
Lhasa	170
Chongqing	169
Yenchuan	160
Chengdu	156
Kunming	182
Lanzhou	156
Urumqi	156
Xining	155
Hohhot	143
Nanning	183

Source: *China Youth Daily*, 10 April 2001.

There is a potential conflict between pricing reforms and poverty reduction policies. Economic pricing requires electricity tariffs to be set on the basis of marginal production costs. That will tend to raise electricity prices. However, the adoption of economic pricing will ensure sufficient capital return to attract sustainable investment. On the other hand, the poverty reduction policies of the Government require power tariffs that are not too high for the poor to afford.

The conflict can be resolved by increasing the efficiency of power distribution. In rural areas, the average electricity tariff is about 1 yuan/kWh, discouraging households from using electricity. High electricity prices are largely attributable to poor management, electricity theft, and outdated and inefficient distribution technologies. Wires and transformers are frequently lost. Studies indicate that rural electricity tariffs could fall below 0.5 yuan/kWh once improvements are made in rural power distribution and system management.[13] Rural households would then be able to afford electricity for lighting, refrigeration, farming, and rural industry development. Power consumption would increase, enlarging the market and thus attracting investment in larger and more efficient power facilities.

In the meantime, the Government should regulate the wholesale price at busbars of power plants on the basis of long-run marginal production costs. Australian power generators prepare their electricity sale bids on the basis of short-run marginal costs of production in order to lower the prices and expand their market shares. Consequently, the electricity prices at the busbars are cheaper than necessary. This situation benefits neither the power companies nor the customers. Using the short-run marginal cost of production to set electricity prices would discourage investment in power generation.

The average net income of rural households in the Western Region ranges from 1,232 yuan (Tibet) to 1,981 yuan (Inner Mongolia). At a tariff rate of 0.5 yan/kWh (based on government policy), an annual consumption of 600 kWh of electricity would cost 300 yuan—9.1 percent of net household income in Tibet and 3.7 percent in Inner Mongolia. To help poor households reach a minimum level of energy consumption the Government is subsidizing the consumption of electricity and diesel for irrigation and other agricultural purposes. Unfortunately, this policy may adversely affect the natural resources and the environment. In India, governments subsidize the use of electricity and diesel in agriculture production. As a result, rural people use more energy than necessary to pump water for irrigation. Not only is there waste of electricity, but water resources are also misused. A better way for the PRC would be to avoid electricity and diesel subsidies but to reduce the taxes on peasants.

ATTRACTING FOREIGN AND PRIVATE INVESTMENT IN THE ENERGY SECTOR

The Government welcomes foreign and private investments in the energy sector of the Western Region. Foreign firms may invest in power plants through such investment mechanisms as BOT arrangements, joint ventures, direct investment, or technology transfer. Speaking at the launching of a major gas pipeline project in March 2000, Premier Zhu Rongji said that foreign investors were allowed take a majority stake in the pipeline and that foreign companies could control its management.[14]

According to a typical policy document from the State Council[15] on attracting foreign and private investment:

> **Implementing preference tax policies.** The corporate income tax of enterprises in government-encouraged sectors that are financed with either domestic or foreign investment in the Western Region should be collected at a reduced rate of 15 percent for a certain period of time. Upon approval by the provincial government, enterprises based in autonomous regions, prefectures or counties may also be granted reduction or exemption of corporate income tax for a certain period of time. New enterprises engaged in transport, power, water

> conservancy, postal service, broadcasting, TV, etc., in the Western Region are eligible for a two-year tax holiday and a 50 percent reduction for the next three years following the tax holiday.… If domestic or foreign investors invest in the Western Region in sectors where investment is encouraged by the government or sectors with a competitive edge and need to import advanced technology and equipment to facilitate their invested projects, these imports, except for those not exemptible by the government regulations, should be exempted from tariffs and import value added tax, provided that the imports are purchased within the total amount of investment.

More detailed policies are also available for the different sectors. In power, the Government issued the New Electricity, New Prices policy in the early 1990s. The policy stated that the purchase price of electricity should be such as to allow an independent power producer to pay back capital and interest and attain profit. Although this policy has brought foreign investment funds into the power sector, many foreign investors have been forced to renegotiate their contracts after completion of construction and accept a lower than anticipated return on equity. The price of electricity from the JinYuan Power Plant (Gansu) sold to the grid was 0.36 yuan/kWh in 2000, but the average price of electricity in the province was 0.27 yuan/kWh.

The Government is planning to reduce the VAT rate for hydropower development. The objective is to attract foreign funds and make hydropower generation competitive with power generation using nonrenewable resources. Similarly, Government-owned banks are following policies to facilitate hydropower development in the Western Region, such as extending the capital return period, which has considerable impact on keeping down electricity prices.[16]

There has been considerable foreign investment in the energy sector. In 1999, the largest foreign participant in the PRC's onshore gas sector was Royal Dutch/Shell. Shell signed a $3,000-million contract with CNPC to jointly explore and develop gas resources in the Ordos Basin of north Xinjiang.[17] The contract allows Shell to tap gas reserves on the Changbei block, which covers 1,600 km^2, build a gas pipeline, and establish a sales network. The pipeline will extend through Inner Mongolia, Beijing, Tianjin, Hebei, and Shandong. The project will supply 3 GL/year of natural gas to the Eastern Region for 20 years. It is expected to start in 2004.

At present, foreign direct investment (FDI) is allowed only in power generation; power transmission is a Government monopoly. The Electric Power Law of 1996 does not forbid foreign and private investment in power transmission, but the vertical integration of power generation, transmission, and distribution effectively prevents private investment. However, a split of power generation assets from other assets is now under way. After this split and the formation of a national transmission company, the power generation companies and the national power transmission company will be able to sell their shares on the stock market. In the Western Region, however, backward power technologies and management may delay institutional reforms.

Policies introduced by the PRC to encourage private investment have done little to facilitate such investments in the Western Region. For example, it is difficult to find a bank or a finance institution that is willing to take risks for private investors. A more detailed study is required to solve these problems.

Over the past decade, some local governments in the Western Region have participated in energy investments, all limited in scope and scale. Local government projects are subject to auditing and approval by the Central Government. The audit process often takes time and projects are sometimes rejected. Abolishing the planning and approval of projects by the Central Government would stimulate

local government investment in the energy sector in the Western Region.

In Australia, the national Government has very little to do with energy project development, which it leaves to second-level governments and the private sector.

IMPACT OF ENERGY DEVELOPMENT ON THE ENVIRONMENT

Pollution control

The Government is paying increasing attention to environmental protection. Environmental protection laws and regulations have had significant impact on the energy industry. The Environment Protection Law of 1989 and the Air Pollution Prevention and Control Law 1987, for example, provide for specific controls on air emissions. These laws and policies have pushed the energy industry to improve energy efficiency and have mitigated air pollution to some extent.

Renewable energy development

In June 1992, in response to the Rio Conference, the PRC prepared a white paper entitled *China's Population, Environment, and Development Agenda in the 21st Century (Agenda 21 Plan)*, which detailed a strategic plan for sustainable development in all economic and energy sectors. Following State Council approval of the plan in 1994, a joint committee of the three key commissions for renewable energy developed the China Sunlight Program, a renewable energy strategy up to 2010. The strategy represents an implementation plan for the goals of *Agenda 21*. It highlights photovoltaic, wind, biomass, fuel cell, ocean, and hydrogen technologies and contains specific goals and funding recommendations for the Tenth FYP period and beyond.

Policies for developing clean and renewable energy range from those designed to encourage R&D to policies for the promotion of commercialization and mass production. These policies include the following:

- *Subsidy*. The Government supports whole funding for demonstration or model projects, and partial funding for renewable energy R&D.
- *Tax*. The Government imposes 6 percent VAT on hydropower business, but 17 percent on other industries.
- *Pricing*. The Government requires grid firms to purchase wind energy even if the price is above the grid average. Similarly, the power grid firms must buy electricity from small hydropower plants at production cost plus reasonable profits. The grid firms are allowed to raise tariffs to cover the loss. This pricing policy has been applied in other renewable energy production. Gas distribution firms, for example, are required to buy biogas in Shanghai at 1.2 yuan/m^3, higher than the price of town gas.
- *Low-interest loans*. The Government has set up a special loan fund with low interest for rural renewable projects. Over the past 10 years, loans from this fund have amounted to about 100 million yuan a year. The Government plans to lend more. The interest rate is about 2–3 percent below normal commercial terms.

One of the PRC's important energy policies is improving the structure of primary energy consumption. In particular, the Government has decided to develop clean and renewable energy on a large scale.

Energy development in the Western Region fits the policy well. Energy programs in the Western Region include the transmission of natural gas and hydropower to the Eastern Region. However, many policy issues have not been resolved, in particular, pricing. Conflicts in electricity and gas prices between energy producers in the Western Region and energy users in the Eastern Region have not yet been solved.

The Central Government has made policies for new and renewable energy development. Now local governments in the Western Region should make their own policies in line with the Central Government's policies, providing incentives in project

finance and income tax to promote the development of new and renewable energy. In particular, there should be incentives to encourage investment from local energy service companies and the private sector in new and renewable energy.

Further effort is required to improve regulations and policies for environmental protection. In Australia power generation companies expect to increase their production of renewable power (not including hydropower) by 2 percent between 2000 and 2010. The effects of energy development on the environment are well known. The Government has environmental protection policies, but these policies need strengthening. Feasibility studies on coal-fired power plants, for example, do not require analyses of the impact of emissions (SO_2, NO_2, and dust) on human health, animals, forests, rivers, and land. Also, power companies applying for new power generation projects are not required to submit strategies for energy conservation and demand-side management. In developed countries, such as Australia, a power company must use arguments from these impact analyses or studies to demonstrate that its planned project is environmentally sound and has provisions for energy conservation and demand-side management.

ENERGY PRICING POLICY

Coal pricing policy

The market has set coal prices since 1993, when the Government allowed free trading in the market (except for supply to power plants) to overcome a coal shortage. Production progressively grew but by 1997 the PRC had surplus coal, and prices fell dramatically. SOEs accumulated most of the surplus because their coal costs (prices) were higher than those of small private enterprises, which were spending much less on safety, environmental protection, and equipment. The SOEs could not compete. The Government therefore decided to close the small and unsafe coalmines and keep coal prices at a reasonable level.

Table 7-22 Market Prices for Datong Mixed Coal

	November 1992 (yuan/t)	July 1993 (yuan/t)	June 1994 (yuan/t)	December 1994 (yuan/t)
Shanghai	190	230	230	267
Guangzhou	228	308	280	315

Source: *China Energy Development Report*, 1997.

Coal prices vary with transportation cost. Table 7-22 shows the prices of Datong coal in Shanghai and Guangzhou.

Another example is Huating coalmine in Gansu. At the coalmine the price of coal is 60 yuan/t, at Lanzhou it reaches 200 yuan/t, and at Longnan, 400 km away, 380 yuan/t.

Oil and oil product pricing policy

The Government does not yet have policies to limit the consumption of oil and oil products. Instead, it uses pricing to promote energy conservation. Over the past few years, it has raised gasoline prices by six times; prices now approach the international level. There is scope for further action. The Government could set standards of efficiency for cars, with a labeling program for car production and sales.

Before 1993, the Government subsidized the petrochemical industry by lowering oil prices. The petrochemical industry grew quickly, but the oil industry went into deficit. The oil and petrochemical industries were reformed and restructured starting in 1994. By 1996, oil prices had been raised three times. In 1998, the Government proclaimed the Pricing Reform for Oil and Oil Products policy to establish an open and competitive market based on the international market for oil production, processing, and consumption.

Power pricing policy

In regard to pricing, the Electric Power Law of 1996 stipulates that power tariffs should include

power production costs, reasonable profit, and tax. Moreover, the tariffs should take into account reasonable cost recovery of the power transmission network and cross-subsidy. They should be attractive to investors in power plants, transmission and distribution network, and retail business.

Case studies in regional development and energy sector finance

This section presents some international experience in regional energy system development and energy sector finance.

ELECTRICITY TRADE IN ASEAN COUNTRIES

Energy trade among the Association of Southeast Asian (ASEAN) countries is becoming important. In 1998, ASEAN put forward a plan for an interconnecting power grid and asked the Australian Agency for International Development (AusAID) and the European Union to undertake feasibility studies. The European Union is expected to finance the project. Several Southeast Asian countries are already interconnected, enabling electricity trade among them. The planned regional power grid will connect all ASEAN countries soon.

ELECTRICITY SECTOR FINANCE IN PAKISTAN

Between the late 1980s and the early 1990s, Pakistan was suffering from a power shortage. To attract foreign investment, the Government set the average price of electricity from private power plants at about $0.065/kWh (1998 prices). This policy drew large investments from American companies. The investments, plus the downturn in the national economy during the Asian financial crisis, contributed to solving the power shortage. Unfortunately, since the Government did not allow electricity prices to rise much and electricity theft was common, Pakistani power utilities could not recover their operational costs and had to sell off assets.

ENERGY CONSERVATION FINANCE IN THAILAND

In the early 1990s, to save energy and protect the environment, the Thai Government introduced a tax on the consumption of dirty energy, mainly fuel for vehicles. Gasoline stations collected the tax and transferred it to Government energy and environment conservation funds. The National Energy Policy Office has collected millions of dollars in taxes from fossil fuel consumption, and has plowed the money into energy and environment conservation. This policy had a big impact and it financed many pilot energy conservation projects. The Energy Star Office Equipment Promotion Program, for example, saves considerable electricity in the use of office equipment.

Implications for energy policies

During the next 20 years, coal will continue to dominate the PRC's energy sector. However, its share will decline. Natural gas, hydropower, and new and renewable energy production and the shares of those forms of energy will increase dramatically. The Western Region will therefore become one of the PRC's most important energy bases. In particular, Xinjiang will serve both as base for energy production and port of entry for energy imports. By 2020, the PRC will be importing 319 Mt (coal equivalent) of energy, including 173 Mt of oil and 90 GL of natural gas. Energy transported from the Western Region to the Eastern Region in 2020 would amount to 250 Mt (coal equivalent), including 227 Mt of coal, 24.3 Mt of oil, 45,000 GL of natural gas, and 364.7 TWh of electricity.

IMPOSING ENVIRONMENTAL PROTECTION TAXES ON DIRTY FUELS

To enhance environmental protection policy, the State Environmental Protection Agency (SEPA) should

work with the National Pricing Bureau to calculate and set taxes on sources of dirty energy. The dirtier the fuel, the higher the tax should be. These taxes should be imposed on the trading of energy, to encourage consumers to consider the use of clean and efficient energy sources, and facilitate energy conservation. The income from duties levied on the consumption of dirty energy should be invested in energy and environment conservation.

For households or industrial sectors that use coal as primary energy source and have access to natural gas and town gas, the Government or an independent regulatory organization should levy taxes for environmental protection. The taxes should be high enough to drive coal users to switch to natural gas or coal gas.

PROMOTING ELECTRICITY TIME-OF-USE TARIFFS

Time-of-use tariffs are good for economic operation of the power system, promotion of demand-side management, and hydropower development. As yet, however, time-of-use tariffs are in use in only a few industrial and commercial sectors in some cities. The Government should extend the use of time-of-use tariffs with the development of power sector reform.

REFORMING PRICES OF NATURAL GAS

In 2001, the PRC still has two pricing systems for natural gas: planned gas price and market price. The former is cheaper than the latter. Natural gas prices should be based on the market equilibrium point.

REGULATING INEFFICIENT POWER PLANTS AND COALMINES

The Government should encourage the replacement of small and inefficient coal-fired power plants and coalmines. To facilitate the substitution, the Government needs to set up independent agencies to monitor and regulate efficiency and safety issues. Power plants or coalmines that do not meet the regulation standards should be shut down.

PROMOTING CLEAN COAL TECHNOLOGY

Coal liquefaction and gasification technologies may help revive the coal industry, especially when international oil prices stay high. The Government should make special policies, such as a tax-free policy, to promote coal liquefaction and gasification technologies.

USING ADVANCED TECHNOLOGY IN POWER GENERATION

Combined-cycle technology with gas turbines for power generation has been widely recognized as state-of-the-art power production technology. This technology has the following advantages:

- Much smaller land area requirement per megawatt than coal power
- Ease of installation in load centers
- Little negative environmental impact
- Very high efficiency (up to over 50 percent)
- Short installation period

Most new power plants in the US use this technology.

In the Western Region, natural gas will be one of the most important primary resources. The combined-cycle technology with natural gas turbines for power generation should be chosen as first priority for power development in the region.

PROMOTING COGENERATION

In the northwest, it is very cold in winter and space heating requirements are substantial. A combined-cycle gas turbine integrated with cogeneration technology should be the best thermal power technology to adopt.

DIVERSIFYING OIL IMPORT CHANNELS

It is important to diversify oil import sources and bring the PRC's oil companies up to international standards. The Government should abolish the oil import quota management system, and allow the national oil companies to decide sources, time, types, and quantities of oil imports. PRC oil companies should produce and trade oil in both domestic and international markets.

PROMOTING OIL AND GAS EXPLOITATION IN CENTRAL ASIA

None of the three PRC oil and gas companies has the capability to make large-scale investments in Central Asia. Special policies are needed to encourage these firms to develop overseas. These policies include:

- Establishing an insurance policy for overseas oil business investment
- Allowing sunk and ineffective capital offset taxes
- Avoiding the imposition of double taxes on overseas profits of oil firms
- Considering oil exploitation equipment to be transported and used overseas as equipment export and therefore tax-exempt
- Freeing oil firms from finance and guarantee limitations. The Government should allow oil firms to be financed and guaranteed by multiple institutions, foreign or domestic.
- Lifting, or in some cases increasing, the foreign exchange limits on oil firms
- Implementing various measures to increase oil stocks, including extending loans from the Import-Export Bank of China to purchase oil or from the Development Bank of China to purchase equipment; providing grants from the Ministry of Finance to reduce loan interest; deferring oil import taxes until the oil is actually used; establishing commercial oil storage companies

PROMOTING RENEWABLE ENERGY

The following policies would promote the development of the Western Region's wealth of renewable energy resources:

- Setting a target for renewable energy consumption (excluding hydropower and biomass) as a proportion of fossil energy consumption, say, 10–15 percent.
- Setting up a national renewable energy development agency, such as a State Renewable Energy Development Commission, to make policy and lead the development of renewable energy.
- Introducing national renewable energy quotas, and encouraging trading in them. Power generators in the east and south, lacking sources of renewable energy, could invest in renewable energy in the Western Region or buy their renewable energy quotas. All the customers of the national power network would therefore contribute to the costs of renewable development (mainly in the Western Region).
- Introducing rebates for the cost of installing wind-powered or solar hot water devices. The Government may raise the funds by imposing tax on dirty fuel consumption.
- Drafting regulations to define the renewable energy technologies eligible for government support, the levels of renewable energy capacity in each grid, the requirements for power grids to provide convenient grid connections for renewable energy power plants and buy all the electricity at fixed prices, and the economic and technical goals of supported renewable energy technologies.
- Rationalizing prices. In 1994, the Ministry of Electric Power issued an executive order establishing the pricing principle for wind power to include production cost, financing costs, taxes, and reasonable profits. The order also required power grids to purchase all the electricity that wind plants generate, and all the customers of the power grid, not just those closest to the wind supply, to bear the additional cost. However, the order did not define the extent of a power grid. Confusion arises as to which customers must bear the price difference. Revisions in the order should clarify the confusion and also cover all renewable energy technologies.
- Strengthening training and communication efforts to increase the awareness of the public, local government officials, and entrepreneurs on the protection of the environment and the benefits of renewable energy technologies.

- Introducing revolving funds for household-scale renewable energy development. In the Western Region, rural households lack access to commercial finance. A revolving fund can fill the gap by marshaling public and multilateral funds to capitalize the account and using household repayments to expand the size of the fund. The fund would help establish and stabilize the market by increasing the number of households that can purchase renewable energy systems.
- Establishing new financing mechanisms. Flexible loan rates and repayment plans can also serve the goal of market development. Many herdsmen in Inner Mongolia, for example, purchase small energy systems for household needs, water pumping, electric shearing, and other uses. If herdsmen pay less in the beginning and more later when business activity expands, the twin purposes of rural economic development and electrification can be served.
- Building an advisory service to provide customers with information on renewable energy
- Introducing new technologies in renewable energy development through international cooperation

PROMOTING ENERGY CONSERVATION

The Government should establish standards for all energy consumption devices, and develop energy labeling programs for them. For example, by 2010, a standard should have been set for gasoline consumption and it should be understood by all car drivers. In addition, a label on the car should indicate its energy efficiency rank, to make it easy for customers to compare each car's efficiency, as indicated on the label, with the standard. The Government should also promote wall and ceiling insulation in buildings.

The Government should build sound systems for energy conservation and demand-side management auditing. Any firm that applies to develop a new energy facility, say, a new power substation, should provide a comprehensive study on energy conservation and demand-side management. Experts from an independent regulatory agency will audit the report to see if the power expansion plan can be delayed by using energy conservation and demand-side management strategies. Only if the answer is no will the firm be allowed to build new power facilities.

ATTRACTING MORE FOREIGN CAPITAL TO THE WESTERN REGION

The Government or the local governments in the Western Region need to make more detailed policies to develop an energy market and attract foreign investment in the energy sector. Power transmission, for one, is under the control of the Government and constitutes a monopolistic marketplace. The Electric Power Law of 1996 does not forbid foreign and private sectors from investing in power transmission. The Government should develop policies that encourage foreign investment in power transmission.

REDUCING THE POVERTY OF MINORITY GROUPS

Providing commercial and renewable energy to rural households plays an important role in poverty reduction for minority groups, which make up most of the rural households in the Western Region. These minority households usually live in remote areas with a very low population density. They are covered by national and international poverty reduction policy, national minority policy, and environment protection policy. Reducing poverty for these groups needs capital from the Government and international grants or special loans. Local governments should use various fund sources to reduce poverty.

Ningxia, for example, has a Donate Coal to the Poor policy. The local government purchases, transports, and distributes coal to poor households free of charge, such that the households no longer see the need to cut trees for firewood. Thus, through the coal donation, taxpayers' money and poverty reduction funds are used to protect the environment.

ATTRACTING DOMESTIC PRIVATE SECTOR PARTICIPATION IN ENERGY DEVELOPMENT

Developing the Western Region needs private investment; government funds alone are not enough. To attract and manage domestic private investment policies and regulations are needed. In the energy sector private investment has focused mainly on small coalmines and small hydropower plants in the Western Region. The small coalmines use simple technology and are quick to develop and profitable, but they also operate dangerously and are wasteful in resource exploitation. The Government needs to establish regulations to enforce the use of modern technology and safety measures.

Private investors could join together to invest in large coalmines. The Government could also allow the domestic private sector to invest in small oil and gas fields that are not economic for the public sector. Since this is a new business, the Government needs to make policies and regulations to guide it. Safety and the rational exploitation of natural resources should be key points of the regulations.

Another policy that would attract domestic private sector investment is nondiscrimination against investors, private or public, in such matters as loan applications, insurance, and interest rates.[18]

IMPLEMENTING INSTITUTIONAL REFORMS AND ENHANCING COMPETITION

Institutional reform is a key issue in the development of the energy sector. As of now, the institutions still operate on the basis of the planning economy. Centralized planning of the energy sector does not fit in with the market economy. The Government should encourage SMEs to participate in oil and gas development by instituting an open bidding system. In the meantime, the Government should reform its institutions to make them suitable for market competition.

To continue power industry reform, the Government should split power generation from transmission, distribution, and retail. For a start, it plans to separate power generation assets and set up power generation companies. Splitting transmission from generation and distribution, and even selling some generation and distribution assets to the private sector, would complete this reform and bring full generation and retail competition to the power industry. To succeed in power sector reform and restructuring, the Government needs to study similar reforms in Australia, Chile, the UK, and the US.

Simplifying the audit and approval process for energy development projects in the Western Region would encourage investment. For example, provincial governments should be given authority to decide which energy facilities to develop with little audit and approval, as long as these projects are environmentally friendly and economically sound.

For private sector investment, there is a need for the Government to improve regulations on safety, minimum size of capital investment, and technologies. These regulations would prevent the development of small coalmines but encourage small hydropower energy.

INSTITUTING POLICIES TO ENCOURAGE R&D IN THE ENERGY INDUSTRY

The Government should make policies to help stimulate R&D in the energy industry. In order to reduce the costs or prices of renewable technologies, the Western Region needs to develop its own new mass production technologies. Government can use tax policy to encourage R&D in energy technologies. For example, it could treat R&D expenditure as a cost of production.

SETTING UP SPECIAL FUNDS TO SUBSIDIZE SPECIAL SECTORS

The Electric Power Law of 1996 requires preferential treatment for rural areas, minority areas, remote areas, and poverty areas. Tariffs in the Western Region have provided cross-subsidies. The average rural electricity tariff in Gansu, for example, is about 0.05 yuan/kWh, or one-sixth of the provincial average. With the development of a free trading market for

power, it will be difficult to continue these subsidies. Rather than providing hidden subsidies, the Government should provide direct assistance through other programs.

Notes

1 State Development Planning Commission (1999b).
2 *China Energy Strategy Study, 2000–2005*. Beijing: China Electrical Power Press, 1997.
3 H. Dai et al. (1992).
4 State Development Planning Commission (1999b).
5 Inquiries by international team member in Sichuan, April 2001.
6 S.P. Qin (2000).
7 State Council 1998, No. 43.
8 State Development Planning Commission (2000c).
9 Huo Yongzhe (2001).
10 Gas transported from Ningxia to Gansu is about 0.1 yuan/m3, according to the Gansu Provincial Planning Commission. The pipelines are almost the same in length.
11 *People's Daily,* 13 April 2000.
12 *People's Daily,* 13 April 2000.
13 See State Development Planning Commission (2001b) and W. K. Han (2001).
14 PennWell (2000).
15 State Council, *Circular on Policies and Measures Pertaining to the Development of the Western Region*. Beijing: China Planning Press, 2000.
16 Interview with Jiang Shao Jun, Director, Long-term Strategy and Planning Department, State Power Corporation, 2001.
17 PennWell (2000).
18 The private sector, thought to be high-risk and unsecure, has generally found it more difficult to apply for loans.