Energy Supply and Fuels Supply in Guangdong
Impact on Air Quality in Hong Kong and Guangdong

Christine Loh

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CIVIC EXCHANGE
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(Updated in June 2006)

Civic Exchange is a non-profit organization that helps to improve policy and decision making through research and analysis.
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I. China’s National Oil Conglomerates
INTRODUCTION

China has an enormous appetite for energy consumption which is largely fuelled through the combustion of conventional energy sources. These conventional energy sources which include coal, crude oil, petroleum refined products and gas\(^1\) create air pollution as well as have an impact on climate change, which combined with energy security issues, makes energy an important focus of Chinese policy makers. Switching to cleaner fuels, practising energy efficiency so less fuel is used to produce the same unit of energy, encouraging energy conservation so as not to waste scarce resources, and investing in renewable energy sources are becoming increasingly important to policy-makers and will continue to do so for the foreseeable future.

This paper forms part of a larger Civic Exchange project\(^2\) which aims to assess the possibility of using cleaner fuels in Guangdong to improve air quality in the short-term, and within this context looks at how fuels are sourced and supplied in Guangdong. However, to provide a better understanding of the complex issues involved, summaries of China’s energy consumption growth, as well as oil refining and trading of oil products are also discussed. An overall description of Guangdong’s power sector including both government run and privately generated power sources are also included and are highly relevant since a substantial portion of Guangdong’s fuel oils are used to privately power generators at manufacturing plants, which are forced to generate their own power to overcome grid supply shortages.

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\(^1\) After crude oil is removed from the ground, it is sent to a refinery, where different parts of the crude oil are separated into useable petroleum products. Most of the petroleum products are used to produce energy. See Figure 6.

\(^2\) A summary of the cleaner fuels policy direction and project work can be found at: [http://www.civic-exchange.org/publications/2005/cleanfuel-e.pdf](http://www.civic-exchange.org/publications/2005/cleanfuel-e.pdf). In addition to this report, a companion study was also published in March 2006. This companion study, written by Bill Barron, Simon NG Ka Wing and Ben Lin Chubin of the Institute for the Environment, Hong Kong University of Science and Technology, titled: “Owning up to Responsibility for Manufacturing Contributions to the Pearl River Delta’s Poor Air Quality” is also available at: [www.civic-exchange.org](http://www.civic-exchange.org) under publications. This companion report features a case study and survey based review of a number of Hong Kong owned manufacturing plants operating in Guangdong. The research aims to better understand the power demand and fuels supply and demand situation in Guangdong. The companion report also provides an overview of manufacturing power demand in Guangdong with specific focus on industries located in Shenzhen and Dongguan, which because of direct wind flows are known to have a bigger impact on Hong Kong’s air pollution.
PART 1: General Background

A. China’s overall energy appetite

China uses only about 1/10th as much energy per capita as the US and 1/6th of the OECD per capita average, so growth prospects remain substantial. Chinese industry consumes 70% of China’s energy, thanks to its mostly coal-powered chemicals, metals, cement, and pulp and paper plants which are all energy intensive and energy inefficient. Compared with most industrialized countries, China’s energy efficiency is low, though its energy intensity has been improving by 4.5% a year since 1975. The 11th 5-Year Plan (2006-2010) aims to reduce energy consumption per unit of GDP by about 20%.

Demand for electricity grew between 14% and 16% in 2004, which was enormous by any measure with aggregate shortages estimated to have been in the range of 20 to 30 GW with perhaps an additional 12 GW at peak periods in the summer. Peak growth appears to have eased however, as real GDP growth has slowed from 11%-12% in 2003, 9%-10% in 2004, and 8%-9% in 2005. The official annual growth projection is expected to be in the range of 7%-9% through 2010 although growth is in fact hard to predict. Some economic historians believe China’s pace of industrialization (and therefore of energy consumption) can be sustained at a strong level because it has been done before by countries such as the US, Japan, Korea and Taiwan. Another perspective is that China’s development model is likely to remain highly energy intensive as the Chinese Government favours investing in infrastructure (16% of...
GDP) which attracts global corporations to outsource manufacturing to China. In 2003, China’s power capacity mix consisted of mostly fossil fuel sources with just under a quarter from hydro and a just over 2% from nuclear.

Figure 1: China’s power capacity 384 GW (IEA 2003)

Figure 2: China’s power generation 1992-2003 (IEA 2003)

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i. Coal

China is now the second largest primary energy consumer in the world (12.1% 2003), after the US (23.6%). China has abundant coal reserves (337 billion tons) and is the world’s largest coal producer. China has increased coal production averaging 9% per annum over the past 50 years, and consumes about 1 billion tons of coal a year.

Figure 3: History of coal production growth 1955-2003 (CEIC)

![Graph showing history of coal production growth from 1955 to 2003.]

Source: CEIC, CLSA Asia-Pacific Markets

Coal is and will likely remain the dominant fuel in China although the relative share of oil, natural gas and nuclear will grow. In 2004, Coal met about 70% of China’s

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It should be noted that the IEA warns that China’s energy consumption is poorly tracked, and highlighted coal in particular, see Jeffrey Logon, US Senate Hearing on Energy and Natural Resources, 3 February 2005, www.iea.org/textbase/speech/2005/jl_china.pdf.

China Statistical Yearbook 2005. This reserve can support consumption for 150 years at current rates of consumption. The World Coal Institute’s estimate for China is 110 billion tons.

However, over-mining has been a persistent problem. An example is Qitaihe in Heilongjiang, where there have been a series of accidents. See Josephine Ma and Lillian Yang, “Dreary city finds itself down in the dumps”, South China Morning Post, 29 November 2005, p. A6. Furthermore, according to statistics from the State Administration of Work Safety, there were 18,071 coal mine accidents, which killed a total of 30,924 miners a year - an average of 1.71 deaths in each accident during the five years, 2000-2004. The number of coal mine accidents, wherein more than 100 deaths have been recorded, has been increasing. Since the People’s Republic of China was established in 1949, there have been 9 coalmine disasters which resulted in more than 100 deaths each. Of those, 7 of them occurred after 2000 and 5 of these 7 accidents happened in a period of just 13 months between 2004 and 2005, see China Labour Bulletin, NewsFlash No.58, 29 November 2005.
energy demand and the overall percentage is likely to remain at this level until 2020, although reliance on coal in the near term is likely to intensify as most of the new power projects approved by the government in 2004-2005 are coal thermal plants. As such, the thermal capacity mix for coal is likely to rise from 74% to 78% of electricity generated in the next few years, despite the government’s goal to reduce coal-power over time. Of the electricity generated using fossil fuels, 95% of it is derived from coal.\textsuperscript{15}

Figure 4: China’s approved power projects (January 2004-July 2005)\textsuperscript{16}

<table>
<thead>
<tr>
<th></th>
<th>Capacity (GW)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>101</td>
<td>83</td>
</tr>
<tr>
<td>Hydro</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Gas</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>121</td>
<td>100</td>
</tr>
</tbody>
</table>

China’s coal has relatively high sulphur content (typically 1%-4%) and much of the coal used is not washed (estimates indicate 60%-80%), which is a major cause of air pollution, acid deposition and greenhouse gas emissions, creating approximately 14% of the global CO2 emissions.\textsuperscript{17}

China is the world’s number one coal (coke) producer and exporter, with much of the domestic production used in steel making. Apart from coal-fired power generation, the other large coal-consuming industry is construction. Coal consumed in this sector expanded 11% in 2004, with most the coal used in making cement. With prices for oil and gas expected to stay relatively high, China is gearing up for massive investments in plants to turn coal into gas and oil (coal liquefaction) costing at least US$24 billion. These projects appear to make economic sense if oil prices stay above US$30-US$40 per barrel although prices are notoriously volatile and have been subject to very large swings.

\textsuperscript{17} Keith Burnard, “IEA-China Power Plant Project” IEA, April 2004, see footnote 11.
However, even if all these plans are built, they would only be equivalent to 15% of China’s current consumption of crude oil.  

### ii. Oil

Changes in China’s oil consumption have been nothing short of dramatic. China only has 2% of the world’s proven oil reserves. Twenty years ago, China was East Asia’s largest oil exporter and it became a net oil importer 13 years ago. By 2003, it became the world’s 3rd largest oil importer after the US and Japan, and at the same time, the world’s 2nd largest oil consumer.

Figure 5: Chinese Oil Demand Forecast 1990-2030, IEA (2004)

In 2004, China’s oil demand stood at 6.38 million barrels per day. The International Energy Agency (IEA) estimated in March 2005 that China’s recent oil demand growth could have been in the order of 250,000-350,000 barrels per day which was likely due the need for oil-fired back-up power generation in the

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face of serious electricity shortages. Other factors influencing demand include the rise in personal car ownership and growing industrial petrochemical needs, which will continue to grow.21 Overall, forecasters expect Chinese demand for crude oil to rise at a double-digit annual pace for the rest of this decade. An important reason for the growth is tied to continuing rapid industrialisation and rising transport demands.

Figure 6: Petroleum refined products made from a barrel of crude oil (gallons)

Oil is refined into various petroleum products, including those for transportation uses, and including the lowest quality fuels (fuel oil or bunker fuel) going to power ships. China’s transportation sector currently accounts for 40% of oil consumption. China’s 10th 5-Year Plan (2001-2005) also created a strategic oil reserve to gradually fill up to 100 million barrels of storage by 2008 (equivalent to 35 days of imports in 2005).22 By 2008, 100 million barrels is estimated to be equivalent to about 25 days of imports.

22 “Strategic oil reserve to be filled next year”, China Daily, 1 July 2005, reported China was likely to start filling its strategic oil reserves from 2007, www.chinadaily.com.cn/english/doc/2005-01/07/content_406619.htm
iii. Natural Gas

China has less than 1% of global natural gas reserves and produces 1% of the world’s natural gas. In south China, there are offshore natural gas basins to the south and west of Hainan. In 2005, natural gas accounted for roughly 2.1% of China’s total generation capacity. The country is building substantial gas infrastructure and by 2020, natural gas is expected to provide 8%-10% of China’s energy. While China can meet its own current demands, this will change dramatically as consumption is expected to grow from 40 billion cubic meters (cm) to 210 billion cm by 2020, of which 60% will have to be imported. Natural Gas in liquid form (LNG) is expected to make up 40% of gas imports by 2020. Developing natural gas is considered important to China’s overall energy policy to lighten dependency on oil and to reduce pollution, as burning natural gas creates less pollution than either oil or coal, the latter being the most polluting.

Figure 7: Chinese Natural Gas Demand Forecast 1980-2025, IEA (2004)

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23 The two basins are the Yingehai Basin and Qiongdongnan Basin.
China’s first gas terminal is in Shenzhen and is scheduled for completion in mid-2006 with a capacity of 3 million tons of LNG imports per year rising to 5 million tons in 2008 in a second phase. The initial volume of LNG will be split around 40% to residential and domestic consumers displacing LPG or naphtha, and 60% for new power generation. The aim is to supply six new 320 MW gas-fired thermal power plants in Guangdong, as well as the existing oil-fired plants, such as the one in Shantou. An A$24 billion (HK$139.2 billion) long-term gas supply contract was signed in 2003 between Australia and Guangdong. Another terminal is being considered in Zhuhai, there is 300 MW coming on stream at Hong Kong Electric’s Lamma Island extension, and Hong Kong’s CLP Power is also lobbying the HKSAR Government to build its own LNG terminal in Hong Kong, as its existing gas supply from the Yacheng gas field off Hainan, which supplies the Black Point power plant, is lower than expected and CLP Power says it will require new gas supplies by early next decade.

While China sees LNG as a major part of future energy mix, mainland companies have not found it easy to secure LNG supplies since 2003 when world energy prices jumped. China wants to leverage its LNG purchase to obtain a stake in the upstream reserves so as to ensure security of their supply but Chinese buyers have set a ceiling on the price they see as “affordable”. Much of the gas demand is for domestic heating and industrial processes, and gas needs to remain reasonably competitive with coal, which has been hard as world energy prices remain high.27

iv. Nuclear

China is also building nuclear plants. There are currently 9 nuclear reactors in operation and a further 2 units under construction producing 6.5 MW. In 2003, nuclear power provided 2.2% of China’s total power generated and is expected to make up 4% (40 GW) of the capacity max by 2020. The first two plants were in Daya Bay, Guangdong, and Qinshan, near Shanghai. The Daya Bay and Lingao reactors in Guangdong provide approximately 10% of the province’s power. One of two units in Tianwan, Jiangsu is expected to start up in the near

27 Securing energy supply through acquisition of upstream resources was Japan’s policy in the 1970s but it paid market price for the LNG. CNOOC was able to secure some equity interest in the Australian North West Shelf and also in Indonesia in 2002-2003 for supply to Guangdong and Fujian but since the price of oil jumped in 2003, China has been much less successful in securing more supplies. See Shai Oster and Patrick Barta, “China Stumbles In Attempt to Cut Use of Coal and Oil,” The Wall Street Journal, 3 March 2006, and Eric Ng, “Shenzhen LNG eyes Australia supply”, South China Morning Post, 25 May 2006, p. B4.
future, making a total of 10 reactors, and to be followed by the next unit some time in 2006.

In May 2004, the China National Nuclear Corporation gained approval to build another 4 pairs (8 in total) of new reactors in Lingdong and Yanjiang, both in Guangdong; Qinshan near Shanghai; and Sanmen in Zhejiang. The Guangdong Nuclear Group has contracted to build two more 1,000 MW reactors at Lingao with operation scheduled for 2010-2011. Under the 11th 5-Year Plan (2006-2010), many more reactors are planned in China, of which there are possibly 7 more reactors in Guangdong (Yangjiang and Taishan). The Yangjiang Nuclear Plant, with a total capacity of 6,000 MW (6 units) has recently been approved and the first two reactors are expected to start operation in 2012. By about 2012, nuclear is expected then to contribute 20% of Guangdong’s total electricity generation representing 50% of China’s total nuclear electricity.28

Figure 8: Operating nuclear power reactors in China (as at 2005)

<table>
<thead>
<tr>
<th>Units</th>
<th>Net Capacity (each unit)</th>
<th>Operation Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daya Bay Units 1&amp;2</td>
<td>944 MW</td>
<td>1994</td>
</tr>
<tr>
<td>Qinshan Unit 1</td>
<td>279 MW</td>
<td>1994</td>
</tr>
<tr>
<td>Qinshan Units 3&amp;4</td>
<td>610 MW</td>
<td>2002 and 2004</td>
</tr>
<tr>
<td>Lingao Units 1&amp;2</td>
<td>935 MW</td>
<td>2002 and 2003</td>
</tr>
<tr>
<td>Qinshan Units 3&amp;4</td>
<td>665 MW</td>
<td>2002 and 2003</td>
</tr>
<tr>
<td><strong>Total (9 Units)</strong></td>
<td><strong>6,587 MW</strong></td>
<td><strong>In 2005</strong></td>
</tr>
</tbody>
</table>

v. Renewable energy

While there is rapid growth in the renewable energy sector, it is starting from a very low base. Nevertheless, the promotion of renewable energy is now a part of the national renewable energy strategy. The goal is to achieve 100 GW of renewable energy capacity by 2020, generating 10% of the total energy supply. The national plan provides for 20 GW from wind, 50 GW from small hydro projects, 1 to 2 GW from solar, 16 GW from biomass and 14 GW from other sources. Installed wind energy capacity in Guangdong as of 2004 was 86 MW with 3 wind farms in Hualai that is scheduled to be commissioned in 2006.29

29 For a thorough discussion about wind power in Guangdong, see Greenpeace, “Wind, Guangdong” 2005
Figure 9: China’s installed capacity by fuel types (GW)³⁰

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Total</th>
<th>Thermal</th>
<th>Hydro</th>
<th>Gas</th>
<th>Nuclear</th>
<th>Wind</th>
<th>Solar</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>319</td>
<td>238</td>
<td>79</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2001</td>
<td>338</td>
<td>253</td>
<td>83</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2002</td>
<td>357</td>
<td>257</td>
<td>86</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2003</td>
<td>385</td>
<td>286</td>
<td>92</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2004</td>
<td>442</td>
<td>325</td>
<td>108</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2010</td>
<td>763</td>
<td>550</td>
<td>180</td>
<td>16</td>
<td>12</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>2020</td>
<td>1,092</td>
<td>650</td>
<td>300</td>
<td>70</td>
<td>40</td>
<td>30</td>
<td>2</td>
</tr>
</tbody>
</table>

2004-2010 (cagr %) | 10 | 9 | 9 | 58 | 10 | 37 | 40

2010-2020 (cagr %) | 4 | 2 | 5 | 16 | 13 | 20 | 15

B. Oil refining in China

i. Changing demands

The oil refining industry in China faces the challenges of having to cope with expanding crude oil imports,³¹ increasing processing volume for high sulphur crude (1% or more) from the Middle East, and improving the quality of oil products to meet the increasing domestic demands.

Figure 10: Changing Crude Diversity in China³²


³⁰ Source, 11th Five-Year Plan.

³¹ China crude oil import in 2003 was 91 million tons, which was a 71% jump from 2002. In 2004, crude imports rose again by 34% to 122.7 million tons.

The two major oil refining companies are Sinopec and PetroChina. Both companies produce a variety of petroleum products including gasoline, diesel fuel and jet fuel. They have three main types of oil refineries:

ii. **Low sulphur crude oil**

PetroChina owns major refineries in Dushanzi, Lanzhou, Dalian, Jinzhou, Fushun and Daqing. They process mainly low sulphur heavy crude from inland and northern China. Sinopec’s refineries in Yanshan also process domestic low sulphur crude oil. The sulphur content of the gasoline produced from these refineries is usually 200 ppm or lower.

iii. **Medium sulphur crude oil**

Sinopec owns most of the refineries in this category. These refineries are capable of producing gasoline equivalent to Euro II (sulphur 500 ppm) and diesel with sulphur content not exceeding 500 ppm. The major refineries that process domestic crude are in Henan (Luoyang) and Hunan (Changling). The major refineries processing imported medium sulphur crude are mainly located along the Yangtze River (Jiujiang, Wuhan, Jingmen and Shanghai).

iv. **High sulphur crude oil**

The refineries that process high sulphur crude oil have high refining capabilities. They also need desulphurization and hydrocracking facilities. PetroChina owns a facility in Dalian, and the rest belong to Sinopec, which include the refineries in Zhejiang (Zhenhai), Shandong (Qilu), Jiangsu (Jinling and Yangzi), and Guangdong (Maoming, Guangzhou, Dongxing). These can produce Euro III gasoline (sulphur 150 ppm) and diesel not exceeding 500 ppm. The crude oil comes from the Middle East, which in 2003 supplied 49% and in 2004 supplied 45% of China’s crude import.

Both companies are expanding facilities to cope with large increases in oil imports and producing more petroleum products to satisfy domestic demands. They aim to transform themselves into large-scale modern oil refineries, integrated with petroleum products production, and to be able to produce...
cleaner products. In Guangdong, Sinopec is expanding the Maoming refinery so that it can produce more Euro III standard fuels.

The oil companies are stepping up efforts to improve product quality to meet tighter environmental regulations. For example, sale of leaded gasoline was banned in 1999 in Beijing, Shanghai and Guangzhou. From 2000, the production of leaded gasoline was prohibited altogether. By July 2000, leaded gasoline sale was banned throughout the country. At the same time, the government introduced new unleaded gasoline quality standards with lower sulphur, benzene, olefin and aromatics contents. As for diesel, there have also been gradual improvement on quality and on 1 July 2005, the sulphur content was tightened to 0.05 wt percent. Diesel must now meet Euro III standard in Beijing, Shanghai and Guangzhou, and there are plans to extend this to the rest of China in 2008. By then, the Chinese Government is aiming for Euro IV standards in the three major cities. China’s overall plan is to harmonize its fuels standards with the Euro standards.

There is an important rider to add. From information derived from suppliers and traders, it appears manufacturers are able to buy non-standard, higher pollution, fuel oil from local private refineries. One estimate suggested these private refineries supplied as much as 40% of the Guangdong fuel oil market in 2004-2005.

C. Trading, importing and distribution of oil products in China and Guangdong

i. State control

Crude oil and petroleum import policies have changed since the days when China was a net exporter. In the past, import and export were characterised by state control over volumes and types of crude oil and petroleum products. State control was exercised through quota and licensing arrangements and carried out by state owned foreign trade companies, most notably, the China National

Chemical Import and Export Corporation (Sinochem).\(^3^4\)

Up until the mid-1990s, China continued to maximize export earnings through exporting crude and products, particularly gasoline and diesel. As China’s own demand surged, exports decreased and China began to export other petroleum products such as paraffin and petroleum coke. By 1999, the coastal refineries, including Maoming and Guangzhou, had been revamped and expanded to treat higher sulphur crude from the Middle East.

ii. **Liberalisation efforts**

There have been various efforts to liberalize the Chinese oil products markets. In 2004, a number of companies apart from Sinopec, PetroChina and CNOOC are permitted to import crude and products, but they are end-users which ensure Sinopec’s and PetroChina’s distribution businesses are not affected. In reality, with the giants controlling most of the refineries, the new importers have to sell crude to the duopoly. Furthermore, the major petroleum products state-trading companies, China International United Petroleum and Chemicals Company, China National United Oil Company and Zhuhai Zhenrong Company, receive most of the allocated import quotas, leaving relatively minor quantities for non-state entities.

China made a first step towards liberalising its market by opening up its jet fuel sales and storage market to domestic competition from August 2005.\(^3^5\) This step now allows Chinese companies to compete, but imports have not been liberalized. The China Aviation Oil Trading Company (CAOT) was the sole import agent of jet fuel into China, on behalf of contractual buyers such as China Aviation Oil Import & Export Company Ltd., Shanghai Pudong International Airport Import & Export Corp., Zhuhai Zhenrong Co. and Sinochem until late 2005. CAOT is a subsidiary of the state-owned China Aviation Oil Holding Company (CAOHC), which owns nearly all the refueling facilities at China’s 140 airports and controls about 70% of China’s domestic jet fuel distribution. The parent companies of both Sinopec and PetroChina also set up a joint venture in

\(^3^4\) Sinochem was allowed to extend into the upstream sector in 2000 by acquiring an oil field in Norway. For a full introduction, see www.sinochem.com

\(^3^5\) China’s jet-fuel consumption is over 250,000 barrels per day, a third of which is imported, while the rest is secured from domestic refinery production. Demand is growing at nearly 10% per annum as airline travel increases.
2004 to provide jet fuel to the Chinese airports so that it can also be a strong competitor since it owns the domestic refineries producing jet fuel.\(^{36}\) Today, China’s jet fuel market has been further loosened to allow Sinopec and PetroChina to get into the import business.

Further discussion of Government Pricing Policies including the liberalization of oil products is included in Part III Section A.

### iii. Impact of WTO entry

China’s WTO entry agreement includes further liberalisation of wholesale and retail sales of crude oil and refined petroleum products.\(^{37}\) By December 2006, foreign companies will be allowed to distribute wholesale imported crude and products. In theory this will enable them to sell directly to Chinese customers although it is currently unclear exactly how the next stage of liberalization will work. There may be an importer registration system set-up with qualifications on various criteria possibly including domestic storage capacity and handling facilities.

Figure 11: Action take in the energy sector since China joined the WTO in 2001\(^{38}\)

<table>
<thead>
<tr>
<th>Commitment</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradually open the crude oil and petroleum products sectors to private traders and end the state monopoly on oil trading.</td>
<td>Import quota management for the three state-owned oil companies—PetroChina, Sinopec, and CNOOC removed on 1 January 2004.</td>
</tr>
<tr>
<td>Open retail oil distribution 3 years after WTO accession and allow foreign firms at least 30 wholly owned gasoline stations each. Open the wholesale market 5 years after accession.</td>
<td>Ten new oil importers ratified in April 2004. In August 2004, all private oil importers ratified.</td>
</tr>
</tbody>
</table>

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\(^{36}\)“Liberalization not to end jet-fuel monopoly”, *Shenzhen Daily*, 10 August 2005.

\(^{37}\)The WTO agreement does not cover upstream oil and gas exploration and production.

iv. International competition

With Sinopec and PetroChina controlling most of the coastal tanks and storage facilities, foreign companies may find it hard to compete. Nevertheless, foreign companies such as ExxonMobil, BP, Caltex and Shell, are actively devising their strategies. For example, some have moved into the Chinese products market by installing service stations in various cities, as well as entering into joint ventures with the Chinese oil companies. Today, they sell oil products by sourcing within the mainland from the Chinese oil companies. The origins of the products may be domestically refined or imported. They are trying to build their brands in China and to provide better service to customers, which include observing international practices in handling and storing fuels to avoid contamination, and providing higher quality fuels to buyers. Exploiting its first mover advantage, however, Sinopec has expanded its total number of petrol stations (over 30,000 sites by 2005 in China as a whole) and secured the busiest retail sites for other fuels in south China. PetroChina has some 18,000 petrol stations sites throughout China in 2005. So far, the international majors together only have about 1,000 sites.

v. Distribution in Guangdong

Sinopec's Guangdong Oil Products Company is in fact the dominant distributor in Guangdong province. Its core marketing operation consists of offering products directly to users through the retail networks of service stations, oil shops, and rural and waterborne sales networks. This business accounts for over 44% of its entire marketing operations. Its next most important distribution business is through direct sales to large users, which accounts for about 30% of its marketing business, followed by wholesaling to specific agents and retail companies, which accounts for about 25% of its marketing business. Its oil products sales in Guangdong totaled 15.6 million tons in 2004, an increase of 27% over 2003. Industrial fuel oil sales was only 0.64 million tons but it was possible that other products may have been used or mixed with industrial fuel oil

40 When Sinopec Corporation was listed on the Hong Kong and New York stock exchanges, ExxonMobil acquired 19% of the newly offered stock.  
42 Guo Sizhi, “Trends of Petroleum Distribution Business in China”, IEEJ, May 2003,  
to power the PRD's factory generators (see Part II, Section C). PetroChina has made significant inroads into south China by having invested in storage terminals in Zhuhai, and other cities in Fujian and Zhejiang.

PART II: Overview of Guangdong’s Power Sector

A. Overall Demand

i. Largest national electricity consumer

Guangdong, and in particular, the Pearl River Delta (the PRD is an area of only about 40,000 sq km or 15,500 sq miles), is one of the strongest economic regions in China. The total export in value terms of the PRD was US$182.43 billion in 2004, equal to 95% of all of Guangdong’s exports, and represented 30% of the whole of Mainland China. Guangdong is notable for its energy consumption appetite, which is higher than any other province in China by a long stretch (see Figure 13). In 2004, the four largest power users – Shenzhen, Dongguan, Guangzhou and Foshan – consumed 39 billion, 35 billion, 30 billion and 29 billion kWh each, accounting for 73% of Guangdong’s total consumption.

Figure 12: 2003 generation fuel mix in Guangdong:

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro-power (Inclusive pumped storage power)</td>
<td>20.7%</td>
</tr>
<tr>
<td>Thermal-power</td>
<td>69.5%</td>
</tr>
<tr>
<td>Coal-power</td>
<td>43.51%</td>
</tr>
<tr>
<td>Oil-power</td>
<td>25.92%</td>
</tr>
<tr>
<td>Waste-power</td>
<td>0.03%</td>
</tr>
<tr>
<td>Nuclear-power</td>
<td>9.6%</td>
</tr>
<tr>
<td>Wind-power and Others</td>
<td>0.2%</td>
</tr>
<tr>
<td>Total</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

The 2003 generation fuel mix in Guangdong was approximately 75% thermal power (including 5% pumped storage power which is treated as hydro-power in figure 12), 16% hydro (net of the pumped storage power included in thermal power), 10% nuclear plus other minor sources. Despite its appetite,
consumption is still relatively low when compared with developed economies.

Figure 13: China’s provincial electricity consumption (1995-2003) (Greenpeace)
Almost 70% of Guangdong’s energy was consumed by industry in 2004 and a third of this industry power was consumed to produce thermal heat for production processes.

Figure 14: Guangdong’s 2004 energy consumption breakdown\textsuperscript{50}

\begin{itemize}
  \item \textbf{ii. Current installed capacity}
\end{itemize}

In 1978, the installed electricity capacity in Guangdong was 2.53 GW with an annual output of 9.42 TWh. The annual per capita electricity consumption was 183 KWh, which was only half the national average (360 KWh). With rapid economic development from the 1980s, Guangdong saw a massive increase in electricity consumption, which led to an unprecedented expansion of generating capacity. Throughout the 1980s, power shortages were frequent. The authorities encouraged the construction of power stations including small and inefficient facilities to keep its growing pool of export factories running. Up to 1997, the province’s installed capacity totalled 28.13 GW with an annual output of 98.12

\textsuperscript{50} Guangdong Statistics Yearbook (2005).
TWh. By then all major cities had been connected to a joint grid and Guangdong became China’s most developed power market. By 2004, the province had nearly 40 GW of electricity generating capacity but was still short 2.9 GW to 4.5 GW of capacity.\textsuperscript{51} Severe shortages became frequent again, leading to the province’s worst experiences in 2004 and 2005.

Figure 15: Guangdong Power Production and Consumption (1995-2004)\textsuperscript{52}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure15.png}
\caption{Guangdong Power Production and Consumption (1995-2004)}
\end{figure}

iii. Sub-optimal capacity mix

In addition to power shortages, another key issue is Guangdong’s suboptimal generating capacity mix. Its power plants consist of a large proportion of highly polluting and cost inefficient small capacity units. Various estimates indicate that small (less than 50 MW) coal-fired and diesel-fired units still accounted for about 35%-40% of the province’s total installed generating capacity as of 2003.\textsuperscript{53}

\textsuperscript{53} One reported noted that 35% of Guangdong’s province’s 33.6 GW capacity consisted of units with less than 50 MW, while modern large units (300 MW or more) accounted for 41% in 2001, see Zeng Lemin, Zhang Chi, Chen Lijia and Xiang Xiaomin, “Guangdong Electric Power Market Reform: Options and Impact”, Center for Environmental Science and Policy, Working Paper 33, Stanford University, November 2004, http://pesd.stanford.edu; and Hongkong Electric Company, “The Guangdong Electricity Market”, powerpoint presentation, 2004, showed that by 2003, the province’s installed capacity had reached 39.2 GW and that 40% of the plants were described as small thermal plants. Furthermore, there are reports that Guangdong has 9,000 MW derived from small plants built to cope of shortages, see Eric Ng, “Guangdong diesel plants ordered to shut down”, South China Morning Post, Business section, 11 August 2005, p. B4.
Optimizing the energy and technology structure of power generation requires larger investments in bigger, cleaner and more efficient plants. While government policy is to phase out the smaller plants, it has in fact not been easy to close them down as it involves highly politicised negotiations, as well as when there are still shortages. Thus, in August 2005, while Beijing ordered Guangdong to shut down more than half of its diesel-powered plants on environmental and economic grounds, after they incurred large losses, no time table was in fact specified. There are other barriers to achieving efficiency quickly in Guangdong as well. These range from management sophistication, technical skills availability, lack of coordinated energy efficiency and conversation programmes, and pricing policies.

iv. Severe shortages in 2004-2006

Guangdong, as with other parts of China, experienced severe power and fuel shortages that started in 2003 and intensified in 2004-2005. This was a period of surging GDP growth. It was during this period that domestic coal supply went from a surplus to a deficit, thereby attracting some previously-closed mines to reopen illegally. This time also resulted in a large jump in oil imports. Overall, China experienced rapid demand growth in many commodities and energy, resulting in areas of severe localised shortages and delivery bottlenecks.

A 500 kV transmission network is the backbone of Guangdong’s power grid, which is part of the China Southern Power Grid Company. Published reports indicated that the China Southern Power Grid Company possibly suffered shortages in 2005 of more than 7,000 MW, which is roughly equivalent to the entire installed capacity of Singapore. In mid-March 2005 alone, 13 power plants supplying the China Southern Power Grid Company reported that their output was restricted due to having insufficient supplies of coal. It was also widely speculated that unregulated (illegal) small power plants were using heavy oil with higher sulphur contents amid the coal shortage to produce power. Guangzhou reported the worst power shortage in a decade during the first quarter of 2005, when on 716 occasions power had to be restricted in specific

areas. Those periods cost the city RMB 10 billion in industrial output.\footnote{Olivia Chung, “Shortage of power costs city 10B yuan”, \textit{The Standard}, 15 April 2005, p.A3.} Guangdong supposedly invested RMB 19.5 billion (US$2.23 billion) in 2005 to step up power grid construction and build additional transmission lines, as well as purchased more electricity from the Three Gorges project and Hong Kong to ease shortage.\footnote{20 April 2005, “Guangdong Invest Heavily to Ease Power Shortage”, \textit{Xinhua News Agency}, \url{www.china.org.cm/english/BAT}. The Guangdong power grid is also interconnected with that of Hong Kong, which is mainly there for CLP Power to import power from its affiliated supply sources in Guangdong, such as the Guangdong Nuclear Power Station at Daya Bay and Guangzhou Pumped Storage Power Station at Conghua, and for the contracted power sales from CLP Power to Guangdong.}

Individual PRD based manufacturers have reported that power outage hours have reached up to 99 hours in an individual month and have averaged 30 hours per month in 2004 and 38 hours per month in 2005.\footnote{Based on personal correspondence with PRD manufacturers.} Power shortage remains a reality of life in Guangdong. In April 2006, the China Southern Power Grid Company informed manufacturing customers that “from April 29 to May 19”, on even days (April 30, May 2, May 4, May 6, May 8, May 10, May 12, May 14, May 16, May 18), there would be “outage from 6:00am to 1:00am on next day and user should stop the power usage automatically except for lighting and residential usage”.\footnote{A copy of the memorandum was obtained by Civic Exchange.}

\section*{B. Power sector reform}

Reforms of the Guangdong electric power sector over the years have been guided by central government policies. The Chinese Government stresses central leadership and provincial compliance. Thus, Guangdong’s electric power sector is very much shaped by central policies.

\subsection{(i) Greater flexibility in Guangdong}

In the early 1980s, while fuel costs remained fixed, Guangdong was allowed to be more responsive to market conditions, and the provincial authorities were given a degree of autonomy in taking decisions in the power sector. By the mid-1980s, Guangdong was allowed to raise funds for power generation projects and the provincial authorities allowed local authorities and even non-government enterprises to build new capacity. What makes Guangdong’s
experience unique is that the liberalization policy attracted many non-government investors so that today, two-thirds of the total capacity is owned by them as compared to most provinces where the central and provincial governments still own the largest share of capacity.\textsuperscript{59}

(ii) Creation of the State Power Corporation

During the latter half of the 1990s, the focus of national reform shifted to formally separate government’s policy making role from the administration of the electric power sector. The Chinese Government created the State Power Corporation in 1997 and related provincial agencies to manage the industry.\textsuperscript{60} During the period of reform from 1985 to 2001 in Guangdong, the electric power generating capacity grew from 4.2 GW to 33.6 GW, making the province the largest provincial power system in China.\textsuperscript{61}

(iii) Creation of state owned generators and regulator

The Chinese Government’s next round of reforms, beginning in 2002, eliminated the State Power Corporation in order to reorganize its generation assets into five state-owned generation companies.\textsuperscript{62} In addition, transmission and distribution assets were given to two new state-owned power grid companies, with the State Grid Company operating in north China and the China Southern Grid Company operating in the south. Guangdong’s reform likewise required the province to implement the “government administration – and – enterprise - separation” policy. The provincial government power company was restructured and it handed over all transmission grids to the China Southern Grid Company, which became responsible for transmitting power to Guangdong, Guangxi, Hainan, Yunnan and Guizhou.


\textsuperscript{60} In 1998, the Ministry of Electric Power Industry in Beijing was abolished and the various bureaux in the provinces were abolished in 2002.


\textsuperscript{62} Generation assets were divided among five companies (Huaneng, Datang, Huadian, Guodian, and China Electricity Investment Group) each given similar size capacities and market shares in various regions, see HKSAR Government, Economic Development and Labour Bureau, “Updates of Guangdong’s Electricity Market”, September 2004, \url{www.edlb.gov.hk/edb/eng/papers/electricity/pdf/Reference15.pdf}
The national policy was also to gradually allow independent power producers to compete with the state generation companies. In 2003, the State Electricity Regulatory Commission was set-up under the State Council as the national regulator. Its terms of reference include promoting competition, enhancing efficiency and encouraging sustainable energy sources. The State Owned Asset Supervision and Administrative Commission overseas the management of state-owned power plants.

(iv) Tariff control and competition

Although these reforms were significant and important, they have not yet created a market oriented system in China. Tariffs, though increased to cover the cost of expansion, are still controlled by the central government through the National Development and Reform Commission’s (NDRC) Energy Bureau, and the provinces do not have full autonomy in decision-making. There are different perspectives and priorities between central and provincial authorities. For example, in the late 1990s, while Guangdong was keen to continue to invest in power generation to meet rising demands, Beijing banned new power projects in Guangdong in order to promote hydro power imports from south-western China believing that they could satisfy demands. Guangdong wanted power from the west as well as to be able to generate more power itself. Banning all new power projects risked future shortage, as there were issues of seasonality, reliability and load curve matching, and by 2002, shortages started to appear.

As Beijing continues to experiment with national reform in the electric power sector, the central and provincial authorities often have different preferences to reform options on issues relating to market structures, inter-provincial trade,
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competition, pricing mechanism, and tariff setting. While Beijing focuses on national development priorities, Guangdong’s interests lie in how to have enough power and keeping prices low so as to remain competitive in its manufactured export products.68 With the severe energy crunch in 2004 and 2005, the central authorities have refocused on promoting expansion of the electric power sector over reforms to promote competition since there is doubt over whether it is wise to push competition in the wholesale market when there is substantial shortage.

C. Private power generation

Beyond using gasoline and diesel fuels for vehicles, these and other oil products are also used in manufacturing power generation. As noted in Part I Section C local private oil refineries supply lower quality non-standard fuels to manufacturers. With unreliable grid power, reportedly 90% of the factories in the PRD run diesel fuelled “back yard” generators of various sizes.69 There have been reports that frequent power cuts, some even without warning from the authorities, could slow production time by as much as 20%, while others say they had to stagger shifts, and shut down their factories two to three times a week.70

Generators are used both for process heat and as back-up to cope with power shortages. A 1,000 KW can sell for approximately RMB1.9 million, while those of 7,000 KW and 18,000 KW have been reported to cost HK$60 million and HK$80 million respectively.71 One report noted that a textile firm with production in Panyu installed a second power generator (18,000 KW) so that it could be independent of electricity from the Guangdong grid. The firm expected there would be shortages in the summer of 2005 and at the same time peak tariffs

68 It is beyond the ambit of this report to discuss the relative preferences of the central authorities and the Guangdong. For a fuller discussion, see Zeng Lemin, Zhang Chi, Chen Lijia and Xiang Xiaomin, “Guangdong Electric Power Market Reform: Options and Impact”, Center for Environmental Science and Policy, Working Paper 33, Stanford University, November 2004, http://pesd.stanford.edu
69 CLP Group, A World Class Electricity Supply for A World Class City – Powering Hong Kong’s Future, January 2005.
there would be raised. By generating its own electricity, the firm thought it could lower electricity costs by 30%.  

Some manufacturers have apparently also switched from not only diesel to fuel oil, but from fuel oil to coal in running their generators. Moreover, even households invest in small generators. Industry sources say this kind of “tertiary power” may amount to a third of the generating capacity of Guangdong. Thus, the fuel shortage in 2005 had wide impact.

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72 The company is Kam Hing International Holdings, a Hong Kong listed textile firm. Its first generator has a capacity of 7,000 kW, see Toh Han Shih, “New power generator to trim costs at Kam Hing”, South China Morning Post, Business section, 22 April 2005, p. B3.


74 Private communication with power sector sources.
PART III: Price Control of Coal and Petroleum Products

A. Government pricing policies

i. Dealing with price fluctuations

For much of the history of the People’s Republic of China, the government has directly controlled not only electricity tariffs but also the price of coal, crude oil and petroleum products. Until price reforms started in earnest in the 1990s, oil prices for example, were set generally below international prices. The reason was to reduce input costs to industry, which were the major consumers. Heavy losses to the state-owned oil companies and the need to import crude oil in increasingly large quantities led to reforms that allowed crude and refined petroleum product prices to rise. However, prices still remained fixed albeit at higher levels.

One consequence of fixing prices was a massive rise in “unofficial imports” of oil products in 1997 and 1998 when international prices fell below Chinese domestic prices, and when there was an oil industry glut that led to a price crash in 1998.\(^{75}\) In China, further price reforms enabled crude oil and product prices to rise considerably. However, with the widening domestic-global price differentials, the cheaper unofficial imports eventually sent Chinese domestic prices down sharply. The government instituted a new “benchmark price system” in 1998 and modified it in 2001 to allow the state oil companies to decide actual sales prices on the basis of a benchmark price it set with reference to international market prices in Singapore, Rotterdam and New York although the exact calculations are not publicly available. Thus, technically, China’s domestic crude and oil products prices are linked to international benchmarks but in reality domestic price increase have only been applied to crude. Domestic products prices have not closely followed those of the international markets and are today still some way behind global prices. Currently, the government, through the NDRC reviews oil products prices once a month despite daily fluctuations in the international markets.

Sinopec and PetroChina have lobbied the government to increase domestic refined product prices. The price disparity problem is of greatest concern to

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\(^{75}\) The international price crash brought oil prices down to as low as US$10 per barrel at one stage.
them since they control 90% of the domestic market for gasoline and diesel. The problem is most acute for Sinopec since it imports most of the crude oil it refines, paying world market prices, and then sells the products at a loss in China. Thus, to expand production, the government needs to reform its domestic refined products pricing policy. There are indications that some form of price increase will be made in the foreseeable future and perhaps a new pricing scheme that reviews prices of gasoline and diesel fuels more frequently than on a monthly basis to better reflect the volatility of the international markets\textsuperscript{76}.

ii. Coal and oil products prices in 2005 and 2006

In early 2005, the NDRC issued a notice setting the price for coal with a ceiling for the year of 8% above the price supplied to the state-owned power plants in 2004. Coal producers reportedly wanted a 20% increase. In 2004, the average Chinese market price for coal was 27% higher than the average price of coal supplied to the state-owned power plants. It can be seen that the Chinese market suffers from substantial distortions along the whole supply chain because the state caps the price power generation companies can charge grid companies, which in turn are limited to how much they can charge end users.

The NDRC also sets oil products prices. For instance, at the end of May 2005, the price for various products in China was roughly US$120 per ton below international prices. This is in reality a subsidy\textsuperscript{77} to product users, such as the automobile sector, and prevents the market from reacting to price signals. Reports also showed that though the NDRC raised the retail price of gasoline in March 2005, it did not adjust the price of diesel fuel. Refiners therefore preferred to produce more gasoline because they could get a better return, which in turn created a nationwide shortage of diesel. It was only at the end of May 2005 that the NDRC allowed diesel prices to rise. Prices were raised again in March 2006 by about 3%-5% but by April, shortages had re-emerged, which resulted in

\textsuperscript{76} On 9 February 2006, there was a meeting of “Reform for Oil-products Prices” held by central government, provincial & municipal government, and Sinopec & Petrochina, in Guangzhou. Although to date, no formal announcements have been made See (Chinese language)

\textsuperscript{77} A subsidy is government funding given to an entity or person intended to benefit the good of society. Subsidies are used to make certain activities cheaper when the activity’s benefit is not represented only by the financial costs. In the case of energy subsidies in many countries, they make energy cheaper to produce or reduce the cost of buying energy in order to increase access to electricity and fuel products to provide a higher standard of living. See Global Energy Network Institute www.geni.org
another round of price increases for gasoline and diesel in May 2006 by about 9.6%-11%.\textsuperscript{78}

In the case of Guangdong, as of 1 May 2005, together with four other provinces, it was allowed to pass on higher fuel costs to end users. For example, power producers could pass along 70\% of coal price increases to distributors and end users if coal prices increased 5\% in 6 months. The new arrangement allowed power producers to recoup some of the higher raw materials costs, especially coal and oil through increasing the tariffs.\textsuperscript{79} Nevertheless, the NDRC also mandated that if local inflation rose more than 4\% year-on-year for three consecutive months, the local authorities could not raise tariffs higher. Guangdong experienced diesel shortages in April and May 2006.\textsuperscript{80}

China controls domestic refined petroleum products prices in order to cushion the impact of inflation on local users, especially to protect rural farmers who use diesel for their equipment. Local authorities may also subsidize certain sectors from time to time in a bid to maintain social stability (e.g. taxi drivers in Shanghai). Analysts believe letting the market set the price of gasoline would increase inflation in China by roughly 2\%.\textsuperscript{81}

iii. Maintaining price control for now

In order to maintain price control which contains inflation and provide subsidies, Chinese control of domestic oil product prices results in a builds up of distortions in the economy. Chinese policy-makers understand the problem well but they also believe they still have to monitor the price of oil products because allowing domestic prices to fluctuate according to international market prices would have a negative impact on China’s economic development. As such, they feel they must continue to follow a course of expansive economic growth because without growth in the range of 7\%-9\% per annum, they fear it would create social instability as jobs would not be created sufficiently quickly enough.


\textsuperscript{79} Denise Tsang, “China lets electricity firms pass along costs”, \textit{South China Morning Post}, Business section, 22 April 2005.

\textsuperscript{80} “Guangdong hit by diesel woes again”, \textit{The Standard}, 16 may 2006, p. A7.

From the policy-makers' perspective, they still need to assist many of the state-owned companies, which are inefficient and going through painful restructuring, to be more market responsive. The Chinese Government therefore has to continue to provide cash injections to help them make adjustments. On 28 December 2005, Sinopec announced it received RMB 10 billion as compensation from the government for its losses arising from price control of oil products. Then there are the workers who have been laid off as part of the restructuring, who are vulnerable to price increases for essential products and services, such as utilities prices. By continuing to control prices, the state believes this to be an essential way to sustain stability while it provides time to continue with market liberalization.

iv. Incentive to export when domestic prices are low

Since international crude oil and oil products prices started to climb in 2003, the gap between international prices and Chinese prices widened substantially in 2005. In the first seven months of the year, China's exports of refined oil products such as gasoline leapt by more than 45% with many shipments bound for Hong Kong and Vietnam. Crude oil exports jumped by nearly 30%, even as Chinese companies search the globe for new sources. In July 2005, the NDRC raised retail prices for domestic refined products. Together with the appreciation of the RMB, the refineries were able to reduce their losses somewhat. The authorities have so far not increased prices again.

Refineries have also responded to government pressure by increasing oil products supplies, which have helped to ease shortages all over the country. Yet, taking gasoline as an example, as already noted above, for each ton refined and sold domestically, the refineries were estimated to incur losses of US$120. In other words, the price cap system in China has forced losses on the refineries in order to subsidise domestic fuel products.

83 The State Development and Reform Commission is responsible for regulating price. In 2005 prices of oil products were increased in March, May, June and July.
84 Since 2003, China has in fact increased retail prices 7 times for a cumulative increase of 34% but over the same period, world oil prices have risen 84%, see Peter S Goodman, “Oil Exports leave China Grappling for Fuel at Home”, Washington Post, 28 September 2005, p.D06.
On 1 September 2005, the Chinese Government also announced that oil companies and refineries could not sign new export contracts although the ban does not affect contracts already in force. The ban did not choke off smuggling from Guangdong with buyers in Taiwan and South Korea prepared to pay higher prices. As of October 2005, Chinese fuel prices were 20%-30% lower than global prices. As described in Part I Section C, in previous years, Guangdong’s petroleum products prices were relatively high, which attracted smuggling of gasoline and diesel fuels into the province from not only neighbouring provinces such as Guangxi but also as far away as Vietnam, which helped to satisfy demand. Fuels have also been smuggled in to Hong Kong. Reports indicate that in the first 6 months of 2005, customs seized 800 tons of smuggled petrol at the Lok Ma Chau border. However with the price disparity, smuggling of petroleum products into China has stopped and the flow reversed with products now being smuggled out of the country. There were widespread reports of gasoline and diesel rationing in many parts of Guangdong in 2005. For example, reports in August 2005 noted that Guangzhou experienced a monthly shortfall of about 12,000 barrels per day of oil products, and Dongguan was short 2,400 barrels per day.

B. Fuel Adulteration

Another way for fuel suppliers and distributors to reduce their losses in view of the large price disparity between local and global prices is to mix products with cheaper, lower quality fuels. Common types of adulteration include the blending of diesel or kerosene with gasoline, or kerosene with diesel fuels; or adding heating oil, industrial solvents or lubricants into fuels;

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90 Formally, the world “adulterated” when used to describe any petroleum product, denotes a petroleum product that fails to meet the specification specified.
91 “Kerosene” is a petroleum fraction free from water, additives, foreign or suspended matter and is used as lighting oil.
92 “Gasoline” is refined petroleum naphtha which is suitable for use as a carburant internal combustion engines.
93 “Diesel fuel” is any petroleum product intended for use as a fuel for engines in which the fuel is injected into the combustion chamber and ignited by pressure without electric spark.
94 “Heating oil” is any petroleum product intended for use as a furnace oil, range oil or fuel oil for heating
mixing benzene and toluene with higher quality fuels, and in some cases, even mixing water with fuels. In other words, widespread adulteration is essentially spurred by the price differential between various petroleum products in a system based on subsidies to contain inflation so as to reduce the risk of sparking social instability.

The International Energy Agency used the term “interfuel substitution” to describe fuel adulteration. In its July 2005 report, it says that there was clear evidence in China that interfuel substitution was playing a role in the reduced demand for fuel oil in the first half of the year, and that some users had turned to “coal mud” and “coal “tar”, which seems close to highly polluting bunker-type fuels (see Part III Section C).

Our research has shown that manufacturers operating their own private power generation units in the PRD use adulterated fuels to produce on-site electricity. There has also been adulteration of vehicular fuels in Guangdong. The burning of such fuels can lead to not only serious equipment and engine failure but also generate more much more air pollution. Adulteration fuels make exhaust gases more poisonous. For example, when kerosene is mixed with gasoline, it does not burn completely and releases more cancer-causing hydrocarbons, nitrous oxides and carbon monoxide, instead of the less harmful carbon dioxide. Adulteration of diesel has a different effect. Adding kerosene lessens diesel’s lubricating function, leading to faster wear and tear of equipment and machinery, and in addition, the soot particles carried by diesel exhausts also have un-burnt and therefore more harmful hydrocarbons from the kerosene.

C. Bunker fuel

While it is beyond the ambit of this paper to discuss bunker fuel in any detail it needs to be mentioned that this much more polluting fuel appears to be used for more than just marine purposes, such as to power private generators when there are shortages. Bunker fuel is also known as heavy oil, Bunker C, residual oil, “resid”, blended fuel oil, furnace oil and other often locally used and cooking purposes to be used in burners.

95 “Lubricants” are products used for the purpose of reducing friction, heat or wear in automobiles, gasoline and diesel engines, and other machines.
96 Water is usually heavier than oil products, such as gasoline, and therefore sinks to the bottom in a tank or drum, making adulteration with water harder to detect when it is being sold to end-users.
names. Normally it is fuel burned in oceangoing ships for propulsion, and consists of 95% residual fuel. When crude oil is refined, the lighter fractions (gasoline, kerosene, diesel, etc.) are removed by distillation. The heaviest materials in crude petroleum are not distilled - the boiling points are too high to be conveniently recovered. These materials carry through refining and the product at the end is known as “resid”. Before selling resid as bunker fuel, a refiner will very often dilute it to meet various sales specifications for trace metals, sulfur and/or viscosity. The colour of bunker fuel is black or dark brown and can often have a tar like consistency. Marine diesel, which is derived from used oil recycling, is another fuel used to power vessels. It is likely that this fuel is also used to power on-land generators.

98 See www.liquidminerals.com for more information about bunker fuel.
PART IV: Observations and Recommendations

A. Observations

i. China’s power sector

In summary, there are SIX general points to note about China’s power sector and its various reforms efforts:

- **Future energy consumption potential**
  The balance of supply and demand of the energy sector in China, including in Guangdong, is achieved at a relatively low consumption level. In Guangdong’s case, which is one of the most developed areas in the country, it is at about 70% of the OECD average. This means consumption level will continue to rise as China continues to develop.

- **Importance of transportation infrastructure**
  China’s coal and oil and most of the gas resources are mainly located in the interior of the country and the main consumption bases are in the east and south. Guangdong’s domestic coal supplies for example are shipped from the northern ports. Transportation infrastructure therefore plays a key role in delivery, including the capacity to handle imports, since bottlenecks affect the entire delivery process.

- **Cleaning up coal production**
  China’s energy needs are so large that there is no single solution to satisfying the needs. Coal will remain the most important energy source for the foreseeable future. Thus, making every aspect of coal production and usage in power generation as environmentally sensitive as possible is vital to air pollution control, climate change and public health.

- **Energy reform covers many aspects**
  In reforming the energy sector, many bases need to be covered and many fronts have to be worked, including to invest in securing raw materials, increasing power generation and transmission capacities, adopting cleaner technologies, as well as reforming commodities prices and tariffs so that they can reflect true costs.
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- **Market liberalisation has begun but will take time**
  Transiting from a state planning system where officials use central administrative control to a market system is highly challenging and Chinese policy-makers feel unable to deregulate too quickly. Thus, substantial market distortions arising from subsidies and price caps will continue. The periodic directives from the NDRC on various types of prices are often conflicting and tortuous, and will likely remain so as it tries to balance a range of economic, financial, social and political priorities. Moreover, China’s power sector is complicated by having multiple regulatory agencies. The good news is that all these problems are well-appreciated by Chinese policy-makers. A recent study put forward by the NDRC to liberalise the sector further proposed that the Chinese Government draft legislation to open-up the upstream market and improve government supervision. The study estimated the process could take 3 to 5 years.  

- **Authorities must intensify pollution control efforts**
  Air quality has deteriorated significant in the whole of the country, including in Guangdong. While China already has a legislative framework in place for air pollution control, provincial and local authorities must be willing and able to implement them. To move forward, many measures are needed to clean-up various combustion processes.

**ii. Guangdong observations**

Guangdong still needs substantial power capacity expansion and energy imports to meet growing demand in the foreseeable future. End-users there are already paying the highest tariffs in the country and the technological capacity mix is still sub-optimal because a large number of small, inefficient and highly polluting power plants are still in operation.

Unreliable grid power has also resulted in the widespread use of ‘back-yard’ generators in manufacturing industries, many of which burn low quality and even adulterated fuels. Power generation is therefore causing serious pollution, which has worsened since 2004 when global crude oil and oil products prices

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started to climb. Air quality problems now affect the whole of the PRD, including Hong Kong. There is hope that over the years that power shortages will improve as more capacity is installed and that concurrently, smaller plants can then close down once and for all and manufacturers will not need to run private generators. However, it may well be difficult for Guangdong to rid itself of the vast numbers of private generators in the PRD in the foreseeable future as power and fuel shortages occur within a system of both supply and demand variables that are difficult to predict.

B. Recommendations

i. Cleaner fuels

One possible short-term solution is to explore whether the manufacturing industries can burn cleaner fuels for power. This simple solution makes sense because burning clean fuels will immediately reduce emissions. The difficulty with this measure is that it can only be voluntary and it needs to be implemented within a mechanism where the end-users can actually buy cleaner fuels.

Our research shows that Guangdong-based refineries are able to refine petroleum products to meet Euro III standards. In other words, domestic refiners are capable of supplying cleaner fuels. Whether they will supply more or less of the cleaner products depend on pricing incentives within a price controlled environment. The province already imports large amounts of fuel oils, and thus also has the capability to source cleaner fuels internationally at higher prices.

When international market prices are much higher than domestic prices and refiners and importers cannot pass the higher costs to their buyers the incentive to supply cleaner, more costly fuels are dampened. Distributors at both the wholesale and retail levels are motivated under this market environment to reduce and limit losses instead which they do through fuel adulteration which results in fuel mixes that are highly polluting. Thus, a successful mechanism to supply cleaner fuels must enable distributors to pass the costs on to end-users. One possibility may be for manufacturers to be able to source cleaner fuels at higher prices. Exporters may be willing to do so, particularly those who produce higher value or brand name products, because burning lower quality fuels, especially adulterated fuels, create not only environmental risks but also
financial risks. Dirty fuels result in higher maintenance costs and lower productive life expectancy. Furthermore the wrong type of fuels can also cause serious damage to production machinery and possibly machinery failure altogether. These costs should be factored into the full production costs. In other words, using lower quality fuels is not as cheap as it appears.

ii. Options for Hong Kong

The question for Hong Kong is whether there are ways for the export manufacturing sector based in the PRD to source and use cleaner fuels to power their private generators, which will have an immediate positive impact on air emissions. It is helpful that there is already awareness among Hong Kong’s industrialists that combustion causes pollution and that their manufacturing plants in the PRD have a direct impact on Hong Kong’s air quality. In 2005, both the Hong Kong Federation of Industries and the Business Coalition on the Environment put forward voluntary schemes to encourage improved environmental practices relating to air quality. Some Hong Kong manufacturers are already concerned about the negative consequence of using lower quality and adulterated fuels. Their concern is that they are unable to source cleaner fuels even if they pay higher prices because they are unable to buy them from local distributors.

As mentioned above, a clean fuel strategy only works if there is a mechanism that allows the costs to be passed on. Thus, industries and business representative bodies need to focus on developing a workable mechanism. They can explore the subject with the oil products distributors, as well as with local authorities. Perhaps some arrangement could be reached between importers of fuel and manufacturing exporters for cleaner fuels to supplied for specified customers, who are prepared to pay the higher costs.

So far the Hong Kong Special Administrative Region Government encourages voluntary action among Hong Kong manufacturers operating across the border

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100 The Business Coalition on the Environment (which operates through the Hong Kong General Chamber of Commerce) created a “Clean Air Charter” which is a voluntary pledge for Hong Kong companies (operating in both HK and the PRD) to adhere to six commitments in relation to emission standards including monitoring, reporting and sharing best practice examples. The charter currently has about 200 signatories. The HK Federation of Industries’ “1-1-1” programme requires businesses to implement a new environmental improvement (including air quality improvements) each year in each factory. The programme currently has about 85 manufactures registered.
to be more environmentally responsible, but it has no jurisdictional power to force action. Yet, local business people are demanding quicker improvements. A possibility is for it to engage its Guangdong counterparts to discuss the use of cleaner fuels by the export manufacturing sector. Guangdong has a record of being a leader in reforms, which provides a base for collaboration on how to take every opportunity to improve air quality even in the short-term, since otherwise one must wait for the longer-term impacts of price reforms and environmental up-grades to kick-in. Showing active willingness to explore short-term solutions together with industries is a good way for both the Hong Kong and the Guangdong authorities to show leadership in public-private sector partnerships. At the same time, the Hong Kong Federation of Industries and various chambers of commerce can help to educate the international investment community, as well as multinational buyers, about the particular problems related to fuel usage in the PRD and that their members are using cleaner fuels and thus to try gain an advantage through a corporate social responsibility perspective rather than just through the lowest possible price.

By having the Hong Kong authorities working with industry as well as capitalizing its ability to deliberate with counterparts in Guangdong, Hong Kong can do something in the near-term to improve air quality rather than wait for much longer-term solutions.

iii. Financing mitigation measures

A recent US study\textsuperscript{101} which focussed on air pollution derived specifically from the manufacture of export goods in the PRD calculated that 10\% – 40\% of air pollutants generated in the PRD are caused by export related activities. The study reasoned that the reason PRD manufactured export goods were so cheap and therefore marketable internationally was because emission controls are lacking or of low performance in the PRD. Certainly, this highlights the issue that goods are considered ‘cheap’ by the rest of the world, specifically places such as the US, which generally have much more stringently enforced environmental performance standards. Without doubt, the cost of goods derived from manufacturing processes in the PRD does not incorporate all costs into

their pricing with the main category of costs missing being ‘external costs’.

External costs are those actually incurred in relation to public health, crop yield, damage to structures (such as through acid rain) the environment and ecosystems, as well as climate change, but not built into the costs of production, including the true costs of the consequences of subsidies. External costs are borne by society at large, and where pollution crosses national borders, even by others. External costs are seldom factored into policy decisions. Indeed, it would be helpful if the study of external costs becomes routine so that policy-makers, business and the public can better understand the full costs of policy decisions, which may help society to make the transits needed sooner in order to focus more on energy efficiency and conservation, as well as invest in technologies that have lower external costs.

The US study\textsuperscript{102} estimated that state of the art pollution controls could be installed at annualised costs amounting to 0.3\% to 3.0\% of the value of the goods produced. It concluded that pollution mitigation measures could be adopted without seriously affecting the prices of exported goods and would achieve considerable human health and other benefits through reduced air pollution in densely populated urban areas. Local commentators\textsuperscript{103} in Hong Kong have also suggested other forms of levies and taxes such as an Energy Tax which could be levied on power users as a way of implementing the “polluter pays principle”. Such taxes would encourage conservation and create a funding pool to finance mitigation measures. Obviously these ideas need to be thoroughly considered but they show there may well be innovative ways to look at solutions if the authorities together with industries are willing to explore them.

Pollution mitigation measures well developed however the financing and implementation mechanisms are still in the developmental phase. While local authorities are supporting each other on a technical level, there is much more which can be done to develop integrated policies to maintain energy supply and at the same time reduce regional air pollution. Cross border co-operation within the private sector is an essential component of the solution and Hong Kong’s long integrated economic partnership with the PRD provides all the tools necessary.

\textsuperscript{102} Ibid. (Streets, et al.)
\textsuperscript{103} Philip Bowring, “Powering up an energy tax”, South China Morning Post, Insight Section, 9 Jan 2006.
After 1949, the Government of the People’s Republic of China nationalized the oil industry and put it under the direct control of the Ministry of Petroleum Industry (MOPI). MOPI became involved in all aspects of the upstream/downstream operations and business. MOPI was also the industry regulator as well as responsible for the workers in the state-owned enterprises. As part of the national reform programme, the Chinese Government in 1981 began to reorganize the sector by firstly contracting with MOPI to meet specific annual production targets and for surplus quantities to be sold domestically. This was done to provide incentives for the industry to maximize exploration, production and upgrade. The next step involved the separation of the regulatory functions from the commercial functions by the creation of new companies to focus on exploration, production and marketing. By 1988, China had set-up three large national oil companies – China National Offshore Oil Corporation (CNOOC), China Petrochemical (Group) Corporation (CPC), and China National Petroleum Corporation (CNPC). MOPI was dissolved. From about the mid-1990s, the government began to encourage the oil companies to explore overseas, as well as make investments and acquisitions abroad. These companies have also become listed on stock markets. Chinese policy is to turn these companies into globally competitive commercial enterprises.

**China National Offshore Oil Corporation**

The first national oil company created was CNOOC in 1982. It was given responsibility to explore, develop and produce oil and gas in China. To boost investment, CNOOC was permitted to enter into production sharing and joint venture contracts with foreign companies. In 2001, CNOOC was restructured to be a Hong Kong company for listing on the New York and Hong Kong stock exchanges. The state holds the majority of the shares through the parent company. CNOOC used to only focus on upstream oil and gas exploration offshore. CNOOC’s largest gas fields are Yacheng and Dongfang, both of them located in the Western South China Sea. Yacheng supplies Hong Kong (CLP Power) and Hainan via offshore pipelines. However, with liberalization of the oil business, Sinopec and PetroChina have both been granted offshore explore licences.

**China Petrochemical (Group) Corporation**

CPC was created in 1983. It was given a dominant position in petroleum refining and petrochemical production. By the 1990s, it owned more than 90% of China’s refining capacity. In 1998, the company was instructed by the government to swap assets with CNPC along
Regional lines so that the reorganized company would become the dominant player in the southern and eastern regions of China. In 2000 after restructuring, the China Petroleum and Chemical Corporation (Sinopec) was listed on the Hong Kong, London and New York stock exchanges.\textsuperscript{105} In 2001, it listed on the Shanghai stock exchange. The state holds the majority of the shares through the parent company. Sinopec’s scope of business today covers oil and gas exploration, oil refining, storage and transportation of oil and gas, production and sales of petrochemicals, chemical fibres, fertilizers and other chemical products, as well as trading and agency businesses. It is China’s 2\textsuperscript{nd} largest crude oil producer, and the largest producer and distributor of refined petroleum products (both wholesale and retail of gasoline, diesel and jet fuel). In 2004, it had 60.5\% of the market share for products. Sinopec is Asia’s largest refiner in terms of capacity and the 2\textsuperscript{nd} largest energy company in terms of market capitalization. It has plans to diversify into LNG.

**China National Petroleum Corporation**

When MOPI was dissolved in 1988, its commercial operations were transferred to CNPC. CNPC assumed various assets and also became responsible for some of the regulatory and workers welfare responsibilities. It was tasked with upstream development of onshore oil and gas businesses. In 1998, swapped assets with Sinopec, where it received Sinopec’s assets in northern and western China. CNPC created PetroChina to focus on its commercial interests.\textsuperscript{106} In 2000, PetroChina was listed on the Hong Kong and New York stock exchanges. CNPC holds most of the issued stock. PetroChina is responsible for the largest and most lucrative oil and gas field in China at Daqing (40\% of total oil production). It is involved in exploration of oil and gas, refining, transportation, storage, marketing and trading activities. In terms of production, it is the largest oil and gas company nationally. It is also the sponsor of the 2,500 mile West-East Pipeline from Xinjiang to Shanghai. PetroChina is Asia’s largest oil and gas producer, with the world’s 2\textsuperscript{nd} largest proven reserves in oil and gas, and the world’s 2\textsuperscript{nd} largest oil company behind ExxonMobil in terms of proven reserves.

\begin{footnotes}
\footnotetext{105}{See www.sinopec.com}
\footnotetext{106}{See www.petrochina.com}
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