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Energy in China: Coping with increasing demand

Abstract (not more than 200 words)

Sustaining the increasing energy consumption is crucial to future economic growth in China. This report focuses on the current and future situation of energy production and consumption in China and how China is coping with its increasing domestic energy demand. Today, coal is the most important energy resource, followed by oil and hydropower. Most energy resources are located in the inland, whereas the main demand for energy is in the coastal areas, which makes transportation and transmission of energy vital. The industrial sector is the main driver of the energy consumption in China, but the transport sector and the residential sector will increase their share of consumption by 2020. China's energy intensity decreased during the 1990s, but it is still high in a global comparison. China is projected to increase its energy consumption at least two times between 2000 and 2025. The government has an equal focus on energy conservation and to develop the current energy resources. Coal will continue to be the most important fuel, but the demand for oil, hydropower, natural gas and nuclear power will also increase. The main future challenges are transportation of energy resources within China and securing oil supply, both domestic and imports.

Keywords

China, energy production, future energy consumption, economic growth, coal, oil

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Energi i Kina: Att klara av ett ökande behov

Sammanfattning (högst 200 ord)

Att upprätthålla den ökade energikonsumtionen är av avgörande betydelse för den framtida ekonomiska tillväxten i Kina. Denna rapport fokuserar på den nuvarande och framtida situationen för energiproduktion och konsumtion i Kina och hur Kina hanterat sitt inhemska energibehov. Idag är kol den viktigaste energikällan, följt av olja och vattenkraft. De flesta energiresurserna är belägna inåt landet, medan den största efterfrågan på energi är längs med kustområdena, vilket gör att transport och överföring av energi är av kritisk betydelse. Industrisektorn utgör den största energikonsumenten i Kina, men transportsektorn och boendesektorn kommer att öka sin andel av konsumtionen till 2020. Kinas energiintensitet minskade under 1990-talet men är fortfarande hög i en internationell jämförelse. Kina kommer att minst fördubbla sin energikonsumtion mellan 2000 och 2025 och regeringen satsar lika mycket på att öka energisparandet och bygga ut sina nuvarande energiresurser. Kol och olja kommer att fortsätta att vara viktiga bränslen, men vattenkraft, naturgas och kärnkraft kommer att öka sina andelar i energimixen. De största framtida utmaningarna är transport av energiråvaror och att säkra oljeleveranser, både inrikes och genom import.

Nyckelord

Kina, energi production, framtida energi konsumtion, ekonomisk tillväxt, kol, olja.

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List of contents

Executive summary

China has to sustain its growing energy consumption in order to fulfil the economic growth plans, which include quadrupling the GDP between 2000 and 2020 building a relatively well off society, the *xiao kang* society. This report is focusing on the current and future situation of the energy production and consumption in China and how China is coping with its increasing domestic energy demand today and in the future.

Today, most of China's energy reserves are located in north, northwest and southwestern China, but much of the energy demand is in the economically prosperous regions in eastern and southeastern China. This makes transportation of energy especially crucial and it is also a main cause for shortages in energy supply.

Coal is the most important fuel in China's energy production, mainly due to its huge domestic reserves of coal. Still it is an inefficient fuel creating much environmental pollution, especially air pollution with particle matters and emissions of carbon dioxide and sulphur dioxide. The Chinese are interested in further development of coal as fuel, including liquefied coal, coal slurry (for pipeline transportation) and coalbed methane or coal gas.

China became the world's second largest oil importer in late 2003. Due to maturing oil fields, imports will continue to increase, as will further domestic oil exploration. Hydropower is another important energy resource in China. The government promotes it as a renewable, clean energy and hydropower dams can also be used to control flooding and as water reservoirs. Hydropower poses huge environmental challenges and the damming of the Mekong has already led to discontent from the affected neighbouring countries. Natural gas is viewed as a clean energy resource and will likely double its share of energy production by 2025. It will be more commonly used in big cities like Beijing and Shanghai and economically prosperous regions currently suffering from pollution. Nuclear power is to increase its capacity from seven reactors today to 37 reactors by 2020.

The industrial sector is the main consumer and driver of energy consumption in China today accounting for 69% of the energy used. The steel, aluminium, cement and chemical industry are the most energy intensive industries. The transport sector has increased its share of oil consumption from 10% in 1978 to 25% in 2002.

China has a relatively high energy intensity in its production, which is due to the high usage of coal, but also because of fixed, relatively low, prices of coal and electricity, which is a heritage from the planned economy and which leads to wasteful energy usage. China's energy intensity has decreased during the 1990s, but its energy efficiency is still far behind the industrialised countries'.

China has a heavily regulated energy market with little room for market oriented energy prices due to the heritage of the planned economy. This often creates problems when the energy prices cannot adjust the supply to the demand in for example times of faster GDP growth than expected. Instead, the heavily regulated market leads to energy shortages, which has happened in the electricity sector where power shortages are common in times of fast GDP growth. Similarly, when GDP growth slows down there has been an oversupply of electricity.

The energy shortages in 2003-2004 have been countered with both expansion of the energy sector and implementation of macroeconomic controls to curb investments in energy intensive industries like steel and aluminium, and energy intensive industries in affected areas have been encouraged to cut down operations as well as increased energy prices. The expansion of the energy sector included building new power plants – often coal power plants, and reopening older power plants (commonly closed because they were too polluting). Other efforts included launching of a "Save Energy"-campaign. Prioritisation of energy supply was given to residential basic usage, foreign companies and other industries viewed as being vital.

Depending on how fast the economic growth rate is and how well the government manages to implement energy conservation measures, China will more than double its energy consumption between 2000-2025. To handle this, the Chinese government will put an equal focus on energy conservation and development of currently used energy resources. The transportation sector and the residential and civilian sector will increase their share of the total energy consumption in 2020, which means that there are many opportunities to implement energy conservation policies in both construction of houses, including requiring double glass in new housing, and production of new motor vehicles, which should consume less fuel than today.

China will continue to use coal as main energy resource, but it could become an importer of coal due to inefficient domestic coal transports. China will also increase its domestic oil exploration and grow long-term relations with oil exporting countries. Natural gas is to expand its share in the energy mix by constructing more natural gas pipelines to transport gas from western China to the east coast, and the pipelines could also be used to transport imported gas from Central Asia. Hydropower will be expanded, although China faces opposition both domestically from environmental protection groups and internationally from neighbouring countries, especially in Southeast Asia, where fish catches have decreased due to Chinese dams upstream of the Mekong. Renewable energy sources will be further explored, with a special focus on wind power. China is currently in the middle of implementing a huge nuclear power program where the current seven reactors are to be 37 in 2020.

The growth in energy consumption is crucial to the economic growth, which is one of the pillars that the Communist Party is legitimising its rule. This makes the Chinese government highly involved in the energy development in China and it is currently promoting a sustainable energy development decreasing the energy intensity and being aware of the environmental effects of the energy production. The main challenges to be overcome in order to cope with the increasing energy demand are the transportation of energy resources, such as railway capacity for coal transport, oil and gas pipelines, and also interconnection of electric grids nationally. Another challenge will be to secure oil supply, both by further oil exploration within China and by expansion of oil imports.

1 Introduction

Energy consumption is a crucial part of China's economic growth and China's ability to sustain its energy needs has implications on its economic growth and geopolitical strategies as well as the global economy and politics. In 2003, China's share of the global total primary energy consumption was 12,1%, compared with 6,3% in 1978.[1] China is now the second largest energy producer in the world after the US.[2] To sustain its energy needs, China is becoming an important actor on the global energy market, especially with regard to oil, of which it became net importer in 1993.[3] In late 2003, China became the world's second largest importer of oil,[4] and it will most likely increase its share of the world market for oil in the future, which will influence its foreign relations as well as global oil prices.

According to the 16th National Congress of the Communist Party in China, China's economy is to quadruple between 2000 and 2020[5] in order to create a well off society, the so called *xiao kang* society. In order to attain this goal, China will face many challenges, of which energy supply to keep the economy growing will be one of the most crucial. This means that how the Chinese government will handle its future energy demands and supply will be crucial to potential economic growth in China in the next decades. With the Chinese economy being increasingly important in the global economy and politics, how China manages to satisfy its energy demand will also influence the global economic growth.

The focus of this report is to study how China currently is handling its energy demand, but also to further explore how China is planning to solve its future energy demand.

1.1 Purpose and problems

The purpose of this report is to look at the current and future situation of the energy production and consumption in China and its relation to economic growth. The main questions to be answered are the following:

(1) How is China producing and consuming energy today?
(2) What is the relation between China's GDP growth and its energy needs?
(3) How is China accommodating for its future energy supply and how much energy will it need?

1.2 Delimitations

With China being more and more integrated into the global economy, its future energy needs will also have a global impact, not only economically but also politically and geopolitically. Especially, China's future oil demand influences its foreign relations and foreign policy. This report focuses on domestic issues arising from China's increased demand for energy, and will not be looking at how China's energy demand, and especially its increasing demand for oil, influences its foreign relations.[6]

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[1] *BP Statistical Review of World Energy* (2004), June, p. 37. Downloaded from July 1, 2004, from http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/publications/energy_reviews/STAGING/local_assets/downloads/pdf/statistical_review_of_world_energy_full_report_2004.pdf .
[2] *Key World Energy Statistics 2003* (2003), IEA, p. 48-56. Downloaded June 14, 2004, from http://library.iea.org/dbtw-wpd/Textbase/nppdf/free/2003/key2003.pdf .
[3] Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p 13. Downloaded May 28, 2004, from http://www.iea.org/dbtw-wpd/textbase/nppdf/free/2000/china2000.pdf .
[4] Energy Information Administration (US) (2004), *China Country Analysis Brief July 2004,* p. 8**.** Downloaded July 30, 2004, from http://www.eia.doe.gov/emeu/cabs/china.html .
[5] Chen Qingtai (2004), "China's Energy Strategy and Policy" in *China Development Review*, Volume 6, Number 1, 2004, p. 2.
[6] For a detailed analysis of how China's energy demand is influencing its foreign and security policy, see Kiesow, Ingolf (2004), *China's quest for Energy; impact upon foreign and security policy*, FOI User Report, FOI-R--1371--SE.

1.3 Method and sources

The material used for this report comes from both foreign and Chinese sources. As China's future energy demand is a topic, which has recently been in the focus of many China analysts, the majority of the material used, constitutes of recent articles and reports accessed through the Internet. The reports used come from both foreign international organisations like the International Energy Agency (IEA), and Chinese government publications like the China Development Report, published by the Research Centre of the National Development and Reform Commission, a State Council think tank, which reflects the plans of the Chinese government. There is also increasing interest in China's future energy demand in the US, which means that especially the Energy Information Administration of the American Ministry of Energy has much information about China's current energy demand, but also looks at the future demand by analysing different economic growth scenarios globally, where China is one important part.

Findings from a seminar on China's future energy needs and its influence on foreign affairs held in Shanghai at the Pudong Institute for American Affairs in September 2004 has also been included.

Finally, a word of caution regarding the statistics in this report: when looking at Chinese statistics, one has to be aware of the fact that Chinese statistics are notoriously unreliable. This is partly due to the way they are collected, partly due to the fact that there is often a huge amount of lying in them, especially as lower ranked bureaucrats get promoted depending on for example what kind of economic growth they report. The Chinese statistical bureau now claims it is adjusting to international standards of statistical methods, and the statistical reporting is better today than it was in the old command economy. Nevertheless, Chinese statistics are used in the report, mainly to give an indication of the trends and orders of magnitude involved.

1.4 Structure of report

After the introduction chapter, chapters two and three study the current situation of energy production and consumption in China. Chapter four analyses China's current needs and their influence on economic growth in order to better understand future energy requirement. Chapter five goes through how the Chinese government is trying to cope with the future energy supply and demand. There is a list of the abbreviations used in the report at the appendix. To simplify for the reader, a China map is also included at the appendix.

2 Energy production

This chapter will address the following question:

- ***How is China producing energy today?***

Findings:

- ***Coal is by far the most commonly used fuel for energy and electricity production.***
- ***Crude oil is the second most commonly used fuel for energy.***
- ***Hydropower is the third most commonly used fuel. Other fuel or energy resources are used to a lower degree.***
- ***Biomass is often used as fuel in rural households, accounting for a substantial part of the energy source in the countryside, although its actual share of total energy production is hard to state.***

China is a resource rich country. When it comes to energy resources, it is particularly rich in coal and has a vast potential in hydropower. Most of the domestic energy reserves are located in remote areas far from the energy demanding industries and cities on the east coast and in the south, as illustrated in table 1. Because the infrastructure and transportation network have not been developed as rapidly as the economy has grown, the transportation and transmission of energy to the energy demanding regions is deficient and costly, which discourages usage of domestic energy resources and encourages import of energy products, especially oil, but also coal and gas. The economically prosperous regions also have the means to import energy products, which increases these regions', and the country's, reliance on imported energy.

%	Coal (1990)	Oil and gas (1990)	Hydropower (1990)	Total share of energy resources (1990)	Electricity consumption (2002) *	Share of GDP (2002)
Northwest China	24	11	10	20	7	5
North China	43	10	1	32	16	13
Northeast China	6	48	2	6	10	10
East China	11	18	4	10	32	38
South Central China	6	8	16	9	25	25
Southwest China	10	5	68	24	10	10

Table 1. Share of different energy resources, energy consumption and GDP in different regions of China. Sources: Allen, Mike and Piper, Jeff (1999), *Coal in the energy supply of China,* p. 19; China Statistical Yearbook 2003 (2003), 3-8; 7-14.
*Figures for electricity consumption in Tibet not available.

Coal is currently the most commonly used fuel for energy production in China. In 2003, China was estimated to use coal for as much as 74% of its energy production,[7] as illustrated in diagram 1 below. Other important fuels are crude oil and hydropower. Since the start of the economic reforms in 1978, coal has remained the most important fuel, whereas crude oil has actually decreased its relative share of total energy production from 24% in 1978 to 15% in 2003, and hydropower has increased its relative share from 3% in 1978 to 8% in 2003. Since energy production has more than doubled in size, the use of crude oil has increased by 64% in 2003 compared with 1978.[8] The decline in production of energy between 1999 and 2001 is due to a moratorium issued by the Chinese government to curb oversupply of energy,

[7] Biomass has been excluded from this diagram due to the difficulties in finding accurate statistics of its use. Biomass will hence be excluded for the main part of the discussions on energy production and consumption. Since biomass is mainly used in the countryside as fuel to heat up houses and stoves for cooking, its impact on for example total industrial production is relatively small.

[8] *China Statistical Yearbook 2004* (2004), 7-1.

which lead to many smaller power plants being closed down and hence led to a decrease in energy production.[9]

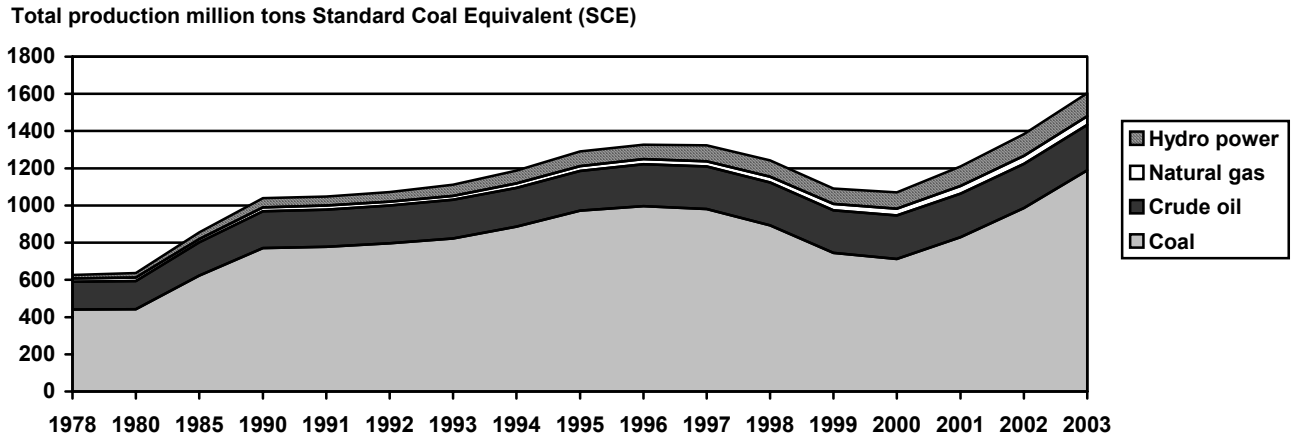

Diagram 1. Total production of energy and composition. Source: *China Statistical Yearbook 2004* (2004), 7-1.

The high dependency on coal as an energy source is also reflected in how China produces electricity, as illustrated in diagram 2 below. Of all the electricity produced in 2003, as much as 84% was derived from thermal power, primarily from coal. In order to better understand China's energy production, the following section will examine the available energy sources and their future potential.

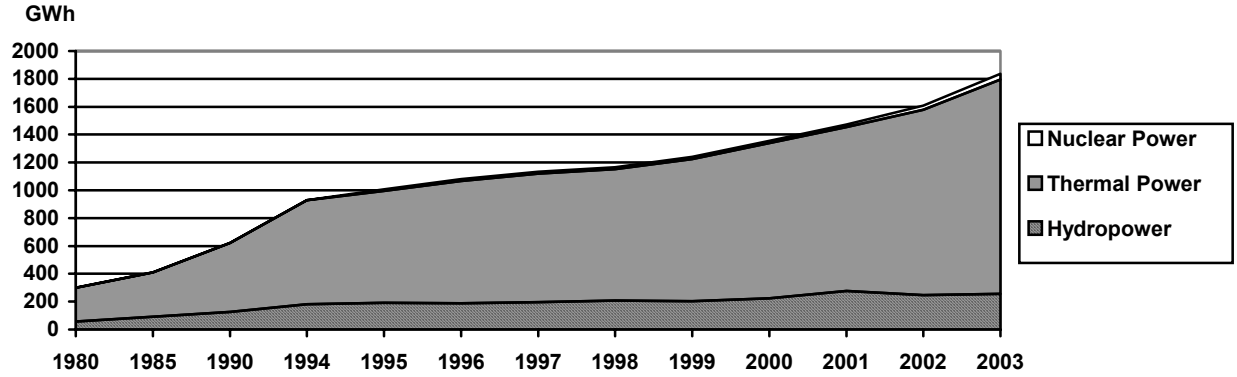

Diagram 2. Output of electricity from different sources. Source: *China Statistical Yearbooks* (1997-2003), 7-6; China National Bureau of Statistics.

2.1 Coal

China has the world's second largest reserves of coal. According to official statistics, China has about 334 billion tons of coal as a base reserve, which means that if China continued to consume coal at the same rate as it did in 2003, [10] it could continue to for another 200 years before reserves ran out. According to other sources, China has between 1 and 4 trillion tons of coal in reserves,[11] although a majority of these reserves are not likely to be economically recoverable. Most of the coal reserves are located in remote areas, especially in the northern and northeastern provinces of Shanxi, Shaanxi, Henan, Shandong, Heilongjiang, and Inner Mongolia, but also in Hebei, near Beijing.[12] Their location is mostly far away from the economically prosperous and energy consuming provinces in southern and eastern China, making transportation an especially important issue. Coal is mainly transported by train, and in 2002 coal made

[9] Energy Information Administration (US), 2004, *China Country Analysis Brief July 2004*, p. 8.
[10] *China Statistical Yearbook 2004* (2004), 1-11, 7-2, calculations by the author.
[11] Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p 28.
[12] Ibid; Allen, Mike and Piper, Jeff (1999), *Coal in the energy supply of China,* Report of the CIAB Asia Committee, Coal Industry Advisory Board, International Energy Agency, p. 24. Downloaded June 20, 2004, from http://www.iea.org/dbtw-wpd/textbase/nppdf/free/1999/coalchina.pdf .

up 44% of the total freight traffic by train in China.[13] Transportation of coal is still a bottleneck, especially in times of rapid economic growth and growing demand.

About 75% of China's coal is bituminous, whereas 12% is anthracite and 13% is lignite. Of the total production, steam coal accounts for 83%, and coking and gas account for 17%.[14] China has relatively good quality coal and the average sulphur content is 1.2% in the major coal deposits in the north. However, in the southern parts, especially in Sichuan and Yunnan, the coal has higher sulphur content with sulphur contents up to 5%.[15] Even if the sulphur content is not extremely high on average, coal still accounts for large sulphur dioxide emissions in China because of its widespread use and deficient cleaning techniques both before using it as fuel and when using it as fuel. This means that coal creates environmental problems with huge emissions of sulphur dioxide, carbon dioxide and particulate matters, especially since only modern large coal-fired plants and recently installed industrial boilers have good cleaning technology. The majority of the boilers and household stoves are large air polluters as they often use both inferior, uncleaned fuel and lack sophisticated cleaning methods.[16] These emissions will continue to be a problem, as coal will remain an important fuel for China, with effects on China's environment, its neighbouring countries and the global environment.

There are three types of coal mines in China: key state-owned mines, which previously were administered by the State Administration of Coal Industry but now have been decentralised to provincial level; local mines administered by provincial and county government; and township, village and private mines, which are managed by small collective organisations or individuals. The third type was encouraged in the 1980s to alleviate coal shortages, especially in rural areas. This increased their share of total coal production and between 1980 and 1984 rural mines expanded by 41%. Today, they account for about 40% of national output.[17] Since 1987 virtually all growth in the coal mining industry has been in this sector.[18] In 1998, there were 94 main state-owned coal mines, 2500 local government mines and 75 000 smaller mines run by townships, villages and private individuals, but about 25 800 of the 75 000 smaller mines were to be closed down. About 5 million people were employed in the coal industry that year.[19]

The big state-owned coal mines are usually modernised and have a relatively high productivity, whereas many of the smaller mines have been set up rapidly, often without any geological or technological evaluation, in order to create revenue as fast as possible. As many as one third of the smaller mines are assumed to have been opened illegally. This has led to an enormous waste of natural resources and the recovery rate of these mines is often very low, which means China's reserves of coal are being wasted. The smaller mines tend to harm the environment more than the bigger state owned mines do. Environmental consequences include the destruction of arable and grazing land, accelerated erosion of exposed topsoil, and increased water and air pollution.[20] Even though the Chinese government is trying to close down as many illegal small mines as possible, and has reportedly closed down as many as 60 000 small mines in the last few years, many of them have reopened to satisfy last year's soaring demand.[21] Illegal mines will most likely continue to remain open and exploit coal as long as they are profitable, and the central government is unable to assert its control over lower level authorities. This could lead to a continued waste of China's coal reserves, continued environment damage, and could also affect coal production in the long run as recoverable coal reserves shrink.

Chinese coalmines have relatively low recovery rates compared to international standards. Usually, Chinese coal production figures refer to the raw fuel, including rocks and clay. Although the large state owned coal mines have increased their recovery rate with modern technology, the smaller mines usually

[13] *China Statistical Yearbook 2004* (2004), 16-20.
[14] Allen, Mike and Piper, Jeff (1999), *Coal in the energy supply of China,* p 31.
[15] Smil, Vaclav (2004), *China's Past, China's Future: Energy, Food, Environment,* Routledge, New York, p 18.
[16] Smil, Vaclav (2004), *China's Past, China's Future: Energy, Food, Environment,* p 17-18.
[17] Allen, Mike and Piper, Jeff (1999), *Coal in the energy supply of China,* p 30.
[18] Smil, Vaclav (2004), *China's Past, China's Future: Energy, Food, Environment,* p 16.
[19] Allen, Mike and Piper, Jeff (1999), *Coal in the energy supply of China,* p 30.
[20] Smil, Vaclav (2004), *China's Past, China's Future: Energy, Food, Environment,* p 16.
[21] Fang, David (2004), "Industrial accidents on mainland drop 13 pc" in *SCMP*, June 14.

sell their coal in the raw state, without any cleaning or sizing, which means that the total recovery rate has not increased over the years, but is rather the same as before.[22] The uncleaned and inferior coal from the smaller mines is thus a more inefficient fuel and contributes to air pollution to a higher degree.

The majority of the Chinese mines are underground, but there are about 78 open cut mines as well in China today. Even though these are smaller than similar mines in Australia or the US, they have the same advantages as open cut mines abroad. They can be brought on line more quickly, are cheaper to run, show higher productivity with lower unit investment and higher recovery rates, and they are a lot safer than underground mines.[23] Mine accidents are common occurances in China: in 2003 more than 6000 miners died in accidents. This means that on average 4.17 miners are killed for every million tons of coal extracted, which is a high figure. In the United States only 0.03 miners are killed per million tons of extracted coal.[24] The smaller mines, and especially the illegal mines, are a lot more dangerous than the big mines.

Coal prices are set according to market prices in China today. Previously, starting in the Mao era, coal was subsidised to support industrialisation, leading to the inefficient use of coal in industrial production. In 1994 coal prices were liberalised,[25] which meant that coal prices rose, and when transportation costs were tallied in, coal was no longer the cheap domestic fuel it once was. Remnants of the old pricing system still persist with a dual pricing system favouring big cities and major power consumers.[26] Thus, even if China's coal sector has become more market oriented, there is still a long way to go. There are plans to aggregate the major state-run coalmines into seven coal corporations by the end of 2005, similar to the oil industry (see below), so that they can begin seeking foreign investment by way of international stock offerings.[27] This would make the Chinese coal industry more market oriented in an orderly way.

As already mentioned, transportation of coal is a bottleneck because the demand for coal is higher than the available cargo transportation can cater for. Even if all available cargo space were to be used to transport coal to the booming eastern and southern regions, this would create inefficiencies in other parts of the economy, as other important industrial goods, like steel, aluminium, copper and grain, could not be transported by rail. The Chinese rail transportation system is already suffering from the prioritisation of coal transport compared to other goods, even though the Chinese government has promised increased investments in new railways and railway cars.[28] Long distance coal transports are also costly and time consuming. The problem of costs is further exacerbated by the fact that the coal has not been washed and cleaned, which means that the railways are also hauling unusable rocks and clay. To illustrate the problem of transportation costs we can note that in 2003, China imported almost 11 million tons of coal, primarily from Australia, because it was cheaper to transport it to the booming coastal areas in eastern China from Australia than to transport it from China's interior by train.[29] Another reason could also be that it is more reliable to import coal from abroad than to buy domestic coal, since the latter may be delayed, once again due to inadequate transportation.

The main challenges for coal energy in the future are to lower emissions and to raise transport efficiency within China. One way of improving coal emissions and coal transport is to make mines more efficient in the recovery of coal. Recovering coal often involves the use of water, however, and many of the mines are located in regions already severely affected by water shortages, which means that this is rarely an option. Similarly, the option of building power plants close to coalmines in order to minimize pollution in the cities, and then transporting electricity over long distance power grids, so called "coal by wire", also runs into the problem of water shortages, as coal power plants need much water for their operation.[30] In-

[22] Smil, Vaclav (2004), *China's Past, China's Future: Energy, Food, Environment,* p 16-17.
[23] Allen, Mike and Piper, Jeff (1999), *Coal in the energy supply of China,* p 35.
[24] Fang, David (2004), "Industrial accidents on mainland drop 13 pc" in *South China Morning Post*, June 14, 2004.
[25] Smil, Vaclav (2004), *China's Past, China's Future: Energy, Food, Environment,* p 19.
[26] *2004 report to congress of the U.S.-China Economic and Security Review Commission* (2004), p. 155. Available on http://www.uscc.gov/researchreports/2004/04annual_report.htm .
[27] Energy Information Administration (US) (2004), *China Country Analysis Brief July 2004.*
[28] *South China Morning Post* (2004), "Railways stuck in time warp in rush to fuel economy", June 15, 2004.
[29] *2004 report to congress of the U.S.-China Economic and Security Review Commission* (2004), p. 154.
[30] Smil, Vaclav (2004), *China's Past, China's Future: Energy, Food, Environment,* p 19.

stalling cleaning equipment existing coal power plants is another option to reduce air pollution, but it is often viewed as too expensive, especially for coal-dependent older state owned enterprises already struggling to survive. Finally, the electric grid network of China needs to be improved, which is yet another hurdle to be overcome for locating coal power stations close to the mines.

2.2 Oil

At the end of 2003, China reported having total oil reserves of 23,7 billion barrels,[31] but its demand for oil is far greater. With dwindling production in the older large oil fields in northeastern China and despite the supposedly rich reserves in the South China Sea and in the Tarim basin of Xinjiang, China's are relatively small in global comparison. In 1993 China became a net importer of oil and since then its imports have surged. In 2003, oil constituted about 23% of China's primary energy use.[32] According to official statistics, about 41% of the petroleum used in China is imported.[33] This means that about 10% of China's energy resources are imported.

The major producing oil fields in China are in the northeast, at Daqing in Heilongjiang, Shengli in Shandong, and in the Bohai Bay in the eastern part of the Yellow Sea. There are relatively large amounts of oil in the Tarim basin in Xinjiang, but most of the fields appear to be small and medium sized ones, which are hard to exploit. There are also oil reserves in the South China Sea outside Guangdong. In the late 1990s, about half of the domestic oil production came from oilfields in Daqing and Shengli and only about 11% of the oil came from Xinjiang. [34] Daqing is a mature field with declining production and in 2003 its production fell by 3,5%,[35] which means that China's oil production in the northeast is decreasing in importance.

In the 1970s and early 1980s, following the global oil crisis and China's opening up to the world outside, Chinese oil findings were believed to be vast and China was projected to be a new Saudi Arabia. Western oil companies were invited to prospect for Chinese oil, mainly in the South China Sea, and multinational oil companies spent 1.7 billion dollars in the effort, but they did not find as much oil as hoped for. In the 1990s there was a similar onrush of foreign multinationals looking for oil in the Tarim basin, but the results once again turned out to be disappointing,[36] so the Tarim basin oil deposits seem not to be as large as expected either. Still, larger deposits of natural gas than expected were discovered, making the Tarim basin a crucial area for not only future domestic oil production but also natural gas production.

China's self sufficiency in oil started to decline in 1985, and in 1993 it became a net importer of oil. The main reason for becoming a net importer of oil was the rapidly expanding economy needing fuel for energy, especially in the southern and eastern provinces whose economic growth sped up significantly after Deng's famous tour of the south (a major political happening), in 1992. Because it was cheaper and easier to import foreignthe share natural gas headed the import of oil.[37] The fact that imported oil was not as heavily state controlled as domestic coal probably also made it more flexible and reliable as energy source. Another reason for importing oil is because factories often use small diesel engines to provide much-needed electricity in times of electricity shortages.[38] In 2003 China imported 91 million tons of crude petroleum oil,[39] as illustrated in diagram 3 below, and it is estimated that imports will rise to 101.1 million tons in 2004.[40] China will have to continue to import crude petroleum oil to fuel its economy, which makes oil an important energy resource in the future.

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[31] *BP Statistical Review of World Energy* (2004), June, p 4.
[32] *BP Statistical Review of World Energy* (2004), June, p 38.
[33] *China Statistical Yearbook 2004* (2004), 7-4.
[34] Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p 22-23.
[35] Energy Information Administration (US) (2004), *China Country Analysis Brief July 2004.*
[36] Studwell, Joe, (2003), *The China dream*, Grove Press, p. 23.
[37] Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p 30.
[38] O'Neill, Mark (2004), "Global rally in oil forces China to raise diesel prices" in *South China Morning Post*, May 19.
[39] *BP Statistical Review of World Energy* (2004), June, p 4.
[40] *2004 Report to Congress of the U.S.-China Economic and Security Review Commission* (2004), p. 155.

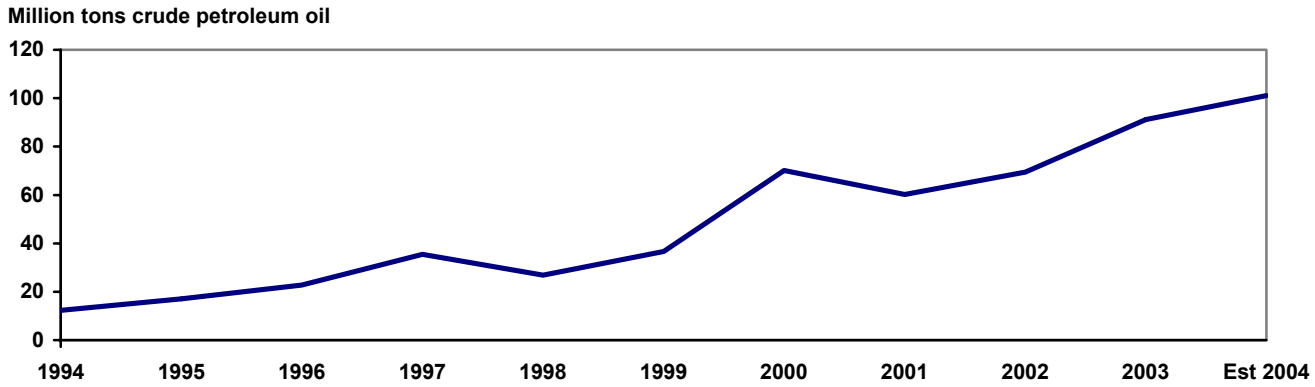

Diagram 3. Import of crude petroleum oil per year. Source: China National Statistics Bureau

China imports oil from all over the world and since it became a major importer, the number of countries of from which it buys oil has grown. In 1990, the main countries of origin for China's oil imports were Indonesia, Oman and Iran, whose oil was similar to the oil China produced domestically. Today, China imports oil from an array of countries with the largest share coming from the Middle East, which accounted for 56% of the oil imports in 2001, as can be seen in diagram 4.[41] How China's increased oil imports are influencing its foreign relations is further analysed in Ingolf Kiesow's report "China's Quest for Energy".[42]

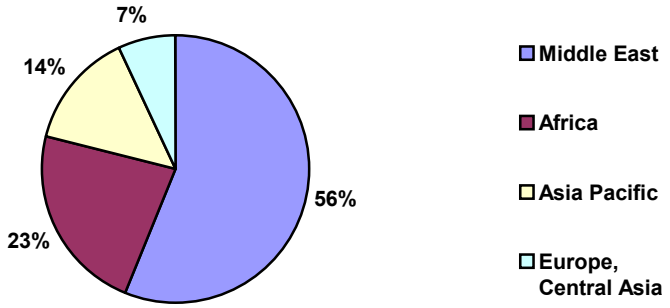

Diagram 4. China's oil imports by region 2001. Source: *2004 Report to Congress of the U.S.-China Economic and Security Review Commission* (2004), p. 156.

The huge imports of crude oil puts great stress on the country's oil receiving facilities, both for imported and domestically produced oil. This has led to shortages with respect to receiving terminals, ports, storage facilities and tanks. The IEA expects the total import and domestic flows to be 150 million tons along the entire coast by 2020, which will require further port expansion and investments in approximately 70-80 large tanks to meet the demand.[43]

The infrastructure of refining oil suffers from capacity shortages and structural imbalances. Earlier, most refineries were built near the oil fields in the north east, but since China started to import oil, refineries have been built in the south and on the east coast. The more recent refineries have been built to take care of oil from abroad, most of which, except for oil from Oman and Yemen, is not similar to Chinese domestic oil. This has forced foreign oil producers, especially oil companies from the Middle East like Saudi Arabia and Kuwait, to invest in modern oil refineries in China to facilitate the use of their oil.[44] One consequence of these investments is that the refineries in southern and eastern China are more modern and technically advanced than the old refineries in the north, reflecting both the uneven regional economic development and the fact that the northern refineries are mainly handling domestic oil.

[41] Ibid, p 156.
[42] Kiesow, Ingolf (2004), *China's quest for Energy; impact upon foreign and security policy*, FOI User Report, FOI-R--1371--SE.
[43] Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p 33-34.
[44] Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p. 33-34, 51-52.

Today, domestic crude oil is often moved by rail within China to reach refineries, which makes it more expensive than the imported oil arriving by tankers to the ports. There are shipments of oil along the coasts and by river transport, with small tankers carrying crude oil to refineries on the Yangtze River.[45] Domestic oil is also moved by pipeline, but the network is far from complete. In 2003 China had 32,600 km of petroleum and gas pipelines,[46] and there are plans to expand the system, especially from the Tarim basin to eastern China. There have been lengthy discussions with large multinational oil companies regarding foreign investments in the largest west-east pipeline, going from Xinjiang to Shanghai. In August 2004, the Chinese decided to leave the international oil companies out and pursue the building of the pipelines alone. The main reason the negotiations failed was said to be that the pricing of the oil and gas to be transported meant that the higher investment returns required by the foreign companies could not be met.[47] This puts question marks on whether the pipeline will generate sufficient returns on investment for the Chinese investors involved, and if it will be profitable even in the long run.

Because China is increasingly dependent on imported oil and also has a high rate of consumption coupled with limited infrastructure to store oil, it has very limited strategic oil reserves. It is estimated that China's strategic oil reserves are only 7-10 days, to compare with Japan, which also is heavily oil-import dependent, but has a strategic oil reserve of 100 days. How large China's actual oil reserves really are is hard to state, especially since the official figures do not take the oil reserves of Chinese oil companies into account. According to Chinese researchers, the domestic oil reserves are currently around 20 days[48] and China is planning to expand her oil reserves to 50-55 days by 2005, and to 68-70 days by the year 2010.[49] Whether this will be possible with the current acute demand and high oil prices remains to be seen. According to Chinese researchers, China will expand its oil reserves when the current high oil prices have decreased.[50] The current situation means that China's ability to maintain the crucial supply of energy would be severely hit by any crisis, including rapidly raising oil prices or if Chinese oil shipments, especially imports, would be delayed or stopped.

There are three main state-owned oil companies in China today: **China National Petroleum Corporation (CNPC)**, which is assigned the northern and western provinces; **SINOPEC**, which is assigned provinces in the south and east China; and **China National Offshore Oil Corporation (CNOOC)** focusing on off shore oil exploration. Despite their being state owned, they are supposed to compete freely, both within China and abroad, in the areas of exploration, production, refining and marketing.[51] In 2000 CNPC diverted most of its high quality assets into a subsidiary, **PetroChina**, and introduced PetroChina on the Hong Kong and New York Stock exchanges, although keeping the major shares within CNPC. BP turned out to be the highest investor and purchased 20% of the shares offered. Similarly both SINOPEC and CNOOC had public offerings of minority shares in late 2000 and early 2001. The main investors in SINOPEC are ExxonMobil, BP, and Shell. The main investor of CNOOC is Shell. In 2002 Chinese oil companies started to look at moving parts of their business operations into subsidiaries, and CNPC set up subsidiaries for drilling services and geological survey work, which could be introduced on the stock exchanges similarly to PetroChina. CNOOC listed its oilfield services unit, **China Oilfield Service, Ltd. (COSL)**, on the Hong Kong stock exchange in November 2002.[52]

Because of heavy competition both within China and abroad, their structures have become more like big western oil companies than like the old Chinese state-owned enterprises. Their main objective is to secure a supply of oil to China, and they do so by both investing abroad and prospecting for oil within China.

[45] Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p 32.
[46] China Statistical Yearbook 2004 (2004), 16-2.
[47] Hoyos, Carola; McGregor, Richard (2004), "PetroChina ends talks on pipeline" in *Financial Times*, August 4, 2004.
[48] Seminar on China's Energy needs at the Pudong Institute for American Studies, Shanghai, September 2004.
[49] *2004 report to congress of the U.S.-China Economic and Security Review Commission* (2004), p. 157-158.
[50] Seminar on China's Energy needs at the Pudong Institute for American Studies, Shanghai, September 2004.
[51] Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p. 35-37.
[52] Energy Information Administration (US) (2004), *China Country Analysis Brief July 2004.*

One of the strategies for securing oil is that the Chinese companies try to gain ownership of oil at the production point,[53] sending it back to China for refining.

The government partially liberalised retail oil prices in 2000,[54] but Sinopec and PetroChina, the two authorised resellers of gasoline and diesel fuel, are only allowed to rise or lower their retail prices to within 8% of the government-set benchmark price[55] - showing that the Chinese oil market is not yet fully liberalised. Foreign resellers of oil products are not allowed to operate in China yet, but will be allowed to operate on the market within a few years as a consequence of China's entry into the WTO.

2.3 Hydropower

China has the world's largest potential hydroelectric resources with at least 378 GW exploitable hydro energy. In 2003 developed capacity stood at 92 GW or about 24% of the estimated total exploitable amount.[56] Hydropower is projected to have a total installed capacity of 200 GW by 2020, according to the IEA.[57] Most of the hydropower capacity is located in southwestern and west central China, through which many of the major rivers of Asia flow from their sources in the Himalayas: the Yangtze River, the Mekong, the Salween, the Red River and the Yellow River.

The first hydroelectric power stations in China were built by the Japanese in Manchuria in the 1930s and early 1940s. Between 1949 and 1972 a total of 12,517 dams were built. The majority of these dams were small and only between 15-30 meters high. Still, especially during the Great Leap Forward, the construction of large dams resulted in 46 dams over 60 meters in height being built between 1949 and 1972. The best-known dam from this period is the Sanmenxia in Henan province which was finalised in 1960 on the Yellow River and had an installed capacity of 1.1 GW. [58] Since the start of the economic reforms, the trend has gone from building small hydro stations, which were often either rock-filled or earth filled and had capacity averaging 48 kW per station, to building bigger hydro stations with capacities averaging 250 kW in the early 1980s. The majority of the small hydro stations from the Mao era are located in the southern provinces and were often the first source of electricity in the rural areas.[59] The largest hydro power station in China will be the much-debated Three Gorges Dam on the Yangtze River when it is completed, according to plans in 2009. When completed it is supposed to have as much as 18.2 GW installed capacity.[60]

Hydropower is often put forward by the Chinese government as a clean, renewable energy resource that has to be exploited further. There are also other benefits that come with hydropower, like the ability of dams to control flooding, and their supposed value as water reservoirs, where water can be transported to areas suffering from water shortages. Despite this, hydropower is still a controversial energy resource due to its social and environmental effects, including the forced relocation of large numbers of people, silting, making flooding upstream more likely, and environmental and ecological destruction. These problems are discussed relatively openly in China among experts and ordinary people although no debate is permitted in legislative bodies or in the major media. There is a small clear opinion against hydropower, mainly respresented by non-governmental operated organisations like Friends of Nature and Greenriver. In the summer of 2004 some of these organisations, together with other foreign non-governmental organisations

[53] *2004 report to congress of the U.S.-China Economic and Security Review Commission* (2004), p. 158.
[54] O'Neill, Mark (2004), "Global rally in oil forces China to raise diesel prices" in *South China Morning Post,* May 19, 2004.
[55] Xie Ye (2004), "Rising oil cost won't derail economy" in *China Daily*, May 11, downloaded May 19, 2004 from http://www.chinadaily.com.cn/english/doc/2004-05/11/content_329590.htm .
[56] *Xinhua* (2004), "China's hydropower resources tops world" in *China Daily*, May 30, downloaded May 30, 2004 from http://www.chinadaily.com.cn/english/doc/2004-05/30/content_334949.htm .
[57] Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p 30.
[58] Smil, Vaclav (2004), *China's Past, China's Future: Energy, Food, Environment,* p 13.
[59] Smil, Vaclav (2004), *China's Past, China's Future: Energy, Food, Environment,* p 44-45, 48-49.
[60] Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p 30.

and Chinese journalists, managed to stop the construction of a mega-dam on the Nujiang (Salween) River.[61]

Far from all hydropower projects have been successful. For example, the Sanmenxia mega-project on the Yellow River suffers from silting and can only operate a few hundred hours per year (normally dams of that size operate on average 2900 hours per year) between flood seasons when the river is relatively free of silt. Its total capacity is only 400 MW, which is one third of the original projected capacity. Also, the silting of the reservoir is extreme, with over 90% of the incoming mud retained in the lake, causing annual flooding in the adjacent Wei River.[62] Today, most Chinese are well aware of the failure of the Sanmenxia, and in 2002, a vice-chairwoman of the Chinese People's Political Consultative Conference even called for the closure of the dam. Following disastrous flooding in the summer of 2003, the debate got even hotter and as late as in June 2004, one of the leading engineers of the construction of the dam said it was a mistake to build it.[63]

The most controversial hydropower project is the Sanxia dam, the Three Gorges dam. Even if its generating power capacity, 18 GW, is much needed for China's energy hunger, it still gives rise to questions regarding human, engineering, economic and environment issues, and it has faced hard opposition both within China and abroad. When the final vote was to be taken on the Three Gorges Dam in April 1992, as many as one third of the National People's Congress (NPC) delegates abstained or voted against it, which was one of the biggest expressions of dissatisfaction in the NPC's history. The Three Gorges project will cost 200 billion RMB, most likely more, and between 1.2 and 1.5 million people have to be relocated. Other problems with the Three Gorges project is siltation of the dam; loss of siltation deposition downstream (which could threaten the agriculture in the Yangtze valley); flooding of sites containing toxic wastes; waste from upstream which will pollute the dam when standing still; risk of earthquakes and rock slides; threat of the ecology of the river, including the rare white river dolphin; and the loss of a major tourist attraction.[64] By now the project has gone so far that it is impossible to stop it.

Other problems facing hydropower developers are the lack of an adequate power grid to facilitate the transmission of the electricity generated into remote areas where hydropower could find its best use, and the critical shortage of water in much of the country. Already today, the water in the dams of the current hydropower stations is consumed for other purposes than the production of electricity. There are even plans to transport water from the Three Gorges up to Beijing to alleviate the water shortage in the capital. The more water is used to other purposes than to generate electric power upstream, the less water there will be to generate electric power downstream. Also, recurring periods of drought exacerbate the problems inherent in hydropower-generated electricity.

Finally, a geostrategic problem facing the developers of hydropower in China is the fact that most of the large Asian rivers crucial to other countries originate in China. This means that China's taming its rivers inevitably affects countries downstream, creating problems in its relations with its neighbours.

2.4 Natural gas

In 2003 about 2.9% of the energy production in China came from natural gas. Even if this is a small share of total energy production, the use of natural gas has still more than doubled since the start of the economic reforms.[65] China has 1.82 trillion cubic metres of natural gas reserves, or about 1% of the world total.[66] Most of the currently known natural gas deposits are located in Sichuan and Xinjiang, in the

[61] Interviews with Friends of Nature, Professor Wang Ming at the Institute of NGO Studies, School of Public Affairs at Qinghua University, Beijing, and Global Village of Beijing, September 2004.
[62] Smil, Vaclav (2004), *China's Past, China's Future: Energy, Food, Environment,* p 191-194
[63] Cheung, Ray (2004), "After 50 years, torrent of criticism is still flowing" in *South China Morning Post*, June 28, 2004.
[64] Smil, Vaclav (2004), *China's Past, China's Future: Energy, Food, Environment,* p 195-199
[65] *China Statistical Yearbook 2004* (2004), 7-1.
[66] *BP Statistical Review of World Energy* (2004), June, p 20.

northern and northeastern parts of China, and in the East China and South China Seas.[67] The natural gas deposits are thus located, like most other Chinese energy reserves, far from the energy-demanding areas of eastern China.

Because natural gas is considered to be a clean fuel, which does not emit sulphur dioxide and particulate matter like other fossil fuel, the Chinese government encourages its use,[68] especially in regions using much energy and experiencing problems with air pollution. In the 10th Five Year plan (2001-2005), the Chinese government stressed the importance of increasing production of natural gas relative to other sources of energy in these five years and beyond. By 2010 natural gas should double its share of energy production and by 2020 China is to have built a well-interconnected nationwide network to transport natural gas to various parts of the country.[69] The target is that about 50% of domestic production is to come from the northwestern and northern basins, with the rest coming from Sichuan. Any deficit should be imported,[70] most likely from Central Asia and Russia, but also from the Middle East in the form of LNG. [71]

Today, the main problem with natural gas is that the gas infrastructure is not well developed, limiting access to natural gas in the eastern regions. Most existing pipelines are not interconnected and instead they tend to only go from one gas producer to one gas consumer.[72] In order to make full use of its natural gas potential, China has to invest in new pipelines, local infrastructure in cities to distribute gas for industrial and residential use, and in LNG terminals to receive imported natural gas from tankers. As China does not have the capacity to create this gas infrastructure, it has to rely on expensive foreign equipment.[73] High cost investments make natural gas an expensive fuel compared to coal, which is the main challenge if natural gas is to become more commonly used in China. To accommodate the need for investments in gas infrastructure, a pipeline stretching from Xinjiang to Shanghai has been built, and pipelines between Sichuan and Hunan are under construction.[74]

In all three LNG projects have been approved along the east coast to import gas for energy, in Guang-dong, Fujian, and Zhejiang, and two are under construction.[75] There are discussions regarding building more terminals located in Shanghai, Tianjin, Jiangsu and Shandong. The average project is to import LNG for at least 25 years to supply LNG to a terminal where it is transformed back into natural gas and delivered to local consumers, including power industries.[76]

It is however risky to invest in costly LNG terminals because of the competition from cheaper coal as fuel and the fact that the energy infrastructure needs to be upgraded to accommodate natural gas as a fuel, which could make it difficult to generate revenues from it unless the government adopts policies to promote natural gas, for example via tax relief for cleaner types of fuel. Another problem with LNG terminals is that the Chinese owners have to have long-term contracts with foreign exporters. Today, China has signed contracts to import LNG from mainly Australia and Indonesia, but is likely to soon also import it from the Middle East.[77]

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[67] Chen, Xavier (2002), *Developing China's gas market: The energy policy challenges*, IEA, p 8. Available on http://www.iea.org/dbtw-wpd/Textbase/publications/newfreedetail2.asp?F_PUBS_ID=475 .
[68] Ögütçü, Mehmet (2002), *Foreign direct investment and the importance of the "Go West" strategy in China's energy sector*, p. 3. Downloaded May 2004 from http://www.oecd.org/dataoecd/1/35/2085596.pdf .
[69] Chen, Xavier (2002), *Developing China's gas market: The energy policy challenges*, IEA, 2002, p 19.
[70] *Offshore* (2001) "Incoherent energy policy may stall China's plans to expand gas", April.
[71] LNG, liquefied natural gas, is natural gas that has been liquefied by compressing it at very low temperatures, making it possible to transport by other modes than pipelines. After arriving at its destination, it is heated up and distributed as natural gas.
[72] Chen, Xavier (2002), *Developing China's gas market: The energy policy challenges*, IEA, 2002, p 19.
[73] Ibid, p 21.
[74] Ibid, p. 9.
[75] China Daily (2004), "LNG terminal network to be deployed" in *China Daily,* October 27, 2004. Downloaded November 2004 from http://www.chinadaily.com.cn/english/doc/2004-10/27/content_386062.htm .
[76] Xie Ye (2004), "Experts warn against rushing into LNG market" in *China Daily*, April 2, 2004.
[77] Ibid; *2004 report to congress of the U.S.-China Economic and Security Review Commission* (2004), p 159.

2.5 Nuclear power

In 2003 nuclear power contributed about 1.3% of the electricity generated in China, showing that it remains a minor energy resource. The first nuclear power plant started operating in 1991, and was located in Qinshan, Zhejiang province, close to Shanghai. Today, there are seven nuclear reactors in operation with a total capacity of 3.6 GW. They are located in Qinshan, Zhejiang, and at Daya Bay and Ling'ao in Guangdong. In 1997 the Chinese government suspended all construction of nuclear power plants due to high investment costs and safety concerns, but in 2003 it began once again to approve new nuclear power plants, most likely due to the shortage of electricity.[78] In the light of China's massive problems of emissions from coal energy production, nuclear power stands out as a clean source of energy, which makes it an interesting alternative despite its high investment costs.

Nuclear power could be said to be an example of how China is learning through others' mistakes before adopting a new technology. Even though there was probably an interest for nuclear power earlier than 1991, it appears that the Chinese government was frightened of nuclear power after the Chernobyl accident and its investment in nuclear power stations was hence delayed. Another lesson learnt has made China look into the storage of radioactive waste at the same time as it is constructing its power stations, something the pioneers of nuclear power did not always do. The existing radioactive waste disposal is said to be under strict supervision by environment protection agencies.[79] China is currently looking into sites where it could store highly radioactive waste and appears to have plans to store it at the Beishan granite site in the Gobi desert in Gansu province, which is sparsely populated and has good geological conditions for storage. It also plans to create an underground research location in connection with these storage facilities. Low-level radioactive waste will be stored near the surface and in aboveground disposal facilities in regional centres near the current nuclear power plants. Higher levels of radioactive waste will be cooled for 15 years in water storage pools before it is reprocessed as fuel.[80]

China's National Development and Reform Commission (NDRC) claims that China is planning to construct at least 30 more reactors generating 32 GW by 2020. Most of these reactors will be located on the east coast of China, close to the sea for cooling water, in energy demanding provinces like Guangdong, Fujian, Zhejiang, Jiangsu, Shandong, Hubei and Liaoning, but also inland at Chongqing and in Hunan, on the Yangtse River.[81] The IEA is more modest in its projections for China and believes that China will have nuclear power capacity of 11 GW in 2010 and 20 GW in 2020. The main reason the IEA is more cautious in estimating China's potential for installing a greater number of nuclear power plants is because of the high investment costs. The capital investment required for a nuclear power plant is three times higher per generated kWh than that needed for a Chinese-built coal plant.[82] Even if the NDRC is enthusiastic about constructing many new nuclear power reactors all over China, finding funding for such investments will most likely remain a problem. Still, if the nuclear power plants projected for the prosperous east coast provinces can guarantee a reliable energy supply for local industry, nuclear power plants may attract investment capital, especially foreign investment capital. Furthermore, the provinces in question have more money than other provinces, which means that they might be able to afford expensive investments in nuclear power.

Most of the Chinese nuclear power plants have been constructed by foreign companies from France, Canada, Russia and Japan. The long-term nuclear development strategy is however to rely on domestic technology and equipment. Still, China says it will continue to rely on international expertise and

[78] *China Daily* (2003),"Nuclear reaction", September 4, 2003. Downloaded July 5, 2004, from http://www.chinadaily.com.cn/en/doc/2003-09/04/content_261101.htm .
[79] Li Zhongliang (2001), "Radioactive waste and spent fuel management in China", speech at *Global 2001: Back End of the fuel cycle from research to solution,* downloaded August 2004, from http://www.cea.fr/conferences/global2001/Opening%20et%20Closing/Opening%20session%20LI%20Zhongliang.pdf .
[80] US Office of Civilian Radioactive Waste Management (OCRWM) (2001), China's Radioactive Waste Management Program, downloaded in July 2004 from http://www.ocrwm.doe.gov/factsheets/doeymp0409.shtml .
[81] *China Daily* (2003),"Nuclear reaction", September 4, 2003.
[82] Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p. 30.

cooperation for a long time ahead since it is still not technologically advanced enough in the field of nuclear power.[83]

The Chinese nuclear power plants are operated by China National Nuclear Corporation, CNNC, which is involved in both military and civilian nuclear activities. CNNC is the successor of the former Ministry of Nuclear Industry, which built China's first atomic bomb and hydrogen bomb as well as China's first nuclear submarine.[84] This indicates that while China is acquiring advanced nuclear power knowledge for civilian purposes from foreign sources, it might very well also be used for military activities. CNNC is also responsible for uranium mining in China, mainly in Guangdong and Shaanxi provinces. China has large findings of uranium[85] and does not have to rely on imports.

2.6 Biomass

Biomass is an important fuel, which is often omitted in statistical surveys on energy. Examples of biomass fuel are wood, crop residues, animal manure and other organic waste. The reason biomass is seldom included in statistical surveys is that it is hard to measure.

Biomass is a widespread fuel in developing countries. In China, biomass is commonly used as fuel in rural areas for cooking and to heat houses, but also to fuel rural industries. In 2000 approximately 706 million Chinese, or 56% of the population, mainly in rural areas, are supposedly dependent on biomass as fuel for cooking and heating. About half of the biomass used is agricultural residues, and 70% is for residential consumption. The IEA estimates that use of biomass in China will decrease by 9% between 2000 and 2030,[86] which is a larger decrease than in most developing countries.

Because it is hard to measure actual biomass use and because it is mainly produced locally, biomass will not be further discussed in this report. In sum, biomass often is an inefficient fuel, not only because it takes time to collect—time which could be used for more productive activities—but also because the stoves used for biomass are less efficient. The use of biomass has environmental effects, such as deforestation, which could lead to flooding, and could make agricultural production less efficient when animal manure is used as fuel rather than fertiliser.[87] Finally, biomass has a higher rate of carbon dioxide discharge than other fuels, which is important to bear in mind when looking at carbon dioxide emissions.

2.7 Other energy sources

Even if the Chinese government claims that it is going to establish renewable energy as a basic national policy,[88] renewable energy sources besides biomass and hydropower currently contribute only marginally to the country's energy production. However, there are signs that China is looking into the potential of renewable energy and Shanghai will introduce green electricity in late 2004 after having constructed a 3,400 kW windmill and a 10 kW solar power generator along the coast in its southern suburbs,[89] but this will only represent a minor share of the city's energy production.

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[83] Xie Ye (2001), "Seeking a power play" in *China Daily*, May 16, 2001. Downloaded July 5, 2004, from http://www2.chinadaily.com.cn/en/doc/2001-05/16/content_56997.htm .
[84] Chen Aizhu (2002), "High costs cap China's nuclear power plants", July 25, *Reuters*. Downloaded June 2004 from http://www.planetark.org/dailynewsstory.cfm/newsid/17001/newsDate/25-Jul-2002/story.htm .
[85] GlobalSecurity.org (2004), "China National Nuclear Corporation " downloaded November 2004 from http://www.globalsecurity.org/wmd/world/china/cnnc.htm .
[86] IEA (2002), "Energy and Poverty" in *World Energy Outlook 2002*, p.27-28. Downloaded June 14, 2004, from http://www.worldenergyoutlook.org/pubs/weo2002/EnergyPoverty.pdf .
[87] Ibid, p. 6-7
[88] Cao Desheng (2004), "'Renewable' becomes new energy priority" in *China Daily*, May 17, downloaded from http://www.chinadaily.com.cn/english/doc/2004-05/17/content_331304.htm .
[89] *China Daily* (2004), "Shanghai targets 'green' power plan", March 23, downloaded from http://www.chinadaily.com.cn/english/doc/2004-03/23/content_317086.htm .

Wind power: China has a huge potential of wind power equivalent to approximately 9% of the world's total available wind resources, or 4,600 TWh per year.[90] At the end of 2000, total installed wind power capacity was 375 MW, and according to the 10th Five-Year Plan (2001-2005), 3-5 wind farms with capacities of 10 MW each are to be built. Today, the majority of the wind power farms are located in Xinjiang, Inner Mongolia and Guangdong. Besides these provinces, windmills are to be built in Shanghai, Jiangsu, Hebei, Jilin, Liaoning and Heilongjiang.[91] The main obstacles facing wind power are the high costs of windmills, connections to electric grids and lack of incentive policies favouring wind power.

Solar energy: Similarly, China has a huge unexploited potential in solar energy. In 1999, total output was 3 MW, but it is hoped that by 2010 it should reach 150 MW and in 2020 solar energy output could be as high as 4-8 GW.[92] Solar energy faces the same obstacles as wind power to be overcome to be a success.

China is also looking into geothermal energy[93] and ocean energy[94] exploration, but at the moment these renewable energy sources remain of minor importance due to costs and lack of efficient technology.

[90] EWEA (2002), *Wind for 12: A blue print to achieve 12% of the world's electricity from wind power by 2020*, p 53, available on http://www.ewea.org/documents/WF12-2004_eng.pdf .
[91] CEI (2002), *Wind power nationwide*, September 19, downloaded June 18, 2004 from http://en.energy-china.com/en/renewable/china/outlook/outlooknr/1682/20020917/15825.html .
[92] CEI (2002), *Solar Energy*, September 17, downloaded June 18, 2004 from http://en.energy-china.com/en/renewable/china/outlook/outlooknr/1682/20020917/15847.html .
[93] CEI, 2002, *Geothermal*, September 17, downloaded June 18, 2004 from http://en.energy-china.com/en/renewable/china/outlook/outlooknr/1682/20020917/15813.html .
[94] CEI, 2003, *The present status of ocean energy exploration in China*, March 4, downloaded June 18, 2004 from http://en.energy-china.com/en/renewable/china/outlook/outlooknr/1682/20030304/24236.html .

3 Energy consumption

This chapter will address the following question:

- ***How is China consuming energy today?***

Findings:

- ***The industrial sector accounts for the largest share of energy consumption. The manufacturing sector, especially the steel, aluminium and chemical industries are the largest consumers.***
- ***About half of the consumed coal is used to produce electricity, gas and water supply.***
- ***New patterns are evolving in petroleum consumption where the transportation sector has increased its share of petroleum consumption from 10% in 1978 to 25% in 2002.***
- ***Electricity is also experiencing changes in consumption patterns as residential usage is slowly increasing its share with the increased ownership in electric consumer goods like TVs, refrigerators, electric fans and air conditioners.***

Even though China's energy consumption has grown considerably during the reforms, energy consumption per capita is still relatively low by global comparison. According to *BP Statistical Review of World Energy 2004*, China accounted for about 12% of the total global consumption of primary energy, whereas the US accounted for 23,6% (Sweden accounted for 0,5%).[95] In diagram 5, per capita energy consumption in 2001 measured as tons of oil equivalent is compared between some countries,[96] showing that developing countries like China and India lag far behind the developed world as well as behind the newly industrialised Asian countries like South Korea and Taiwan.

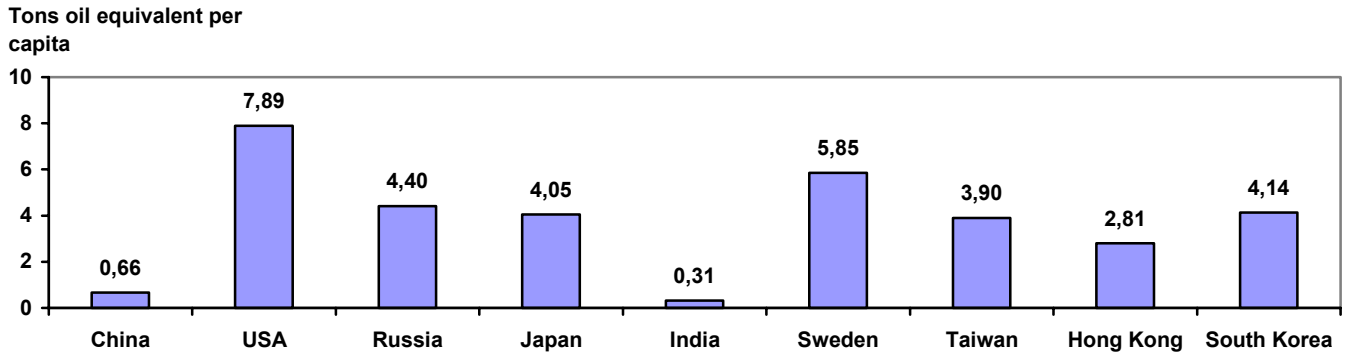

Diagram 5. Per capita energy consumption measured as tons of oil equivalent (Toe), 2001. Source: *Key World Energy Statistics 2003*, IEA, p. 48-56 and *BP Statistical Review of World Energy*.

The structure of these sectors' energy consumption in China has been relatively stable since 1990. The industrial sector is by far the largest, though the transport sector has increased its share of the total energy consumption during the 1990s.[97] In 2002, Chinese industry consumed 69% of the total energy consumed whereas residential consumption was the second largest consumer with 11% of the total, as illustrated in diagram 6a below.

Manufacturing stands out with a total 78% share of the total energy consumption in the industrial sector as illustrated in diagram 6b below. Within the manufacturing sector, the sub sector dealing with smelting and pressing ferrous metals, especially the steel and aluminium industries, is a large consumer together

[95] *BP Statistical Review of World Energy* (2004), June, p. 37.
[96] *Key World Energy Statistics 2003* (2003), IEA, p. 48-57.
[97] *China Statistical Yearbook 1997* (1997), 6-7*; China Statistical Yearbook 1998* (1998), 7-7; *China Statistical Yearbook 1999* (1999), 7-9; *China Statistical Yearbook 2000* (2000), 7-9; *China Statistical Yearbook 2002* (2002), 7-9; *China Statistical Yearbook 2003* (2003), 7-9; *China Statistical Yearbook 2004* (2004), 7-9.

with the chemical industry accounting for 19% and 14% of the total industry consumption respectively. 12% of the industrial energy consumption goes to the sector in charge of electric power, gas, water production and supply. Cement production is also one of the more energy intensive industries,[98] which explains why the energy need has increased with the recent years construction boom.

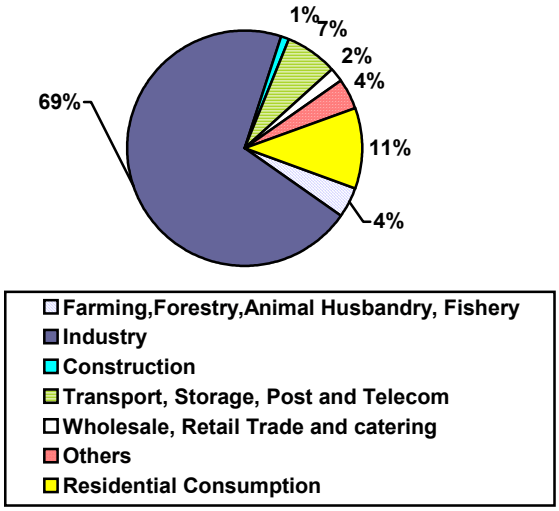

Diagram 6a. Energy consumption per sector, 2002, Source: *China Statistical Yearbook 2004* (2004), 7-9.

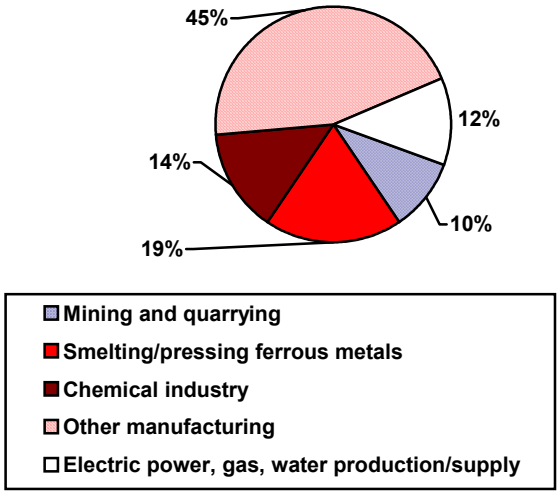

Diagram 6b. Energy consumption in different industry sectors, 2002. Source: *China Statistical Yearbook 2004* (2004), 7-9.

3.1 Coal consumption

Looking at different kinds of energy, the industrial sector dominates coal energy consumption, accounting for 90% of the total. Within the industrial sector, 48% is consumed in the electric power, gas, and water production and supply sector. 35% is used in manufacturing, and 80% of the coal consumed in the manufacturing sector is used in the smelting and pressing of ferrous metals, production of non-metal mineral products and the chemical and petroleum processing industrial sectorindustries.[99] As long as steel and chemicals retain their status as major Chinese industries, coal will almost certainly remain their most important source of energy.

3.2 Petroleum consumption

The industrial sector is also the heaviest consumer of petroleum, accounting for about 50% of the total amount consumed in 2002. For crude oil consumption, the majority is used in petroleum processing, to refine crude oil into other fuels including diesel oil and fuel oil.[100] The transportation, storage, and post and telecom industries have increased their respective shares of petroleum consumption since the early 1990s, accounting for 25% of the petroleum used in 2002, compared to 10% in 1980[101] (see diagram 7). This has to do with the major shift in the mode of transportation which has occurred since the start of the economic reforms: in 1978, 44% of the transported goods went by rail and 34% went on highways; in 2003, 14% of the transported goods went by rail and 74% by highway.[102] Passenger transportation has similarly shifted from railways to roads, with 6% travelling by train and 92% by highway in 2003 compared to 32% by train and 59% by highway in 1978.[103]

[98] Yergin, Daniel; Roberts, Scott (2004), *Riding the tiger: the global impact of China's energy quandry*, CERA Advisory Service, p. 8.
[99] *China Statistical Yearbook 2004* (2004), 7-9.
[100] *China Statistical Yearbook 2004* (2004), 7-4; 7-9.
[101] *China Statistical Yearbook 2004* (2004), 7-4.
[102] *China Statistical Yearbook 2004* (2004), 16-8.
[103] *China Statistical Yearbook 2004* (2004), 16-6.

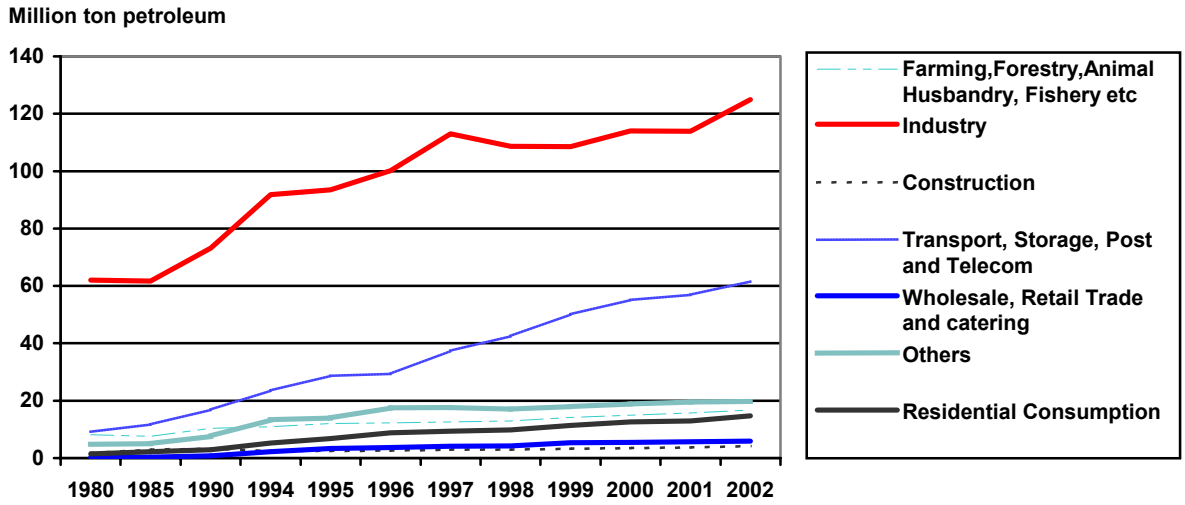

Diagram 7. Consumption of petroleum in different sectors. Source: *China Statistical Yearbooks* (1997-2004), 7-4.

Obviously, increased mobility following the economic reforms has had a great effect on the volume of passengers, which has gone up more than six times between 1978 and 2002. This is also reflected in the rapid growth of petrol-driven vehicles in China, as illustrated in diagram 8, which shows the rapid increase of private vehicles the last few years. In 2002, local car manufacturers launched a price war as tariffs on cars were lowered after China's entry into the WTO, causing the demand for cars to soar.[104] In 2003, car sales increased by a staggering 75%.[105] Many Chinese, especially in urban areas, view having a car as a wealth marker, but more and more simply find it convenient to own a car. This suggests that the trend of more and more cars on the Chinese roads will continue, which will increase the demand for petrol. Today, China has approximately 20 cars per 1000 inhabitants, compared with the global average of 120 cars per 1000 inhabitants, which means that the car market is likely to expand rather than decrease in the future. The actual demand for cars will depend on income levels of potential car owners, but also on whether China can solve the problem of energy supply shortages or not, as well as on their ability to solve the problems of congestion and environmental pollution.[106] Another problem facing the Chinese car market is the fact that Chinese cars consume 10-20 % more fuel than cars in developed countries do, and that the maximum permissible emission rates are higher than those of the US and Western European countries,[107] which means that Chinese cars both consume more fuel and generate more pollution.

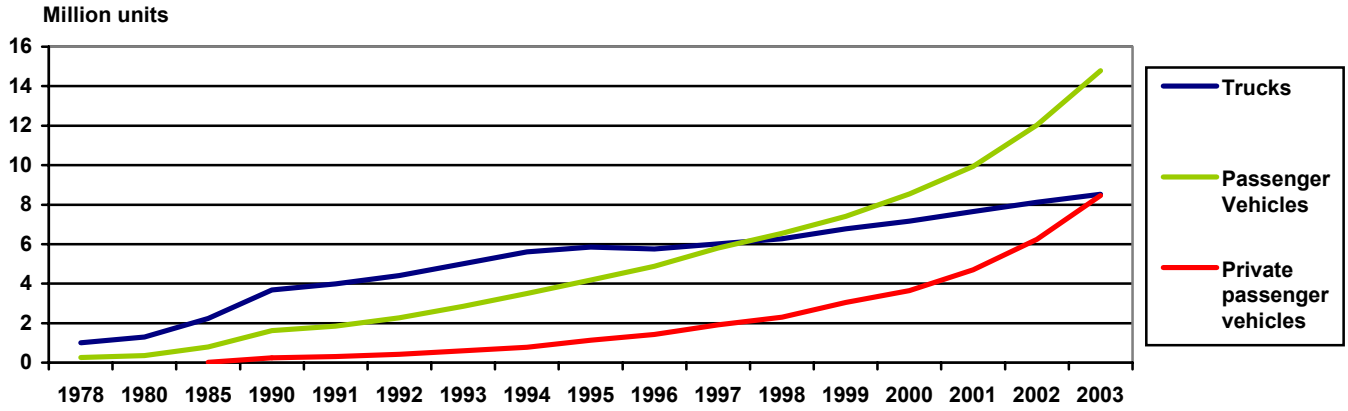

Diagram 8. Number of civil motor vehicles owned. Source: *China Statistical Yearbook 2004* (2004), 16-28, 16-29.

[104] Energy Information Administration (EIA) (2004), *International Energy Outlook 2004*, p. 32 downloaded on July 7, 2004, from http://www.eia.doe.gov/oiaf/ieo/pdf/0484(2004).pdf .
[105] *Dagens Nyheter* (2004), "Kinas efterfråga på råolja ökar", March 28, 2004.
[106] *China Daily* (2004), "Vehicle market growth poses challenges", May 11, 2004.
[107] Energy Information Administration (2004), *International Energy Outlook 2004*, p. 32-33.

At the same time, there has been a major shift within the railway sector from coal-driven steam locomotives, which dominated in 1978, to diesel locomotives[108] (most of the Chinese railway network is not electrified). This also affects petrol consumption in the transport sector, although not to the same extent as the expansion that has taken place in the transportation of goods and passengers by highway.

3.3 Electricity consumption

As with total energy consumption, the industrial sector stands out as the main consumer of electricity, with the same industries as the heavy consumers. There has not been as sharp an increase in the various specific industries' consumption of electricity as was the case with petroleum, except for a slight increase in residential use.[109] The existing electricity services are often unreliable and of poor quality, with undependable and sometimes unsafe wiring and meters,[110] which makes electric supply cuts a relatively common feature in China. Still, the trend is that electricity consumption is increasing rapidly, as will be seen in next section on energy and economic growth.

Despite the fact that more than 98% of the Chinese population was supposed to be connected to electricity in 2000,[111] leaving at least 26 million Chinese without electricity, the difference in electricity consumption between urban and rural areas is large. The difference has decreased since 1989, following the rapid electrification of China. In 2002 the per capita residential consumption of electricity was 238 kWh in urban areas compared with 106 kWh in rural areas.[112] One reason for this is the faster economic growth in urban areas, which has led to a greater purchasing power than in the rural areas reflected in e g the ownership of electric household products driving up the electricity consumption. Rural households are more likely to only use electricity to light up their houses and watch TV, while continuing to use biomass for heating and cooking.

In diagram 9 below, we can see that urban residents have higher ownership rates of colour TVs, electric fans and refrigerators compared to rural residents. The difference is especially evident with refrigerators and colour TV sets, but also with respect to air conditioners, which only averaged about 3 per 100 rural households in 2002, compared with 51 per 100 urban households. Refrigerators and air conditioners are said to be the largest household power consumers, using up nearly half the residential power supply today. Because frequent power shortages are a challenge to the demand for household appliances in China, domestic manufacturers are encouraged to develop energy-saving household appliances. [113] If Chinese industry is successful in doing this, it could create comparative advantages for the Chinese manufacturers of household appliances. The future demand for household appliances will mainly depend on increased income, but also on the supply of electricity and people's ability to handle electricity shortages.

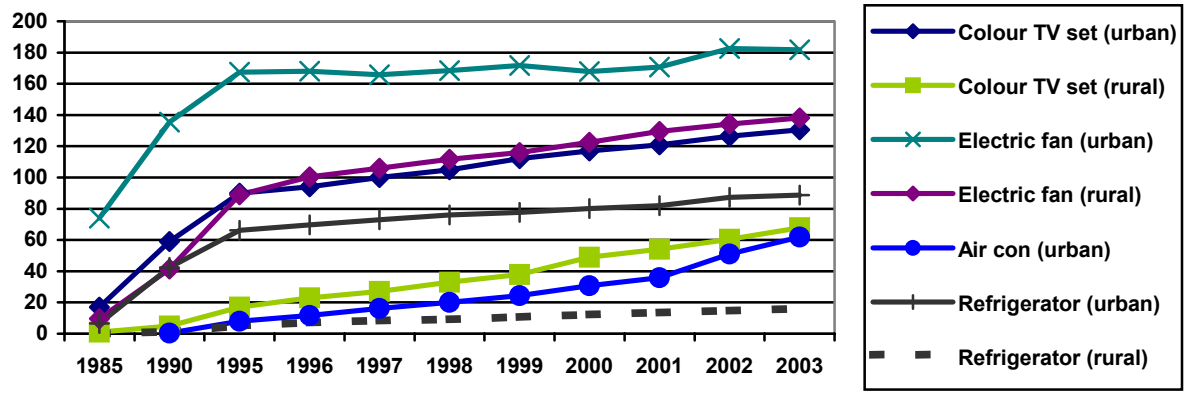

Diagram 9. Average number of products owned per 100 households. Source: *China Statistical Yearbook 1998* (1998), 10-13; 10-24; *China Statistical Yearbook 2000* (2000): 10-24; 10-11; *China Statistical Yearbook 2003* (2003), 10-16; 10-29; *China Statistical Yearbook 2004* (2004), 10-17; 10-30.

[108] *China Statistical Yearbook 2004* (2004), 16-17
[109] *China Statistical Yearbook 2004* (2004), 7-6
[110] IEA (2002), *Energy and poverty*, p.14.
[111] Ibid, p. 13
[112] *China Statistical Yearbook 2003* (2003), 10-1
[113] Zhang Lu, 2004, "Firms switch on to energy-saving items" in *China Daily,* March 5, 2004.

4 Economic growth and energy demand

This chapter will address the following question:

- ***What is the relation between China's GDP growth and its energy needs?***

Findings:

- ***China's GDP growth appears to have led to investment in energy saving industry equipment, while non-profitable state-owned enterprises have been closed down, which has led to a decrease in energy intensity in production.***
- ***Due to a heavily regulated market with low prices on electricity, it is common with power shortages when the economy is growing faster than expected, as the market cannot adjust to the demand by raising prices.***
- ***Lack of electricity slows down the GDP growth, but as there are moratorium on investments in industries with heavy energy consumption and lighter industries demanding less electricity, the electricity shortages of 2003-2004 appears to have had little effect on slowing down the GDP growth rate.***

Energy and economic growth are closely linked due to the fact that energy is one of the chief input factors for economic growth, along with capital, labour and technology. Diagram 10 illustrates the year on year growth of China's GDP, energy and electricity consumption. Until 2002, GDP growth was faster than the growth of both electricity and energy consumption. In 1999, electricity consumption grew faster than GDP growth. One reason for this is that China modernised its energy sector and has electrified the country since the mid-1980s. The dip in energy and electricity consumption in 1998 was mainly due to a government moratorium on the construction of power plants, and the closing down of small power plants to curb a temporary oversupply of energy and electricity.

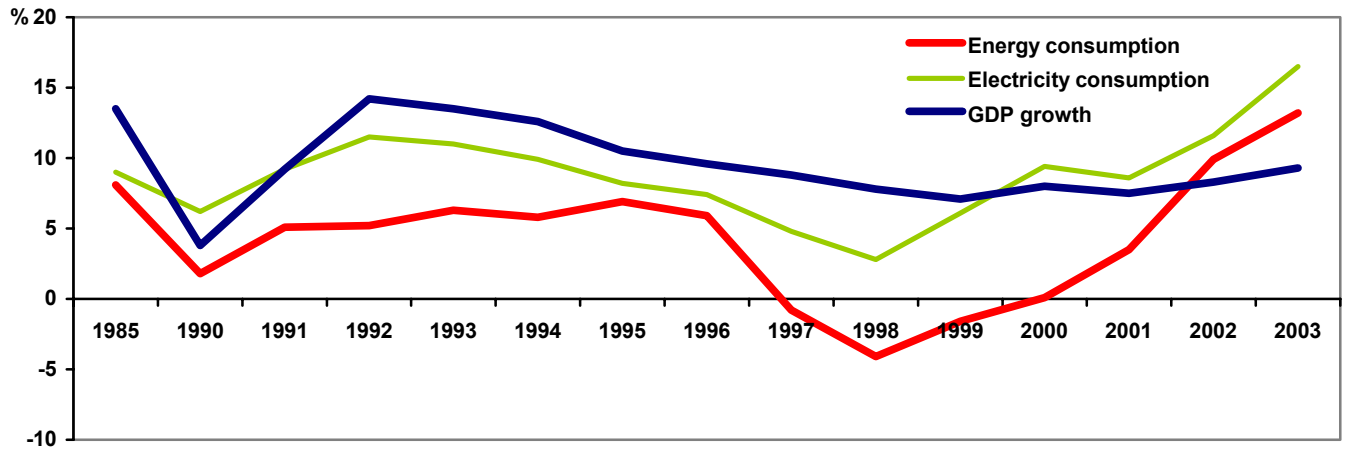

Diagram 10. Growth of GDP, energy and electricity consumption 1985-2002 as percentage compared with previous year. Source: *China Statistical Yearbook 2004* (2004): 7-8

The differences in growth rates between energy and GDP in the 1990s made some economists, like professor Thomas G. Rawski at University of Pittsburgh, question the speed of China's economic growth, implying that the GDP figures could in fact be falsified.[114] One item of evidence offered in support of the falsified GDP figures thesis[115] was the argument that the economy could not have grown so fast if, as

[114] It is common knowledge that Chinese statistics are not always reliable due to under and over reporting by local officials and also because there is politics behind the figures. However, the last few years, the statistics has improved and starting in 2004, China Statistical Bureau is to use international standards for statistical reporting.

[115] Rawski, Thomas G. (2002), "How fast is China's economy really growing?" in *The China Business Review*, March-April; 29; 2; p. 40-43. Other examples of falsified GDP growth rates, according to Rawski, were the fact that farm output increased in

claimed, energy consumption dropped by a total of 6.5% between 1997-1999 while GDP was supposed to have grown by 23.7%. Others, like professor Justin Yifu Lin at the China Centre for Economic Research at Peking University, claim that the reason why China was able to maintain a high growth rate of GDP while energy consumption declined was because of changes in its technology structure, where investments made firms adopt more energy-efficient technology, while less energy-efficient firms closed down.[116]

Nevertheless, many problems arise when economic growth is greater than the growth of available energy, so that energy requirements exceed the supply, leading to shortages. This is particularly evident with respect to electricity supply, where shortages were especially severe in 2003 and 2004 when electricity production failed to expand to meet economic growth. This poses the questions of whether and how long China will be able to sustain its economic growth despite energy shortages, and how China will deal with the situation. In a huge country with highly regulated electricity and energy prices, the Chinese market suffers when the supply of energy becomes insufficient as growth exceeds ecpectations. When, on the other hand, growth is slower than expected, overproduction immediately appears. Studying how China has handled energy shortages the last few years can be useful to give an idea of what might happen in the future, although the Chinese might solve the problems of shortages differently in the future, maybe by allowing market prices on electricity and energy. Below, we will look into the current situation of electricity shortages.

4.1 Case study: Energy shortages and rapid economic growth 2003-2004

In 2003 economic growth surged and the demand for especially electricity led to power shortages.[117] In 2004 the electricity shortage became even more severe, and there has been estimates of China's suffering from shortages ranging between 20-30 GW, with electricity demand growing between 11-12% and generating capacity only growing 9.6%. The main explanation offered for the present-day electricity shortage is that that there was insufficient investment in the electricity production sector in the late 1990s, due to overproduction at that time. Another reason for the shortage of electricity in 2004 is said to be the fact that electricity producers underestimated how much coal they would need in 2004 when making purchases at the annual coal fair in 2003.[118]

Electricity shortages have been particularly severe in prosperous provinces like Guangdong, Zhejiang, and Jiangsu as well as Beijing and Shanghai. Local governments in these areas repeatedly lobbied the central government for approval to construct new power plants to meet the demand and cash in, although the central government appears to have been somewhat restrictive granting the same, because they do not want to risk an oversupply of power in the future, as in the late 1990s. This, however, has led many local governments to go ahead and set up their own local power plants to meet the demand for electricity; approximately one fifth of all power plants currently under construction in China are said to be unauthorized.[119] Rapid economic growth has thus spurred illegal operations, making it harder for the central government to exercise a modicum of control over what takes place on the local level and thus to plan efficiently for the country's future development. It also affects the official statistics by underestimating the actual amount of energy consumed. In total, 200 billion RMB were invested in power generating projects in 2003, which was equal to the amount invested in 2001 and 2002 together.[120] This shows that the Chinese are taking active measures to meet the growing energy demand.

1998 despite severe flooding the same year; industrial production rose despite lower growth rates in products; investment rose despite low output of steel and cement; retail sales grew faster than household consumption spending; but also that unemployment has risen and there is deflation, which usually does not spur economic growth.

[116] Lin, Justin Yifu (2003), *Is China's growth real and sustainable?* Paper prepared for Fifth Goh Keng Swee Lecture on Modern China, given at East Asian Institute, National University of Singapore on December 15, p 12.

[117] Energy Information Administration (US) (2004), *China Country Analysis Brief July 2004*, p. 8.

[118] Energy seminar at the Pudong Institute of American Studies, September 2004.

[119] Xie Ye (2004), "Warnings of overheating in power sector" in *China Daily*, March 5.

[120] *People's Daily* (2004), "Severe energy shortage warned", June 13, downloaded from *http*://english.people.com.cn/200406/13/eng20040613_146171.html .

The majority of the new power plants constructed in 2003 and 2004 are coal fired, chiefly because they are cheaper to build, owing to the availability of domestic coal and reliance on domestic technology.[121] Many old power plants have probably also been reopened to meet the demand. This has led to an increased demand for coal, whhich in turns increases the pressure on the transportation network, especially the railways. Inadequate coal transport capacity is said to be responsible for about 1 GW of shortages.[122] Energy shortages spurred diesel consumption as many small industries use diesel engines to keep production going.[123] The trend thus appears to be that if China's economy grows faster than projected, older, less efficient and less environmentally friendly power plants are likely to reopen and diesel engines will come into increasing use. More coal and more diesel fuel are the initial reaction to power shortages.

Another method of handling energy shortages was the central government's use of macroeconomic controls to curb energy demand in the rapidly growing economy. In the spring of 2004 the Chinese government implemented policies such as cutting loans to energy-intensive sectors and other areas of the economy showing a tendency to overheat. A number of new construction projects were banned. These policies appear to have had effect with the economy cooling down slowly,[124] although not to the desired level. The Chinese government has an apparent wish to use macroeconomic management measures to control the economy, but shows an inability to efficiently use these kinds of measures as the Chinese economy still suffers from its heritage of the old command economy, including low prices on energy and electricity and a high share of state owned companies. If energy shortages are too severe this will hamper the important foreign investments, which was another import incentive to cool down the economy.

Other measures to alleviate the electricity shortage are to increase electricity prices,[125] which are fixed at relatively low levels,[126] although artificially low prices encourage wastefulness, and are generally not on par with the input price of primary energy raw materials. Cutting off electricity while trying to protect basic living needs of local residents has been another measure. During the summer of 2004, many energy-consuming factories sent their workers on "involuntary vacations" or shifted their operating hours to save energy. Foreign companies and important enterprises are given priority. Similarly, people have been encouraged to raise the settings of their air conditioners to save energy[127] in the "Save Energy campaign" pursued by environmental authorities and non-governmental environmental organisations. In Guangzhou, the local energy authorities proposed cutting the electricity to unnecessary decorative lighting, and considered importing energy from Hong Kong and other mainland provinces.[128] In Shanghai, the local government switched off decorative lightening when temperatures rose above 36 degrees Centigrade. An extreme measure has been to use artificial rainfall to lower the temperatures in cities.[129]

It is interesting to note the priorities applied in the distribution of energy during shortages due to rapid economic growth: first, there has to be power for residential use (to avoid popular discontent); secondly, power is distributed to foreign companies and other industries viewed as vital and whose needs the authorities feel they must respect; thirdly, electricity-intensive users are encouraged to close down temporarily so that energy can be made available to the first two categories.

4.2 Energy efficiency

One way of measuring the input rate of energy in economic growth is to look at the development of energy intensity during the economic reforms. Energy intensity is measured as the amount of energy consumed per unit of output, and diagram 11 shows million tons of Standard Coal Equivalent (SCE) used

[121] Batson, Andrew (2004), "China's choke-hold over Asia" in *Far Eastern Economic Review*, July 5, p. 29.
[122] Cao Desheng (2004), "Power plants hungrier for coal" in *China Daily Weekend*, June 19-20.
[123] O'Neill, Mark (2004), "Global rally in oil forces China to raise diesel prices", in *South China Morning Post*, May 19, 2004.
[124] Cheung, Allen T. (2004), "Statistics point to cooling economy", in *South China Morning Post,* June 11, 2004.
[125] Liu Li (2004), "Black-out, pricing to save electricity" in *China Daily*, June 10, 2004.
[126] Yergin, Daniel; Roberts, Scott (2004), *Riding the tiger: the global impact of China's energy quandry*, CERA Advisory Service, p. 10.
[127] Xiao Liang (2004), "Heavy energy consumers shift operation hours" in *China Daily*, June 10, 2004.
[128] Shi Jingtao (2004), "Sucked dry, Guangdong casts nets for energy", in *South China Morning Post*, March 30, 2004.
[129] Guo Nei (2004), "Electricity rate hike hearings to be held" in *China Daily Weekend*, June 19-20, 2004.

per billion 1990 RMB GDP.[130] Usually, developing countries have higher energy intensity per GDP output than developed countries because they use less efficient fuel, like biomass. When a country is developing, energy intensity usually increases at first, peaks at a certain point of time, and then decreases.[131] As can be seen, there has been a steady decline in China's energy intensity rate during the 1990s, which supports Justin Yifu Lin's argument that investments in new technology made Chinese industries more efficient. Other reasons for the decline in energy intensity are that there has been a shift in the industrial sector, moving from a focus on self-sufficient domestic heavy industry to a stronger focus on export-oriented, light industry. Changes in the energy pricing system, going from heavily regulated, lower prices to more market-oriented, although still regulated, higher prices,[132] have also made firms more attentive to energy-saving measures. Finally, an additional explanation for decreased energy intensity could have to do with inaccurate statistics, with over-reported GDP and under-reported energy production.[133]

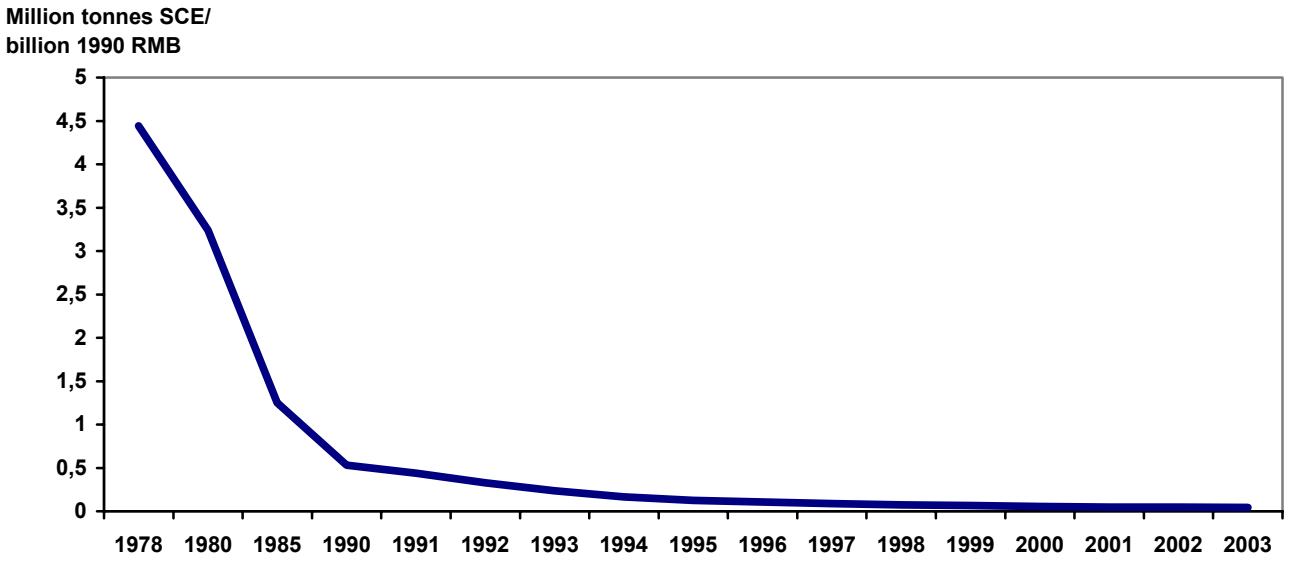

Diagram 11. Energy intensity: million tons of Standard Coal Equivalent (SCE) used per billion 1990 RMB. Source: *China Statistical Yearbook 2004* (2004), 3-4; 7-2.

But even if China exhibits declining energy intensity, its energy efficiency is still only about 33%, which is 10% less than the developing countries,[134] meaning that China is still not using energy efficiently. Currently, the rapid growth of the steel and cement industry catering to the real estate boom in many Chinese cities and the increased use of motor vehicles and electric appliances, exercises a restraint on energy efficiency.[135] Energy could be used a lot more efficiently, especially in the transportation sector, by reducing the amount of the fuel used, but also in the residential sector, since as Chinese houses are not well insulated, which means that much energy is wasted.

Another trend that could account for future declining energy intensity is that China has started to import more energy-intensive industrial products like steel and aluminium than before. In 2003 steel imports

[130] Standard Coal Equivalent, SCE, is a measure of energy used in coal rich China (globally, Oil Equivalent is more commonly used). The coefficient for the conversion rate of SCE into electric power is calculated on the basis of heat value equivalent where 1 kwh equals 0.1229 kg SCE, according to China Statistical Yearbook 2004 (2004), p.274. 1 ton of SCE equals 0.7 ton ton oil equivalent.
[131] Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p.16.
[132] China Coal Association (2003), *Zhongguo nengyuan fazhan baogao 2003 (China's Energy Development Report)*, Zhongguo Jiliang Chubanshe, Beijing, p. 86-87.
[133] Fisher-Vanden, Karen; Jefferson, Gary H.; Liu, Hongmei; Tao, Quan (2004), "What is driving China's decline in energy intensity?", in *Resource and Energy Economics*, Vol 26, p 81-87.
[134] *People's Daily* (2004), "Severe energy shortage warned", June 13, downloaded from http://english.people.com.cn/200406/13/eng20040613_146171.html .
[135] *People's Daily* (2004), "Energy consumption drops 4% annually", June 4, downloaded from http://english.people.com.cn/200406/04/eng20040604_145322.html .

increased by 50% over the previous year, and China accounted for 36% of global steel consumption, which influenced global steel prices. Furthermore, there is a minor trend of Chinese investments in energy-intensive industries abroad. For example, China has invested in the construction of steel mills in Brazil, which is its largest foreign investment ever, and has invested in an aluminium project in Vietnam.[136] This is an interesting trend as it means that China may increasingly influence world market prices of energy-intensive products, and that its foreign investments in energy-intensive industries may continue to rise in the future.

Declining energy intensity levels are interesting in the context of assessing the future energy needs of China, both because they show how advanced China's energy consumption is becoming, and also because it suggests that in the future China may not need as much energy to keep up its GDP growth rate as it has. However, China will most likely continue to exhibit relatively high energy intensity figures, due to its strong reliance on coal, which is an inefficient fuel compared to oil or natural gas.

[136] *The Economist* (2004), "China's material needs: The hungry dragon", February 19.

5 Energy in the future

This chapter will address the following question::

- ***How is China accommodating for its future energy supply and how much energy will it need?***

Findings:

- ***According to different projections, China will more than double its energy consumption between 2000 and 2020.***
- ***To accommodate to the increased demand, the Chinese government is focusing on both energy conservation and further developing current energy sources.***
- ***Coal with remain the most important energy resource in China, but there are plans to further develop coal into liquefied coal as an alternative to petrol and also to produce coal energy near the coal mines by using "coal by wire".***
- ***Oil will remain the second most important energy resource and China will cope with its increased demand by increasing its domestic oil exploration and grow longterm relations with oil exporting countries.***
- ***Hydropower, natural gas and nuclear power will be further expanded, with the greatest expansion is to take place with nuclear power, as the current seven reactors are to be 37 in 2020.***

China will need much energy to sustain its future economic development if it is to attain 7-8% annual growth in order to quadruple its GDP by 2020 compared to 2000, as expected in official planning. This will not only have domestic but also global implications. Because economic growth and improved living conditions are important to legitimise Communist rule, the central government is acutely aware of the problem of future energy demand, and it is actively working to secure future energy supplies. To handle the increased demand, the Chinese government is looking at both improving energy efficiency and further developing existing energy resources under the slogan "Develop energy and save energy equally much".[137]

5.1 Projections of energy demand in the future

Projecting energy requirements is a difficult task as there are many unknown variables involved, one of which is economic growth itself, which is simultaneously a dependent and an independent variable If future GDP is not as high as projected, the corresponding energy requirements will also be lower, whereas if the GDP grows faster than projected and the growth of energy supply is not equally fast, as in 2003 and 2004, further may be affected and slow down. This is why it is important to look at different growth scenarios when analysing China's future energy needs. Similarly, it is important to also study how energy intensity could decline by choosing different strategies and improving the technologies in use today.

Because of the many variables involved in projecting future energy demand, one has to use sophisticated statistical models and methods to calculate the future energy demand, which means that it is mainly larger governmental organisations that have the resources of doing these kinds of projections. In this section, we will look at projections made by the American Energy Information Administration, EIA, the International Energy Agency, IEA, and the Chinese National Development Research Centre of the State Council. There are few projections on future energy needs made by individual researchers due to the complexity of analysis. This means that one has to use the figures presented below as indications of trends and the magnitude of the future energy demand, and be aware of the uncertainty involved in the projections.

[137] China Coal Association (2003), *Zhongguo nengyuan fazhan baogao 2003 (China's Energy Development Report)*, Zhongguo Jiliang Chubanshe, Beijing, p. 1

The American Energy Information Administration, EIA, has made projections regarding total global energy consumption by looking at different growth scenarios. In their reference growth scenario, China's economy is supposed to grow by 6.1% annually between 1990 and 2025 and the global economy as a whole is assumed to grow 3% annually during the same period. In this scenario, China is projected to increase its energy consumption 2.4 times, or about 9.9% per year between 2000 and 2025, from 931 million tons oil equivalent in 2000 to 2294 million tons oil equivalent in 2025, as illustrated in diagram 12. In global comparison, this means that China's share of the world's total energy consumption will increase from 9% in 2000 to 15% in 2025, accounting for about 23% of the total growth in energy consumption.[138]

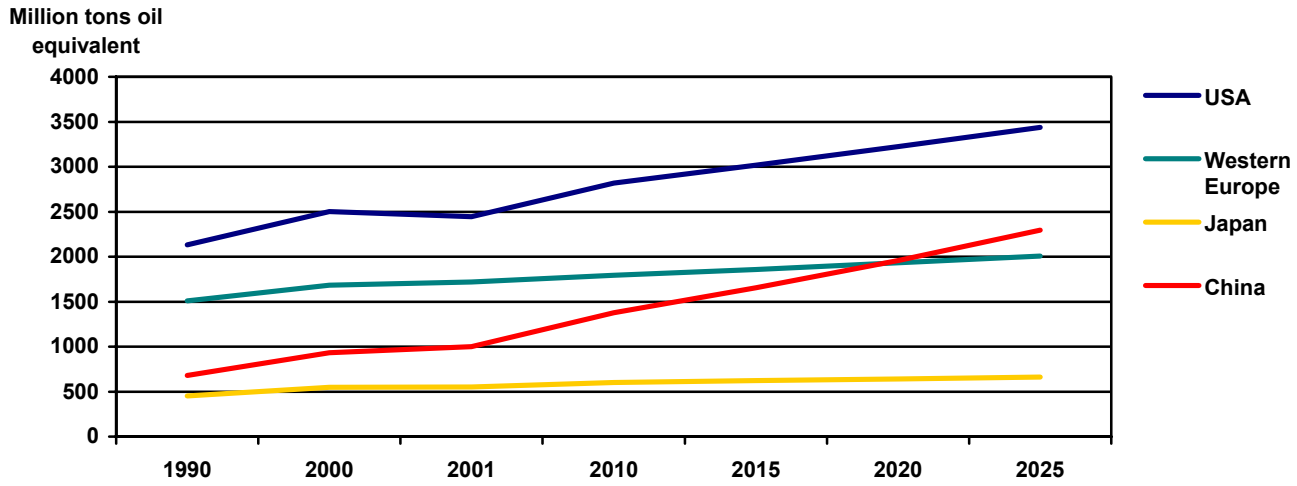

Diagram 12: World total energy consumption in oil-equivalent units per region. Source: *EIA International Energy Outlook 2004*, p 176.

The International Energy Agency, IEA, has also made projection about the future energy need of China, mainly based on the current economic growth rate, which they assume will slow down slightly after 2010, stating that China is likely to double its energy demand by 2030. China will account for one fifth of the global increase in primary energy supply and demand from 2000-2030,[139] which is a similar figure to the American EIA projections.

EIA has made extensive projections on China's future energy needs, looking at its requirements from many perspectives, including varying economic growth rate scenarios.[140] In diagram 13 the development of China's energy needs measured in million tons oil equivalent from 1990 to 2025 is shown in terms of three different scenarios: a low growth scenario with annual growth set at 5,1%, a medium growth scenario at 6,1% annual growth, and a high growth scenario at 7,1%. The difference between the lower growth scenario and the higher growth scenario is almost 40% in 2025.

Chinese authorities on the other hand, focus their projections of future energy demand on assumptions about how successful they will be in implementing different energy saving policies, holding the economic growth rate at the officially projected pace. In their scenario A, energy saving policies are implemented at a normal rate, whereas in scenario B and C, they are be more fiercely and successfully implemented, thus helping China to keep energy consumption at lower levels. According to the Chinese projections, China's energy needs will increase between 1.8 and 2.4 times from 2000 to 2020.[141] By implementing "a correct

[138] Energy Information Administration (2004), *International Energy Outlook 2004,* p. 166.
[139] *People's Daily*, 2003, "Energy conservation high on agenda", December 4, downloaded from http://english.people.com.cn/200312/04/eng20031204_129708.shtml .
[140] To calculate future energy needs, the EIA uses its own SAGE model (System for the Analysis of Global Energy Markets), which is based on current energy consumption patterns, existing stocks of energy using present-day equipment, characteristics of available new technology, and new sources of primary energy supply. For further information see the Energy Information Administration, 2004, *International Energy Outlook 2004*, p. 235.
[141] Feng Fei (2004), "Strategic concept for China's energy development" in *China Development Review*, vol 6, no 1, p. 10-11.

energy strategy and [if] relevant policies and measures are taken", China will be able to keep its energy demand growing at a relatively low rate, despite increased economic growth. It is interesting to note that the EIA and the Chinese projections turn out quite similarly, although they are calculated in different ways: the EIA uses market economy as their base for projections whereas the Chinese use policy implementation as their base for projections.

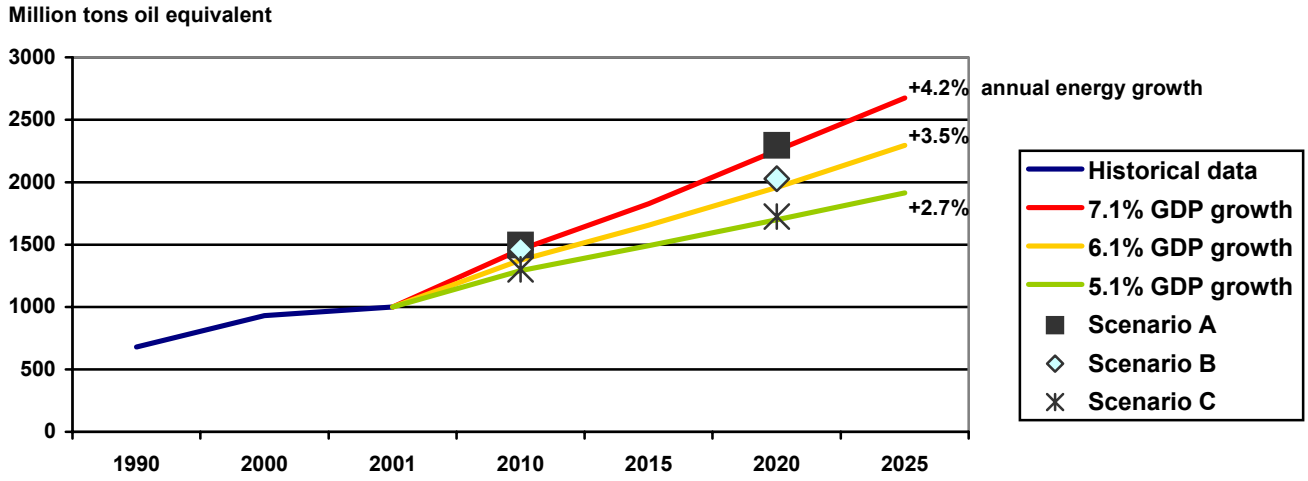

Diagram 13. Total historic and projected energy consumption in China 1990-2025, million tons of oil equivalent in different growth scenarios by EIA, compared with different energy saving scenarios projected by the Chinese National Development Research Centre. Source: EIA *World Energy Outlook 2004*, pp. 176, 194, 231; Feng Fei (2004), "Strategic concept for China's energy development" in *China Development Review*, volume 6, no 1, p. 10.

The above scenarios might appear optimistic as they consider China's economy growing at rates around 5-7%. If the Chinese economy does not keep up this fast economic growth, or China does not manage to implement energy conservation efficiently, the figures of projected energy consumption will most likely look different. If the Chinese economy slows down, energy consumption is likely to slow down as well. The other scenario where the economy continues to grow without energy conservation being implemented, the energy consumption is likely to increase further, but this would also lead to increased global and domestic energy prices, which would lead to a slow down of the economy in the long run.

5.2 Increasing energy efficiency

The Chinese government considers increasing energy efficiency equally important as further developing its current energy resources. One reason for this is the rapid decline in energy intensity. Making efficient use of the energy produced today would not only cost less than expanding energy production, it is also more environmentally friendly. Thus, the Chinese government has started to focus on sustainable energy development strategies to promote energy conservation. By promoting sustainable energy development strategies, the focus will increase on environment protection results rather than only promoting economic growth.[142]

Focusing more on the environment rather than solely on economic growth is consistent with the government's promoting "Green GDP", which is frequently mentioned in the Chinese debate about sustainable development.[143] The concept of Green GDP recognises the fact that China has to achieve sustainable development in the long run, which implies using existing energy resources wisely, decreasing pollution, and accepting slower long-term GDP growth. Currently, air pollution is for example estimated to cost between 3-7% of GDP.[144] Whether or not the discussions about Green GDP and its consequences for

[142] Chen Qingtai (2004), "China's energy strategy and policy", in China Development Review, Vol 6, no 1, p. 4-6.
[143] See for example Hu Angang (2004), *Zhongguo: xin fazhan guan (China: New Development Strategy),* p. 277-289, Zhejiang People's Publishing House.
[144] *People's Daily* (2003), "Energy conservation high on agenda", December 4, 2003.

energy consumption and economic growth will be manifested in Chinese economic policies in the near future remains to be seen. Still, by combining suggested government policies to promote an environment friendly energy strategy with increased public participation and with pollutants emission trading,[145] the promotion of sustainable development in energy could have an impact on China's improved energy efficiency.

Today, China's energy consumption per produced unit is relatively high in a global comparison. In specific high energy-consuming sectors, Chinese production is using almost 50% more energy than the average level in advanced countries.[146] The main reason for this is found in the relatively low prices of electricity and coal, both in the industrial sector and in the civilian sector. These are part of the heritage of the planned economy and leads to high tolerance of waste. The use of old technology in some energy-.intensive industries also stands in the way of improved energy efficiency. The EIA claims that China's energy consumption could be lowered by 30-50% if industrial energy efficiency could be raised to international standards.[147]

The State Council's National Development Research Centre says that energy efficiency could be increased by system innovation, technology innovation and government policies. One way of doing this is to allow the market reforms to expand so that energy prices can adjust themselves, forcing companies to improve their energy intensity in order to increase production revenues. Other measures would be to implement incentive policies for energy conservation as well as creating energy efficiency standards to improve the energy efficiency.

The State Council lists increased energy efficiency as one of the ways to go to attain a secure future energy supply.[148] Examples of how to increase energy efficiency include curbing blind investment and blind duplication in some industries, which should include further moves toward a full market economy. Today many localities are fiercely guarding their own interests and resist sharing their production with other regions. Curbing this kind of behaviour could lead to increases in not only energy efficiency but also in overall economic efficiencies.

Looking at the changes in the future energy consumption patterns we can also see that there are many opportunities to further improve energy efficiency in the sectors whose energy consumption is due to expand. This is especially true of the transportation and construction sectors, where energy efficiency could easily be promoted. As Chinese automobiles use 10-20% more fuel than automobiles in the industrialised world,[149] fuel-saving vehicles will most likely be promoted. For construction and residential use, much energy could be saved if all old and new buildings conformed to advanced energy conservation standards, which include simple measures such as double-glazing. Today, Shanghai has implemented regulations on energy saving measures in new construction,[150] but there is still a long way to go in this area. Another simple measure to increase energy efficiency is to provide cheaper, energy-efficient stoves to the rural population,[151] who often use biomass burning stoves, which are not only inefficient but also large producers of carbon dioxide emissions.

5.3 Changes in future energy consumption patterns

The creation of a relatively well-off society, the so-called *xiao kang* society, by 2020, when the economy is to have quadrupled compared with 2000, would mean that the current consumption structure would change significantly. By 2020 it is assumed that 60% of the Chinese population will live in urban areas,[152]

[145] Chen Qingtai (2004), "China's energy strategy and policy", in China Development Review, Volume 6, number 1, p. 5.
[146] Feng Fei (2004), "Strategic concept for China's energy development" in *China Development Review*, volume 6, number 1, p. 12-13.
[147] Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p.17
[148] *China Daily* (2004), "Cabinet OK's energy plan to 2020", July 1, 2004.
[149] *People's Daily* (2003), "Energy conservation high on agenda", December 4, 2003.
[150] *People's Daily* (2004), "Severe energy shortage warned", June 13, 2004.
[151] Smil, Vaclav (2004), *China's Past, China's Future: Energy, Food, Environment,* p. 26.
[152] Note that in China, urban areas also include semi-rural communities like townships.

compared with 40% in 2003. This, together with the expansion of the real estate sector in urban areas, means that consumption will increase in the housing and civilian sectors. Similarly, energy consumption in the transportation sector will rise, with many more vehicles, especially privately owned cars, diesel-driven trains, buses and lorries, transporting Chinese people and goods.

If we look at the projections for future energy consumption patterns produced by the National Development Research Centre, we see that these two sectors are deemed likely to account for 41-44% of the total energy consumption by 2020. Even though the industrial sector will remain the main consumer of energy in the future, the commercial and transportation sectors will account for between 50-60% of the total growth in energy consumption.[153]

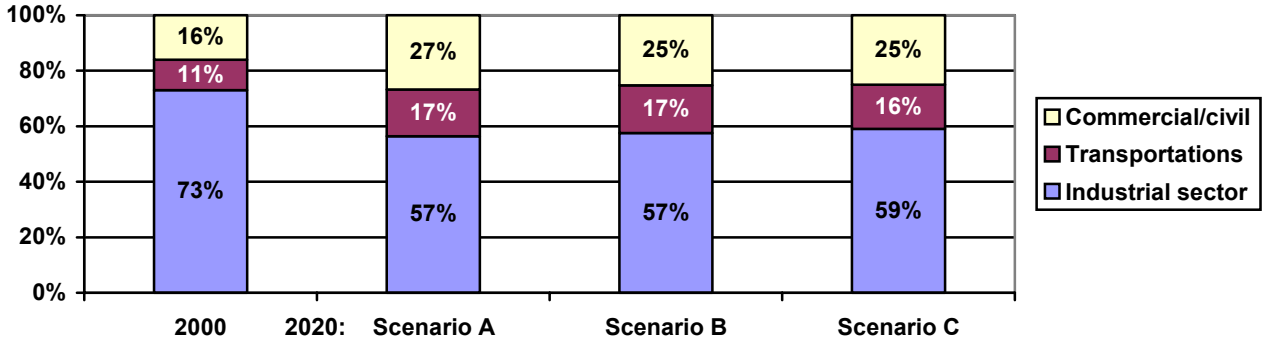

Diagram 14. Structure of energy consumption 2000-2020 in different scenarios. Source: Feng Fei (2004), "Strategic concept for China's energy development" in *China Development Review*, volume 6, number 1, p. 16.

5.4 Expanding the energy supply

The other important factor in China's overall strategy for dealing with its future energy requirements is to further develop the energy resources currently available in China. This will be done both by making energy companies more market oriented, and by relying on globalisation and China's membership in the WTO. The latter obviously implies that China will become even more dependent on imports of energy raw materials, especially oil.

Investments in the energy sector will most likely be very high, and the IEA estimates the total investment in energy production facilities between 2001 and 2020 to approximately 1.4 trillion US dollars. That sum is almost the same amount investments that Africa and Latin America are projected to make together the same period.[154] The investments in the energy sector will be both in technology improvements of energy efficiency and in expanding energy production facilities.

Looking into the use of different energy sources, coal will most likely continue to be the dominant source. According to other EIA calculations comparing 2001 with a projected 2020, China's future energy source structure will remain relatively similar to the current one, with coal dominating the scene and oil and hydropower remaining important secondary fuels. Natural gas and nuclear power are projected to double their present, very small share. The distribution of energy sources in 2001 compared with the projected distribution in 2020 are illustrated in diagram 14.

It should be noted that these projections were made before the Chinese government announced that it was going to expand the number of nuclear power reactors from 7 in 2004 to 37 reactors in 2020. This change has not been calculated into the projections below. The estimate now is that nuclear power will account

[153] Feng Fei (2004), "Strategic concept for China's energy development" in *China Development Review*, vol 6, no 1, p. 16.
[154] Yergin, Daniel; Roberts, Scott (2004), *Riding the tiger: the global impact of China's energy quandry*, CERA Advisory Service, p 7.

for about 5% of total electricity generating capacity in 2020, according to China Coal Association,[155] or, according to the National Development Research Centre, for 7% of total power generation in 2020.[156]

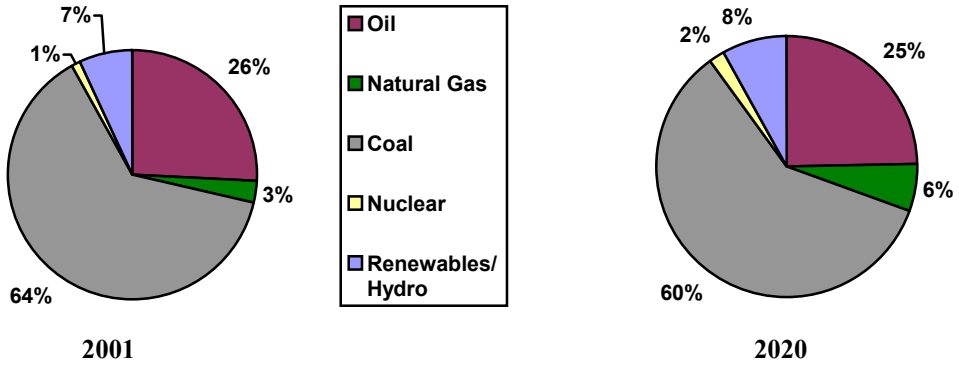

Diagram 14: Share of different energy sources in China 2001 vs 2020. Source: U.S.-China Economic and Security Review Commission, *Hearing on China's Energy Needs and Strategies*, (2003), testimony of Guy Caruso of the EIA, October 30, p. 18.

5.4.1 Coal

Coal will continue to be the most important fuel in China. This poses huge threats to the global environment, since China is expected to account for about 17% of total global carbon dioxide emissions in 2020, of which about 70% will come from coal, according to the EIA.[157] Since enhancing environmental protection is one of the areas China will focus on according to its Energy Development Programme from 2004 to 2020,[158] China will need to take srong measures to decrease its emissions if coal is to remain an important fuel. China will thus have to develop cleaner coal fuel. To improve the environment in the polluted urban areas, using coal by wire could be an option, but coal by wire is not necessarily clean and has environmental impact as well.

Another likely trend is that China will start importing coal to sustain its need. By 2010 China's coal supply is projected to be 100 million tons short of demand, and in 2020 it may be 600 million tons short of demand.[159] This means that coal consumption in China could go a similar way as oil, where China stops being an exporter and instead becomes an importer, and thus more active on the international coal market. China is also looking into how to make use of coal gas, i.e. coalbed methane, and how to make coal slurry for cheaper transportation by pipeline. Furthermore, China is becoming more open to foreign investment in its coal sector, and has expressed a strong interest in coal liquefaction technologies to develop liquid fuels based on coal as a petroleum substitute for transportation.[160] This could be an interesting substitute for gasoline and diesel fuel in a future in which oil might become too expensive to use as fuel for motor vehicles.

5.4.2 Oil

Oil will maintain its share of China's total energy consumption, but demand for oil will increase greatly, as will the country's dependence on imported oil, as is illustrated in diagram 15. The EIA expects China to consume 10.9 billion barrels per day by 2025, up from 5.26 million barrels per day in 2002. This means that China will have to import 7.5 million barrels per day,[161] which is more than all the oil Africa exports

[155] China Coal Association (2003), *Zhongguo nengyuan fazhan baogao 2003 (China's Energy Development Report)*, Zhongguo Jiliang Chubanshe, Beijing, p. 25.
[156] Feng Fei (2004), "Strategic concept for China's energy development" in *China Development Review*, vol 6, no 1, p. 17.
[157] Energy Information Administration (2004), *International Energy Outlook 2004*, pp. 172, 190, 206.
[158] Xinhua (2004), "Cabinet OK's energy plan to 2020", in *China Daily*, July 1, 2004.
[159] *People's Daily* (2004), "Severe energy shortage warned", June 13, 2004.
[160] Energy Information Administration (2004), *China Country Analysis Brief July 2004.*
[161] Energy Information Administration (2004), *China Country Analysis Brief July 2004*.

today.[162] In 2020 about 75% of the oil consumed in China will be imported, according to EIA projections.[163] The Chinese State Council's National Development Research Centre puts the figure for imported oil at nearly 60 per cent of the country's future total consumption.[164] Oil imports will be very important for the transportation sector. The implications of the increased dependence on imported oil is further analysed in Ingolf Kiesow's report on *China's quest for Energy; impact upon foreign and security policy*[165].

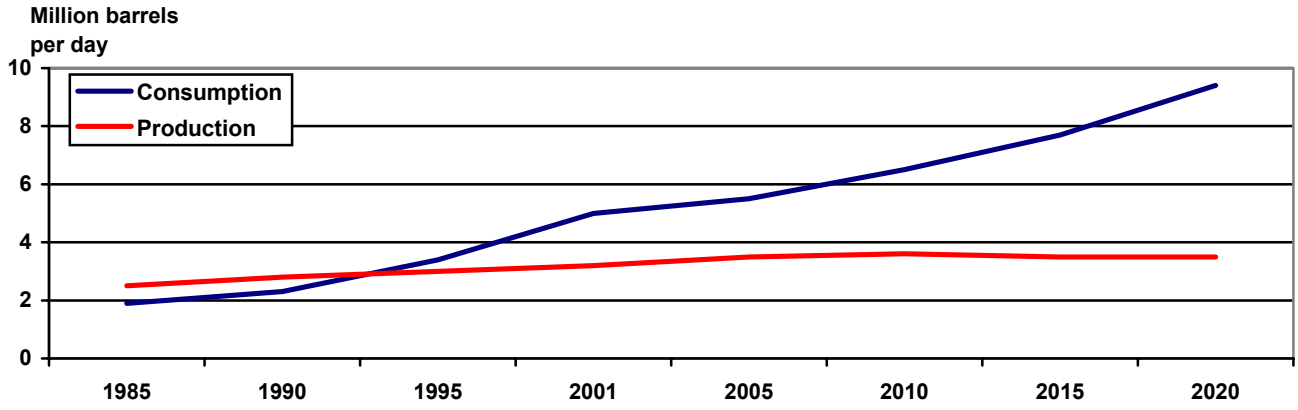

Diagram 13. Current and projected consumption and production of oil as million barrels a day. Source: EIA, *World Energy Outlook 2004*.

With stagnating domestic oil fields in the northeast and new oil fields situated in the far west,[166] construction of pipelines has high priority in securing the domestic oil supply, but the distances involved are enormous, like the 4,200 kilometers of the envisaged pipeline from the Tarim basin in Xinjiang to southwestern and eastern China.[167] Not only are new inland fields being exploited but offshore fields are being explored more thoroughly as well. Currently, production has been taken up in fields in the East China Sea, in the Bozhong field in the Bohai Gulf area, and in the south near the Pearl River outlet, and production will most likely continue in these offshore fields. Maritime boundaries complicate this activity, but improvements in relations with Vietnam have recently opened the way for both oil and gas exploration in the Gulf of Tonkin.[168] All of these actions are consistent with China's White Paper on Minerals, which says that China will try to increase domestic oil production to meet the increased demand. Emphasis will be put on trying to find more oil in deeper layers in the old fields, and to develop the newer oil fields in the west, as well as accelerating the exploration of offshore gas and oil, but also to discover new deposits.[169]

Higher oil prices poses a threat to Chinese economic growth, especially as China's oil purchases often are spot transactions, which makes China vulnerable in the face of volatile oil prices. Higher oil prices not only raise China's import costs but consumer prices as well, possibly leading to inflation,[170] which could affect the economic growth negatively. At the moment China's reliance on oil is not as high as the that of the United States, which means that China currently is relatively less vunerable to high oil prices compared to the US or Japan. Still, the Chinese are concerned about the impact of rising oil prices and do

[162] *Imports and Exports 2003, Energy in focus; BP Statistical Review of World Energy June 2004* (2004), p. 19.
[163] *China's energy needs and strategies, Hearings before the US-China Economic and Security Review commission* (2003), October 30, p 8, 18-19 available on http://www.uscc.gov .
[164] *China Daily* (2003), 15 December.
[165] Kiesow, Ingolf (2004), *China's quest for Energy; impact upon foreign and security policy*, FOI User Report, FOI-R--1371--SE.
[166] Energy Information Administration (2004), *China Country Analysis Brief July*, p. 4.
[167] Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p 24
[168] Energy Information Administration (2004), *China Country Analysis Brief July 2004,* p.4.
[169] *White Paper on mineral resources* (2003), "III. Increasing the Domestic Capability of Mineral Resources Supply", accessed June 19, 2004, available at http://www.china.org.cn/e-white/20031223/index.htm .
[170] Xu Jianguo (2004), "When oil prices soar" in *Beijing Review*, June 10, p. 10.

not favour high oil prices [171] — high oil prices make production more expensive in China, which could slow down foreign investments and economic growth. According to China's *White Paper on Minerals*, hopes are to reduce its dependence on spot trade by signing long term supply contracts with foreign companies and importing oil from diversified sources,[172] a trend that has already begun and is discussed further in Ingolf Kiesow's report *China's quest for Energy; impact upon foreign and security policy*[173].

It should be noted that China is currently driving the growth of consumption on the world oil market. In 2003 it accounted for as much as 30% of global consumption growth, and over the past several years it has accounted for 40% of this growth. This has strongly affected oil prices and made them increase, even though the Chinese blame today's high oil prices on instability in the Middle East.[174] China's fast-growing import of oil is, however, likely to continue to affect oil prices in the future. According to the EIA, China's oil demand will account for 16-22% of the global growth in oil demand between 2000 and 2025.[175]

Another problem with the future supply of oil is domestic. Much of China's future oil will come from Xinjiang, the home of a large minority group, the Moslem Uyghurs. Significant numbers of Uyghurs feel discriminated against by the Han Chinese and many are convinced that the Han Chinese are looting their land.[176] After September 11, 2001, the Chinese authorities have struck hard against any forms of resistance among the Uyghurs, labelling them terrorists, which has not created a good environment between the Moslems and the Han Chinese. If the Uyghurs do not feel they are receiving their share of the wealth generated by the oil industry in Xinjiang, tensions could grow even more serious. This could easily result in production problems, which in turn could make the Chinese dependence on imported oil even stronger. Another aspect is that much of the imported oil comes from Moslem countries, who may not react favorably if the Uyghurs are openly suppressed, which in turn could affect the imports.

5.4.3 Natural gas

The use of natural gas will likely expand rapidly in coming years, both as imports and via pipelines from the large deposits in western China and offshore. Increased demand for gas has already attracted investment in China's vast resources, mostly situated in the west. Gas is harder and more costly to transport by train than oil, which makes it is necessary to construct new pipelines for gas as well across the entire country. The construction of one of the largest pipelines which links fields in the Xinjiang province with the Shanghai area has already been finalised and is soon to be started for larger scale use. On the way east it will connect up with newly discovered fields in the Ordos Basin in Inner Mongolia.[177] According to the National Development Research Centre, domestic output of natural gas is to increase by four to five times by 2020, compared to 2002. Large-scale pipelines will also be constructed to simplify natural gas imports. It is likely that these pipelines are the same pipelines running from the western parts of China to the eastern parts and China will use them for imports of natural gas from Central Asia. The extent to which natural gas will be able to replace coal depends on if the price of natural gas is competitive and acceptable to consumers.[178]

The number of natural gas power plants has increased and many more are projected, especially on the east coast. Because natural gas is viewed as a clean energy source (although emitting carbon dioxide), both

[171] Chen, Allen T. (2004), "Mainland denies responsibility for rising international oil price", in *South China Morning Post*, May 26, 2004.
[172] *White Paper on mineral resources* (2003), "IV. Widening the Opening of, and Cooperation in, Mineral Resources Exploration and Exploitation".
[173] Kiesow, Ingolf (2004), *China's quest for Energy; impact upon foreign and security policy*, FOI User Report, FOI-R--1371--SE.
[174] Chen, Allen T. (2004), "Mainland denies responsibility for rising international oil price", in *South China Morning Post*, May 26, 2004.
[175] Energy Information Administration (EIA) (2004), *International Energy Outlook 2004*, p. 167, 185, 201.
[176] Fuller, Graham F.; Starr, S. Frederick (2004), *The Xinjiang Problem*, Central Asia-Caucasus Institute, p 4-6.
[177] Energy Information Administration (2004), *China Country Analysis Brief July 2004.*
[178] Feng Fei (2004), "Strategic concept for China's energy development" in *China Development Review*, volume 6, number 1, p. 17.

Beijing and Shanghai are investing in it, and Beijing is said to plan to replace many of its highly polluting coal-burning thermalelectric power plants with plants generating electricity from natural gas in time for the Beijing Olympics in 2008. Shanghai is similarly preparing for a cleaner environment at the World Expo 2010. Still, the central government will need to implement policies promoting the use of natural gas if the latter is to take off. These policies include tax rebates, stricter environment requirements, standardisation of natural gas, integrating current and future pipelines, and encouraging long-term power purchase agreements.[179]

5.4.4 Hydropower and other renewable energy sources

Hydropower will continue to be developed, but challenges are not only posed by nature itself through silting and water shortages, but by domestic opposition and complaints from neighbouring countries downstream. Currently, 66% of China's hydropower resources are located in minority nationality autonomous areas,[180] which means that future expansion of hydropower will also influence relations between Han Chinese and the minorities. However, many of the minority groups living in the mountainous areas in the southwest, where the hydropower resources are located, are relatively small and poor; they are less likely than the Uyghurs to be able to mount a threat to the expansion of hydropower.

Other renewable energy sources are likely to be developed, but only on a small scale due to what are currently high investment costs. According to the National Development Research Centre, renewable energy resources are to be actively developed to lay a foundation for future massive replacement of fossil fuels. Energy production from renewable fuels is to double between 2000 and 2020. Most of this expansion is to be through hydropower, but wind power is to expand its share to up to 20% of the mix of renewable energy resources, and biomass is to account for 10% and is to be used as a commercial fuel.[181]

5.4.5 Nuclear power

Nuclear power will also increase in terms of share of energy production. It is viewed as a relatively clean fuel, and as already mentioned, China's National Development and Reform Commission (NDRC) is projecting to construct at least 30 more reactors generating 32 GW by 2020[182] to meet the demand for electricity. Most nuclear power plants, which require large amounts of water for their reactors, will be located on the coast in the country's economically prosperous regions.

[179] *People's Daily* (2003), "Energy conservation high on agenda", December 4, 2003.
[180] *China Statistical Yearbook 2003* (2003), 2-8.
[181] Feng Fei (2004), "Strategic concept for China's energy development" in *China Development Review*, vol 6, no 1, p. 17.
[182] *China Daily* (2003), "Nuclear reaction", September 4, 2003.

6 Summary and conclusions

Today, China is using coal, oil and hydropower as main sources for the production of energy, and they will remain main energy sources in the foreseeable future. Natural gas and nuclear power provide only minor shares of the country's total energy production today but they are projected to at least double their share in China's future energy production. Industry, with steel, aluminium, cement and chemicals representing the most energy-intensive branches, account for 69% of energy consumption and is a main driver of energy demand.

China's GDP growth has until recently been faster than the growth in energy consumption. This could either be due to inaccurate statistics, including inflated GDP growth and deflated energy statistics, or due to restructuring in the Chinese industrial sector where inefficient state owned enterprises have been closed down and the focus has moved from heavy to light industry.

China will most likely more than double its energy consumption between 2000-2025 according to current economic growth projections provided by the EIA and others. The Chinese use lower projections for their energy consumption in 2020, stating that their energy consumption will increase between 1.8-2.4 times even if the economy is to quadruple in size. They plan to attain this lower increase in energy consumption by improving energy efficiency and decreasing the energy intensity, which is fairly high in a global comparison.

To handle the increased energy consumption, China will encounter large challenges. China degree of success in adjusting to its energy needs will be crucial to its future economic development. Providing enough energy to feed its economic development will also be crucial for the Communist Party, as continued economic development with rising standards of living is one of the most important components of its legitimacy. It will be crucial to increase energy efficiency, especially in industrial production, the main user of energy today, as well as in the transportation and construction sectors, which are projected to expand their energy demand in the future. The main challenges to be overcome are the transportation of energy resources, such as railway capacity for coal transport, oil and gas pipelines, and the interconnection of nationwide electric grids. Another challenge will be that of attaining access to secure oil supplies, both by further oil exploration within China and by expanding oil imports.

7 Appendix

List of abbreviations

CCP – Chinese Communist Party
CIAB – Coal Industry Advisory Board
CNNC – China National Nuclear Corporation
CNOOC – China National Offshore Oil Corporation
CNPC – China National Petroleum Corporation
CSY – China Statistical Yearbook
EIA – Energy Information Administration (US)
FEER – Far Eastern Economic Review
IEA – International Energy Agency
LNG – liquefied natural gas
NDRC – China's National Development and Reform Commission
NPC – National People's Congress
SCMP – South China Morning Post

Map of China

8 Bibliography

China Coal Association (2003), *Zhongguo nengyuan fazhan baogao 2003 (China's Energy Development Report)*, Zhongguo Jiliang Chubanshe, Beijing.
China Statistical Yearbook 1998 (1998), China Statistical Press, Beijing.
China Statistical Yearbook 1999 (1999), China Statistical Press, Beijing.
China Statistical Yearbook 2000 (2000), China Statistical Press, Beijing.
China Statistical Yearbook 2001 (2001), China Statistical Press, Beijing.
China Statistical Yearbook 2002 (2002), China Statistical Press, Beijing.
China Statistical Yearbook 2003 (2003), China Statistical Press, Beijing.
China Statistical Yearbook 2004 (2004), China Statistical Press, Beijing.
Fuller, Graham F.; Starr, S. Frederick (2004), *The Xinjiang Problem*, Central Asia-Caucasus Institute.
Hu Angang (2004), *Zhongguo: xin fazhan guan (China: New Development Strategy)*, Zhejiang People's Publishing House.
Kiesow, Ingolf (2004), *China's quest for Energy; impact upon foreign and security policy*, FOI User Report, FOI-R--1371--SE.
Lin, Justin Yifu (2003), *Is China's growth real and sustainable?* Paper prepared for Fifth Goh Keng Swee Lecture on Modern China, given at East Asian Institute, National University of Singapore on December 15.
Smil, Vaclav (2004), *China's Past, China's Future: Energy, Food, Environment*, Routledge, New York.
Studwell, Joe, (2003), *The China dream*, Atlantic Monthly Press, New York.
Yergin, Daniel; Roberts, Scott (2004), *Riding the tiger: the global impact of China's energy quandry*, CERA Advisory Service.

8.1 Web sources

2004 report to congress of the U.S.-China Economic and Security Review Commission (2004). Available on http://www.uscc.gov/researchreports/2004/04annual_report.htm .
Allen, Mike and Piper, Jeff (1999), *Coal in the energy supply of China,* Report of the CIAB Asia Committee, Coal Industry Advisory Board, International Energy Agency. Downloaded June 20, 2004, from http://www.iea.org/dbtw-wpd/textbase/nppdf/free/1999/coalchina.pdf .
BP Statistical Review of World Energy (2004). Downloaded from July 1, 2004, from http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/publications/energy_reviews/STAGING/local_assets/downloads/pdf/statistical_review_of_world_energy_full_report_2004.pdf .
Cao Desheng (2004), "'Renewable' becomes new energy priority", *China Daily*, May 17, downloaded from http://www.chinadaily.com.cn/english/doc/2004-05/17/content_331304.htm .
CEI (2002), *Wind power nationwide*, September 19, downloaded June 18, 2004 from http://en.energy-china.com/en/renewable/china/outlook/outlooknr/1682/20020917/15825.html .
CEI (2002), *Solar Energy*, September 17, downloaded June 18, 2004 from http://en.energy-china.com/en/renewable/china/outlook/outlooknr/1682/20020917/15847.html .
CEI, 2002, *Geothermal*, September 17, downloaded June 18, 2004 from http://en.energy-china.com/en/renewable/china/outlook/outlooknr/1682/20020917/15813.html .
CEI, 2003, *The present status of ocean energy exploration in China*, March 4, downloaded June 18, 2004 from http://en.energy-china.com/en/renewable/china/outlook/outlooknr/1682/20030304/24236.html .
China Daily (2004), "Shanghai targets 'green' power plan", March 23, downloaded from http://www.chinadaily.com.cn/english/doc/2004-03/23/content_317086.htm .
China Daily (2003),"Nuclear reaction", September 4. Downloaded July 5, 2004, from http://www.chinadaily.com.cn/en/doc/2003-09/04/content_261101.htm .
China's energy needs and strategies, Hearings before the US-China Economic and Security Review commission (2003), October 30, p 8, 18-19 available on http://www.uscc.gov .
Chen, Xavier (2002), *Developing China's gas market: The energy policy challenges*, IEA. Available on http://www.iea.org/dbtw-wpd/Textbase/publications/newfreedetail2.asp?F_PUBS_ID=475 .

Chen Aizhu (2002), "High costs cap China's nuclear power plants", July 25, *Reuters*. Downloaded June 2004 from http://www.planetark.org/dailynewsstory.cfm/newsid/17001/newsDate/25-Jul-2002/story.htm .
Energy Information Administration (EIA) (2004), *International Energy Outlook 2004*, downloaded on July 7, 2004, from http://www.eia.doe.gov/oiaf/ieo/pdf/0484(2004).pdf .
Energy Information Administration (EIA) (2004), *China Country Analysis Brief July 2004***.** Downloaded July 30, 2004, from http://www.eia.doe.gov/emeu/cabs/china.html .
EWEA (2002), *Wind for 12: A blue print to achieve 12% of the world's electricity from wind power by 2020*, available on http://www.ewea.org/documents/WF12-2004_eng.pdf .
GlobalSecurity.org (2004), "China National Nuclear Corporation " downloaded November 2004 from http://www.globalsecurity.org/wmd/world/china/cnnc.htm .
IEA (2002), "Energy and Poverty" in *World Energy Outlook 2002*. Downloaded June 14, 2004, from http://www.worldenergyoutlook.org/pubs/weo2002/EnergyPoverty.pdf .
IEA (2003), *Key World Energy Statistics 2003*. Downloaded June 14, 2004, from http://library.iea.org/dbtw-wpd/Textbase/nppdf/free/2003/key2003.pdf .
Li Zhongliang (2001), "Radioactive waste and spent fuel management in China", speech at *Global 2001: Back End of the fuel cycle from research to solution,* downloaded August 2004, from http://www.cea.fr/conferences/global2001/Opening%20et%20Closing/Opening%20session%20LI%20Zhongliang.pdf .
Offshore (2001) "Incoherent energy policy may stall China's plans to expand gas", April.
People's Daily (2003), "Energy conservation high on agenda", December 4, downloaded from http://english.people.com.cn/200312/04/eng20031204_129708.shtml .
People's Daily (2004), "Energy consumption drops 4% annually", in June 4, downloaded from http://english.people.com.cn/200406/04/eng20040604_145322.html .
People's Daily (2004), "Severe energy shortage warned", in June 13, downloaded from http://english.people.com.cn/200406/13/eng20040613_146171.html .
US Office of Civilian Radioactive Waste Management (OCRWM) (2001), *China's Radioactive Waste Management Program*, downloaded in July 2004 from http://www.ocrwm.doe.gov/factsheets/doeymp0409.shtml .
White Paper on mineral resources (2003), accessed June 19, 2004, available at http://www.china.org.cn/e-white/20031223/index.htm .
Xie Ye (2001), "Seeking a power play", *China Daily*, May 16. Downloaded July 5, 2004, from http://www2.chinadaily.com.cn/en/doc/2001-05/16/content_56997.htm .
Xie Ye (2004), "Rising oil cost won't derail economy" in *China Daily*, May 11, downloaded May 19, 2004 from http://www.chinadaily.com.cn/english/doc/2004-05/11/content_329590.htm .
Xinhua (2004), "China's hydropower resources tops world" in *China Daily*, May 30, downloaded from http://www.chinadaily.com.cn/english/doc/2004-05/30/content_334949.htm .
Ögütçü, Mehmet (2000), *China's worldwide quest for energy security*, IEA, p 13. Downloaded May 28, 2004, from http://www.iea.org/dbtw-wpd/textbase/nppdf/free/2000/china2000.pdf .
Ögütçü, Mehmet (2002), *Foreign direct investment and the importance of the "Go West" strategy in China's energy sector*. Downloaded May 2004 from http://www.oecd.org/dataoecd/1/35/2085596.pdf .

8.2 Articles

Batson, Andrew (2004), "China's choke-hold over Asia" in *Far Eastern Economic Review*, July 5.
Cao Desheng (2004), "Power plants hungrier for coal" in *China Daily Weekend*, June 19-20.
Chen Qingtai (2004), "China's Energy Strategy and Policy" in *China Development Review*, Volume 6, No 1, 2004.
Chen, Allen T. (2004), "Mainland denies responsibility for rising international oil price", in *South China Morning Post*, May 26.
Chen, Allen T. (2004), "Statistics point to cooling economy", in *South China Morning Post,* June 11.
Cheung, Ray (2004), "After 50 years, torrent of criticism is still flowing" in *South China Morning Post*, June 28.
China Daily (2004), "Cabinet OK's energy plan to 2020", July 1.

China Daily (2004), "Vehicle market growth poses challenges", May 11.
Dagens Nyheter (2004), "Kinas efterfråga på råolja ökar", March 28.
Fang, David (2004), "Industrial accidents on mainland drop 13 pc" in *South China Morning Post*, June 14.
Feng Fei (2004), "Strategic concept for China's energy development" in *China Development Review*, volume 6, number 1.
Fisher-Vanden, Karen; Jefferson, Gary H.; Liu, Hongmei; Tao, Quan (2004), "What is driving China's decline in energy intensity?", in *Resource and Energy Economics*, Vol 26, p 81-87.
Guo Nei (2004), "Electricity rate hike hearings to be held" in *China Daily Weekend*, June 19-20.
Hoyos, Carola; McGregor, Richard (2004), "PetroChina ends talks on pipeline" in *Financial Times*, August 4.
Liu Li (2004), "Black-out, pricing to save electricity" in *China Daily*, June 10.
O'Neill, Mark (2004), "Global rally in oil forces China to raise diesel prices" in *South China Morning Post,* May 19,
Rawski, Thomas G. (2002), "How fast is China's economy really growing?" in *The China Business Review*, March-April; Volume 29, no 2.
Shi Jingtao (2004), "Sucked dry, Guangdong casts nets for energy", in *South China Morning Post*, March 30.
South China Morning Post (2004), "Railways stuck in time warp in rush to fuel economy", June 15.
The Economist (2004), "China's material needs: The hungry dragon", February 19.
Xiao Liang (2004), "Heavy energy consumers shift operation hours" in *China Daily*, June 10.
Xie Ye (2004), "Experts warn against rushing into LNG market", April 2, in *China Daily*.
Xie Ye (2004), "Warnings of overheating in power sector" in *China Daily*, March 5.
Xu Jianguo (2004), "When oil prices soar" in *Beijing Review*, June 10.
Zhang Lu, 2004, "Firms switch on to energy-saving items", March 5, *China Daily*