

Oil and Gas in China

Paper no. 1

Developments in the Chinese Market for Oil and Gas

with Reflections on

- the Overall Energy Picture,
- Environmental Problems
- and Economic Growth.



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Introduction

China has had one of the fastest growing economies in the world since 1978 with an average of 7.4% annual real growth in GDP (Maddison, 1997). Such growth brings with it a rapid increase in energy demand reflecting the development of industry, the rise in motorised transportation, the urbanisation and the overall higher standards of living.

From the inception of the People's Republic in 1949, China was a net exporter of energy for nearly half a century. Not being able to cover its domestic demand anymore, however, China has increased imports, and became a net importer of oil in 1993. Yet, extraction of oil and gas make up a relatively small part of the overall energy production in comparison to coal, of which China has an enormous production and even export. Hence, China didn't become a net importer of *energy* as a whole until 1995.

The energy sector is a necessary force to keep the economy going, and to ensure high living standards. It is also a very capital demanding sector. Further, the production and use of hydrocarbon energy is the main source of environmental problems for the world. China recognises the strategic importance of the energy supply, of energy security and of the environmental problems. Still, due to the size of the economy, Chinese authorities will have huge problems implementing appropriate policy responses to the difficulties mentioned. The importance of state control for the authorities also mean that they will have to find some new and controversial solutions to these problems.

This paper is the first of three articles about Oil and Gas in China. Whereas this first article shall focus on Oil and Gas in the overall energy perspective, the domestic market and its relation to Chinese economy, and the environmental issues, the other two articles will take a deeper look into the organisation of the industry, and China's access to external petroleum resources, respectively.

Oil and Gas in the Overall Energy Picture

Primary Energy Production

The proven coal reserves in the beginning of this decade was around 990 billion short tonnes, which is more than 35% of the world total, and more than any other country. (Liu, 1997) Still, only 126 billion short tonnes of this is profitable to extract under today's economic and technical conditions (EIA, 1999). In 1995 solid fuels accounted for 76.9% of China's primary energy production. (IEA, 1998) This shows that coal is the backbone of Chinese energy production today. However, there are problems with this lack of diversity. First of all, coal is often unpractical in final energy consumption, and therefore has to be converted to other energy forms, losing a lot of the energy. Second, the coal reserves are geographically very uneven distributed, thus resulting in a problem of distribution. Finally, coal combustion is not a very clean burning, and it releases different waste gases that poses a threat to the environment. Still, the vast coal reserves will make coal an important element of the energy production mix also in the future, though expectedly decreasing the share of solid fuels to 67.3% of the total by 2020. (IEA, BAU, 1998)

Proven oil reserves in China 01.01.1998 was 24 billion barrels (IEA, 98). xx of world reserves. The Chinese expects the number to grow quickly, as they are currently rapidly increasing exploration activities. Still, with expected future oil production barely increasing from today's rate of 19% of total primary energy production, and economic growth leading to high increase in demand for oil - mainly for transportation - china prepares itself for large scale imports in the future.

Proven natural gas reserves in China 01.01.1999 are 1.359 Tcm. (EIA, 99) xx of world reserves. Of this 0.020 Tcm are extracted annually. This makes up 2.0% of China's total primary energy production. Natural gas is much more expensive to transport than oil and coal, because it has so big volume per unit of energy. Normally, it is converted into LNG for transportation, which is also quite expensive. Still, natural gas burns much more clean than oil and gas, and electricity generators based on gas are cheap to build. The Chinese authorities therefore plan to increase the share of natural gas in the total production mix to 4.1% through 2015. (Liu, 1997)

Hydro electricity represents an enormous potential for Chinese energy production. Total potential, based on annual water flow, is 676 GW. Just as overwhelming is the share of technically and economically available potential, which is 380 GW. This makes up an annual production potential of 1.920 TWh, or 15% of the world potential. (Liu, 1997) Although hydro electricity represents a certain environmental cost, in that dams must be build, waterfalls must be piped, and river paths must sometimes be changed, the positive aspects should not be undervalued. First of all, hydro electricity is a renewable energy source. Second, although it requires huge investments, the marginal cost of the production is less than any other energy source. And finally, unlike generation technologies based on burners, hydro power has the unique property of being able to adjust production on a few minutes notice - which is essential for an efficient electricity distribution. Still, in 1995, China had a hydro power production of only 191 TWh. (IEA, 1998) That amount to 1.9% of total primary energy production. With several ambitious projects on the line, this will expectedly increase to about 3% over the next 20 years. (IEA, BAU, 1998) Also the hydro electricity generating capacity is geographically quite uneven distributed, with 70% of the total capacity in the south-western

part of the country. (Liu, 1997) Together with the coal resources, however, the overall energy resources is to a certain degree evened out.

China's first nuclear plant became operational in 1991, the second in 1993. These are of Chinese design, and their annual generation lies around 13 TWh, which is only 0.3% of total primary energy production. Still, Chinese authorities sees "controlled thermal nuclear fusion as a renewable energy of the next generation". (Song, W.J., 1997) Another four projects are now under development with Russian, French and Canadian firms. Official plans call for ca 150 TWh in 2010 and 300 TWh in 2020. Given that nuclear is a capital-intensive option - with per kW costs three times higher than those of a Chinese coal power plant - and given the long lead time in such projects, Internatioanl Energy Agency expects in their Business as Usual projections about half the projected capacity to be built. (IEA, BAU, 1998)

China has abundant renewable energy resources. In some remote off-grid locations, development of alternative energy can be economic. Such development is given priority in many provinces, and is often included in rural electrification programmes. Wind energy has the largest potential, with 250 GW. (Ca 900 TWh/y given 40% utilisation) Expected capacity will be 2 GW in 2010 and 4 GW in 2020. (IEA, BAU, 1997) There are also photovoltaic and geothermal potential, but development are expected to be of limited importance in the near future.

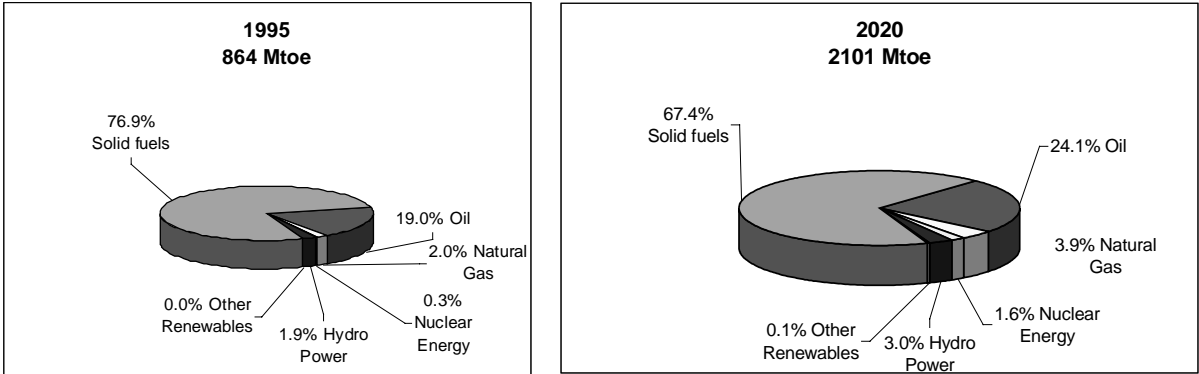
The amount of energy generated through burning of bio mass is difficult to estimate. This is not commercial energy use, thus burning of bio mass usually is ignored when talking about energy production. Still, an average of reliable resources gives an estimate of annually generation of 200 Mtoes in 1995, or as much as 19% of China's primary energy production. Bio mass consists of fuelwood and agricultural residues (straw and stalks), and it is directly burned in low-efficiency energy devices. The energy is used for heating, cooking, and preparation of animal feed. Virtually all bio mass energy is used in Rural areas, where approximately 70% of the population live.

Table 1: Primary energy production in Mtoe

	1995		2010		2020		Annual growth rate
Solid fuels	664	76.9%	1087	69.7%	1416	67.4%	3.1%
Oil	164	19.0%	355	22.8%	506	24.1%	4.6%
Gas	17	2.0%	57	3.7%	81	3.9%	6.5%
Nuclear	3	0.3%	19	1.2%	33	1.6%	9.6%
Hydro	16	1.9%	39	2.5%	62	3.0%	5.5%
Other renewables	0	0.0%	2	0.1%	3	0.1%	
Total	864		1559		2101		3.6%

The numbers are derived from the 1998 IEA BAU-projection. Biomass, which expectedly constitutes 19% of total primary energy production, is here excluded.

Figure 1: Primary energy production



Generation of Electricity

In 1997, electricity generation in China was 1036 TWh. (EIA, 1999) Compared to Australia, USA or Japan. Table 2 shows the composition of the electricity generation, and how IEA's BAU-projection expects the development over the next 20 years. The enormous growth in electricity demand is likely to be met with China's most abundant resource, coal. Still, coal's share in the electricity generation mix is projected to decline to two thirds, as some incremental demand is covered by hydro and nuclear energy.

Table 2: *Electricity Generation in China in TWh*

	1995		2010		2020	
Solid fuels	767	74.0%	1729	69.2%	2612	67.7%
Oil	63	6.1%	168	6.7%	257	6.7%
Gas	2	0.2%	65	2.6%	123	3.2%
Nuclear	13	1.3%	72	2.9%	127	3.3%
Hydro	191	18.4%	457	18.3%	726	18.8%
Other renewables	0	0.0%	7	0.3%	11	0.3%
Total	1036		2498		3856	

The numbers are derived from the 1998 IEA BAU-projection.

Demand

In the past, energy consumption in China was allocated rather than individually chosen. Further, although trade in oil and gas is carried through, it has been on a low level. Hence, the consumption of energy to day is not very different from the production. In the future, however, this is expected to change as demand different from supply leads to trade.

On the demand side, there is expected a rapid penetration of oil and gas. Gas grids already exist in many large cities. The growth in demand will partly have to be covered by imports. China's energy demand for mobility is relatively low. Whereas energy used in transportation on an average make up a 33% share of total final energy demand in OECD countries and 23% in developing countries, the share is only 9% in China. The demand for mobility, mostly oil, is, however, expected to increase with nearly 5% annually the next 20 years. (IEA, BAU, 1998) This, as well, will partly have to be covered by imports.

The industrial sector in China accounted for about 66% of total final energy consumption in 1995. This is relatively much compared to OECD average, which is 31%. The iron & steel and chemical industry combined demand about 50% of this share. The inefficiency is big due to a large stock of small-scaled plants. The industry uses mostly coal.

About 68% of electricity is consumed in the industrial sector, and 23% in the residential and commercial sector. The demand of electricity is expected to grow 1:1 with real income, thus at rate of ca 5.4% over the next 20 years (IEA, BAU, 1998). This high growth rate is due to substitution of electricity for coal in many industries, as the structure shift towards less energy intensive industries, when energy prices rise to world level. In the residential and commercial sector, energy demand growth will be increased by further penetration of electrical appliances - everything from washing machines to computers. Only about 80% of China's population is connected to the electricity grid. (EIA, 1999) Continued electrification in rural areas, will therefore be another factor for increasing electricity demand.

Conclusion

After the U.S., China is the largest energy consuming country in the world, with about 10% of total energy consumption. The most striking feature of the Chinese energy market is its overwhelming dependence on coal. In 1996, coal accounted for more than three quarters of primary energy supply, and for almost the same share of primary energy consumption. Oil accounted for about one fifth, with gas and hydro sharing the remainder. Still, this excludes the non-commercial consumption of bio mass energy, which, if included, would probably account for one fifth of total energy use.

Total primary energy demand in China is expected to grow from its rate of 0.65 toe (7,5 MWh) per capita per year (compared to Australia's 5.17 toe/c/y) with about 3% per annum over the next 20 years. (Peng, 1996) Thus, the energy intensity (Energy consumption/GDP) is expected to fall, as it has been doing through the whole period of fast economic growth the last 20 years.

The distribution of energy will be an important challenge in the coming years. While major coal and oil resources are in the north, and while most of the hydro electricity potential is concentrated in the southwest, the main energy consuming regions are in the south. Huge bottlenecks already exist in electricity transfer and coal transportation. For example, 60% of rail transport is tied up in transporting coal. (EIA, 1999) In the future, this problem is likely to be met with a high voltage cable grid connecting the different parts of the country. Coal energy will be transformed to electricity where it is extracted. (Song, 1997)

Energy prices in China are mostly controlled by the government. Almost all fuel prices were traditionally below economic cost and below world market price level. In June '98 following the Asian financial crisis and the oil price fall, the State Council decided to link crude oil prices closely to international prices on a monthly basis. One can expect that this will cause big changes in the industry and in oil demand, now that prices are back at high levels.

Since the early 80s, successive Chinese governments have introduced different measures to reform the energy industry. Policy mechanisms and the behaviour of economic agents are in a process of substantial change. Yet, the following example shows that the state owned firms, although underlined substantial independence, still have to follow government foreign policy concerns when making sales decisions: Although a net importer of crude oil, China is exporting significant amounts of crude, mostly to Japan. When CNPC (China National Petroleum Corporation) decided to cut the sale to Japan, to focus on the domestic market, the Japanese protested to the State Bureau of Petroleum and Chemical Industries. CNPC had to continue the supply. (EIA, 1999)

As this chapter has shown, oil and gas makes up a relatively small share of the total energy production picture in China. Still, China represents a huge market because of its great population. Moreover, in the industrial sector, as well as in the residential and commercial sector, the main expected change in the fuel mix, is the rapid penetration of oil and gas at the cost of coal. Oil and gas consumption is expected to show an annual growth of 4.5% and 5.2% respectively. Solid fuels only 2.4%. (IEA, BAU, 1998)

Relations between Economic Growth and Consumption of Energy

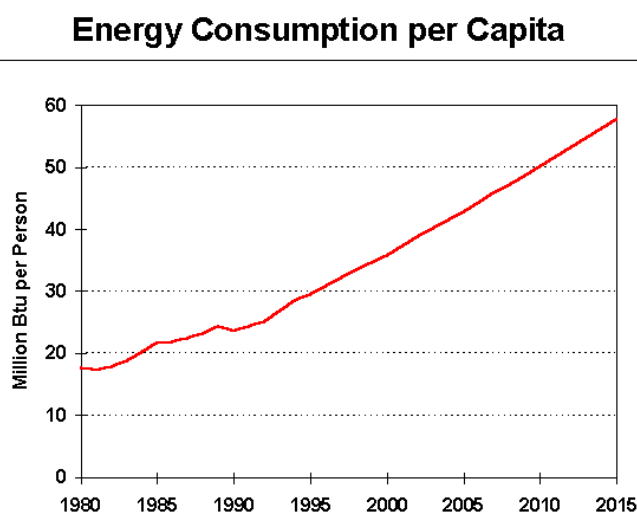
In the connection between economic growth and the energy usage, we have to consider the energy consumption per. capita, energy intensity and energy consumption per dollar of gross domestic product (GDP).

Energy consumption per. capita

China's consumption of energy per capita is very low compared to the developed countries. In 2015, the average American is expected to consume over 6 times as much energy as the average person in China (source: EIA). The average in the developed economies of the Organisation for Economic Cooperation and Development (OECD) is 8 times higher. Note that this is only the developed countries in OECD. Comparable Asiatic countries like Taiwan and South Korea are using 4 times as much.

Although China's energy consumption per. capita is low, we expect it to rise steadily over the next 20 years. On average the growth rate is estimated to be 4.3% annual growth between 1995 and 2015, although the last 10 years are showing a weak expansive tendency, which might indicate the start of an energy consumption trend-change towards a more demanding society.

Figure 2 – Energy consumption per capita in Mbtu per person (source: EIA)



As we can see from figure 2, EIA expects to have a steady linear increase in the energy consumption per capita. Figure 3 compares this to the energy usage in the US.

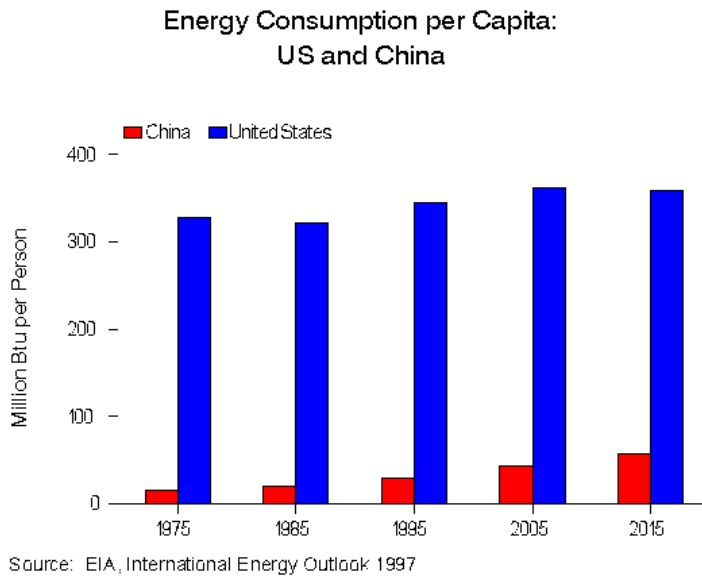


Figure 3 – Energy consumption pr. capita, US/China comparison

Energy intensity

The energy intensity of China has been declining since 1980, when the level was 120 000 Btu per GDP dollar (1990 dollars). This is fairly high compared to the US energy intensity, which was 20 000 Btu per GDP dollar. In 1980 that was very high on an international level. Despite significant improvements, China still has one of the world's highest energy intensity values.

The energy intensity measure is important, as it is an indication of the level of technology and efficiency in energy usage of a country. Factors like more efficient power plants and factories are highly influential, both on the economy and the welfare of the nation.

Since 1980, the energy intensity measure of China has been decreasing rapidly, annually 4 000 Btu per GDP dollar, which is about 4 times higher than the development in the United States. That indicates that China's power-producing efficiency is improving fast. The 1995 measures are 60 000 Btu per GDP dollar, compared to US' 18 000 Btu per GDP dollar.

Going forward to 2015, we expect the energy intensity to drop about 1200 Btu per GDP dollar each year – while the US has stabilised itself at what is recognised to be a minimum at 16 000 Btu per GDP dollar, decreasing only 100 Btu per GDP dollar per annum.

Energy Intensity: China and United States, 1970-2015

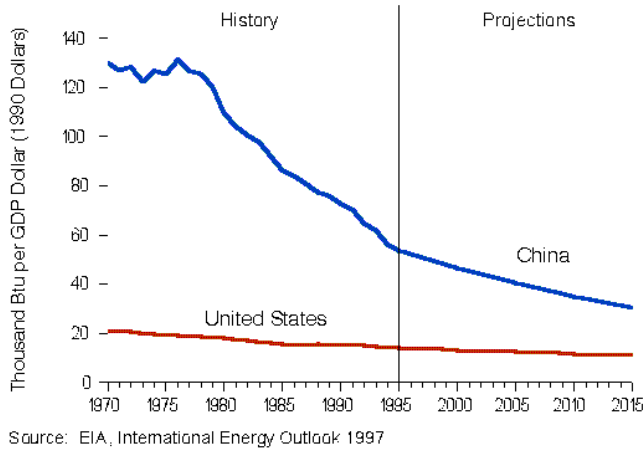


Fig. 4 - Energy Intensity Development, History and Projected – Source : EIA Outlook

Conclusion

As mentioned in the introduction, there is a clear relation between economic growth and the usage of energy. The decrease in energy consumption/dollar GDP, as well as the decrease in energy intensity, is a clear sign that the efficiency of the Chinese power plants and the efficiency of the industry powerusage is increasing. What is worrying, is that the energy production is not increasing fast enough compared to the increasing demand for energy. If the oil-production is not speeded up, this will slow down the industrial growth and hence the economic growth.

A point worth noticing is the importance oil has in the infrastructure. Oil is a mobile source of energy, and is closely connected to the transport-section, which is very important for the development of the Chinese society. Oil is also a chemically complex product that works as a source for a large petrochemical industry to produce plastics, fertilisers, synthetic textiles and so on. A lot of these products are very important in the ongoing industrialisation. The oilsector is therefore much more than just energy.

As China increases production onshore and offshore, and also involves foreign partners into the petroleum industry, this will benefit other industries as well. The oil is therefore extremely important for the economic growth of China.

Overview of the domestic production of oil and gas

Corporations and structure

China's petroleum industry has been reorganised into two integrated firms, the China National Petroleum Corporation (CNPC) and the China Petrochemical Corporation (Sinopec). These two organisations emerged as a reorganisation in 1998, of trying to separate the petroleum-industry's functions of government from those of the standard SOE's. The second goal of the reorganisation was to increase the state control over the domestic oil sector.

CNPC had originally been involved in mainly upstream production and exploration activities, while Sinopec took care of downstream refining and distribution. The reorganisation unified them to two regional entities, with CNPC in the north and west and Sinopec in the south. Sinopec transferred four northern refineries to CNPC, while CNPC transferred eight southern oil fields to Sinopec.

The total domestic production capacity is 2.95 million bbl/d, with CNPC utilising 2.20 million bbl/d and Sinopec 0.75 million bbl/d. Total domestic refining capacity is 4.50 million bbl/d, with CNPC at 2.05 million bbl/d and Sinopec at 2.45 million bbl/d.

There are also two other major state petroleum companies. China National Offshore Oil Corporation (CNOOC) handles offshore exploration, production and accounts for roughly 10% of China's domestic oil production. China National Star Petroleum was established 1997.

Geographic dispersion

Approximately 90% of the Chinese oil production is located onshore. The largest field, Daqing, supplies 1.0 million bbl/d of China's production, out of a total of 3.2 million bbl/d. This field is maturing and is expected to slow down production in the years to come. The government would like to stabilise the production in the eastern regions at current levels, increase productions in new fields in the west and develop the infrastructure required to deliver the western oil and gas to consumers in the east. The most notable recent discovery has been the Tarim Basin in the Xinjiang province in western China. The production is currently at only 80,000 bbl/d and the cost of transporting the oil to the east is high.

As previously mentioned, CNOOC has so far controlled the offshore oil production, but the other state firms are also beginning offshore projects. Recent exploration has been focused on the Bohai Sea area, east of Tianjin, which holds an estimation of 1.5 billion barrels. Another major offshore field has been developed in the Peral River Mouth area by a consortium consisting of Chevron, Texaco, Agip and CNOOC. It is estimated to reach a production of 27.000 bbl/d when it's fully operational. Improvement in Sino-Vietnamese relation also allowed exploration in the Beibu gulf. The Sprately islands are also expected to hold significant oil and gas reserves, but this area is claimed by several neighbouring states.

Foreign investment

The Chinese encourages foreign investment, provided that the Chinese partner holds a controlling interest. The main foreign firms involved include Agip, Exxon, Shell, Texaco and Mitsubishi.

According to previously mentioned statistics, China expects to be more dependent on oil imports in the future. China has as such been acquiring interests themselves in exploration and production abroad. CNPC holds concessions in Kazakhstan, Venezuela, Iraq, Sudan and Peru. The most significant acquisition so far is a 60% stake in the Kazakh oil firm Aktobemunaigaz.

There are studies underway to consider the feasibility of a pipeline carrying crude from Kazakhstan to China.

The downstream infrastructure development works primarily on upgrading existing refineries rather than building new ones. A problem which has arisen is the lack of refining capacity for heavier middle eastern crude, which will become necessary as Chinese imports increase in the future. It is estimated that China will only have about 1 million bbl/d heavy crude refining capacity by 2005.

Natural gas

China expects that gas will contribute to 6% of the total energy usage by 2010.

The largest reserves of gas are located in the western part of China, again proving the necessity of making pipeline infrastructure to carry gas and oil to the eastern cities. Imported gas is supposed mainly to be used in the coastal area. The Guangdong province has already launched a project to construct six 320 megawatt gas-power-plants, and to convert existing oil-fired power plants with a capacity of 1.8 gigawatts to using gas instead. This is a healthy development for the environment as well as the economic situation of China. The south of China will also benefit a lot from offshore production increases, such as the Yacheng field which began its production in 1996.

Oil and Gas in the Environmental Context

Background

30 years ago, most Chinese peasants were too poor to buy coal. Instead, in the relatively cold climate, with temperatures below zero most of the winter, they burned dried leaves and the like to warm their huts. People were used to having their walls white with frost. During the last 20 years, however, economic reforms have been giving people money enough to enable them to buy coal. In the same period, the industry has sixfolded its consumption of natural gas and tripled its consumption of oil. This should be good news, because burning coal has made the Chinese somewhat warmer in the winter for the first time in history, and the industries' increased production supply the people with goods. However, multiply the story by China's huge populations, and its hundreds of thousands of industry plants, and one understands why nearly 1 of 3 deaths there is linked to the bad conditions of air and water. (Time, 1999)

The environmental aspects should never be forgotten in a discussion about production and consumption of energy. As the last paragraph shows, this is especially true for China. Further, it is natural to focus on the polluting emissions from combustion of fossil fuels, including coal, oil and natural gas, since this represents the biggest environmental problem for China - and for the world. The biggest of the rising environmental threats of the 21st century in a global view, is perhaps the danger of an overall climate change. This danger will be emphasised here. The more local problems will be mentioned closer to the end.

The Emissions

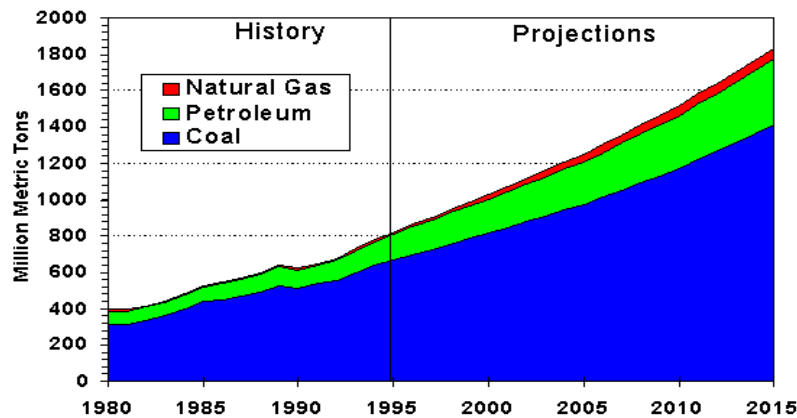
During the oil shocks in the 1970s, the question asked was "*Will we run out of gas?*". Today we know that this is not the right question to ask. We have enough carbon based fuel to see us through the next century. The issue now is that if humans burn anywhere near that much carbon, we'll burn up our place on the earth as well. Burning of fossil fuels are changing the balance of CO₂ and other heat-trapping gasses in the atmosphere. The *greenhouse effect* has, according to scientific theory, the potential to make substantial changes to the climate on earth in a relatively short span of time. At today's emission rates, atmospheric CO₂ concentrations will double by the middle of the next century. According to the Intergovernmental Panel on Climate Change (IPCC), this will result in an increase in world atmosphere temperatures by 1.5 - 4.5 C° and cause mean sea levels to rise by 0.25 - 0.5 meters.

China is, after the U.S., the world's second largest emitter of GHGs (greenhouse gases). Energy consumption accounted for more than 80% of total GHG (greenhouse gas) emissions in China in 1990 (Johnson, 1996). Thus, if China doubles its energy consumption over the next 20 years, as we have seen it is expected to do, it will move up to number one on the GHG emission statistics. Although energy intensity (Energy consumption per unit GDP) has been cut nearly in half since 1970, the industries continue to use energy far more intensively than in developed countries.

The main greenhouse gases are CO₂ (carbon dioxide), CH₄ (methane), N₂O (nitrous oxide) and chlorofluorocarbons (CFC). Using the so-called GWP (global warming potential), one can compare the importance of the different gases to each other. According to this method, CO₂ make up 85% of China's GHG gases, methane 13% and N₂O 2%. CFC, which in addition to being a potent greenhouse gas, also destroy the ozone layer, are drastically reduced in China and are being phased out under the Montreal Protocol Convention. Consumption of coal and oil are the main reasons for CO₂ emissions in China. Industry and power generation produce 75% of the emissions together. Methane emissions are released in the

process of oil and gas production, oil refining, natural gas transmission and from coal mining. (Johnson, 1996)

Figure 6: *Chinas carbon emission by fuel,*



China's carbon emissions are expected to increase about 4 percent annually through 2015. The country's total carbon emissions should exceed 1.8 billion metric tons in 2015, more than double the 1995 emissions. (EIA, 1999)

Potential Climate Change Impacts on China

The low income countries are likely to be most affected by an eventual climate change, because their economies are more dependent on climate-sensitive sectors, such as agriculture, and because they don't have the same possibility to adapt necessary measures, like building dikes. A doubling of CO₂ will lead to higher temperatures, soil evaporation, and more frequent and severe storms. As this will have negative impact on production of e.g. rice, wheat and cotton, one expects agricultural production to fall by 10 - 12% in developing countries. (Johnson, 1996)

Since China has a huge part of its population living in low-lying coastal plains, the rising sea level should be of great concern. A 1 meter increase in sea level, combined with tides and storms, will flood areas below a 4 meter contour line in Chinas coastal plains. The flooded land would cover cities like Shanghai and Canton, and would displace around 70 million people. (Johnson, 1996)

Possible Options for Reduction of Emissions

There is substantial uncertainty in the climate change process and in the predicted impacts of an increase in temperature. Until this uncertainty is reduced, it is rational for China to focus on a policy for GHG reduction that additionally make sense for economical, social or other environmental reasons. This because a low-income country, like China, have many other urgent developmental needs. Some possible solutions are shortly outlined below.

Improvement of energy efficiency by reducing the amount of necessary energy to produce one unit has the greatest potential for reducing emissions in an economic way. The first step to achieve this is to adapt high world prices on all fossil fuels. This will lead to restructuring in the industries to save energy. The modernisation should include adaptation of more up to date industrial processes, achievement of economies of scale and improved management. Since China today has huge amounts of smaller industrial plants, the increase in plant scales have

probably the highest potential for saving. Further, classic industrial energy conservation projects should be carried through, including improved waste heat, gas and waste stream recovery. The state should control energy efficiency of new models of widely used equipment. Last but not least should the supply of coal be underlied stricter control, including washing, screening and sorting.

In addition to improved energy efficiency, the other main option for large scale reduction of GHG is the substitution of non carbon alternatives for fossil fuels. Most of the low-carbon fuels that could play a role here are judged to be more costly than coal and oil over the next 25 years, even when costs of meeting strict environmental standards for fossil fuels are added (Johnson, 1996). There are, however, some opportunities for expanding economically reasonable investments in the energy supply. This includes investments in hydroelectric power, the use of coal-bed methane, fuelwood production and wind powered electricity generation. Expanded exploration and development of natural gas is also economically rational, and consumption of natural gas is relatively clean compared to oil and especially gas. Further development of nuclear power is also a possibility. Still, this is also quite expensive, and brings with it other environmental concerns.

By instituting a massive afforestation program, China could reduce net GHG emissions by 10 % in 2020 compared to expectancy. An increase of forested land by 4-5 million hectares per year would be necessary. Such plantations sequester not so much carbon on a net basis, but it also bio mass, a substitute for fossil fuels. By efficiency improvement in the agricultural sector, further GHG emission reduction could be made.

Environmental energy related problems of local character

Among the problems resulting from the extremely high and inefficient use of coal, is the dust floating in the air and water. It is not peculiar that the deaths from local pollution is as high as mentioned, when you find 9 of the 10 most air polluted cities in China.

The controversy surrounding the immense hydro project *the Three Gorges* on the Yangtze River deserves to be mentioned as an environmental issue as well. When completed, in about 2010, it will have a capacity of 18.2 GW (around 100 TWh/year), an important contribution to Chinas future need for Energy. Still, the negative side effects are immense. The Yangtze River, the third longest river in the world was diverted from its natural course in 1997, to clear the way for the construction of the worlds biggest dam, 185 meters high and 1.6 km wide. The project forces more than a million people to reallocate and it submerges archaeological monuments. The indirect side effects are impossible to estimate. Major disturbances to the ecosystem in the region could be the result.

Lastly, the negative effects of nuclear power generation should not be forgotten. Nuclear power plants produce radioactive waste for which storage has to be provided. In addition comes the tiny, but significant risk that an accident happens.

Conclusion

China's current 5-year plan (1996 – 2000) is the first to include environmental protection. Nearly \$40 billion are planned used over the five years to restrain pollution, especially from coal and oil. In China's Agenda 21 Program for sustainable environmental development goals, emphasis is made on increased energy efficiency and renewable energy sources. China also states its intention to shift, to the extent possible, away from coal towards natural gas in power generation. Moreover, an agreement is signed, at the October 1997 summit between the presidents Clinton and Jiang, including a joint program of conducting research on

environmental problems, data sharing, expanded use of clean and efficient energy technologies, and facilitating trade and investment in these technologies.

Environmental regulatory policy is a necessary tool in all economies to encourage enterprises to use clean forms of energy and to use energy more efficiently. China has already established such a regulatory system. Although it is quite comprehensive, it needs upgrading to make it more effective in a market system, and the enforcement need improvement.

Political awareness is an important factor to turn the negative trend outlined in this chapter. Yet, success in economic reform is a key factor influencing future levels of polluting emissions. Economic reform leads to structural changes in the economy, and thus to a higher production and consumption – thereby heightening the level of polluting emissions. Still, structural changes in the economy, following deregulation in the industries, also leads to efficient use of production factors – including energy. Competition of a successful transition to a market economy is therefore fundamental to the Chinese government's economic development policy.

This chapter has focused on the globally polluting emissions of energy production and usage in China. In the closing stages of the chapter, it is perhaps worth shortly to reflect over where the moral responsibilities of global pollution lies. If looking at carbon emissions per capita, China emits 0.7 tons, while the US emits 5.6 tons. Thence, although China's huge population totally has a high level of emissions, it is important for the developed countries not to focus too much on China, on the expense of the self-consciousness.

Terms and Conversion Factors

LNG - Liquefied Natural Gas

Soild fuels - mostly coal

Oil

- 1 tonne is a metric ton, i.e. 1000 Kg
- toe – tonnes of oil equivalent, used to compare amounts of different energy sources based on amounts of energy.
- Mtoe = million toe

Natural Gas

- Tcm (trillion cubic meter)
- 1 cubic meter =35,3 cubic feet

Coal

- 1 short ton = 0.9072 metric tonnes

Electricity

- TWh = trillion Wh
- GWh = billion Wh
- MWh = million Wh
- 1 GW on full capacity = $24 \times 365 = 8.76$ TWh/year

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