Long-Term Energy Demand and Supply Outlook for the 31 Provinces in China through 2030

-- Development of Province-Based Statistics and Energy Projection Using Econometric Model --

Komiyama, Ryoichi, Researcher, Energy Data and Modeling Center (EDMC), IEEJ
Zhang, Ping, Senior Researcher, Energy Data and Modeling Center (EDMC), IEEJ
Lü, Zheng, Researcher, Energy Data and Modeling Center; Doctor's course of New Area Creation Department of Scientific Research, The University of Tokyo Graduate School
Li, Zhi Dong, Visiting Researcher, IEEJ; Assistant professor of Nagaoka Science and Technology University
Kokichi Ito, Managing Director, IEEJ

Introduction

Since the late 1970s, China has implemented its “reform and opening-up” policy and achieved high annual economic growth of around 10%. Growth has remained stable. Real gross domestic product growth came to 9.3% in 2003, 10.1% in 2004 and 9.9% in 2005, remaining above 9% for three years on end. For 2006 as well, real GDP growth is forecast to top 9%. Factors leading the high economic growth in China include highly competitive processing trade and industrial production supporting such trade in the coastal regions. In 2004, exports, imports and added value for industrial production posted high growth. Fixed asset investment has recently shown remarkable growth. Supported by robust industrial production, investment in plants has been brisk. In addition, investment has been proactive in roads and other infrastructure in the run-up to the 2008 Beijing Olympics and the 2010 World Exposition in Shanghai. China is thus expected to sustain development over the medium to long term.

Such rapid economic growth in China has led to a rapid increase in energy demand. In 2004, the increase in China’s oil demand came to 800,000 barrels per day, having a great impact on the international oil market by helping boost crude oil prices. In 2006, the increase in the country’s oil demand is projected at 400,000 b/d (against a global increase of 1.8 million b/d), putting pressure on crude oil prices to rise further. China has thus been steadily enhancing its presence in the international oil market. Backed by substantial oil demand growth, China’s policies and energy challenges have shown dynamic change and had a growing influence on the international market. This means that Japan, which depends on imports from the international oil market for most

of its oil supply, must grasp China's energy challenges as accurately as possible and consider relevant responses.

Studies or analyses regarding China's energy challenges have generally focused on the whole of China. But regions in China vary in economic growth and energy demand/supply conditions. For example, the Central Coast region, which consists of Jiangsu Province, the Shanghai Municipality and Zhejiang Province, features the largest gross domestic product of any Chinese region, accounting for some 20% of China's total GDP. It also boasts the highest economic growth rate. Its per capita GDP is double the nationwide average. In contrast, the Southwest, which includes the Sichuan and Yunnan Provinces, and the Guangxi Zhuang and Tibet Autonomous Regions, is one of the least developed regions in China. Its per capita GDP and GDP growth are the lowest among the eight Chinese regions. The Southwest's annual per capita energy consumption is the lowest (equivalent to 0.44 tons of oil), equal to some 20% of the Northern Municipalities' level (1.8 tons) that is the highest in China. Given such a wide gap, region-by-region analyses including the oil, gas, coal, electricity and other energy markets are important for projecting China's energy demand/supply conditions. Such a region-by-region approach will be essential for considering China's measures to save energy and prevent global warming.

In this study, we have developed economic and energy demand/supply statistics for each of China's 31 administrative provinces, built an econometric model for predicting energy demand/supply for each of them and made predictions for the period through 2030. Through these steps, we quantitatively analyze energy demand/supply structure changes in China's coastal and inland areas.

1. Structure of Prediction Model

1.1 Administrative Provinces

In this study, we divide China into 31 administrative provinces, build an energy demand/supply model for each province and predict energy demand/supply for each province (excluding the Tibet Autonomous Region) for the period through 2030.

Predictions are given for the 31 provinces respectively. And a calculated result is put together for the eight regions as for which economic statistics are normally employed (Northeast, Northern Municipalities, Northern Coast, Central Coast, Southern Coast, Central Region, Northwest and Southwest), and inland (20 provinces) and coastal (11 provinces) areas.

Figure 1-1 China's 31 Administrative Provinces for Modeling

Table 1-1 China's 31 Administrative Provinces for Modeling

Region	Province, Municipality, Autonomous Region					
Northeast	Heilongjiang	Jilin	Liaoning			
Northern Municipalities	Beijing	Tianjin				
Northern Coast	Hebei	Shandong				
Central Coast	Jiangsu	Shanghai	Zhejiang			
Southern Coast	Fujian	Guangdong	Hainan			
Central Region	Shanxi	Henan	Anhui	Hubei	Hunan	Jiangxi
Northwest	Inner Mongolia	Shaanxi	Ningxia	Gansu	Qinghai	Xinjiang
Southwest	Sichuan	Chongqing	Yunnan	Guizhou	Guangxi	Tibet

*This study excludes Tibet.

Table 1-2 China's 31 Administrative Provinces for Modeling (Inland and Coastal Areas)

Area	Province, Municipality or Autonomous Region				
Coastal Area	Liaoning	Beijing	Tianjin	Hebei	Shandong
	Jiangsu	Shanghai	Jiangsu	Fujian	Guangdong
	Hainan				
Inland Area	Heilongjiang	Jilin	Shanxi	Henan	Anhui
	Hubei	Hunan	Jiangxi	Inner Mongolia	Shaanxi
	Ningxia	Gansu	Qinghai	Xinjiang	Sichuan
	Chongqing	Yunnan	Guizhou	Guangxi	Tibet

*This study excludes Tibet.

1-1-1 Outline – Coastal Areas

(a) Northern Municipalities

The Northern Municipalities of Beijing and Tianjin are directly controlled by the central government. Their population and size are small. But they have heavily populated urban zones so their population density is the highest among the eight regions. In 2004, the Northern Municipalities' gross domestic product totaled 721.5 billion yuan. Their per capita GDP was 29,000 yuan, the highest among the eight regions. Primary industries' share of industrial production in the municipalities is small. But tertiary industries' share exceeds 50%, standing at the highest level among the eight regions. Major industries include metallurgy, automobiles, electronics and communications, and chemicals. In Tianjin, spinning is prosperous. Key roads are concentrated in the Northern Municipalities, making them traffic hubs.

Urban construction and infrastructure development have been under way in the run-up to the 2008 Beijing Olympics. Since universities and other research institutes are concentrated in the region, an important goal is the development of biotechnology, information technology and other advanced industries. Water shortages have been a matter of concern but will be eased by such projects as the "Nan Shui Bei Diao" project to transfer water from the Yangtze River by changing the river basin. Beijing, Tianjin and their vicinity are integrated into a metropolitan economic zone. Along with the Zhu Jiang delta including Guangdong Province, and the Yangtze delta including Shanghai, the Beijing-led Pan-Bohai region (including Liaoning, Shandong and Hebei Provinces) is expected to see development.

(b) Northern Coast

Rich with mineral resources, the Northern Coast region is ranked second in iron ore deposits and third in oil reserves (with the Shengli oilfield) among the eight regions in China. It is also one of the regions with the largest secondary industry share and the

biggest industrial production value. Its key secondary industries include steel, chemicals and machinery.

In particular, Shandong Province has achieved fast development over the recent years. Agriculture and manufacturing industries have developed there. Manufacturing industries cover foods, consumer electronics, machinery and other products for domestic consumption. The province is in the midst of urban construction and expected to see rapid urbanization.

(c) Central Coast

The Central Coast region's population density is the second highest after that in the Northern Municipalities. The region has the largest GDP among the eight regions in China, accounting for about 20% of nationwide GDP. Its per capita GDP is double the national average. It is one of the regions where foreign direct investment has been concentrated. Foreign companies' exports exceed 60% of the region's total exports. The region's exports have been growing even faster than those in the Southern Coast region. It has been the center of China's light industries (including spinning and fibers). High tech industries (including electronics, drugs and aerospace) have also developed. The region has become a major production foothold for machinery and electronics. It also has a big steel production base including Baoshan Iron & Steel Co.

Among the eight regions, the Central Coast has scored one of the highest economic growth rates since the early 1990s. Foreign companies have recently been positive about investing in this region, helping boost imports and exports rapidly. The region features a strong industrial base ranging from heavy, light, machinery and shipbuilding industries to advanced sectors like electronics, information and biotechnology. Its function as a financial center is expected to be enhanced. But there is a fear that local property bubbles could burst. This region is also criticized for failing to take sufficient environment conservation measures. Water pollution and other environmental problems have grown more serious.

(d) Southern Coast

The Southern Coast has been a priority area for the reform and opening-up policy. Foreign investment there started earlier than in other regions. The region boasts the largest number of enterprises and the highest investment amount in China. Production value is high for electric home appliances, electronics, clothing, spinning, plastics and automobiles. The region features the highest exports and imports in China. Foreign firms account for more than 60% of the region's exports. The massive presence

of foreign companies means that the region will lack potential for autonomous or sustainable development. Energy consumption per unit GDP in the Southern Coast has been the lowest among the eight Chinese regions. Exports and imports as a percentage of GDP have been the largest in China. But the percentage has been falling. Some problems have emerged, including shortages in guest laborers and environmental pollution.

1-1-2 Outline – Inland Area

(a) Northeast

The Northeast is rich with mineral resources, accounting for 41% of China's total oil reserves and 30% of its total iron ore endowment. It is also a major coal-producing region. But coal output has been decreasing with depletion of resources. With Daqing and other giant oilfields, the Northeast is the largest oil-producing region in China. But crude oil output has been leveling off since the 1990s. There are many state-run corporations. Energy, metallurgy, machinery, chemical and other heavy industries are concentrated in the region. Economic growth in this region has been relatively low. A large number of people have become unemployed due to restructuring of state-run corporations. Energy consumption per unit of GDP in this region has been the highest among the eight regions in China.

Energy, metallurgy, chemical and other heavy industries will likely remain the region's mainstay. State-run corporations will retain their large presence. The central government's northeast development policy is expected to lead the region's machinery industry to develop further. Some attempts have recently been seen in the region to sell off state-run corporations to foreign companies.

(b) Central Region

The Central Region has the largest population among the eight regions. Its population at 370 million accounts for 28% of China's total. Per capita GDP is below the national average. Primary industries account for a large share of GDP. Economic growth has been relatively low.

The region is rich with mineral resources. Including Shanxi Province in the north, it is China's largest coal-producing region, supplying massive amounts of coal to other regions. The region also excels in nonferrous metal reserves. The southern part is rich with hydraulic power resources. The region features greater hydropower generation than other regions. With large and medium sized power stations including the Three Gorges Dam, the world's largest, it has been increasing electricity supply to

the coastal area. The Central Region is also a major farming zone. With less competitive manufacturing industries, however, it is expected to lag behind other regions in economic development.

(c) Southwest

The Southwest is one of the least developed regions in China. It has the lowest per capita GDP and GDP growth among the eight regions. Agriculture accounts for a large share of GDP. Secondary industries' share of GDP in the region is the lowest.

The region is relatively rich with coal, natural gas and iron ore resources. It accounts for 20% of China's natural gas endowment and boasts of the largest natural gas production volume. The region is also rich with nonferrous metal resources (including zinc, tin and manganese), accounting for more than half of China's total resources for these resources.

New railway construction will enhance the region's link with the Southern Coast. The Three Gorges dam construction will make transportation through the Yantze River more convenient, helping increase domestic shipping. The region is also expected to deepen economic relations with Southeast Asia. Supported by tourism as well as these developments, some cities in this region will develop. But it will be difficult to boost the whole of the regional economy.

(d) Northwest

While accounting for more than 40% of China's land area, the Northwest has the least population among the eight regions. Per-capita GDP is the lowest, and far below the national average. Primary industries' share of GDP is high. Energy consumption per unit of GDP is the highest among the eight regions.

Rich with mineral resources, the Northwest accounts for 40% of total coal reserves in China, 30% of total oil reserves and 70% of natural gas deposits. It ranks second in production of coal, crude oil and natural gas. The region also relays crude oil and gas imports from Central Asia. The Xinjiang Uyghur Autonomous Region is becoming one of China's most important oil-producing regions. It is also one of the regions boasting the largest rare metal and rare earth resources like those of nickel and cobalt. Backed by the rich oil and natural gas reserves, some parts of the region have developed an energy industry.

The Xinjiang Uyghur Autonomous Region is expected to develop on growing trade with Central Asia. Xian and its vicinity, with a relatively high degree of industrial concentration, are also expected to achieve further development along with some cities

in Inner Mongolia. Any autonomous development will be difficult in other parts of the Northwest.

1-2 Development of Statistics

For this study, we have developed a time series of economic indicators, industrial activity indexes and energy balance sheets for each administrative province for the period between 1986 and 2002, using such publications as the China Energy Statistics Yearbook, the China Statistics Yearbook and the China Transportation Yearbook. These times series form the base for the econometric energy demand/supply model. The energy balance sheet is a format to grasp energy flow between final consumption, conversion and primary energy consumption sectors for each energy source. It is the basis for the econometric energy demand/supply model as described later.

1-2-1 Comparison between China's Province-Based and International Energy Statistics

China now has 31 provinces, municipalities and autonomous regions. All of them excluding the Tibet Autonomous Region have energy statistics including energy balance sheets.

As for China as a big country, we believe that it would be effective to analyze and predict energy demand/supply at the provincial, municipal or autonomous regional level. This is the reason we have developed the province-by-province energy statistics.

As is well known, the credibility of the Chinese government's official national-level statistics is frequently questioned. Therefore, we must ascertain the credibility of regional statistics. We have compared the aggregation of regional statistics with national data and statistics given by international organizations[1] and found that differences existing between them were not so great.

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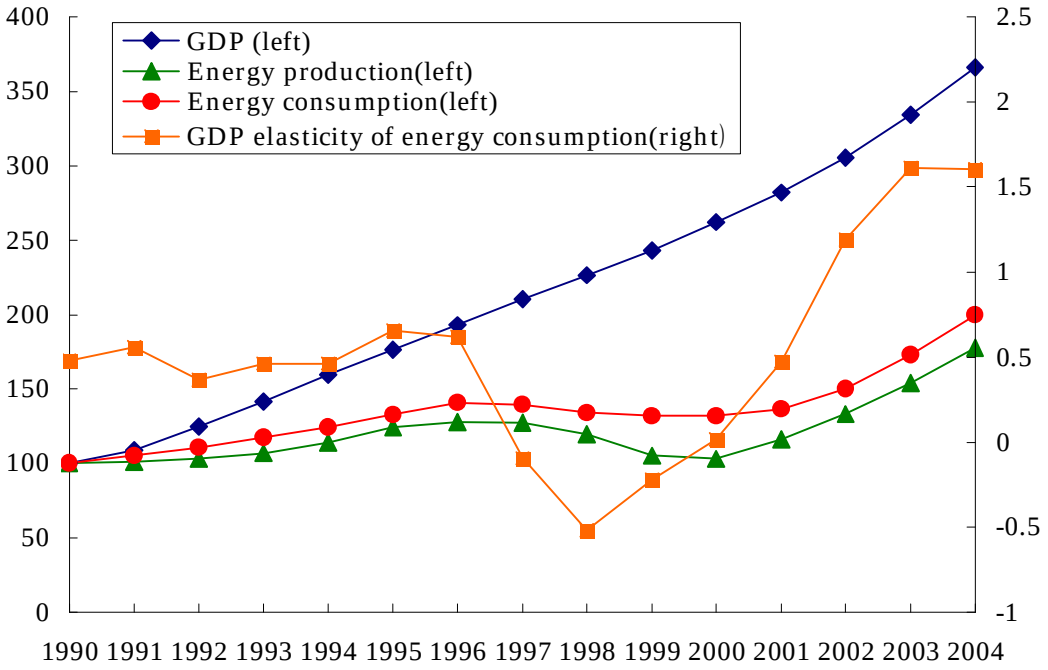
[1] China's province-by-province energy statistics as developed for this study are compared with the APEC Energy Database and the IEA's statistics (Energy Balances of OECD countries, Energy Balances of Non-OECD countries). The IEEJ serves as the secretariat for the APEC Expert Group on Energy Data and Analysis (EGEDA), collecting and developing APEC energy statistics. The APEC Energy Database includes Chinese energy balance sheets based on data that have been provided by the Energy Division, Department for Industrial and Communication Statistics, National Bureau of Statistics. These energy balance sheets, excluding some conversion factors, are basically the same as China's official data and may have the same problems as those with energy statistics of China's National Bureau of Statistics. The IEA has also received data from the Energy Division, Department for Industrial and Communication Statistics, National Bureau of Statistics, and used them for developing energy balance sheets. China has yet to join the OECD and is not required to submit data to the IEA. But China and the IEA have maintained cooperative relations. The IEA might have made some modifications to Chinese data in a bid to solve problems accompanying these data.

1-2-2 Primary Energy Demand/Supply

Figure 1-2 indicates GDP and energy production and consumption indexes based on data from China's National Bureau of Statistics. Between 1996 and 2000, based on the data from the National Bureau of Statistics, China's energy consumption posted an average annual fall of 1.6% with the GDP elasticity of energy consumption remaining negative, while GDP saw an annual average growth rate of 7.9%. There is a contradiction that an energy consumption decline coincided with economic growth.

As shown in Figure 1-2, China's real GDP has grown persistently since 1990. But energy production and consumption decreased from 1996 to 1999. The GDP elasticity of energy consumption remained around 0.5 until 1996 and turned negative before rising to 1.6 in 2003.

Figure 1-2 China's GDP, Energy Production and Consumption (1990=100)



Source: China Statistics Yearbook 2005

Figures 1-2a and 1-2b show a comparative analysis of the aggregate Chinese energy data developed for this study, the APEC Energy Database and the IEA statistics (Energy Balances of OECD countries, Energy Balances of Non-OECD countries). In Figure 1-2a, the three lines representing the respective data sources indicate similar trends for primary energy supply. But the IEA line indicates primary energy supply leveling off between 1996 and 2000, deviating somewhat from the APEC Energy

Database line based on data from the National Bureau of Statistics. This apparently means that the IEA has made some modifications to the same Chinese data. The data submitted to APEC by the National Bureau of Statistics do not cover renewable energy. The province-by-province data edited for this study include renewable energy data based on statistics published by China's Ministry of Agriculture since 1991. The data including the supplementary renewable energy data are close to the IEA statistics covering renewable energy (see Figure 1-2b).

Figure 1-2a Comparison of Primary Energy Supply Data (10^4 ktoe)

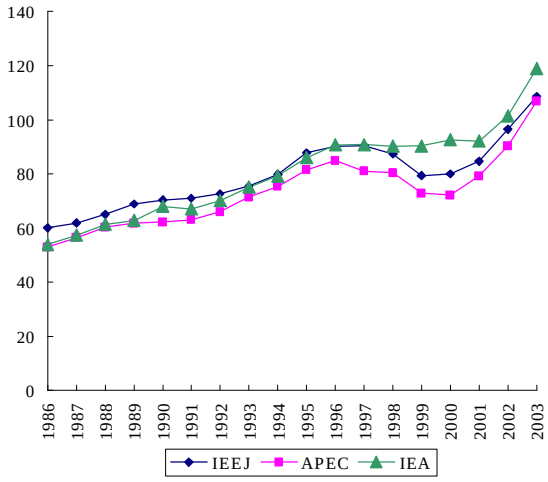
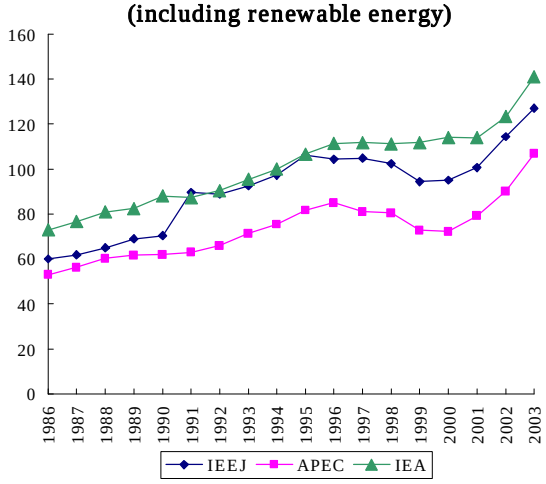
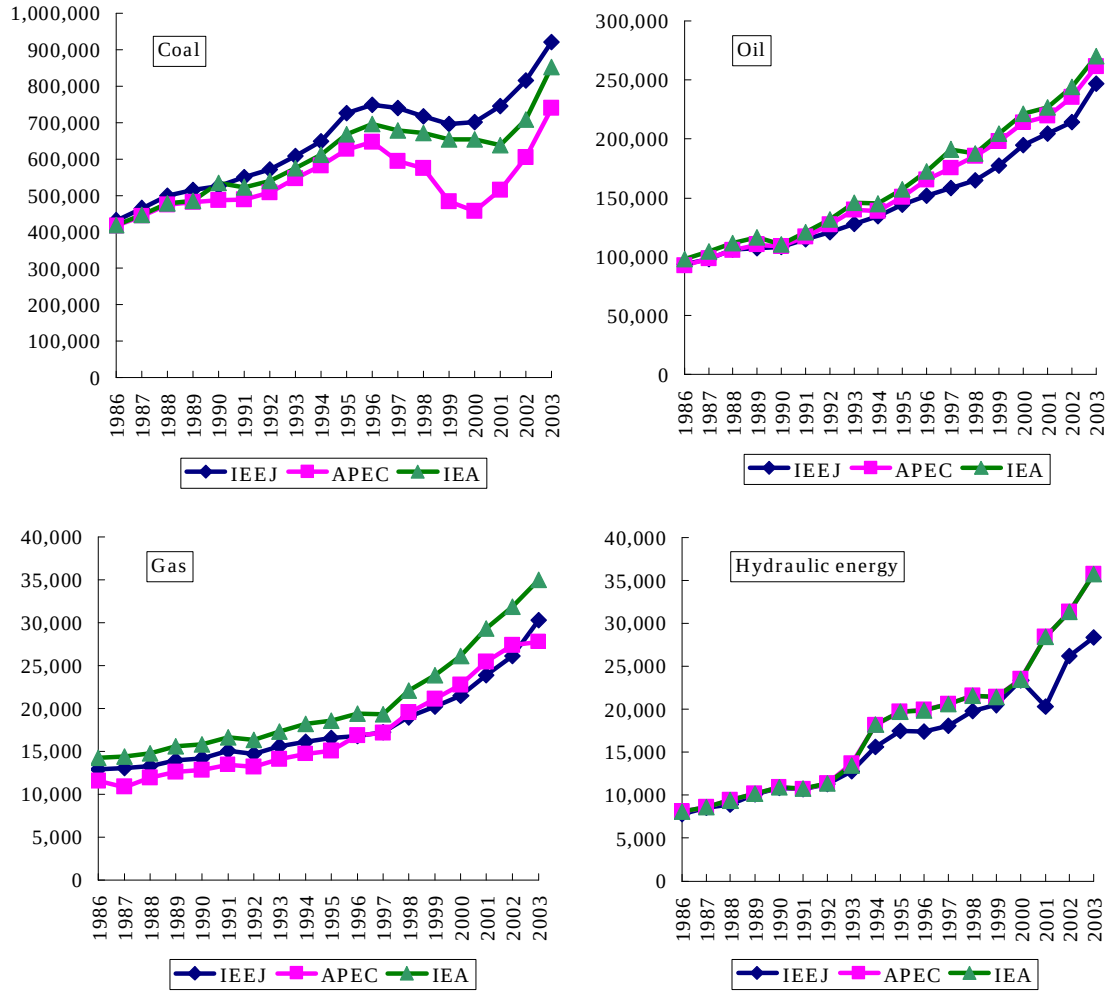


Figure 1-2b Comparison of Primary Energy Supply Data (10^4 ktoe) (including renewable energy)



Sources:
IEEJ: A total of province-by-province energy consumption data developed for this study based on the China Energy Statistics Yearbook
APEC: APEC Energy Database
IEA: Energy Balances of OECD countries, Energy Balances of Non-OECD countries
(The same sources are used for the following figures.)

Figure 1-3 Comparison of Primary Energy Supply Data by Energy Sources (ktoe)



Sources: Same as for Figure 1-2a

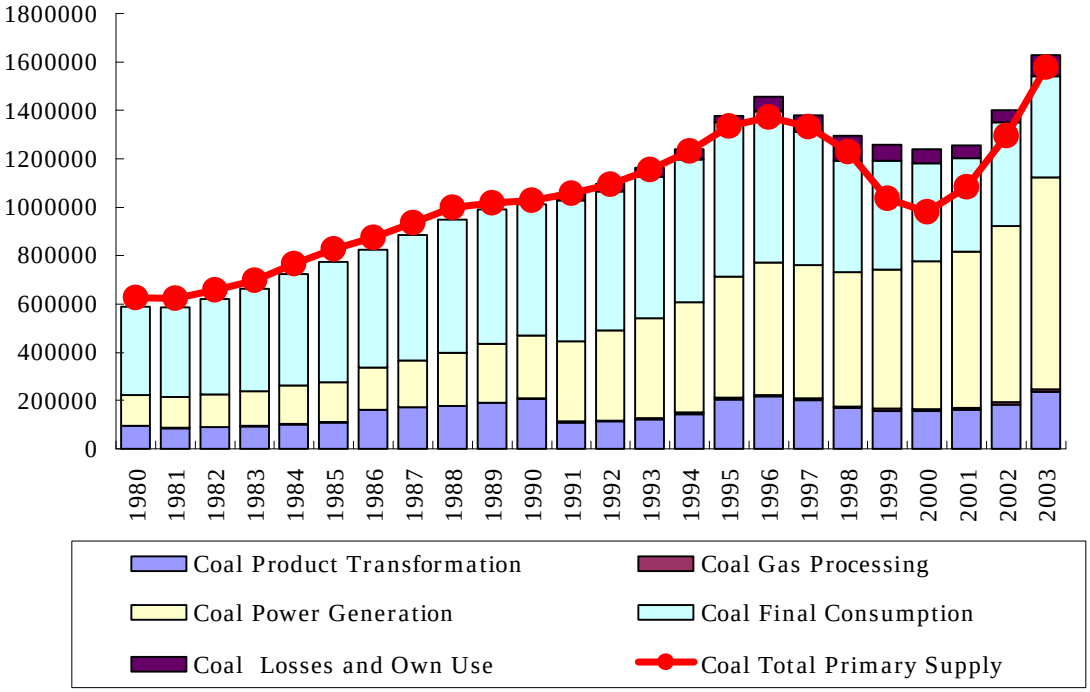
The figures by energy source make for three lines indicating similar trends for oil, gas and hydropower, irrespective of small absolute gaps. For coal, however, absolute gaps are far wider (see Figure 1-3). This appears to mean that the IEA statistics, though based on data from China's National Bureau of Statistics, have been modified regarding coal. For this study, we have also made modifications to the totals for province-by-province data in the way described later. The modified totals and the IEA data indicate a similar trend. Due to conversion factors, our primary energy supply estimates for this study are higher than the other data for coal and lower for oil.

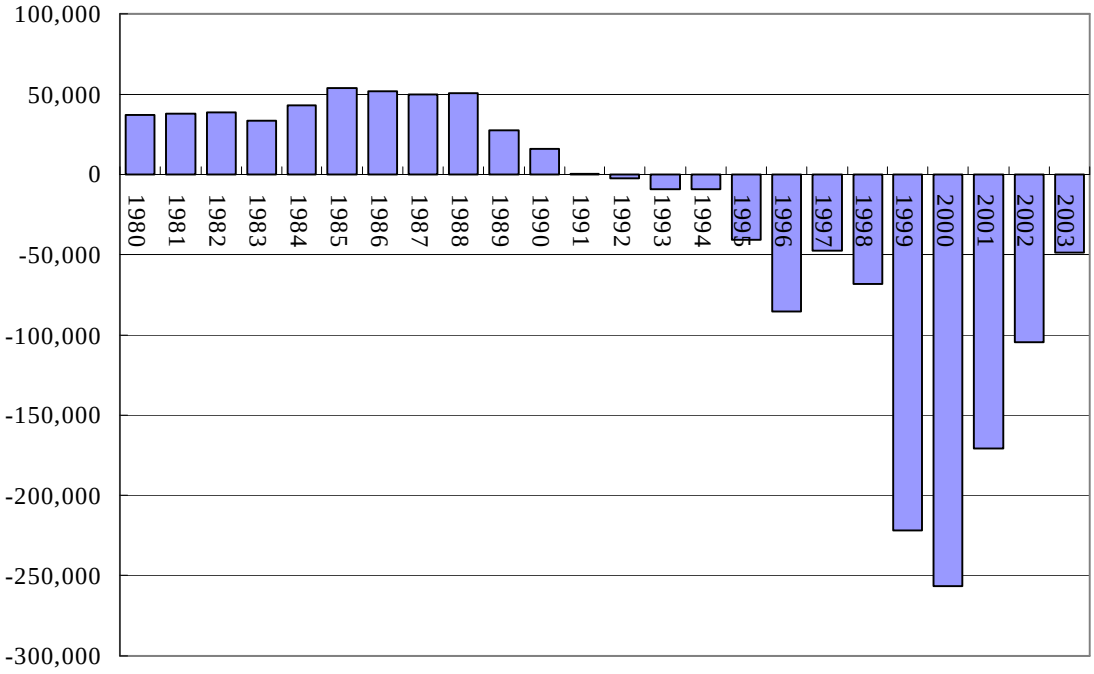
1-2-3 Domestic Production

An energy supply decline seen in the late 1990s (see Figures 1-2a and 1-2b) is attributable primarily to a coal production reduction. In the second quarter of 1996, China saw its first ever overproduction of coal. But financially squeezed state-run coal mines expanded coal production even further to avoid an income fall and maintain market share, leading to a price-cutting race. This resulted in a vicious circle of lower coal prices, swelling inventories and delays in buyers' payments. Coal mines' financial situation deteriorated further.

The government then forced coal mine shutdowns and production cuts in a bid to curb overproduction and inventories and improve production efficiency in the coal industry. As a result, more than four coal mines were shut down in China between 1997 and 2000, resulting in a decline of 400 million tons in annual coal production on a statistical basis. As indicated by Figure 1-4, however, coal demand did not decrease so much between 1997 and 2000. The fast decline in production widened the demand-supply gap for coal. Since 2001, however, this gap has been narrowing.

Figure 1-4 China's Coal Demand/Supply (upper) and Statistical Gap between Primary Energy Supply and Coal Demand (lower) (ktoe)





Source: APEC Energy Database

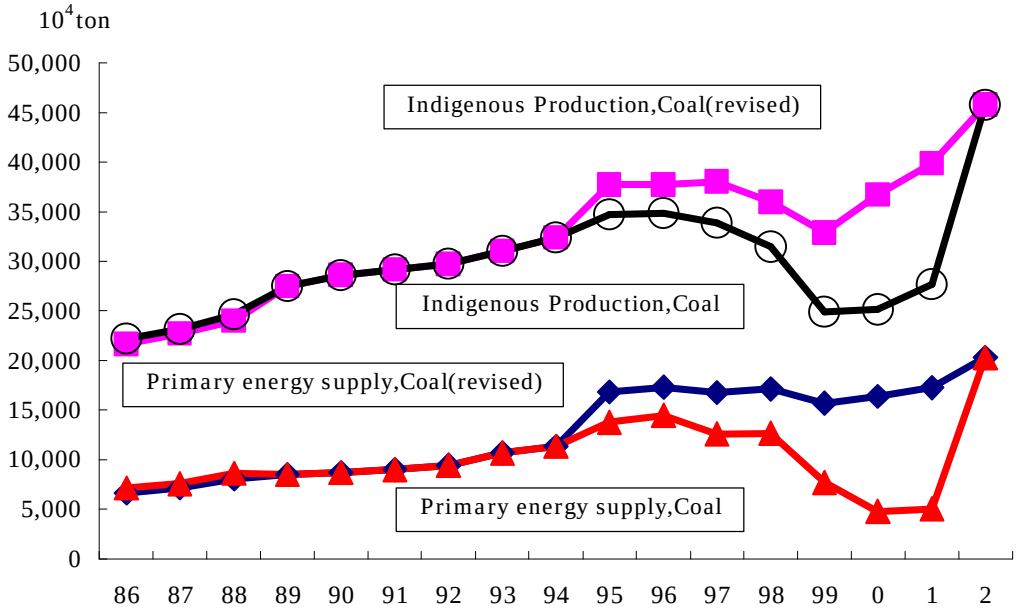
The government-forced coal mine shutdowns to cut production had a real impact. But the production reduction may have been smaller than indicated by the statistics. One reason for such a view is a media report that local governments led workers at small mines subjected to shutdowns to give only the impression of carrying out shutdown procedures when inspectors from the central government came but resume production immediately after their departure.

The problem is mirrored by the statistics for Shanxi Province, China's largest coal production base. There had been a limited gap between coal demand and supply from 1986 to 1994. But the gap came to 30 million tons in both 1995 and 1996, 40 million tons in 1997, 32 million tons in 1998, 80 million tons in 1999, 116 million tons in 2000 and 122 million tons in 2001. One possible reason for such a gap is that small mines continued producing coal and refrained from reporting output. Or, the government of the province subject to tough coal production curbs manipulated data to nominally lower output in accordance with a coal output reduction target set by the central government.

We have taken the above into account and added the demand-supply gap to coal output between 1995 and 2001. The results are shown in Figure 1-5. Since Shanxi

Province is a net coal exporter, regional supply is reasonably less than output. Regional supply increased rapidly in and after 1995 due to a sharp rise in the supply of coal processed into coal products. Production declined on a fall in supply to other regions amid a weak coal market. But regional coal supply has been stable.

Figure 1-5 Coal Production and Supply in Shanxi Province



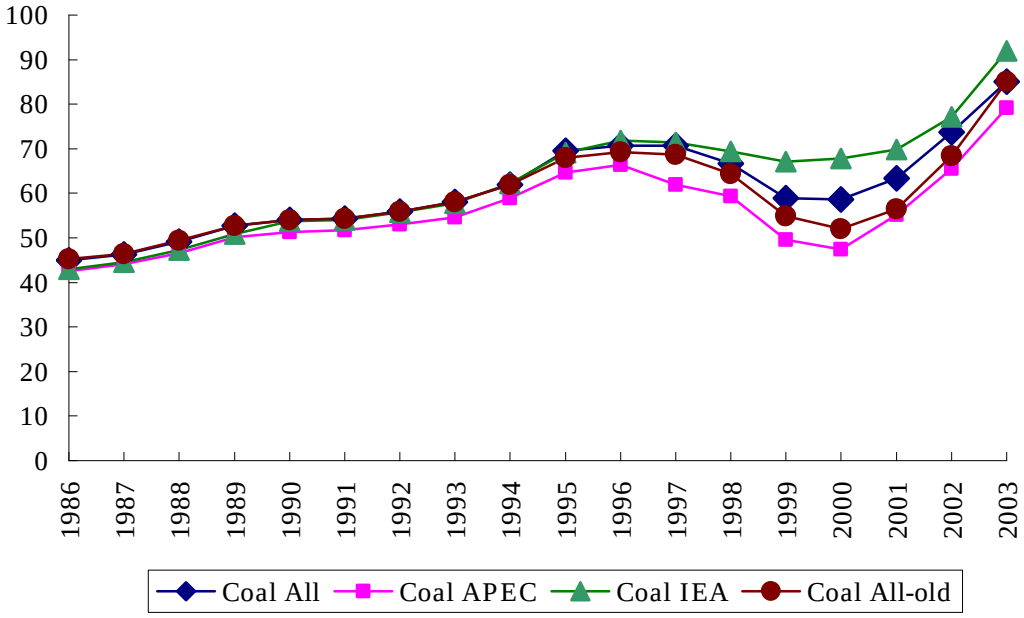
Sources: China Energy Statistics Yearbook, EDMC estimates

Statistical modifications for Shanxi Province allowed the total of province-by-province data to become closer to the IEA statistics[2]. In Figure 1-6, the "Coal All-Old" represents total province-by-province figures before modifications. The line for modified data comes between the IEA and APEC data lines, indicating that the modified data are closer to reality.

[2] Coal demand-supply gaps to the Shanxi Province gap were seen in Henan, Heilongjiang, Jiangxi, Hunan and Guizhou Provinces. But we made no modifications to their data since the gaps were not wide enough to have any large influence on the total.

Figure 1-6 China's Coal Production

Unit: 10,000 kilotons



Sources:
Coal All: Total of province-by-province energy consumption data developed for this study based on China Energy Statistics Yearbook
Coal APEC: APEC Energy Database
Coal IEA: Energy Balances of OECD countries, Energy Balances of Non-OECD countries
Coal All-old: Total province-by-province energy consumption based on the China Energy Statistics Yearbook

1-2-4 Final Energy Consumption

Energy data from China's National Bureau of Statistics include no industry-by-industry breakdown, making it impossible to specify captive consumption. The province-by-province data we have developed for this study are based on these data and include part of the captive consumption in final consumption, so final energy consumption estimated for this study is greater than that indicated by other data.

Figure 1-7a indicates final energy consumption excluding renewable energy. Figure 1-7b shows final energy consumption including renewable energy. In the IEA statistics, renewable energy has been taken into account since 1994. Data developed for this study include renewable energy consumption for the years after 1991.

Figure 1-8 shows final energy consumption broken down by energy source. It indicates that the total of province-by-province data is close to the IEA data for all energy sources other than coal.

The gap seen for coal is attributable to a difference regarding industrial coal consumption (see Figure 1-9). APEC and IEA data indicate that industrial coal

consumption declined rapidly after 1996, while the total of province-by-province data developed for this study shows a leveling-off trend for industrial coal consumption. The IEA and APEC data may be interpreted as hinting that coal was replaced by other energy sources for consumption due to environmental measures. But we believe that the reliability of the rapid falling trend for coal consumption around 1996 should be reconsidered. The province-by-province data developed for this study may be closer to reality.

Figure 1-7a Comparison of Chinese Final Energy Consumption Data

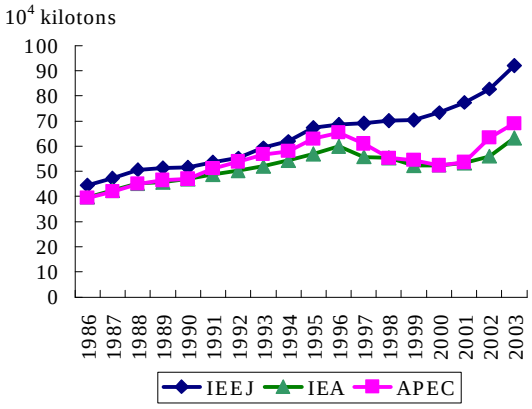
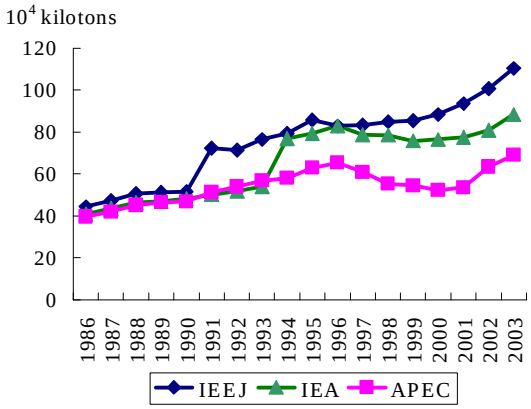
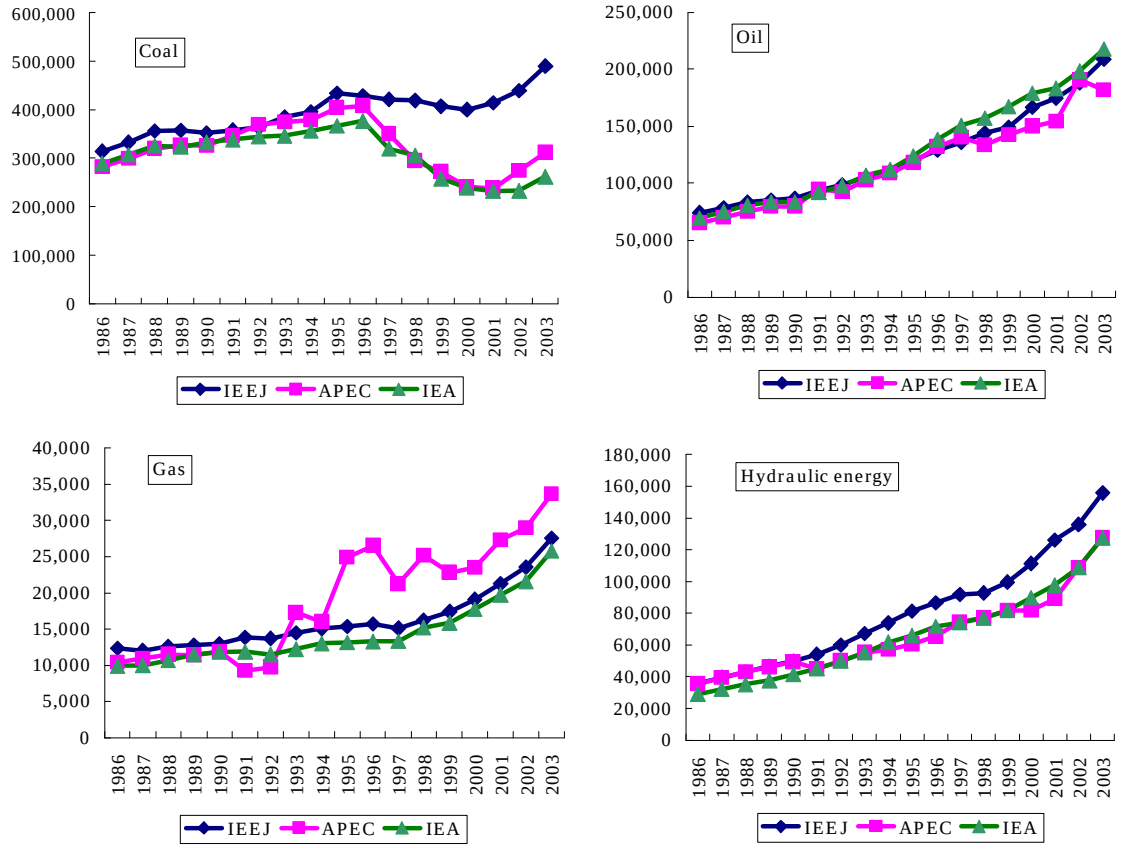


Figure 1-7b Comparison of Chinese Final Energy Consumption Data (including renewable energy)



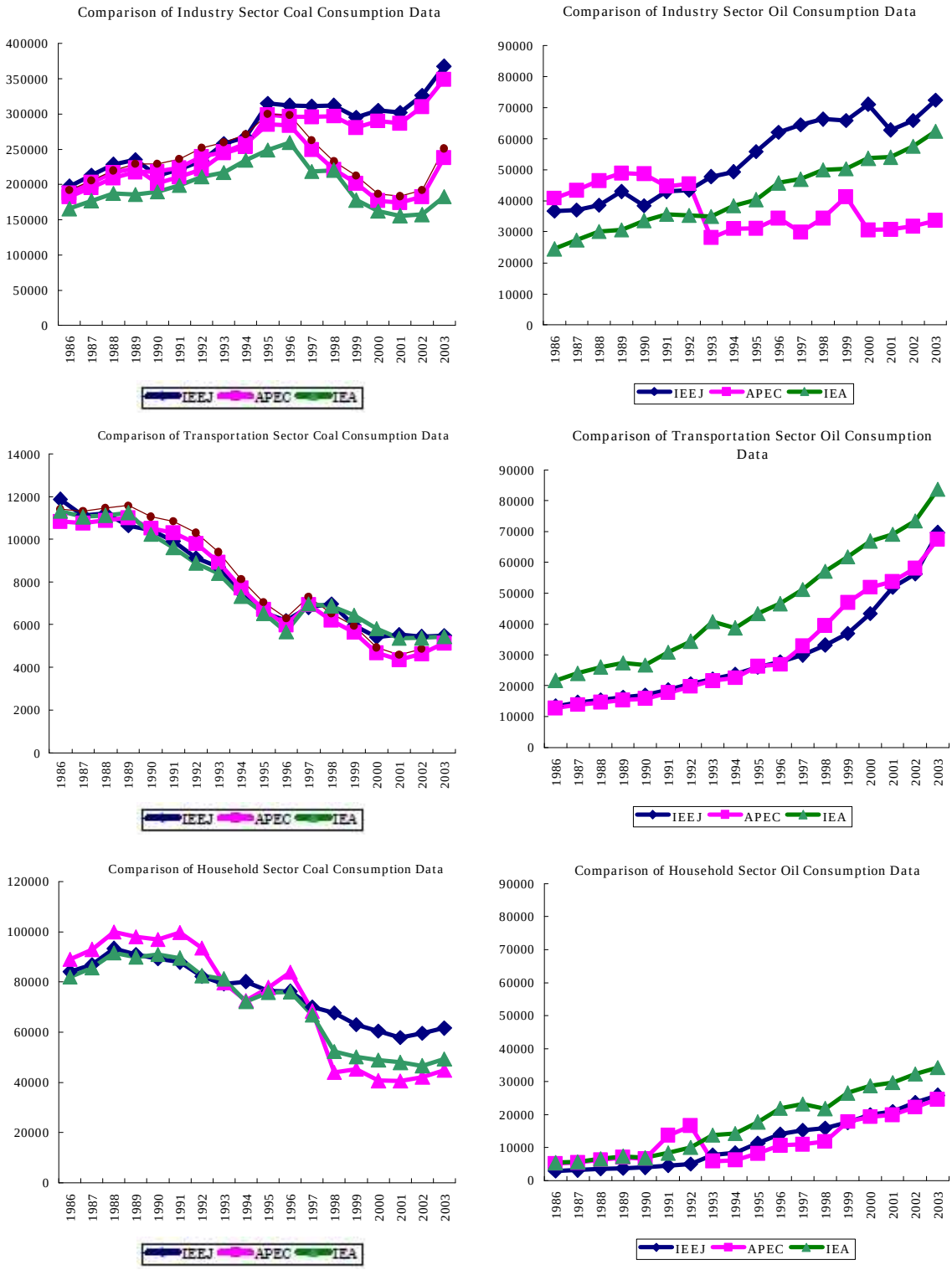
Sources: Same as for Figure 1-2a

Figure 1-8 Comparison of Chinese Final Energy Consumption Data by Energy Source (ktoe)



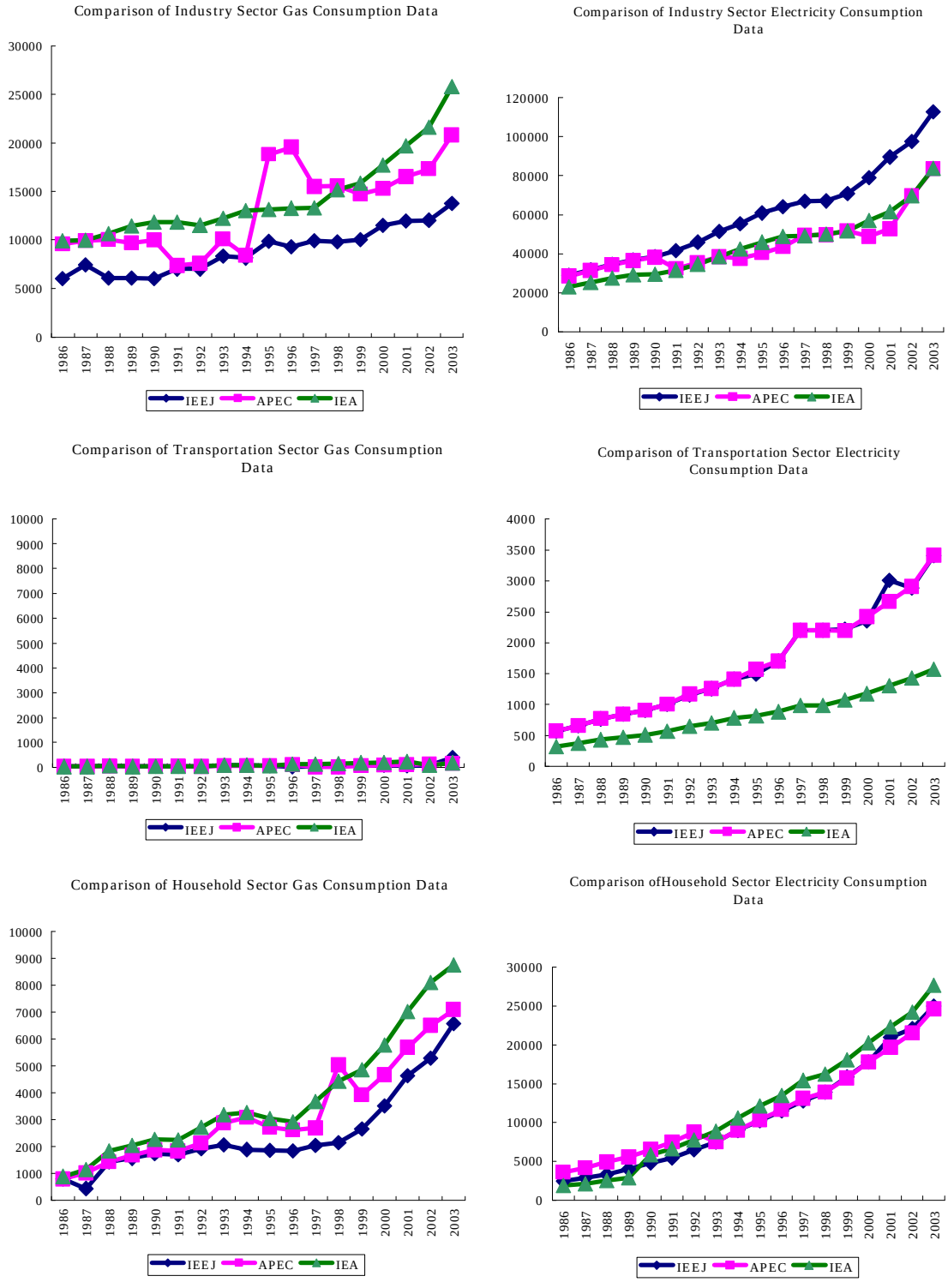
Sources: Same as for Figure 1-2a

Figure 1-9 Comparison of Coal and Oil Consumption Data by Sector (ktoe)



Sources: Same as for Figure 1-2a

Figure 1-10 Comparison of Gas and Electricity Consumption Data by Sector (ktoe)



Sources: Same as for Figure 1-2a

As for oil consumption, the total of province-by-province data developed for this study is close to the IEA data. In the APEC data, some definitions may have been changed since 1993. While transportation sector energy consumption data should cover all transportation, as the IEA data do, China's transportation sector energy consumption data cover only transportation companies (including railway and taxi firms). The IEA's energy data may include modifications and estimates regarding transportation systems for China. The province-by-province data developed for this study and the APEC energy database include no such modifications. Due to such differences, our transportation sector oil consumption figures are lower than the corresponding IEA data and our industry sector oil consumption figures are higher. Why household sector oil consumption in the IEA figures are higher than in other data remains unknown.

Regarding gas consumption, the IEA data give the largest figures but are close to the total of province-by-province data developed by this study. The three sets of data show similar trends for household sector electricity consumption. For the transportation sector, however, IEA consumption figures are lower than other figures. APEC data indicate that some definitions have been changed since 1993.

1-2-5 Conclusion

After comparing province-by-province energy data we have developed for this study with APEC and IEA energy data, we believe that our data for this study have some problems but can be viewed to be as reliable as data released by international organizations. As earlier noted, the Chinese government's official data for the whole of China have various contradictions. The National Bureau of Statistics may be well aware of such contradictions. But official government data cannot be changed easily. The next nationwide census should give a good opportunity for the government to correct problem-plagued energy statistics. Chinese statisticians are likely to realize this point. Recently, China's energy statistics have been expected to become more accurate once new statistics are published this autumn following the completion of the nationwide census.

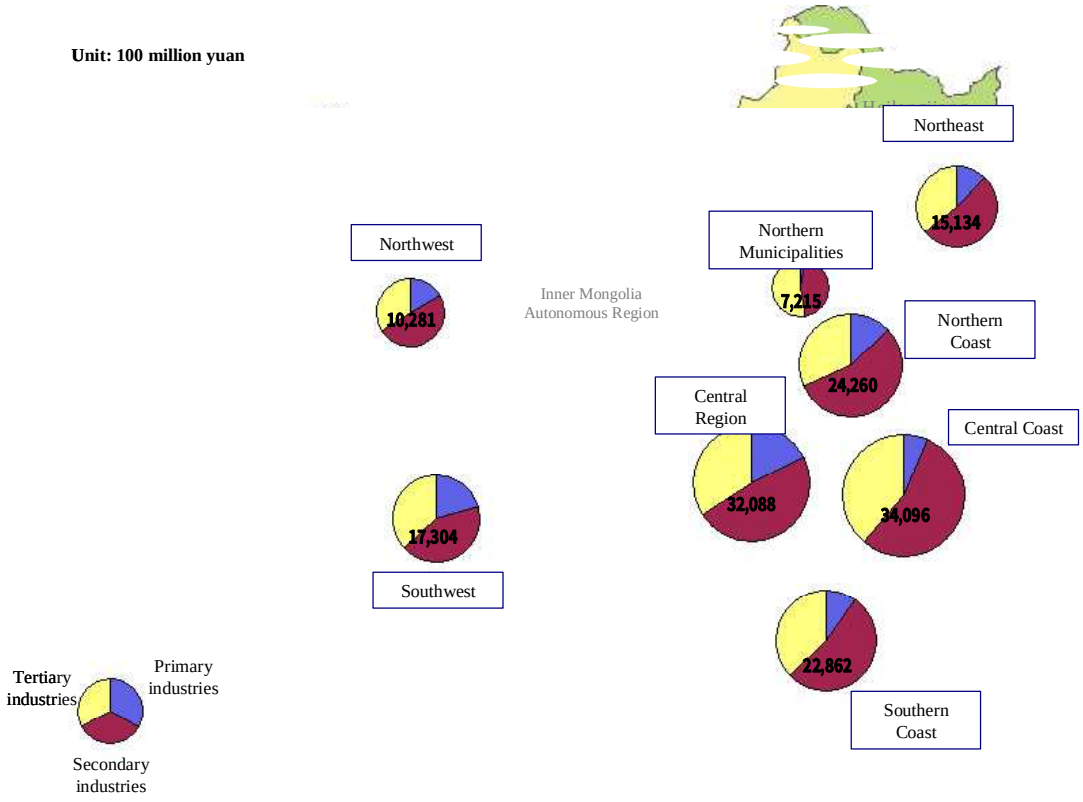
1-3 Province-by-Province Energy and Economic Conditions in China

We here would like to grasp the present conditions of factors affecting future Chinese energy demand/supply on a regional basis.

1-3-1 GDP

Coastal regions, which have been the base for China's economic development, account for some 60% of the nation's total GDP. Secondary industries account for a large share of coastal region GDP, while primary industries (including agriculture) accounts for a large portion of inland region GDP. The five largest provinces in terms of GDP in fiscal 2004 were Guangdong with 1,604 billion yuan in GDP, Shandong with 1,549.1 billion yuan, Jiangsu with 1,540.3 billion yuan, Zhejiang with 1,124.3 billion yuan and Henan with 881.5 billion yuan. Most of them are coastal provinces.

Figure 1-11 Regional GDP in China (2004)

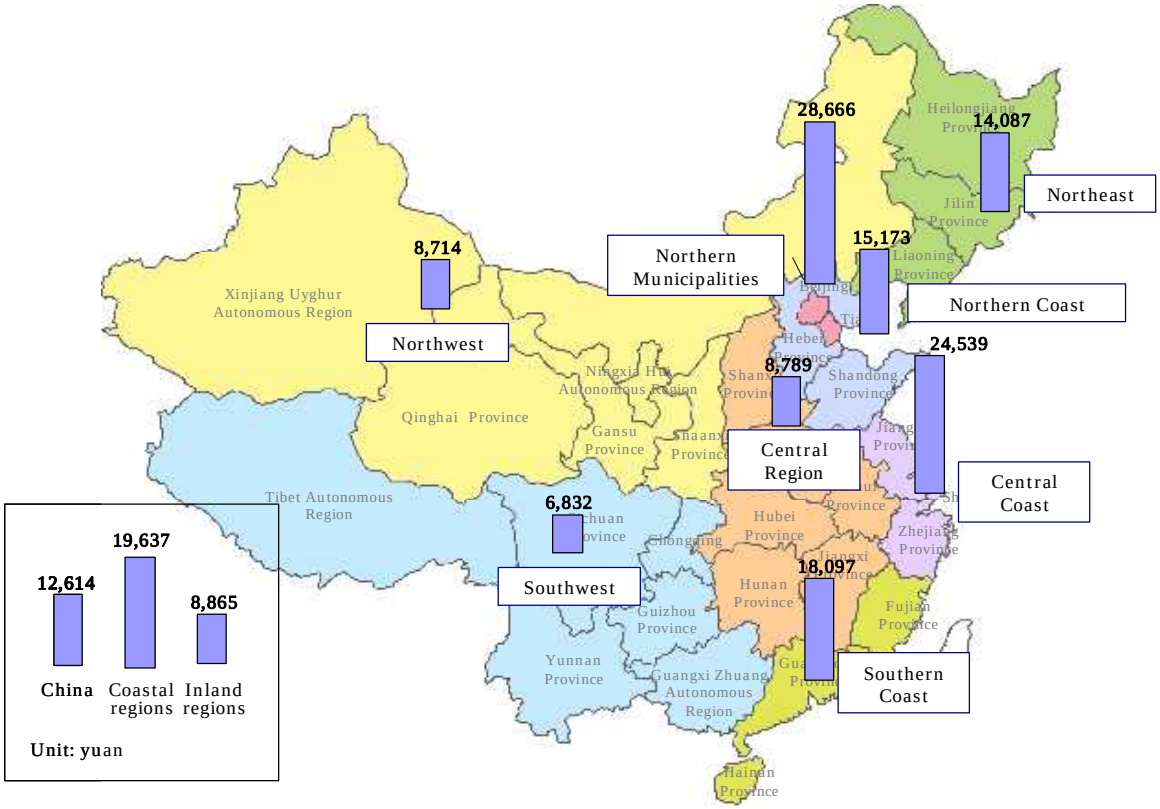


Source: China Statistics Yearbook

1-3-2 Per Capita GDP

Regional per capita GDP in China is seen as a key factor for estimating regional energy consumption. In 2004, income in coastal regions was 2.2 times more than in inland regions. Per capita GDP in the Northern Municipalities was 4.2 times more than in the Southwest.

Figure 1-12 Regional Per Capita GDP in China (2004)

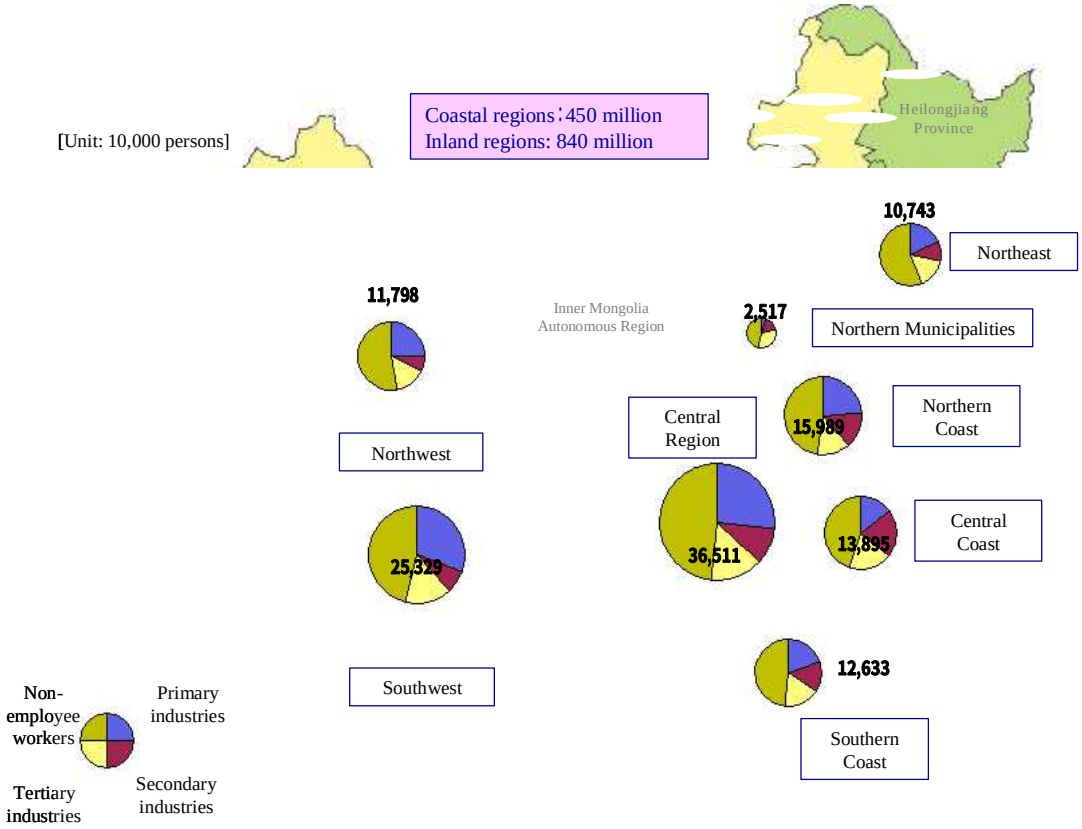


Source: China Statistics Yearbook

1-3-3 Population

China boasts the world's largest population. Among the Chinese provinces, Henan was ranked top in population with 96.67 million people in 2004, followed by Shandong with 91.25 million people, Sichuan with 87 million people, Guangdong with 79.54 million people and Jiangsu with 74.06 million people. Among the eight regions, the central region had the largest population at 370 million people. Population totaled 450 million in coastal regions against 840 million in inland regions. Regarding employment, primary industry workers (farmers) account for a greater share of the working population in inland regions.

Figure 1-13 Regional Population and Employment in China (2004)

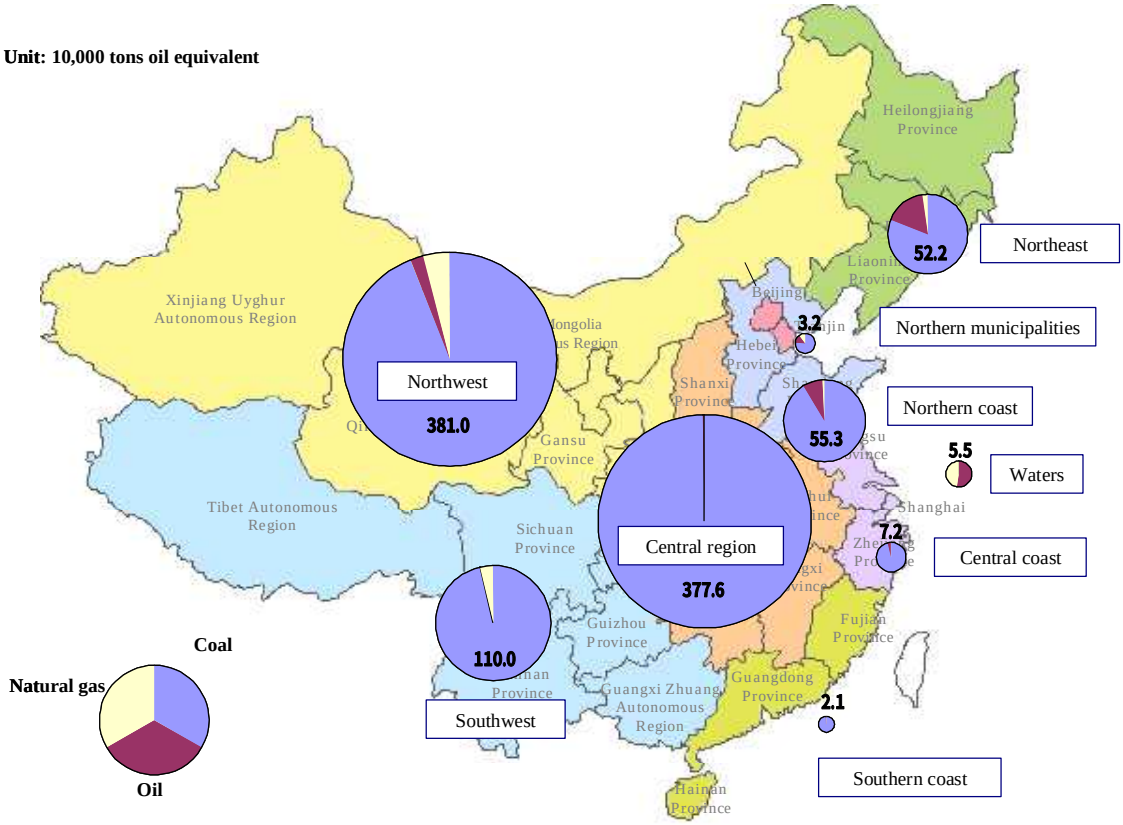


Source: China Statistics Yearbook

1-3-4 Distribution of Fossil Fuel Resources

China is one of the largest coal-producing countries in the world. The Central Region and Northwest each boast the largest coal reserves in China, followed by the Southwest. Coal endowment are thus concentrated in the inland regions. Oil and gas reserves are limited compared to coal deposits. Oil reserves are abundant in the Northeast, while gas reserves are concentrated in the Northwest and Southwest.

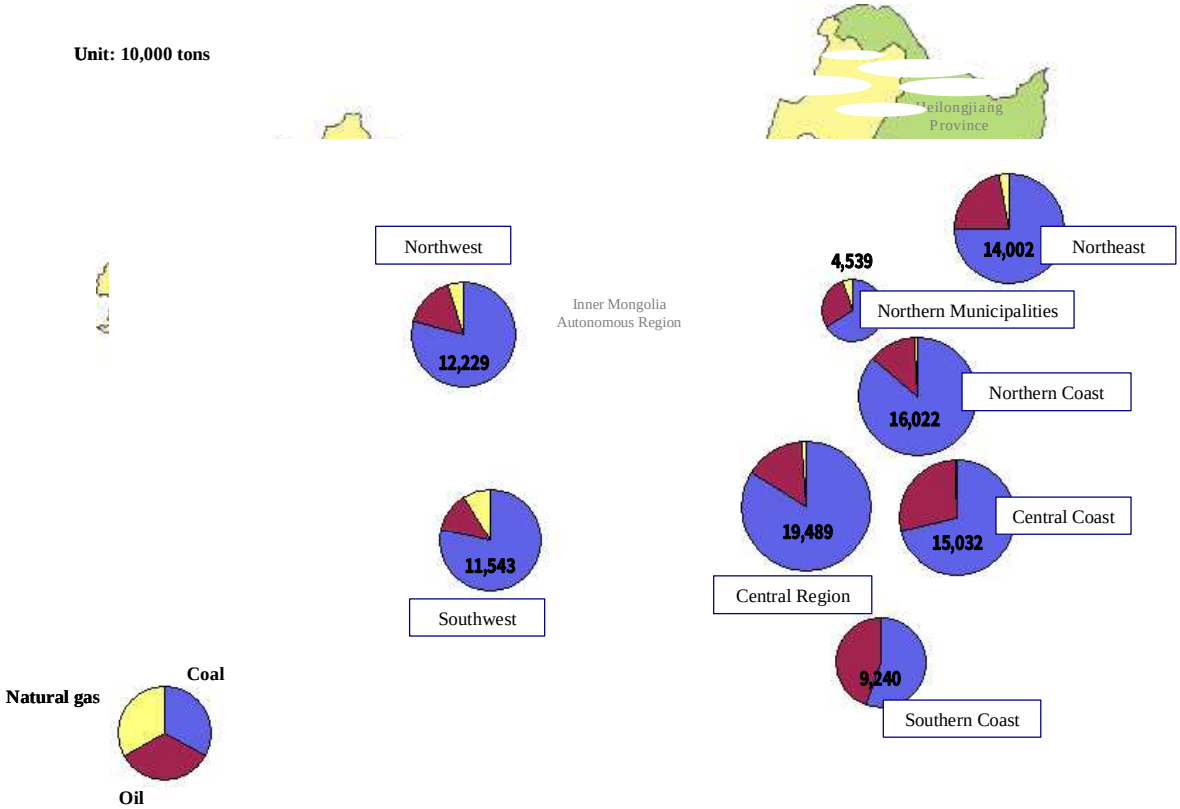
Figure 1-14 Distribution of Fossil Fuel Resources in China



1-3-5 Fossil Fuel Energy Consumption

Coal consumption has been dominant in all of the regions in China. But oil's share of energy consumption has been expanding due to the motorization trend accompanying economic growth in the coastal regions including the Southern Coast, Central Coast and Northern Municipalities.

Figure 1-15 Distribution of Fossil Energy Consumption in China

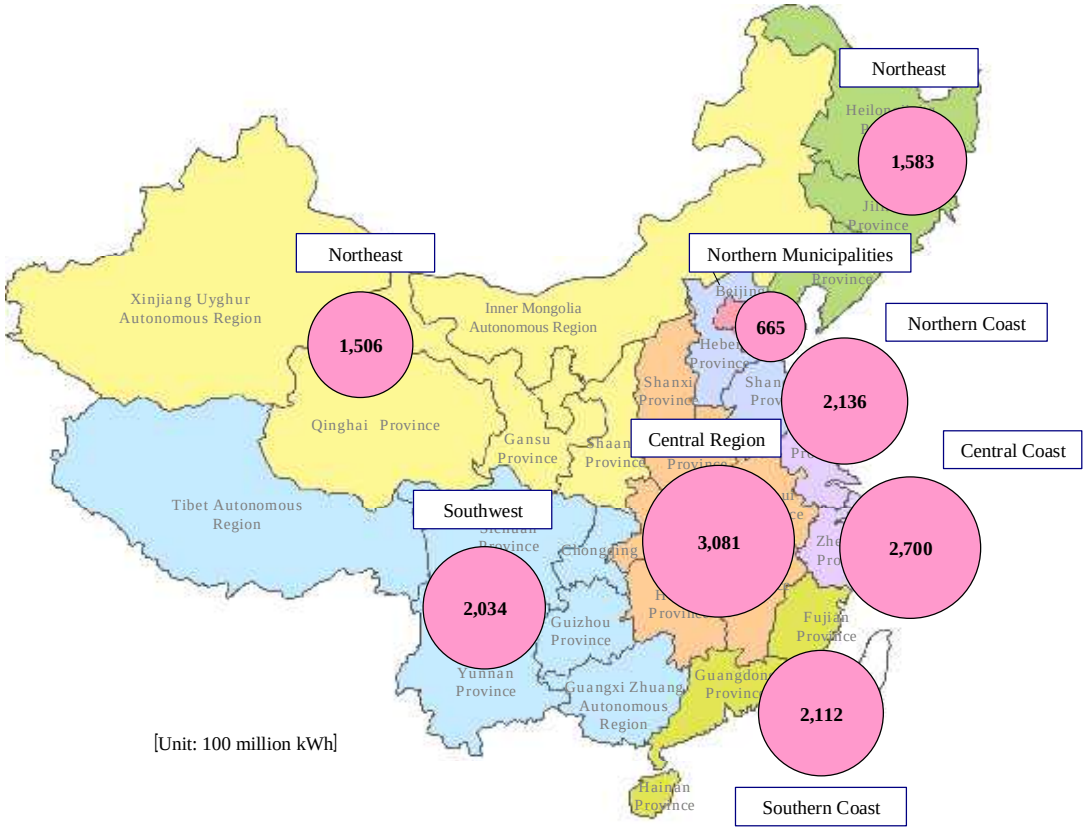


Source:

1-3-6 Electricity Consumption

The Central Region and Central Coast have been leading electricity consumption growth in China. Each of the two regions has the same electricity demand as the Japanese service area for Tokyo Electric Power Co.

Figure 1-16 Regional Electricity Consumption in China (2002)

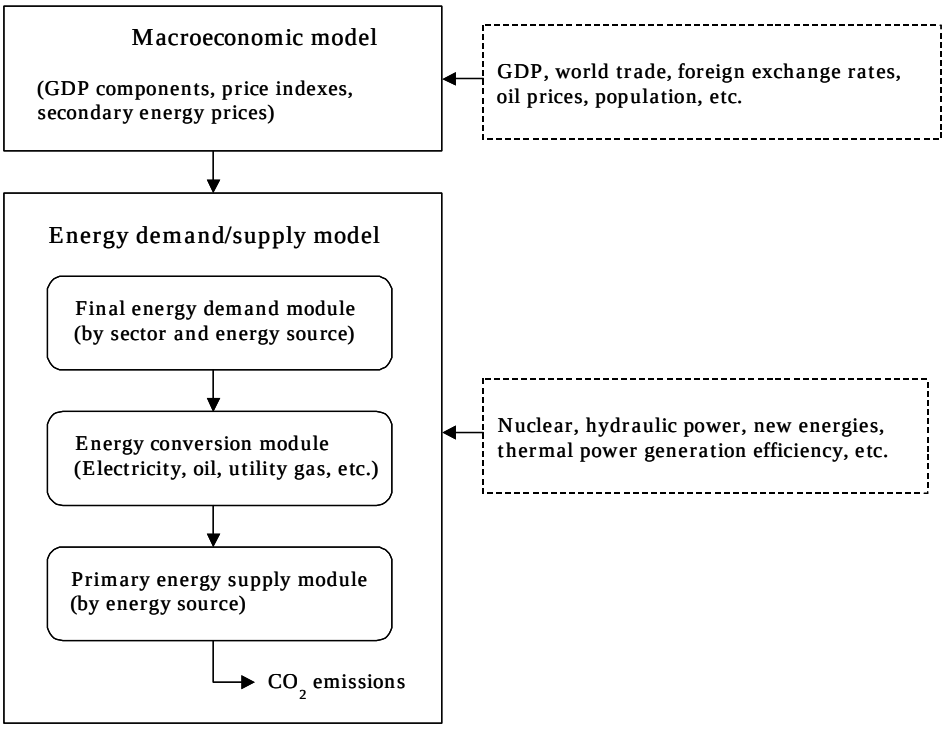


2. Framework of Projection

2-1 Econometric Energy Demand/Supply Model

In this study, we build an econometric energy demand/supply model for each of the 31 provinces in China to predict energy demand/supply for each region.

Figure 2-1 Basic Structure of Macroeconomic and Energy Demand/Supply Model



Energy consumption is econometrically estimated, based on 1986-2002 data prepared through statistical development. The period is shortened in cases of data shortages and serious structural problems. Energy consumption simulation is done for each year between 2003 and 2030.

2-2 Preconditions for Predictions

Preconditions for the model include economic growth, population, energy prices, nuclear power and hydropower. Among them, economic growth is one of the key factors affecting energy consumption.

China has seen sustained, rapid economic growth over the recent years. But regional growth rates have been different. Economic growth in coastal regions has been faster than in inland regions, expanding the economic gap between the coastal and inland regions. Figure 2-2 shows regional GDP growth rates between 1987 and 2004. Every region has maintained relatively high economic growth. But coastal regions have persistently seen higher growth than the inland regions. In most years, growth rates in inland regions have been several percentage points lower than in coastal regions.

Figure 2-2 Regional GDP Growth

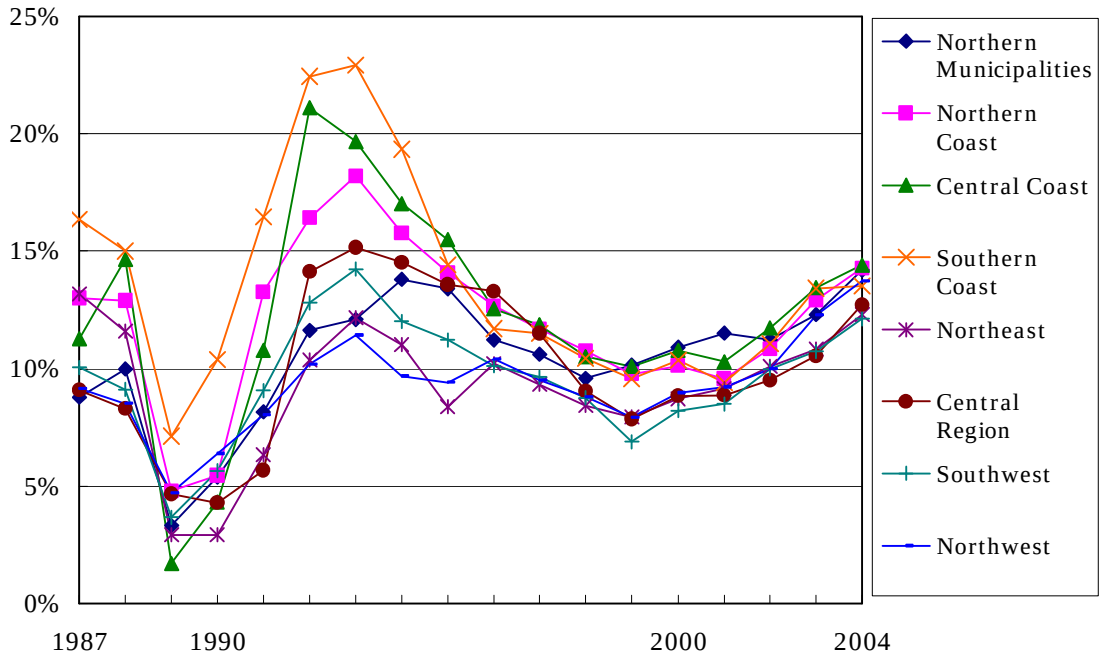
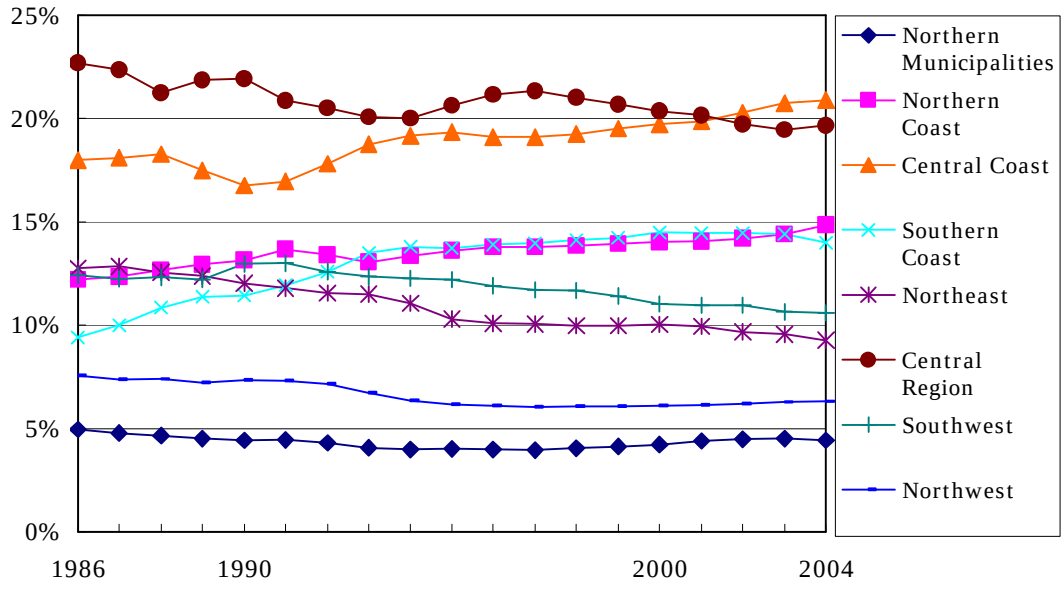


Figure 2-3 Region-by-Region Breakdown of GDP in China

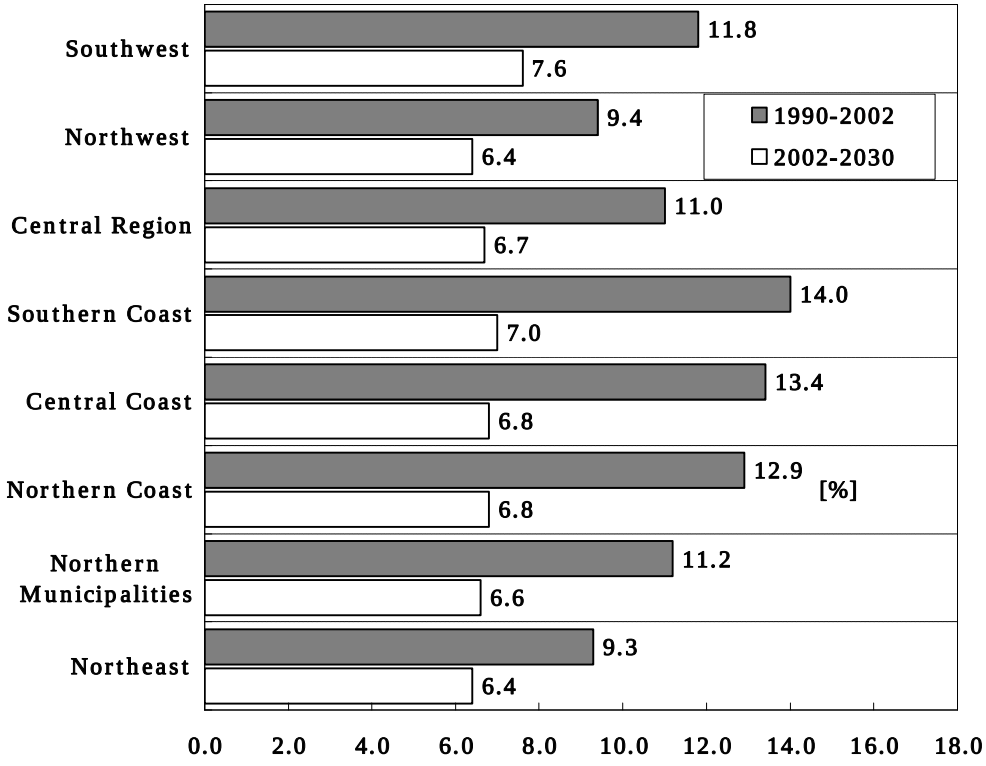


As indicated by Figure 2-3, the economic growth gap allowed the Northern, Central and Southern Coasts to expand their respective share of China's total GDP. The

four inland regions saw their respective shares decline. Such a decline is remarkable particularly for the Central Region and Northeast.

In this study, we have projected economic growth rates for each province through 2030, based on the past time series of growth data for the whole of China and the 31 provinces, and China's growth through 2030 as projected in certain literature (Li, Ito, Komiyama, "China's Energy Demand/Supply Outlook through 2030 and A Study on Northeast Asia Energy Community -- Auto and Nuclear Strategies of Fast-growing China," IEEJ, April 2005). This means the past changes in economic growth rates are presumed to continue for the whole of China and each province. Regional economic growth predictions are indicated in Figure 2-4.

Figure 2-4 Regional Economic Growth Predictions



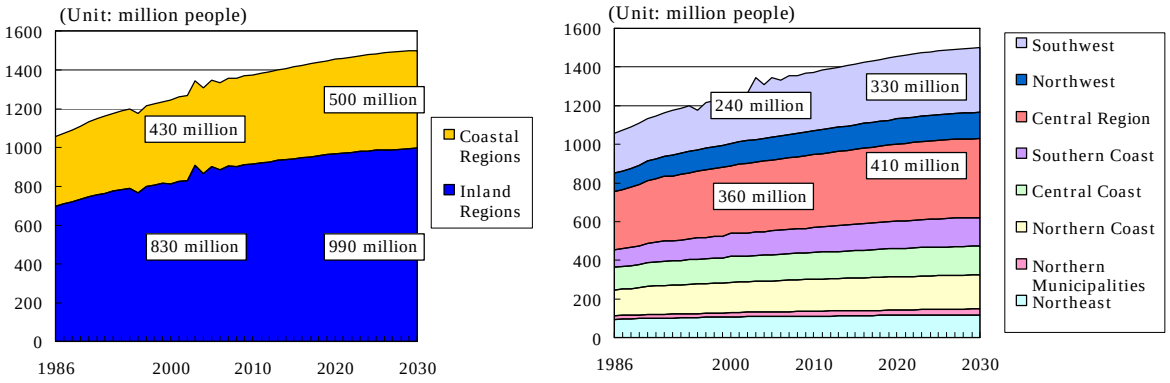
Source: China Statistics Yearbooks, IEEJ for predictions

In predicting the future trends in the Chinese economy, we need to bear in mind that the central government has shifted priority from the acceleration of GDP growth to the construction of a better-balanced society. The Great Western Development, the promotion of traditional heavy industry bases mainly in the Northeast, the enhancement of energy-saving measures, the construction of healthcare, pension and

other social security systems, the strengthening of industrial competitiveness and the improvement of creativity in science, technology and industry will be key to predicting China's future economic growth.

Although the population fluidity is uncertain, we have used the same method to predict population growth, based on the past trend (see Figure 2-5). Inland population is predicted to increase from 830 million in 2002 to 990 million in 2030, while coastal population is projected to rise from 430 million to 500 million. Inland regions are forecast to account for some 70% of China's total population, against the remaining 30% in coastal regions.

Figure 2-5 Province-by-Province Population Outlook in China



Future energy price predictions are based on the IEA's long-term outlook. Predictions regarding nuclear power and hydropower are based on the Chinese government's published plans and media reports.

3 Prediction Results

3-1 Predicted Province-by-Province Primary Energy Consumption

Figure 3-1 indicates predicted province-by-province primary energy consumption. Energy consumption in the coastal regions is predicted to expand some 2.7-fold from 540 million tons (ton of oil equivalent) in 2002 to 1,480 million tons in 2030. As a result, coastal regions' share of China's total primary energy consumption will rise from 51% in 2002 to 55% in 2030, reflecting their sustained economic growth. Coastal regions will thus expand their energy consumption faster than the inland regions, becoming a center of energy demand.

Figure 3-1 Primary Energy Consumption Outlook (Inland and Coastal Regions)

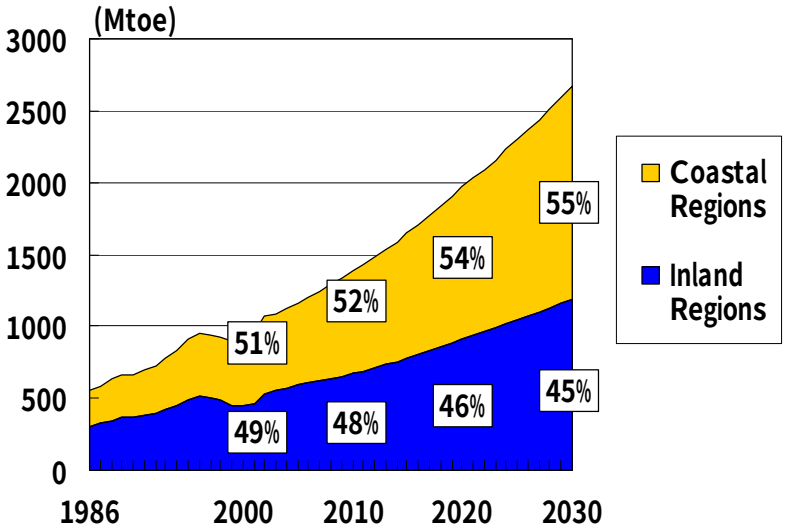


Table 3-1 Primary Energy Consumption Outlook

Mtoe			
	Inland	Coastal	Total
2002	529	542	1,071
2010	671	714	1,385
2020	912	1,057	1,968
2030	1,190	1,481	2,671
Share、%			
	Inland	Coastal	Total
2002	49	51	100
2010	48	52	100
2020	46	54	100
2030	45	55	100

Figure 3-2 indicates primary energy consumption predicted for each of the eight regions. Among the coastal regions, the Central Coast is predicted to expand primary energy consumption at the fastest rate, followed by the Northern Municipalities, Southern Coast and Northern Coast. The Central Coast's share of China's total primary energy consumption will rise from 15% in 2002 to 20% in 2030. The Northern Municipalities' share will increase from 4% to 6%. These regions will lead energy consumption growth in China.

Figure 3-2 Primary Energy Consumption Outlook (by Region)

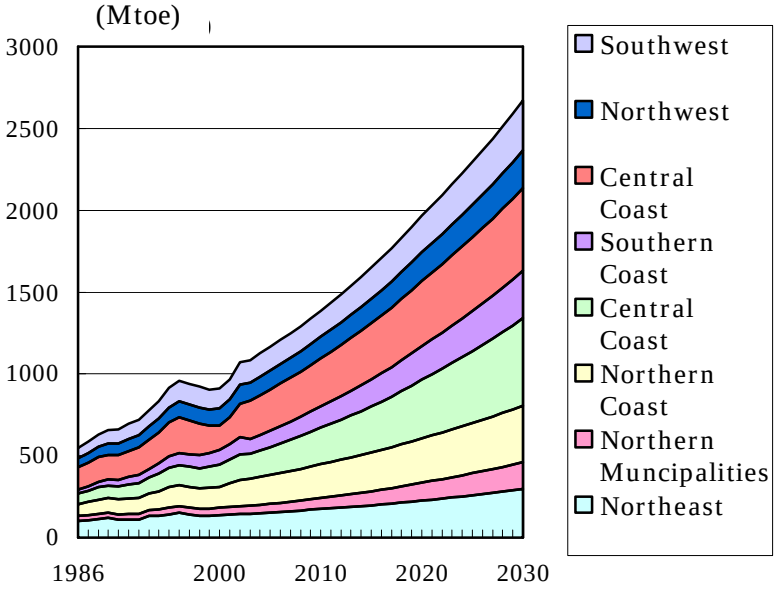


Table 3-2 Primary Energy Consumption Outlook (by Region)

Mtoe	Northeast	Northern Municipalities	Northern Coast	Central Coast	Southern Coast	Central Region	Northwest	Southwest	Total
2002	143	48	160	157	104	204	119	135	1,071
2010	176	67	206	222	131	294	130	158	1,385
2020	227	109	272	357	206	397	175	225	1,968
2030	298	162	346	534	290	508	229	305	2,671
Percentage share									
	Northeast	Northern Municipalities	Northern Coast	Central Coast	Southern Coast	Central Region	Northwest	Southwest	Total
2002	13	4	15	15	10	19	11	13	100
2010	13	5	15	16	9	21	9	11	100
2020	12	6	14	18	10	20	9	11	100
2030	11	6	13	20	11	19	9	11	100

Figure 3-3 Primary Energy Consumption Outlook (by Region)

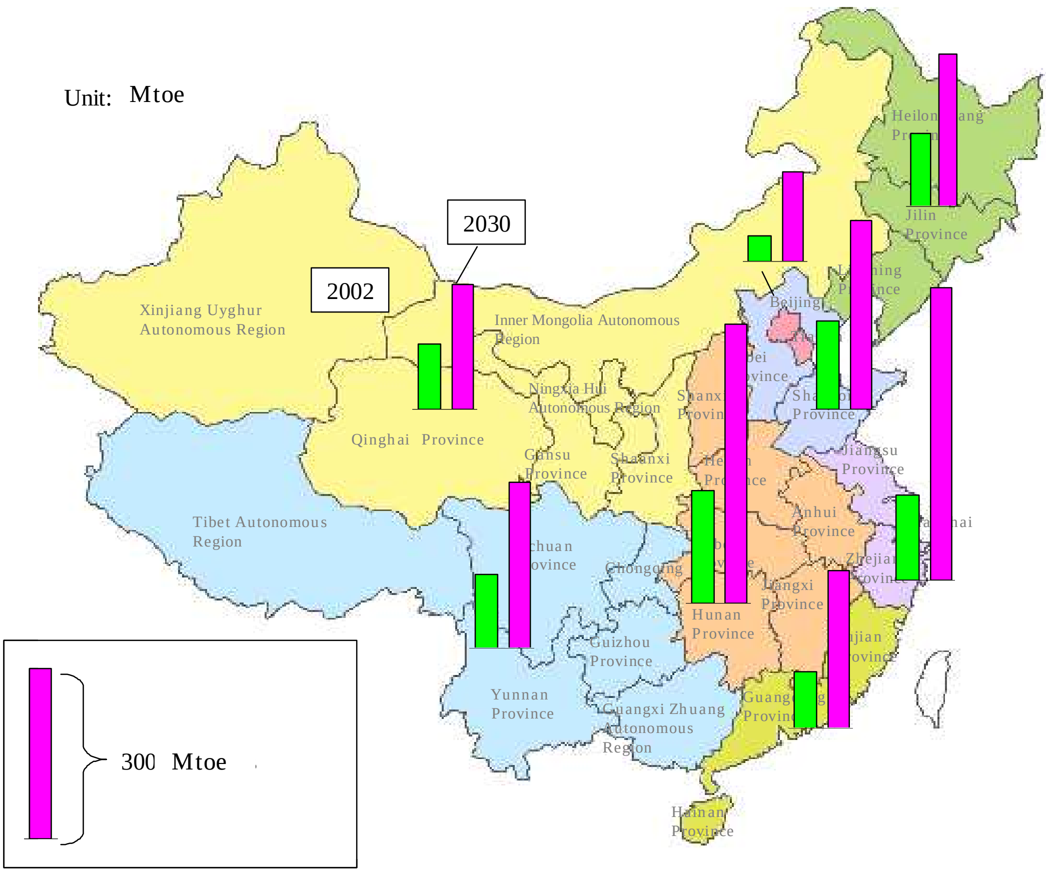


Figure 3-4 indicates a province-by-province primary energy consumption outlook for China. Among the 31 provinces, Hebei Province on the Northern Coast was the largest energy consumer with consumption at about 82.8 million tons in 2002. As its GDP continues to grow about 7% annually, its primary energy consumption will reach 170 million tons (excluding non-commercial energy consumption) in 2030, double the level of Taiwan's 2002 consumption. Four other coastal provinces -- Zhejiang, Jiangsu, Guangdong and Shandong – will each expand primary energy consumption to nearly 200 million tons in 2030, as much as South Korea's present level. Liaoning Province and Shanghai Municipality will each increase primary energy consumption to 150 million tons in 2030. This consumption level far exceeds the level of some 100 million tons each for Taiwan, Indonesia and Australia in 2002.

Figure 3-4 Primary Energy Consumption Outlook (by province)

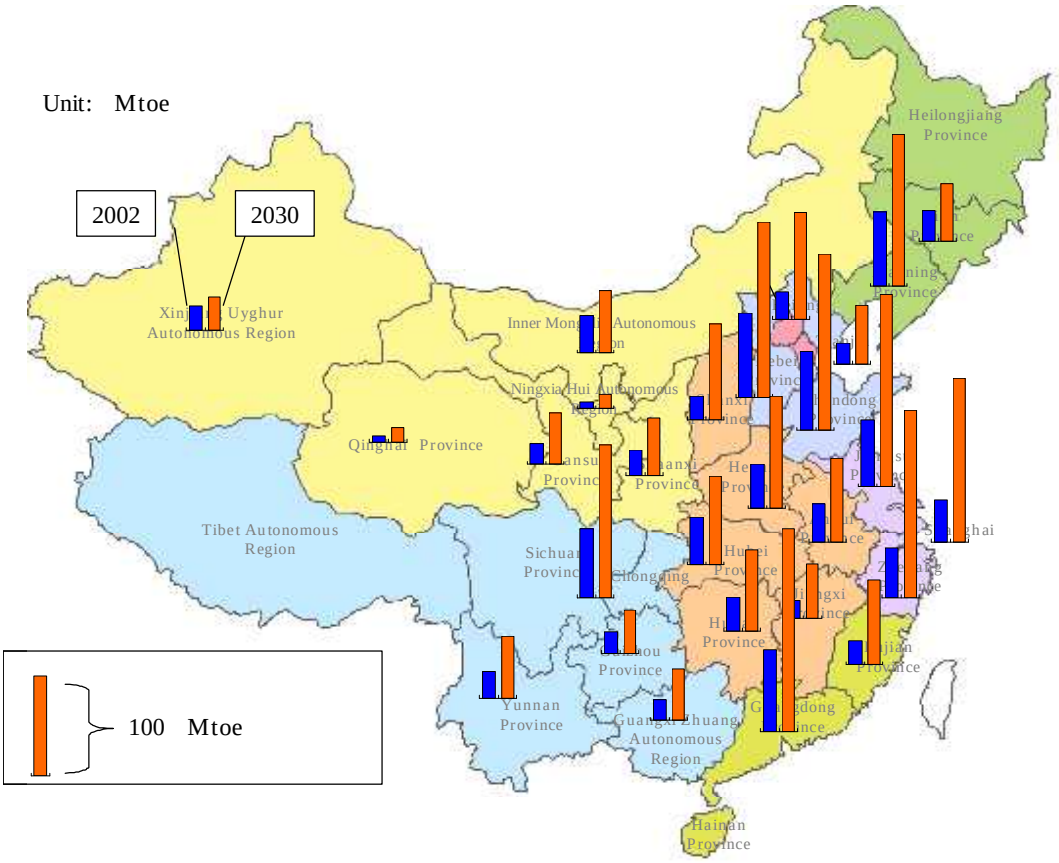
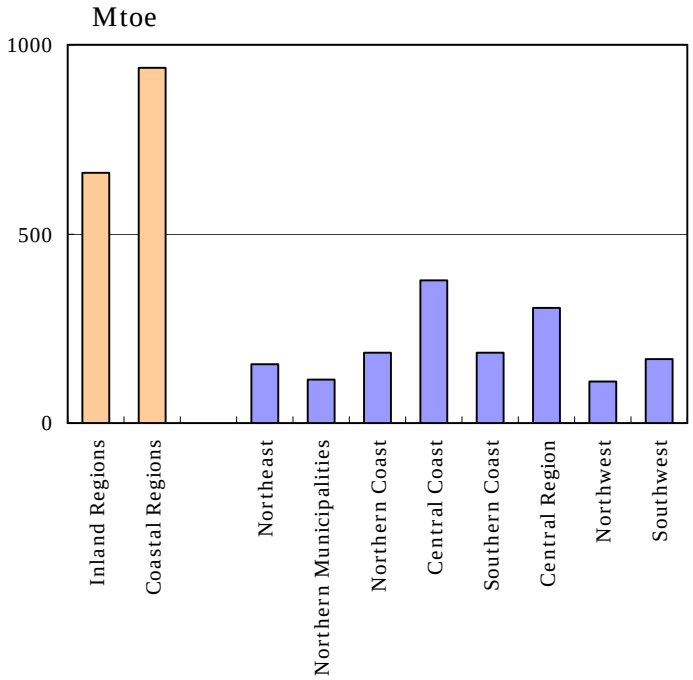


Figure 3-5 Primary Energy Consumption Growth from 2002 to 2030 (by region)



Primary energy consumption will increase by 660 million tons from 2002 to 2030 in the inland regions and by 940 million tons in the coastal regions. Future energy consumption growth in China will thus be led by the coastal regions. Coastal regions will account for nearly 60% of China's energy consumption expansion.

Among the eight regions, the Central Coast will see the largest primary energy consumption increase of 380 million tons, followed by the Southern and Northern Coasts. Among the inland regions, the Central Region, with the largest population of any region in China, is expected to expand energy consumption by 300 million tons.

3-2 Province-by-Province Oil Consumption Outlook

Figure 3-2 indicates a province-by-province oil consumption prediction for China. Coastal regions will expand oil consumption fast on income growth and motorization. Specifically, the regions' oil consumption will increase some 2.9-fold from 130 million tons in 2002 to 380 million tons in 2030. As a result, the coastal regions' share of China's oil consumption will rise from 62% in 2002 to 66% in 2030 on sustained economic growth. The regions will grow as China's oil consumption base.

Figure 3-6 Oil Consumption Outlook (inland and coastal regions)

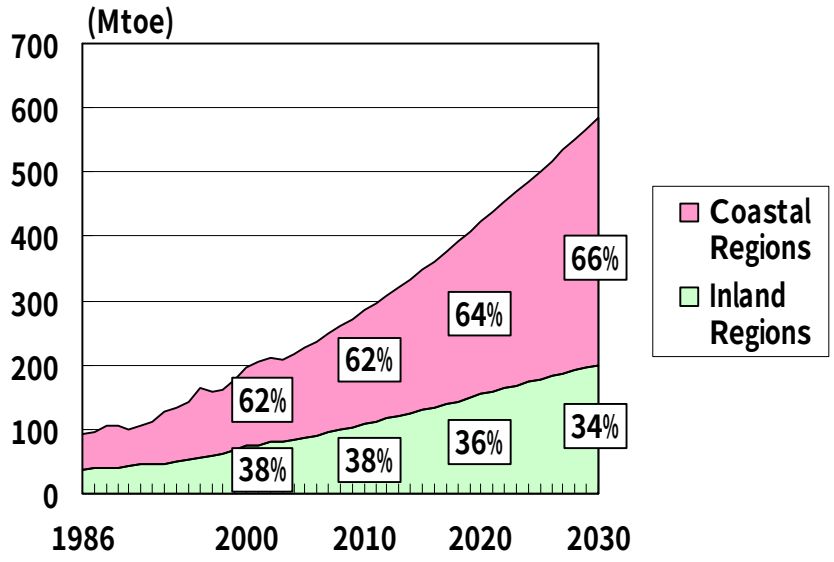


Table 3-3 Oil Consumption Outlook (inland and coastal regions)

Mtoe			
	Inland regions	Coastal regions	Total
2002	82	131	213
2010	108	177	285
2020	155	269	424
2030	201	384	584
Percentage share			
	Inland regions	Coastal regions	Total
2002	38	62	100
2010	38	62	100
2020	36	64	100
2030	34	66	100

Figure 3-7 indicates a region-by-region oil consumption outlook for China. China's oil consumption is expected to increase mainly in coastal regions, particularly the Central Coast. The Central Coast will boost its share of China's total oil consumption by 8 percentage points from 20% in 2002 to 28% in 2030, leading China's energy consumption growth.

Figure 3-7 Oil Consumption Outlook (by region)

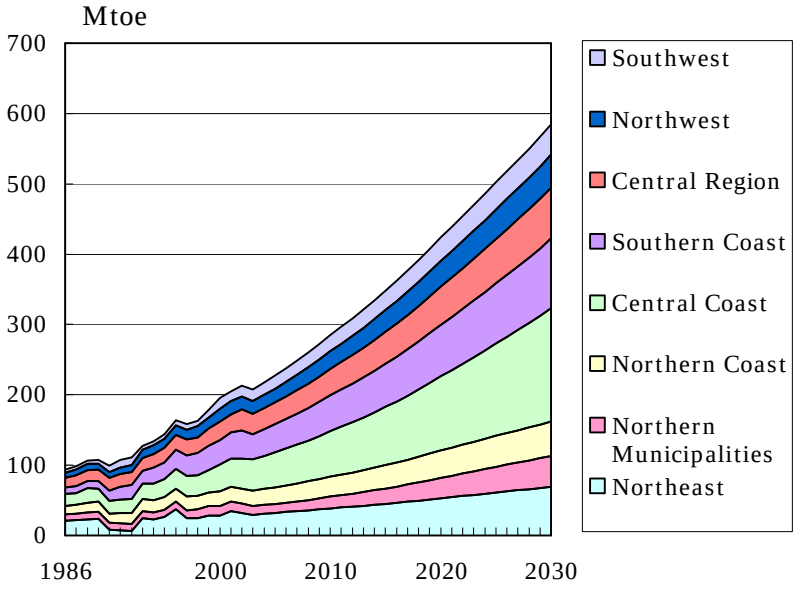
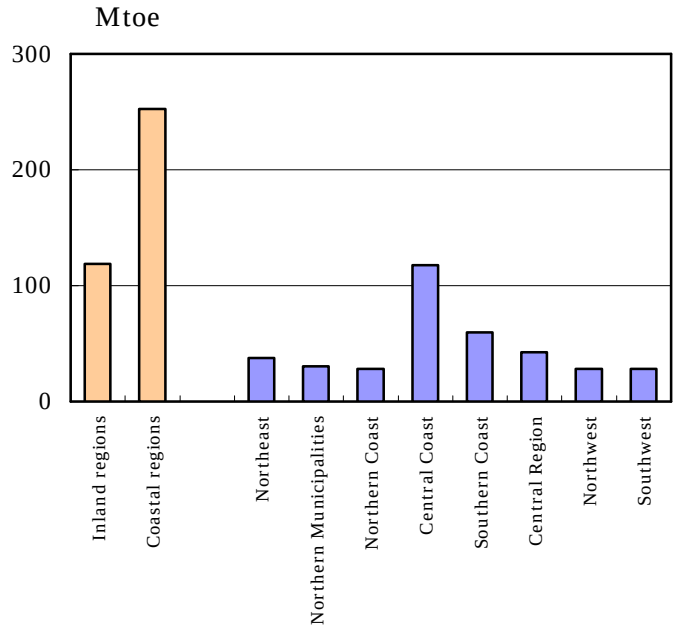


Table 3-4 Oil Consumption Outlook (by region)

Mtoe	Northeast	Northern Municipalities	Northern Coast	Central Coast	Southern Coast	Central Region	Northwest	Southwest	Total
2002	32	13	21	43	39	30	19	15	213
2010	39	16	28	65	51	38	25	23	285
2020	53	29	39	106	73	54	37	33	424
2030	69	44	49	161	99	72	47	43	584
Percentage share									
	Northeast	Northern Municipalities	Northern Coast	Central Coast	Southern Coast	Central Region	Northwest	Southwest	Total
2002	15	6	10	20	19	14	9	7	100
2010	14	6	10	23	18	13	9	8	100
2020	13	7	9	25	17	13	9	8	100
2030	12	7	8	28	17	12	8	7	100

Figure 3-8 indicates China's expected oil consumption growth between 2002 and 2030. Oil consumption will expand by 120 million tons in the inland regions and by 250 million tons in the coastal regions during the period. The expansion for the coastal regions will thus be double that for the inland regions. This means that the coastal regions will account for some 70% of China's total oil consumption increase during the period.

Figure 3-8 Oil Consumption Growth between 2002 and 2030 (inland and coastal regions, eight regions)



3-3 Region-by-Region Energy Consumption Outlook for Each Energy Source (Inland and Coastal Regions)

Region-by-region energy consumption characteristics in China indicate fast-growing coastal regions will shift energy consumption from coal to natural gas and nuclear energy that emit less carbon dioxide than coal. The steady energy shift will lead coal's share of energy consumption to gradually decline in coastal regions. In inland regions, however, coal will remain the dominant energy source to support economic growth.

Table 3-5 shows the primary energy consumption outlook as broken down by energy source for the coastal regions. In these regions, as seen in the whole of China, coal will lose its weight with natural gas and nuclear energy consumption expanding fast. Coal's share of total primary energy consumption in coastal regions will fall from 71% in 2002 to 58% in 2030, while the share will rise from 1% to 9% for natural gas and from 1% to 5% for nuclear energy. Oil consumption will also increase steadily, with its energy consumption share remaining 26% until 2030.

Table 3-5 Primary Energy Consumption in the Coastal Regions

Mtoe	2002	2010	2020	2030
Coal	379	456	522	606
Oil	131	177	218	269
Gas	6	41	65	89
Nuclear	7	13	31	55
Hydro	5	6	6	6
Renewables	2	10	14	21
Share,%	2002	2010	2020	2030
Coal	71	65	61	58
Oil	25	25	25	26
Gas	1	6	8	9
Nuclear	1	2	4	5
Hydro	1	1	1	1
Renewables	0	1	2	2

Inland regions will also make a shift from coal to oil, natural gas and hydropower to diversify energy consumption in a manner that will be different from that in the coastal regions. Coal's share of primary energy consumption will fall from 76% in 2002 to 68% in 2030, while the share will rise from 16% to 17% for oil, from 4% to 7% for natural gas and from 3% to 5% for hydropower. Nuclear energy will also be introduced to some extent in the inland regions including the Northeast.

Table 3-6 Primary Energy Consumption in Inland Regions

Mtoe	2002	2010	2020	2030
Coal	393	466	533	614
Oil	82	108	130	155
Gas	20	38	51	64
Nuclear	0	0	2	4
Hydro	17	38	43	48
Renewables	2	7	10	14
Share,%	2002	2010	2020	2030
Coal	76	71	69	68
Oil	16	16	17	17
Gas	4	6	7	7
Nuclear	0	0	0	0
Hydro	3	6	6	5
Renewables	0	1	1	2

3-4 Regional Energy Consumption Outlook by Energy Source (eight regions)

Table 3-7 indicates predicted primary energy consumption as broken down by region and energy source:

Table 3-7 Regional Primary Energy Consumption Outlook by Energy Source

Northeast

Mtoe	2002	2010	2020	2030
Coal	104	124	130	143
Oil	32	39	45	53
Gas	4	8	9	10
Nuclear	0	0	6	12
Hydro	1	1	1	1
Renewables	1	3	4	6
Share,%	2002	2010	2020	2030
Coal	74	71	67	63
Oil	23	22	23	24
Gas	3	4	5	5
Nuclear	0	0	3	5
Hydro	0	1	1	1
Renewables	1	2	2	3

Northern Municipalities

Mtoe	2002	2010	2020	2030
Coal	30	40	48	57
Oil	13	16	22	29
Gas	2	8	12	19
Nuclear	0	0	0	0
Hydro	0	0	0	0
Renewables	0	1	1	2
Share,%	2002	2010	2020	2030
Coal	65	61	57	54
Oil	29	25	26	27
Gas	5	12	15	17
Nuclear	0	0	0	0
Hydro	0	0	0	0
Renewables	1	2	2	2

Northern Coast

Mtoe	2002	2010	2020	2030
Coal	138	167	185	207
Oil	21	28	33	39
Gas	1	9	12	13
Nuclear	0	0	4	8
Hydro	0	0	0	0
Renewables	0	3	4	6
Share,%	2002	2010	2020	2030
Coal	86	81	78	76
Oil	13	14	14	14
Gas	1	4	5	5
Nuclear	0	0	2	3
Hydro	0	0	0	0
Renewables	0	1	2	2

Central Coast

Mtoe	2002	2010	2020	2030
Coal	107	132	158	192
Oil	43	65	83	106
Gas	0	13	23	35
Nuclear	1	5	9	15
Hydro	1	1	1	1
Renewables	0	3	4	6
Share,%	2002	2010	2020	2030
Coal	70	60	57	54
Oil	28	30	30	30
Gas	0	6	8	10
Nuclear	1	2	3	4
Hydro	1	0	0	0
Renewables	0	1	1	2

Southern Coast

Mtoe	2002	2010	2020	2030
Coal	50	53	65	79
Oil	39	51	61	73
Gas	0	8	13	16
Nuclear	5	7	14	23
Hydro	4	5	5	5
Renewables	1	2	3	4
Share,%	2002	2010	2020	2030
Coal	50	42	41	39
Oil	40	40	38	37
Gas	0	6	8	8
Nuclear	6	6	9	12
Hydro	4	4	3	2
Renewables	1	2	2	2

Central Region

Mtoe	2002	2010	2020	2030
Coal	163	231	262	297
Oil	30	38	45	54
Gas	2	12	19	27
Nuclear	0	0	0	0
Hydro	6	9	10	11
Renewables	0	2	4	5
Share,%	2002	2010	2020	2030
Coal	81	79	77	75
Oil	15	13	13	14
Gas	1	4	6	7
Nuclear	0	0	0	0
Hydro	3	3	3	3
Renewables	0	1	1	1

Northwest

Mtoe	2002	2010	2020	2030
Coal	90	88	100	113
Oil	19	25	31	37
Gas	6	9	11	13
Nuclear	0	0	0	0
Hydro	2	6	7	9
Renewables	0	1	2	3
Share,%	2002	2010	2020	2030
Coal	76	68	66	65
Oil	16	19	20	21
Gas	5	7	7	7
Nuclear	0	0	0	0
Hydro	2	5	5	5
Renewables	0	1	1	2

Southwest

Mtoe	2002	2010	2020	2030
Coal	90	87	108	132
Oil	15	23	28	33
Gas	10	13	16	19
Nuclear	0	0	0	0
Hydro	9	23	25	27
Renewables	2	2	3	4
Share,%	2002	2010	2020	2030
Coal	72	59	60	61
Oil	12	15	16	15
Gas	8	9	9	9
Nuclear	0	0	0	0
Hydro	7	15	14	13
Renewables	1	2	2	2

The Northeast as one of the industrial zones is characterized by massive industrial coal consumption. As a result, coal's weight in primary energy consumption is heavy. The region has great potential to use natural gas as industrial fuel. Its natural gas consumption will expand gradually. The region's electricity generation sector will also gradually shift away from coal as the Liaoning and Jilin Provinces plan to build nuclear power plants. Coal's share of primary energy consumption in the Northeast will fall from 74% in 2002 to 63% in 2030.

The Northern Municipalities -- Beijing and Tianjin -- on the Bohai Bay coast have proceeded with environmental conservation policies, calling for a shift to natural gas and other cleaner fuels. They are thus expected to rapidly expand natural gas consumption.

The Northern Coast is rich with primary energy resources and one of the regions boasting the highest secondary industry share. Its secondary industries include steel, chemical and machinery manufacturers. The region is one of the leaders in industrial production value. Therefore, its industry consumes massive amounts of coal. As the region including Shandong Province makes gradual progress in urbanization, its energy consumption will increase. Shandong Province has nuclear power plant plans including a reported plan for a domestically developed new nuclear power plant.

The Central Coast will fast increase energy consumption due to its remarkable industrial development. But environmental conservation requirements will lead the region to shift from coal to cleaner energy sources. In particular, gas consumption for power generation will increase. Zhejiang Province already has nuclear power reactors and Jiangsu Province is building several nuclear reactors. There are additional nuclear power plant construction plans. The region is thus expected to steadily diversify energy consumption. Coal’s share of energy consumption in this region will fall from 70% in 2002 to 54% in 2030. In contrast, the share will rise from almost zero to 10% for natural gas and from 1% to 4% for nuclear energy.

In the Southern Coast, which is also characterized by rapid industrial development, natural gas consumption will expand due to LNG imports in the Guangdong and Fujian Provinces. Natural gas’s share of energy consumption will rise to 8% in 2030. While Guangdong Province has several nuclear reactors in operation, the region has many nuclear power plant construction plans. Nuclear energy’s share will thus increase from 6% in 2002 to 12% in 2030. As a result, coal’s share will decline from 50% in 2002 to 39% in 2030.

The Central Region is rich with natural gas resources as well as coal deposits. But it is unlikely to see fast expansion of natural gas consumption as natural gas prices are relatively higher than in the coastal regions due to slower economic development. Coal's share of energy consumption in the region will still be as high as 75% in 2030. Hunan Province has nuclear power plant construction plans. Regarding hydropower, this region has the Three Gorges Dam, the largest in the world. But it has limited potential to undertake any more large-scale dam development projects in and after 2010.

The Southwest will be the largest natural gas producer and consumer in China in the immediate future. Its natural gas industry and utility gas infrastructure are relatively developed, indicating a smooth expansion in gas consumption. Regarding nuclear energy, Sichuan Province's nuclear power plant plan has been turned down by the central government. But the province and the Chongqing Municipality are eager and likely to construct nuclear power plants in the future. This region has a number of large rivers with large waterfalls. There are many plans to build hydropower stations each with capacity of millions of kilowatts, although worries remain about their effect on the environment.

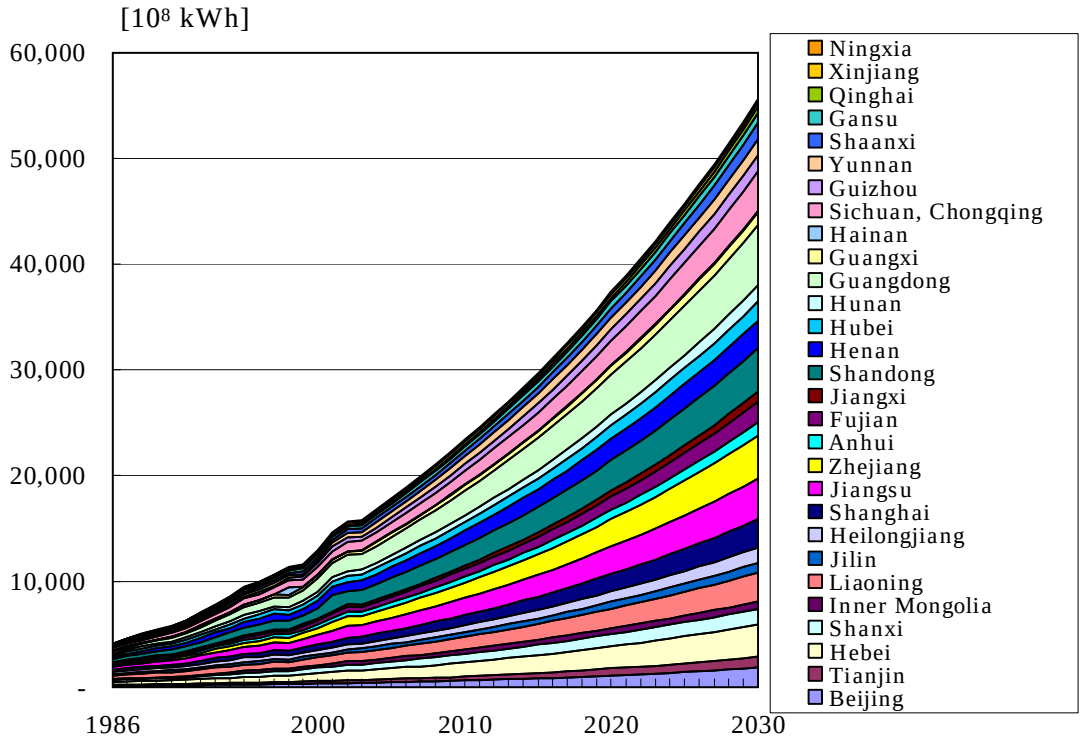
The Northwest is unlikely to substantially increase energy demand. Coal's share of energy consumption will fall moderately as oil, natural gas and hydropower consumption expand gradually. The region, which has rich fossil resources and low demand for energy, has little need for more nuclear power plants. The region has plans to build 1-million-kilowatt hydropower stations mainly for the middle stream of the Yellow River as well as its upper stream in the Tianshan Mountains.

3-5 Electricity Consumption Outlook

Figure 3-9 indicate a province-by-province electricity consumption outlook. The electricity demand-supply relationship has been tight nationwide. Electricity demand is expected to continue its upward trend nationwide as energy consumption rises on income growth.

Among the provinces, Zhejiang, Shandong and Jiangsu will each expand electricity demand to about 400 billion kWh by 2030 (compared with some 280 billion kWh in demand in Tokyo Electric Power Co.'s service area in Japan in 2002). Demand will exceed 250 billion kWh in Hebei, Liaoning, Shanghai, and Henan. Guangdong Province, which boasted the largest electricity consumption among the 31 provinces in China in 2002, will boost such consumption 3.6-fold from 157 billion kWh in 2002 to 566 billion kWh in 2030.

Figure 3-9 Electricity Consumption Outlook (by province)



Conclusion

In this study, we predicted province-by-province energy consumption in China through 2030. In future, we will improve statistics to increase the reliability of predictions. We will also scrutinize present and future regional energy demand/supply trends further. From the viewpoints of international energy security and global warming, China is urgently required to promote energy-saving and anti-global warming measures. In this respect, we plan to consider the region-by-region effects of China's energy-saving technology introduction, based on predictions in this study.

(Appendix) Primary Energy Consumption Outlook for China and Its Comparison with Predictions by International Organizations

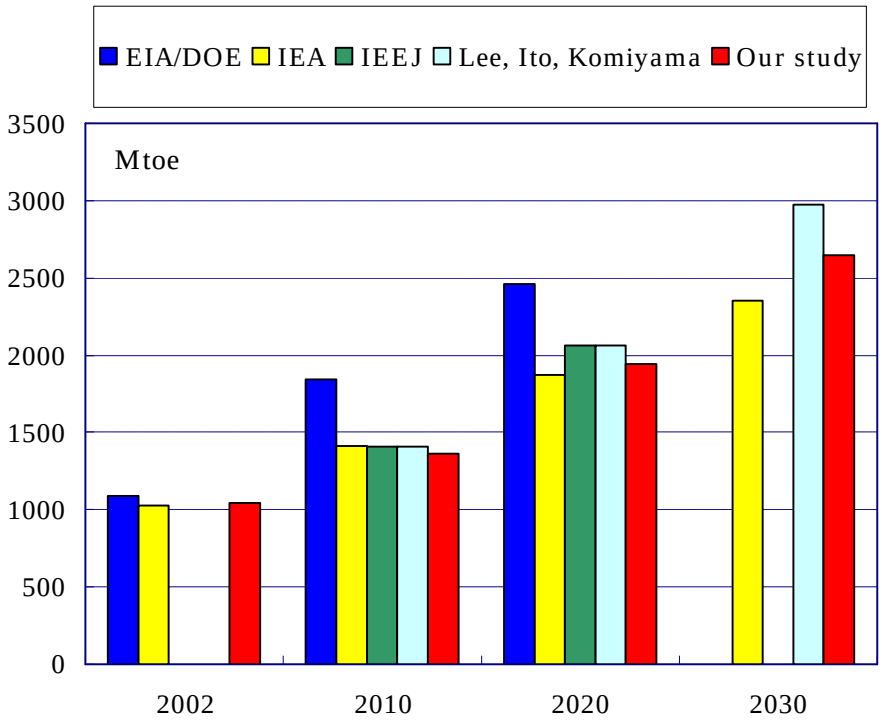
The following is China's primary energy consumption outlook as an aggregate of province-by-province predictions.

Appendix Table 1 Primary Energy Consumption Outlook by Energy Source (for China)

Mtoe	2002	2010	2020	2030
Coal	772	922	1,220	1,594
Oil	213	285	424	584
Gas	26	79	153	237
Nuclear	7	13	59	111
Hydro	22	44	54	65
Renewables	4	17	35	57
Total	1,044	1,360	1,944	2,648
Share, %	2002	2010	2020	2030
Coal	74	68	63	60
Oil	20	21	22	22
Gas	2	6	8	9
Nuclear	1	1	3	4
Hydro	2	3	3	2
Renewables	0	1	2	2

The following is a comparison between China’s primary energy consumption predicted by international organizations and the IEEJ's primary energy consumption outlook aggregating province-by-province predictions made for this study:

Appendix Table 2 Comparison of Primary Energy Consumption Predictions in China



Sources: EIA/DOE International Energy Outlook 2005; IEA World Energy Outlook 2004; IEEJ Asia/World Energy Outlook; Li, Ito, Komiyama, "China's Energy Demand/Supply Outlook through 2030 and A Study on Northeast Asia Energy Community -- Auto and Nuclear Strategies of Fast-growing China," IEEJ.

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Contact: report@tky.ieej.or.jp