Notebook

Notebook provides data not easily found elsewhere, background descriptions of important aspects of the energy system and reports on new developments. Contributions are invited.

China's Oil Refining Industry in Transition: Critical Issues and Outlook for Foreign Participation

FRANK C. TANG

Introduction

As in many developing and industrialized countries, the oil refining industry is a critical link in the energy chain in China, transforming crude oil into transportation fuels (gasoline, jet fuel, and diesel), residual fuel oil (widely used as a fuel in industry and electric power sector), and other products such as kerosene, used for lighting and cooking in rural areas. About four decades ago, the demand for oil products in China was centred on a few large cities and, as a result, few refineries were built in the country. Since then, because of the rapid pace of economic growth, demand for oil products has increased steadily, and the oil refining industry has expanded significantly.

However, the rapid economic development and unleashed oil demand since the early 1990s have led to a situation such that China's refining industry is at a critical crossroad. Despite huge capacities, China's refining industry is finding it increasingly difficult to meet the domestic demand for petroleum

Frank C. Tang is a Visiting Fellow with the Program on Resources: Energy and Minerals, East-West Center, Honolulu, Hawaii.

products. China's refining industry has been highly concentrated geographically and has largely been aligned with the country's historical crude oil production regions in the North, whereas oil product demand in the Southern coastal areas has been experiencing rapid growth. In order to meet this rapidly growing demand and to reduce regional supply/ demand imbalances, the oil refining industry must significantly expand its capacity in the Southern coastal areas. Moreover, a majority of the refineries were designed to run China's domestic low-sulphur crude oil and many refineries lack the sophisticated processing facilities required to maximize the yield of high-value transportation fuels (gasoline and diesel) and to improve product quality. These refineries, by the very nature of their design, produce a considerable proportion of residual fuel oil, which used to be a dominant product in the Chinese consumption profile. The changes in consumption patterns that have occurred since the early 1980s — and the likely continuation of these trends — have made it necessary for refineries substantially to increase the yields of distillates (especially middle distillates such as diesel) by the installation of facilities to change the product profile. With the levelling-off of China's crude oil production, imports of Middle East high-sulphur crude oil will be inevitable. In addition, concerns about environmental issues require serious action on stricter oil product specifications. Again, refineries require additional processing facilities to reduce sulphur content and to improve product quality.

This paper examines a number of critical issues in the transition of China's refining industry and analyzes the opportunities for foreign participation in its expansion. The rest of the paper proceeds in the following way. In the next section, we provide an overview China's petroleum sector. The third section reviews the development of China's oil refining industry. Some of the critical issues facing the oil refining industry are examined in more detail in the fourth section. Then, the outlook for foreign participation in China's refining industry is presented, followed by a brief summary.

Overview of China's Petroleum Sector

Corporate Structure

China's petroleum sector is under the control of national companies. Currently, there are six national corporations operating in the petroleum sector: China National Petroleum Corporation (CNPC), China National Petrochemical Corporation (Sinopec), China National Offshore Oil Corporation (CNOOC), China National Chemical Import-Export Corporation (Sinochem), China International United Petroleum and Chemicals Company (Unipec), and China National United Oil Company (China Oil).

The first three corporations report directly to the State Council (China's Cabinet), while the others are under the jurisdiction of the Ministry of Foreign Trade and Economic Cooperation. China National Petroleum Corporation (CNPC) was formed from the former Ministry of Petroleum Industry in 1988. CNPC is responsible for all onshore upstream oil and gas operations in the country, including shallow water areas to a depth of 16 feet. China National Offshore Oil Corporation (CNOOC) was formed in 1982. The initially designated scope of CNOOC's business included the exploration of Chinese offshore petroleum resources by way of Sino-foreign cooperation and self-run programs. China National Petrochemical Corporation (Sinopec) was established in 1983 as a national refining company to consolidate all major refineries in the country. Prior to this time, most refineries were under the control of the Ministry of Petroleum Industry, but oil refining had also been handled by several other ministries and local governments.

China National Chemical Import-Export Corporation (Sinochem) held a monopoly position in China's oil trading for more than four decades — until 1993, when two joint trading companies were formed. The first of these companies is China International United Petroleum and Chemicals Company (Unipec), which is a joint venture between Sinopec and Sinochem. Its business scope includes the im-

port and export of crude oil and petroleum products, petrochemicals, and related equipment, as well as the financing, transport, and storage functions related to this trade. On behalf of Sinopec, it also engages in contract engineering services, labour services, and processing deals. The second of these joint trading companies is China National United Oil Company (China Oil), which is a joint venture between CNPC and Sinochem. It is a joint marketing company involved in the import and export of crude and products. Since China Oil has close linkages with CNPC, its formation has effectively given CNPC the flexibility to export its own crude directly.

Crude Oil Production

The development of China's modern oil industry dates back to the late 1950s, when the Daqing oil field was discovered in the Songliao basin of Northeast China. For nearly 20 years, the industry achieved annual growth rates in output averaging 20%, despite the use of largely obsolete technologies. However, the limits of these technologies were reached in the late 1970s, when production at Daqing and other large oil fields peaked, which led to a period of overall stagnation in the industry, lasting from 1978 to 1983. Following the emergence of higher crude prices and the infusion of foreign technology for enhanced recovery, strong output growth was resumed in the second half of 1980s. Since 1990, the growth of China's crude oil production has slowed down again. Crude oil production increased from 2.77 million barrels per day (b/d) in 1990 to 2.92 million b/d in 1994, representing an average annual growth rate of only 1.3%.

An overwhelming share of China's crude oil is produced onshore. The Daqing oil field, in the Songliao basin of Heilongjiang Province, is by far the largest oil field in China. For many years, its output has amounted to over 1 million b/d, and accounted for approximately 40% of the country's total production. The second largest oil field in China is Shengli, in Shandong Province. Shengli's output increased rapidly for most of the 1980s, but production has declined slightly in recent years. The Shengli field's output of 620 thousand b/d of crude oil in 1994 was 21% of the country's total production. The Liaohe oil field in Liaoning Province became China's third largest oil field when its production surpassed that of the Huabei oil field (in Hebei Province) in 1986. Liaohe's production of 300 thousand b/d of crude oil in 1994 was 10% of the national total. All three of these oil fields are located in Northeastern China. In 1994, the output from the above three oil fields accounted for about 70% of the national total, but production from these fields has recently stagnated. In fact, all of China's incremental onshore production from 1990 to 1994 came from Xinjiang Autonomous Region in the West, which has oil fields in three major basins: Jungger, Tarim, and Turpan-Hami. Crude output from these three basins increased from 140 thousand b/d in 1990 to 225 thousand b/d in 1994. China's major onshore oil fields are illustrated in Figure 1. Offshore production accounts for only a small share of the country's total crude output, but its relative importance has been increasing: from 1.0% in 1990 to 4.4% in 1994 (130 thousand b/d was produced offshore in 1994). Indeed, about two-thirds of the country's incremental output in this period came from offshore sources.

On an overall basis, no big boost in domestic crude production is expected before 2000, although output from some areas (such as offshore) is likely to show substantial increases. Even though China has been seeking foreign investment to install enhanced oil recovery (EOR) capacity in the Daqing oil field, output from this field can be maintained at the current level only until 2000, at best. Crude output from Shengli is expected to continue to decline slightly. Production from two other major oil fields—Huabei and Zhongyuan—has been declining, and will likely continue to do so. Among China's major Eastern oil fields, only Liaohe, the country's third largest field, is expected to show a slight increase in output, but this growth can barely offset production losses from Huabei and Zhongyuan. Therefore, it seems very likely that China's incremental crude production up to the year 2000 will mainly come from offshore areas and from the

Figure 1: China's Major Oil Fields and Provinces

remote Western oil fields in Xinjiang (notably the fields in the Tarim basin). Offshore production is expected to increase from 130 thousand b/d in 1994 to 240 thousand b/d in 2000, and production from the oil fields in Xinjiang is expected to rise to 400 thousand b/d.

It is projected that China's crude oil production will be 3.2 million b/d in 2000. Historical and projected production levels for each major field are shown in Figure 2. Total output could be lower if Daqing production decreases significantly after the exhaustion of EOR options and if output from Shengli declines more rapidly than expected. On the other hand, if Liaohe shows substantial production gains and additional offshore discoveries are made, China's crude production will be higher than the levels projected here.

Oil Trade

China has been one of the important oil exporters and importers in the Asia-Pacific region since 1973, when it recorded its first exports of crude oil to Japan. Government policy before 1986 (when international oil prices plummeted) was to maximize oil exports. Crude oil and product exports increased steadily in this period and reached an all-time high of 740 thousand b/d in 1985, accounting for nearly 30% of that year's crude oil production. Since the collapse of international oil prices in 1986, China's oil trade policy has evolved from one of solely maximizing exports to a more rationalized program of import and export management. While oil exports decreased only slightly, oil imports (especially oil products) surged in 1989, 1992, and 1993. As a

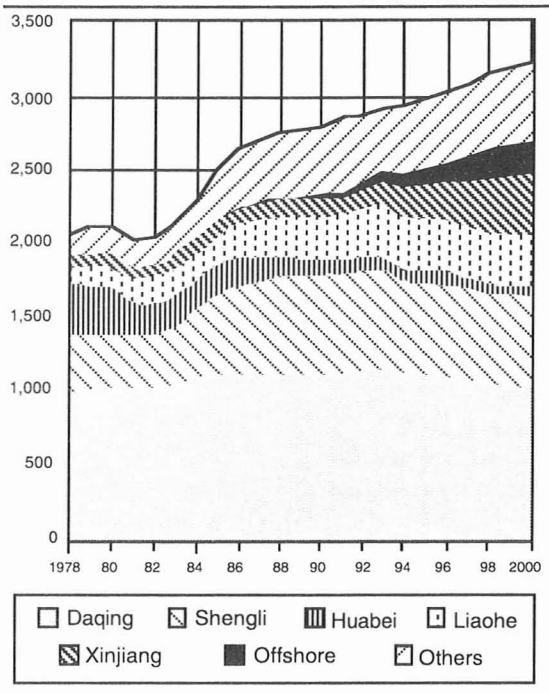

Figure 2: Historical and Projected Crude Production 1978-2000 (thousand b/d)

result of the product import surge of 1992, China became a net refined product importer in 1992 for the first time since the mid-1960s, and a net oil importer (crude oil and refined oil products) in 1993 when net imports of crude and oil products reached about 200 thousand b/d, a shift in trade flows of over 900 thousand b/d in eight years. The historical evolution of China's oil trade is presented in Figure 3.[1]

The Role of Petroleum in China's Energy Consumption

China is one of the few countries in the world that still uses coal as its principal energy source. During the 1950s, when China's oil production was low and oil imports were limited, coal accounted for 95% of the country's primary energy consumption. Today, about three-quarters of China's primary energy consumption still comes from coal. With the significant increases in domestic oil production experienced in the 1960s and 1970s, that fuel's share of China's primary energy consumption rose steadily, from less than 5% in the late 1950s to 23% in 1978. However, this share declined in the 1980s as a result of the government's policy of maximizing oil exports, coupled with the national policy of "oil-to-coal" substitution. With the import surges of recent years, China's oil consumption has picked up considerably since the early 1990s; the share of oil in total primary energy consumption increased from 17% in 1990 to 20% in 1994.

The share of oil in China's primary energy consumption is expected to increase in the future, even if gains in domestic oil production are projected to be limited. When China was still relying on oil primarily as a boiler fuel, it was easily substitutable by coal in most cases, but the decline in the relative share of fuel oil in final demand and the massive increase in demand for transportation fuels has meant that up to 50% of China's consumption of petroleum is essentially non-substitutable at any reasonable cost, at least in the short term. This characteristic of petroleum use limits China's abilities to rely on domestic resources; in short, if domestic production falls short of satisfying demand, the balance will need to be imported — the prospects for substitution away from oil being severely constrained, at least over the short term.

The Development of China's Oil Refining Industry

China's refining industry has experienced three periods of rapid expansion since the early 1960s, following the discovery and development of large domestic oil fields. The first of these periods occurred in the late 1960s, when a number of large-scale refineries were brought on stream to run Daqing, Shengli, Huabei, and Liaohe crudes. Total refining capacity (distillation capacity) increased from 250 thousand b/d in 1964 to 880 thousand b/d in 1970. In this period, refinery expansion was largely planned in tandem with the growth in domestic crude oil production, and almost all

1/ For a more detailed discussion, see Frank C. Tang and Fereidun Fesharaki (1995) "China: Evolving Oil Trade Patterns and Prospects to 2000," Natural Resources Forum 19(1): 47-58.

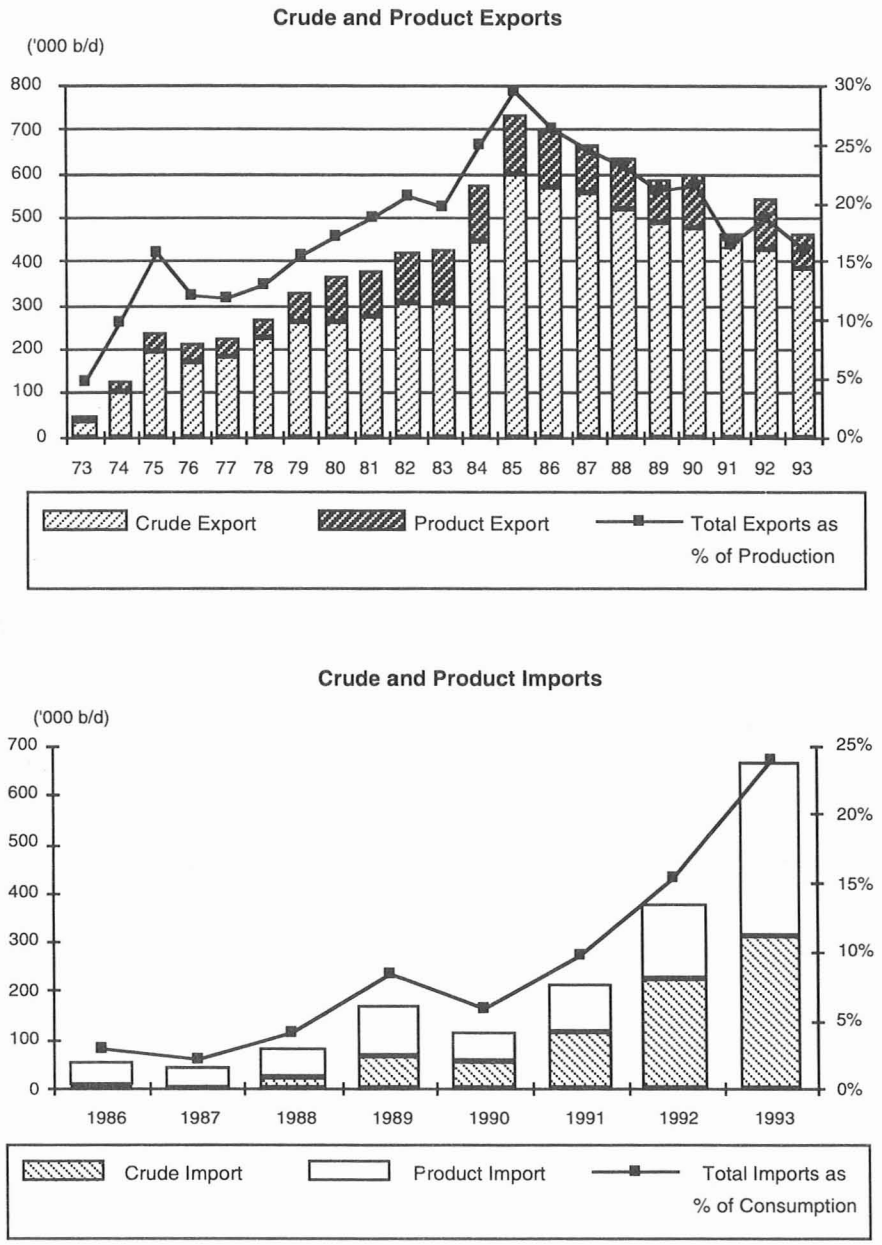

Figure 3: Oil Imports and Exports in China

refineries were constructed in the Northern crude oil producing areas.

The second period of rapid expansion occurred in the mid-1970s. The capacity growth in this period was spurred by the expansion of the crude pipeline network, which permitted the expansion of existing refineries in the Southern coastal region and the construction of grass-roots coastal refineries. As a result, the share of refining capacity located in the main consumption centres experienced a moderate increase. Total refinery capacity reached 1,860 thousand b/d by 1978. Much of the capacity expansion during this period, however, came

in the form of new distillation units with few upgrading facilities. Cracking capability in 1978 was only about 21% of distillation capacity.[2] Therefore, the average yield from refineries became heavier, with residual fuel oil yields reaching nearly 50% of total output. (This product was burned directly as boiler fuel without any further upgrading.) Moreover, this period coincided with China's "cultural revolution" — a period of internal political turmoil. As a result, many of the refineries constructed during this period were poorly planned and located, and, as might be expected, their efficiency was fairly low.

In 1983, Sinopec (China National Petrochemical Corporation) was established as a national refining company to consolidate all major refineries in the country. Since its establishment, Sinopec has invested heavily in the upgrading of the entire system, and worked to rationalize the distribution of crude oil and the operations of individual refineries.[3] These developments set the stage for the third major period of refining capacity expansion, which started in 1988 when China's refining capacity totalled slightly more than 2.3 million b/d. Within six years, refining capacity had expanded by more than one million b/d, with all but 50 thousand b/d of this amount coming from the expansion of existing refineries. Further, the rapid growth of distillation capacity in this period was associated with an even more rapid growth in upgrading units. As a result, the overall yields of heavy ends fell from 50% of output in 1978 to 21% in 1994.

Among China's upgrading categories, however, FCC/RCC far outweighs all the others.[4] In 1994, for example, the ratio of FCC/RCC capacity to crude capacity was 30%, a figure second only to that of the United States. This can be attributed to: (1) the relative success with which China has developed its domestic catalytic cracking technology; and (2) the incentive for producers to maximize gasoline production, owing to the product pricing system in China, which has historically priced gasoline at a significant premium over diesel. However, the capacity of other secondary units has not attained much significance. For instance, the current ratio of hydrocracking (HDC) to crude capacity is only about 3.3%. China has not obviously been as successful in developing its domestic HDC technology as it has been with FCC. The lack of sufficient hydrogen (partly due to the low catalytic reforming capacity in the country) and the massive investment requirements of HDC have also contributed to the low HDC capacity in China. The relatively low capacity of catalytic reforming (only around 4.4% of distillation capacity) is, in turn, attributable to the fact that China's domestic crudes contain only a small fraction of naphtha and that a large quantity of the available naphtha is consumed as ethylene plant feedstock. While delayed coking is the most widely used process in China for the upgrading of residual oil, its total capacity is only about 5.8% of distillation capacity. A major factor that has restricted the development of coking capacity is the limited market for refinery coke. Table 1 presents the historical development of China's major refining facilities.

While China's refining capacity has experienced rapid growth since the early 1960s, refinery utilization rates have remained low for most of the ensuing years. This was mainly attributable to three factors, the first of which is technical. Since China's refining system has been inherently dispersed and poorly coordinated, it simply can not operate at full production rates. The second factor is related to China's petroleum policy. As noted earlier, during the period from 1973 to 1985, the goal

2/ In this paper, cracking capability is defined as the percentage of distallation capacity of four major processes: fluid catalytic cracking (FCC) and residue catalytic cracking (RCC), hydrocracking (HDC), thermal cracking, and coking.

3/ Currently, Sinopec controls about 88% of China's refining capacity. The remainder is under the jurisdiction of CNPC (China National Petroleum Corporation) and local governments.

4/ Both fluid catalytic cracking (FCC) and residue catalytic cracking (RCC) are key refining processes, which consist of breaking down the larger, heavier, and more complex hydrocarbon molecules (in the fuel or residue range) into simpler and lighter molecules (in the gasoline and diesel range).

Table 1: The Development of China's Major Refining Facilities ('000 b/d)

Year	CDU	FCC/ RCC	Thermal Cracking	Coking	HDC	Catalytic Reforming
1957	49	-	-	8	3	0
1965	285	32	-	38	9	2
1970	880	100	-	68	20	10
1975	1,353	220	-	101	15	27
1978	1,858	396	-	97	14	29
1980	1,877	419	-	102	15	33
1985	2,123	667	-	118	38	45
1990	2,904	860	-	150	114	92
1993	3,320	925	154	180	114	147
1994	3,417	1,015	195	200	114	152

Source: Sinopec Annual Report,various issues.

Notes:

•CDU stands for "crude distillation unit."

•FCC/RCC stands for "fluid catalytic cracking and residue catalytic cracking." Thermal cracking is included in FCC/RCC, except for 1993 and 1994.

•Thermal cracking is a refining process in which heat and pressure are used to break down, rearrange, or combine hydrocarbon molecules.

•Coking is a thermal refining process used to produce fuel gas, gasoline blend stocks, distillates, and petroleum coke from the heavier products of distillation.

•HDC stands for "hydrocracking," a refining process that uses hydrogen and catalysts for converting middle boiling or residual material to high octane gasoline, reformer charge stock, jet fuel and/or high grade fuel oil.

•Catalytic reforming is a refining process using controlled heat and pressure with catalysts to rearrange certain hydrocarbon molecules, thereby converting low-octane gasoline boiling range fraction into higher octane stocks suitable for blending into finished gasoline.

of the national petroleum policy was to maximize crude oil exports. As a result, there was not enough crude oil available to supply the country's own refineries. Finally, a third factor is that domestic crude production has stagnated since the late 1980s. Some upgrading units, notably FCC (fluid catalytic cracking), have also been under-utilized. As a gasoline-producing technology, FCC is apparently not commensurate with the country's increasing demand for middle distillates. China's refining capacity, throughput, and refinery utilization from 1964 to 1994 are presented in Figure 4.

Critical Issues Facing China's Oil Refining Industry

Growing Oil Product Demand and Changing Product Demand Pattern

Since the early 1980s, the growth rate of petroleum product consumption in China has been moderate compared to the country's rapid economic growth. For example, in the 8-year period from 1984 to 1992, real GDP grew at 9.0% per annum on average, whereas aggregate oil consumption increased by only 5.8% annually in this period. However, the consumption of lighter products (mainly gasoline and diesel) increased more rapidly than average, owing to the expansion of motor transportation. From 1984 to 1992, passenger-mileage and freight ton-mileage of motor transportation increased at average annual rates of 11.5% and 11.8%, respectively. In the same period, gasoline and diesel consumption grew at respective annual rates of 9.7% and 8.5%. In other words, the consumption of products other than gasoline and diesel increased relatively slowly, at an average rate of only 3.1%, between 1984 and 1992. As a result, the consumption of fuel oil as a proportion of total oil consumption decreased from 33% in 1984 to 25% in 1992.

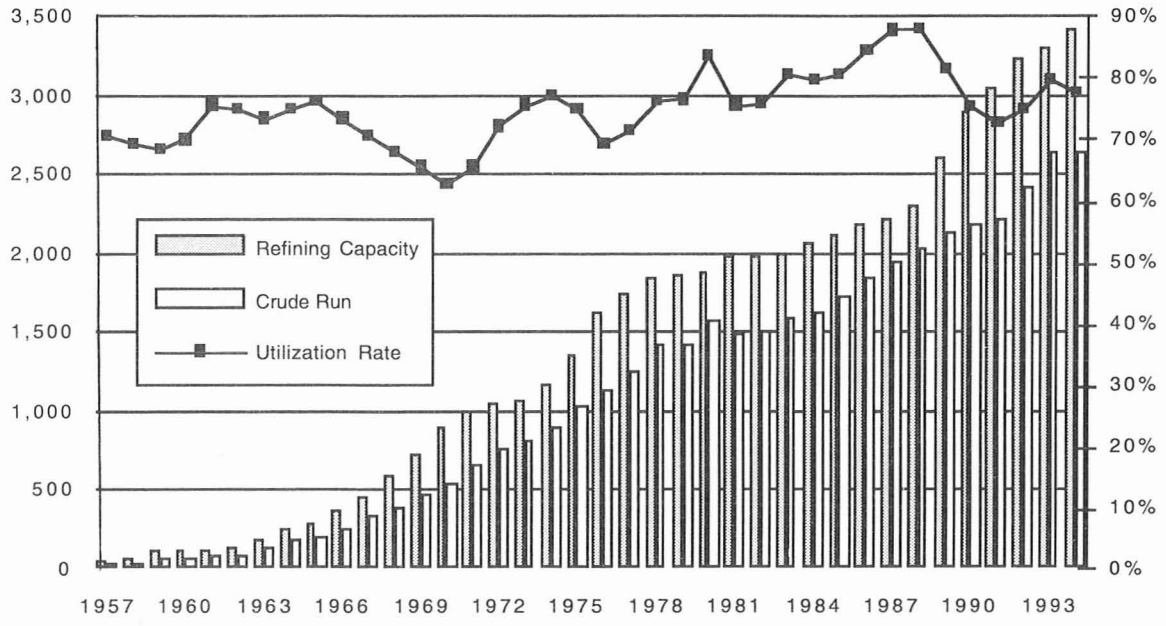

Figure 4: China's Refining Capacity, Throughput, (thousand b/d) and Utilization Rate 1957-93

China's real GDP and petroleum consumption grew, respectively, at 12.7% and 8.0% annually from 1992 to 1994. Many believe that such growth rates will not be sustained in the future. The projections assembled for this paper suggest that China's GDP will increase 8.0% per annum on average for the six-year period extending from 1994 to 2000, while petroleum product demand is projected to increase to 3.9 million b/d in 2000, an average growth rate of 5.0% per annum during this period.[5] Product demand will continue to slant toward lighter products, owing to the rapid expansion of the country's motor transportation. Among the major petroleum products, gasoline will continue to lead with an annual growth rate 8.5%, followed by diesel at 7.4%. Fuel oil demand (mainly that for low-sulphur fuel oil) is expected to increase 2.0% annually. Table 2 presents China's actual petroleum product demand by major product in 1984, 1992, and that projected for 2000. As this table shows, the product demand pattern is expected to change significantly over the next few years, as indicated by Figure 5, which shows the 1992 product demand pattern compared with the incremental demand pattern projected for the period through 2000. Transportation fuels (gasoline, kerosene/jet fuel, and diesel) accounted for 54.5% of product demand in 1992; this is expected to increase to 62.5% by 2000.

Table 2:: Petroleum Product Demand, 1984-2000 ('000 b/d)

Product	1984	1992	2000
Gasoline	278	581	1,116
Kerosene/Jet Fuel	82	89	101
Diesel	360	693	1,227
Fuel Oil	528	619	736
Other[1]	351	501	720
Total	1,600	2,483	3,900

1/ Including LPG, naphtha, gasoil-range chemical feedstock, and direct burning of crude oil.

Although jet fuel is projected to increase rapidly, the demand for kerosene in the countryside is expected to decline considerably be-

5/ The aggregate oil demand projection presented in this paper is based on projections of individual product demands. For example, a log-linear relationship was established to project passenger movement and gasoline demand.

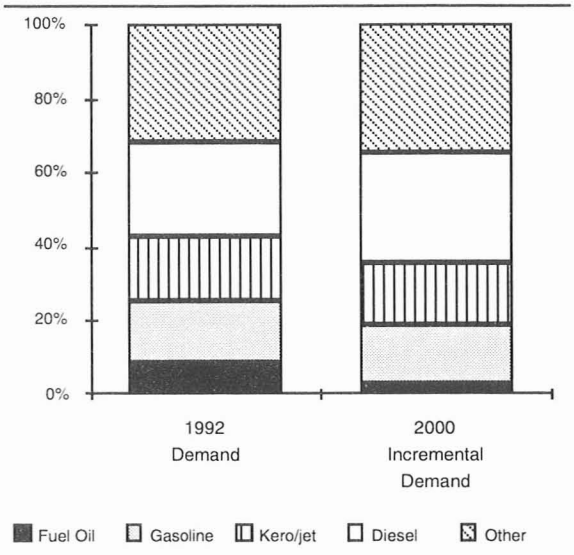

Figure 5: Current and Incremental Demand Patterns 1992-2000

cause of the growing availability of electricity. As a result, about 76% of the incremental product demand from 1992 to 2000 will likely be in the form of gasoline and diesel.

The current product yield patterns of China's refining industry can not match the country's changing demand patterns. Given the current refining capacity, diesel in particular could become in short supply. Therefore, the industry needs not only to expand capacity to keep pace with the rapid growth in product demand, but it must also have additions of expensive, sophisticated upgrading technologies to match the changing demand patterns.

In addition, the geographical distribution of China's refining capacity is still largely aligned with its historical crude oil production pattern, even if the development of the crude pipeline network has led to the construction of a number of refineries in the country's petroleum demand centres. Refining capacity in the three provinces of the Northeast region, where slightly more than 50% of China's crude oil is produced, accounts for 30% of total national capacity. In contrast, no refinery has been built in the Southwest region, where no crude oil is produced, but which is home to 16% of the country's population (190 million) and which accounts for 10% of the country's total GDP. As noted earlier, most of China's crude oil is produced and a majority of the refineries are located in the Northern region, whereas oil product demand in the South has experienced rapid growth in recent years. For example, the oil consumption of the six Southern coastal provinces increased from 22% of the national total in 1986 to 30% in 1993.[6] Because no inter-provincial product pipelines have been constructed,[7] the growth of oil product demand in the South has exacerbated product transportation problems between refining centres and demand centres. In order to reduce these regional imbalances, significant refinery expansion in the Southern coastal areas is urgently required.

Import Reliance and Crude Oil Quality

With the rapid growth in oil product demand on the one hand, and the limited growth in crude oil production on the other, China's oil import requirements are expected to increase significantly in the years to come. It is estimated that China's net oil imports will reach 1.0 million b/d by 2000, and that 85% of crude imports will likely come from the Middle East. In particular, imports of crude oil are expected to outstrip foreign-sourced purchases of products since importing refined products places additional strains on the country's foreign exchange balance. However, the import mix of crude oil and refined products will depend on the expansion and improvement of the country's refining industry and its ability to process high-sulphur crudes from the Middle East.

Chinese crudes are known for their low sulphur and high wax content. The average API gravity of Chinese production was estimated at 30.0 in 1994. The only domestic crude which is considered somewhat high in sulphur is Gudao, produced at the Shengli oil field. The average sulphur level of domestically pro-

6/ The six southern coastal provinces include Shanghai, Jiangsu, Zhejiang, Fujian, Guangdong, and Guangxi.

7/ The only exception is a small product pipeline used for military purposes, which transports refined products from small refineries in Qianghai province to Tibet.

duced crude oil is currently around 0.37% by weight and is expected to decline slightly because Gudao production will be stagnant.

The crude slate as a whole, however, contains an increasing proportion of crude imports from the Middle East. In 1993, China imported 313 thousand b/d of crudes, accounting for almost 12% of the country's slate, with Oman and Indonesia together providing over 80% of these imports. However, with the tightening of Asia-Pacific crude markets, an increasing proportion of China's imports is expected to be high-sulphur crude oil from the Middle East. As a result, the average sulphur content of China's refinery throughput will increase. Figure 6 gives the historical and projected average API and sulphur content for the country's refinery slate from 1978 to 2000, under the assumption that all of China's import requirements will be in the form of crude oil. In this calculation, it is also assumed that China's crude exports will decline from 390 thousand b/d in 1993 to 200 thousand b/d in 2000, and that all additional crude imports will come from the Middle East (in a combination of two-thirds Arab Light to one-third Arab Heavy). While average API gravity is likely to rise slightly for the rest of this decade, the average sulphur content is also projected to increase from 0.45% in 1994 to 0.74% in 2000. Although this projected increase in sulphur content may not be dramatic, the upward trend is accompanied by an increasing demand for cleaner refined products. This shift from processing entirely low-sulphur domestic crudes to a mix of domestic and higher-sulphur Middle East crudes presents a major technical challenge to China's refining industry.

Product Quality and Specification Trends

As the world moves toward cleaner fuels, China's refining industry is facing the challenge of improving its refinery configurations for producing high-value light products, which would not only satisfy the product demand pattern, but also meet increasingly restrictive environmental regulations. Although China's current product specifications are still quite loose, mounting concerns about environmental issues have made serious action on stricter petroleum product specifications more likely in the next few years. Currently about 50% of all the gasoline produced in China is still leaded, and about the same proportion still has a rating of MON 70.[8] As a gasoline component, straight-run naphtha accounted for about 15% in 1993, whereas the shares of reformates and alkylates in gasoline were very low (only 2.5% and 0.8% respectively). Although Sinopec has been implementing a plan to increase the octane number to an average of RON 90 and to phase out leaded gasolines by 2000, the ability of Sinopec to attain these goals is in part dependent on the speed at which additional alkylation, MTBE plants,[9] and other octane enhancers are built.

Although China's current official sulphur specification on light diesel is 0.2%, some refineries running high-sulphur crudes do not meet this specification. In addition, according to Sinopec, a 0.05% sulphur specification on light diesel will be imposed by 2000. This would prove to be a serious challenge for refineries since a shortage of hydrotreating units is a chronic problem for China's refining industry. Indeed, China currently allows up to 3% sulphur in its heavy fuel oil, but few crudes, aside from the Shengli oil field's Gudao, produce such a high sulphur level in the residual cuts. On average, fuel oil in China contains about 1% sulphur; as things now stand, however, sulphur content is expected to rise rapidly, as a larger proportion of imported high-sulphur crudes will be processed and used domestically.

Outlook for Foreign Participation

China's refining industry is a product of the

8/ Motor octane number (MON) is a product quality specification for gasoline, which defines its combustion properties. MON indicates the gasoline's performance under more severe operating conditions than does the research octane number (RON).

9/ MTBE (methyl tertiary-butyl ether) is a lead-free octane enhancer for gasoline.

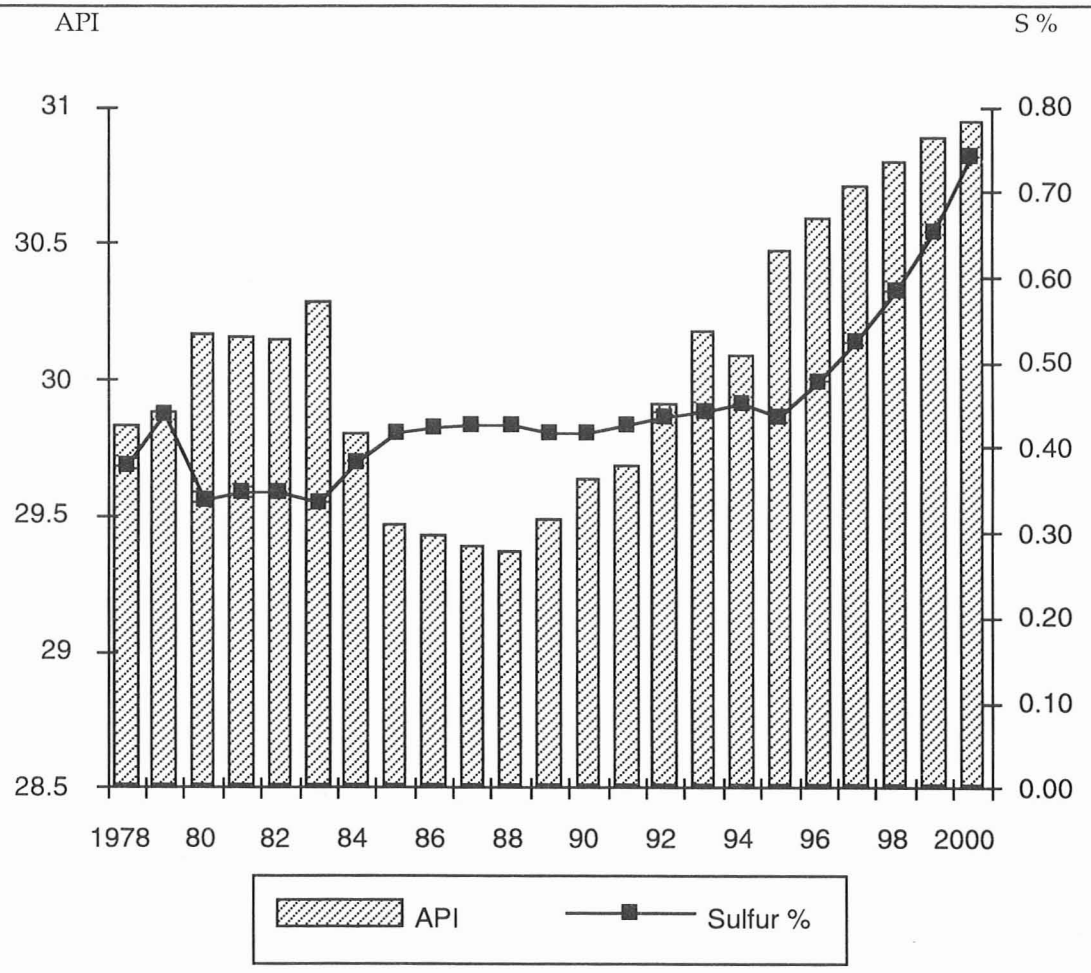

Figure 6: API and Sulphur Content of China's Refinery Throughput 1978-2000

country's national policy of "self reliance." Considered as a highly sensitive and strategic industry for national development, the refining sector was considered off-limits to direct foreign involvement until the late 1980s, when Shell proposed a grass-roots refinery partnership with China National Offshore Oil Corporation (CNOOC). In addition, direct equity participation in existing Sinopec refineries was restricted until 1992. Since then, it seems that Chinese authorities have been made aware of the critical issues facing the refining industry and of their potential impact on the country's oil product balance. Today, China is looking for foreign partnerships to help accelerate the development and modernization of its refineries, and to bring in the skills and expertise needed to create a more internationalized and competitive industry. It is recognized that foreign companies can introduce modern managerial techniques, marketing techniques, new technologies, know-how in handling a wide mix of high-sulphur crudes, international marketing tie-ins, and also assist in formulating projects that are competitively viable in order to secure funding on international financial markets.

Sinopec has been seeking foreign partners for the expansion of seven coastal refineries, located at Dalian, Shanghai, Nanjing, Fujian, and Guangdong. Total capacity additions planned for these refineries are expected to reach 600 thousand b/d. Sinopec hopes that at least half of these expansions will come on

stream by 2000, with the remainder completed before 2005. At the same time, three grassroots refinery projects, two of which do not involve Sinopec as the major Chinese partner, are currently under way or under serious consideration. These include the 100 thousand b/d Sinochem/Total refinery in Dalian, which is planning to start operations in late 1995; the 120 thousand b/d Elf/Sinopec refinery at Shanghai, currently at the feasibility study stage; and the 160 thousand b/d Shell/CNOOC refinery/petrochemical complex in Guangdong, which awaits final approval. In addition, there are two entirely foreign-funded refineries under construction: one is the 120 thousand b/d Hohbond (UK registered) refinery in Hainan province; another is a complex of a 100 thousand b/d refinery and a 300 thousand tonnes/year ethylene plant funded by Concord (US registered).

However, the penetration of foreign investment in China's refining industry has been very slow, despite several years of discussions and negotiations. Except for the Sinaochem/Total Dalian joint venture, which has been under construction for several years, no joint venture project is likely to be completed by 2000. Foreign companies are facing several challenges in securing a foothold in China's refining industry. One of the major challenges is that Chinese authorities have classified refining as a "pillar" industry. In late 1993, as part of the further liberalization of other sectors of the economy, China explicitly defined four sectors as "pillar" industries to remain under national control; these include the refining industry.[10] As part of the policy on "pillar" industries, the government has restricted foreign ownership to no more than 49%, which effectively deprives a foreign company of management control in a joint venture. Although certain contractual arrangements can be made to ensure a strong voice for the foreign partner in joint ventures within the refining industry, the most successful joint ventures in China in the last few years — and a growing trend in new joint ventures — are those with majority foreign ownership.

The second problem arises from China's non-membership of GATT (now, the World Trade Organization — WTO). Although China fully intends to return to this world body, doing so will require the reform or the termination of a number of practices that discriminate against foreign companies. In the refining industry, foreign companies, which enjoy some preferential treatment in taxation, are generally excluded from access to domestically produced crude oil. They are also restricted from directly marketing products in China. In addition, international trade in oil is controlled by a system of licenses and quotas, which gives preferential treatment to domestic companies. Moreover, the currency is not convertible, and foreign-investment projects are currently required to balance their foreign exchange needs through exports, despite China's status as a net oil importer.

Finally, any foreign company investing in a Chinese refinery must also deal with issues relating to the work force. Chinese refineries are considered more than enterprises, they are generally self-contained societies in themselves, supporting up to 20-40,000 people involved in production, management, support services, housing, education, cultural events, and so on. The government has already let it be known that the outlook for all employees must be considered in any joint-venture project, and that in general, large-scale layoffs will not be allowed.

Although foreign companies face the entire range of the above challenges, many of them have decided that the longer-term prospects for investment in China's refining industry are quite attractive. Some investors are trying to buy time by carrying out extended feasibility studies, hoping that the circumstances will change by the time these studies are completed. However, Chinese authorities should realize that the cost of waiting too long might prove quite heavy for China. Attractive investment opportunities are available in other countries, and much-needed funds and technology may be diverted elsewhere. If that happens, China will have to rely to an even higher degree on imports of refined products,

10/ The other three "pillars" are the electronics, telecommunications, and automobile industries.

which are more costly and less secure.

Summary and Conclusions

After three decades of rapid growth, China's crude oil production increased at an average annual rate of only 1.3% between 1990 and 1994. During the same period, however, China's oil demand increased rapidly as, consequently, did imports. Demand for petroleum products increased from 2.07 million b/d in 1990 to 2.91 million b/d in 1994, thus rising at an average annual rate of 8.9%. For the first time since the 1960s, China became a net oil importer in 1993. It is estimated that China's net oil imports will reach 1.0 million b/d by 2000. Whether China will import crude oil for domestic refining or import refined products depends directly on the expansion of the country's refining industry.

China's refining industry has expanded rapidly since the early 1960s. With 3.4 million b/d of crude distillation capacity in 1994, China's refining industry is the second largest in the Asia-Pacific region (after Japan's) and the fourth largest in the world (after the USA, Russia, and Japan). The overall refinery utilization rate, however, has been relatively low, owing to the existing widely dispersed and poorly coordinated refining system, and to the inadequate supply of domestic crude oil. In addition, the industry is confronting several major challenges, namely changing demand patterns, a worsening crude quality, and tightening product specifications.

Product demand is projected to increase at a rate of 5.0% per annum on average for the rest of the decade. The pattern of demand will continue to shift to lighter products; about three-quarters of the incremental demand will likely be in the form of gasoline and diesel. Stricter specifications on gasoline and diesel quality are expected to be imposed. Leaded gasolines and products with a rating of less than MON 70 will be phased out by 2000; sulphur specifications on diesel are expected to change from the current 0.2% to 0.05% by 2000. However, the average sulphur content of the refining throughput is projected to increase from the current 0.44% to 0.74% in 2000, as high-sulphur imported crudes replace domestic production.

These changes require the installation of additional capacity for sophisticated processes such as hydrocracking, residue desulphurization, and hydrotreatment, for which China has neither the money nor the technology. China has been vigorously seeking foreign participation in its future refinery expansion, and foreign companies appear to be just as interested in investing in China's refining industry, as China is in attracting foreign investment. However, the process has been slow, even if many projects have been proposed. Foreign companies still face a number of challenges to successful investment in China's refining industry, such as management control and market penetration. If this process is to be accelerated and if additional foreign participation in China's refining industry is to be secured, some changes in government policy will clearly be needed.