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Final Technical Report

East-West Center Coal Project

July 1994

DISCLAIMER

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Contents

INTRODUCTION

The overall goal of the contract is to provide general support and advice to the Department of Energy, Office of Fossil Energy (DOE/FE) on the opportunities for coal and Clean Coal Technology trade in the Asia-Pacific region. Dynamic changes are underway in a number of Asian economies that will change the pattern and growth rates of coal use and the rate of adoption of Clean Coal Technologies. This report provides an analysis of these changes, with emphasis on strategic implications for U.S. government and industry policies and strategies.

The EWC Coal Project research strategy has been to develop long-term relationships with senior people in the governments and utilities in the region in order to understand their planning and decision-making process pertaining to the role of coal and the introduction of Clean Coal Technologies. Development of this closer on-going working relationship provides valuable insights into the energy policy process, and energy related investment opportunities in the region. In addition, we follow the Asian press to understand evolving government and industry views toward energy, and implications for both coal and Clean Coal Technology markets. The EWC Coal Project also actively assists the U.S. Department of Energy in its role chairing the APEC Experts Group on Clean Coal Technologies and periodic conferences.

The second main component of our research strategy is to ensure that rigorous thinking and analyses are used in examining the information we collect in Asia. This ensures that overly optimistic or pessimistic plans and projections of governments and utilities are recognized, and more realistic assessments can be prepared. The program has developed considerable analytic capability, particularly in the area of forecasting. The Coal Project maintains numerous databases for Asia in the areas of coal production, consumption, trade, electricity generation, the environment and technology, and economic growth indicators.

SUMMARY

The report which follows is divided into six subsections, each pertaining to separate subtasks the U.S. Department of Energy requested. Subtask A includes two reports, one which outlines important coal and clean coal technology news events which occurred during the second half of 1993, and another which outlines the potential for Clean Coal Technology in the Asia-Pacific Region. Subtask B and the first paper in Subtask C contain advisories and briefing papers that present and explain the coal, electricity and Clean Coal Technology situation in China. The second paper in Subtask C is an overview of the coal supply, demand and trade situation in the Asian region with coal projections to the year 2010. Subtask D is an overview of meetings with Asian energy and policy representatives which were carried out to (1) gather key information relevant to this contract, and (2) examine areas for closer cooperation on important coal/CCT-related energy issues. The tasks listed in the contract proposal as Subtasks E and F are summarized in respective sections of this report. Subtask E specifies the activities carried out under the APEC Experts' Group on Clean Coal Technologies, and Subtask F explains the work done by the Coal Project in building contacts and working relationships with key energy and technology planners in China (including The State Science and Technology Commission, the Ministry of Electric Power and Tsinghua University, and the State Planning Commission). The Subtask E section also includes activities to develop and strengthen the role of the APEC Experts Group on Clean Coal Activities.

EXECUTIVE SUMMARY

(1) Coal demand in Asia accounted for more than 75 percent of the growth in global coal demand over the past decade, and is projected to account for 60-70 percent of world growth over the 1994-2010 period. In total, Asia (including Australia) is nearly sufficient in coal supplies, and most growth in demand is projected to be met by supplies within the region. Total coal consumption is projected to increase from about 1.7 billion tons in 1994 to about 3.0 billion tons in 2010.

(2) Coal related environmental problems are severe in some areas of Asia, with China facing the most serious problems. China's share of Asia's total emissions is approximately as follows: 2/3 of the SO_2 and 1/2 of the NO_x and CO_2. Even though the exact emission levels are uncertain, the general level of emissions are highly likely to be correct. The conclusion is that China cannot be left out of any serious plan to control the levels of coal related environmental emissions in Asia. In China NO_x and CO_2 pollution is found predominantly in the most industrialized eastern half of the country. However, most SO_2 pollution is presently in the southern half of China.

(3) There are a number of options for ameliorating coal related environmental problems in Asia. Substitution to less polluting energy options (natural gas, nuclear, and hydropower) are viable alternatives in selected areas, but have limited scope to fundamentally change the magnitude of Asia's demand for coal and related environmental problems. Most major coal using economies do not have competitive energy options to replace coal for base-load ele^ctricity generation. This is particularly true for the lower income economies in Asia.

(4) The four main options for economies that will continue to rely on coal burning are (1) use cleaner coal (lower ash and sulfur), (2) install more efficient coal burning equipment, (3) locate plants further from population centers (reduces groundlevel contamination) and (4) installation of SO_x and NO_x control equipment (broadly defined here as Clean Coal Technologies).

(5) Most coal users in Asia are relying on burning low sulfur coals and more efficient technologies to meet stricter environmental standards. The higher total cost of SO_x control options (0.5-1.0 cents/kwh) are a deterrent to the installation of CCTs, particularly in the lower income economies. In addition, there is less familiarity with these technologies in lower income Asian economies and more caution toward their introduction.

(6) The long term market potential for CCTs in Asia is large, with high income economies (Japan, Taiwan, and South Korea) the dominant markets during the 1990s, and China becoming an important factor after "about" 2000. EWC Coal Project estimates are that about 20 percent of China's total coal capacity could have high efficiency CCTs by 2010, the main market for U.S. CCT exports. Under this scenario, China would become the largest user in Asia of CCTs by 2010. These estimates must be used with caution, because the CCT market has yet to develop on a significant scale in China. It is possible that medium efficiency, lower cost CCTs, primarily manufactured within China, will dominate the market, leaving a more limited market for imported CCTs.

(7) Growth in electricity demand in China is expected to average at least 1,000 Mw per month over the next 15 years, with most new capacity being coal-fired. The role of BOT power plants is projected to be large, however this market has yet to develop on a large scale due to differences over the more acceptable internal rate of return(IRR) on investments. Foreign investors have been asking for an IRR of above 15 percent, whereas the Chinese have been suggesting an IRR of 12 to 15 percent is reasonable. There is considerable confusion about the exact methods to be used in setting the IRR.

(8) Both the Japanese and U.S. governments are anxious to obtain a share of the China CCT market. However, the strategies of the two governments f\are different. The U.S. appears to be emphasizing the most advanced CCTs(IGCC, for example), whereas the Japanese are focusing on less advanced technologies that could be manufactured in China at lower costs. The Japanese approach needs closer examination, but appears to have considerable commercial merit.

(9) The issue of establishing special environmental technology loans needs to be examined. Access to concessional loans for CCTs would accelerate this introduction.

Section 1

Subtask A -- Asia Coal and CCT Summary Reports

Asia-Pacific Coal News

Biannual Summary and Outlook

January 1993 through June 1993

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CONTENTS

Notes:
1. The period covered by this coal summary is the first quarter 1993 through second quarter 1993 (January 1, 1993 to June 30, 1993).
2. All dollar values are in US dollars except otherwise indicated in the text; Coal Project = The East West Center Program on Resources: Energy and Minerals Coal Project.

SUMMARY

Asian Trends

- The further reduction in coal prices during the first half of 1993 reflects the continued existence of excess coal producing capacity and a sluggish worldwide economic recovery. Steam coal trade in Asia is expected to double by 2000 because of the addition of an estimated 160 GW of coal fired capacity, while coking coal demand is expected to remain stagnant.

- Expansions in coal exports from Indonesia have contributed to increased competition and lower coal prices in Asia. Exports from Indonesia are expected to reach 20 million tons in 1993.

- Contract steam coal prices dropped \$1 to \$3/ton in the first half of 1993, and coking coal prices, both in contract and spot purchases, decreased \$1 to \$2/ton.

- Due to environmental concerns, there is a strong possibility that proposed and some existing coal-fired power stations in many Asian countries will be equipped with more sophisticated emission control technologies.

- The market for Clean Coal Technologies (CCT's) in Asia will increase substantially after the year 2000. In China, a recent EWC Coal Project study estimated that by 2010 roughly 20 percent of China's electric generating plants are likely to require high performance CCT's to meet SO_2 emission goals. Plants with capacities of 50 MW and above are the most likely CCT candidates. Also, major opportunities exist in selected Chinese provinces for build-own-operate (BOT) power plants, such as are being built by Hopewell Holdings in Guangdong province.

- Asia's continued electricity shortage, which is due mostly to the rapid growth of most economies, is a main factor in the decision by many countries to allow foreign private investors to develop at least a portion of their electricity capacity. Increasingly, state-owned power utilities are allowing foreign investors to establish joint ventures with domestic companies or to establish wholly owned subsidiaries. The most common contract types for these investments are build-own-transfer (BOT) or build-own-operate (BOO) arrangements.

Key Country Issues

Australia

- Export facilities are being improved to increase capacity in order to meet the rising demand for Australian steam coal in Pacific Rim countries, particularly in Japan and South Korea. Australian coal continues to be viewed as the largest stable supplier of competitive coal in the Asian region.

- CRA acquired controlling interest of Coal & Allied Industries, which is NSW's largest coal exporter with 11 Mt/yr of output. CRA is now Australia's second largest coal producer and exporter after BHP.

- A number of Asian companies and government organizations are investing in joint ventures with Australian coal mining companies or, as in the case of some Japanese companies, are acquiring mine projects outright.

China

- China is projected to account for over half of the CCT market in Asia in the 2001-2010 period. The CCT market potential appears largest in 7 heavily industrialized areas which make up less than 7 percent of the total area of China. Coal is projected to account for 70 percent of China's electricity generation to 2010.

- China plans to export 35 Mt/yr of coal by 2000. However, potential imports to southern China could substantially reduce net exports.

- The Chinese government is expected to remove the 1.3 billion ($227 million) coal subsidy to the China General Coal Corporation. The main objective of the price reforms is to close the gap between coal demand and supply.

- The Chinese government is negotiating with Australian mining companies to jointly develop coking coal quality deposits to be exported to China. Stable domestic supplies of good quality coking coal appear insufficient to meet the projected growth in steel making capacity.

Hong Kong

- Although Hong Kong's utilities continue to sprea[illegible] [illegible]al purchases among a number of coal sources, the share of coal [illegible] lower cost exporti[illegible] [illegible]ntries, including Indonesia, incr[illegible]d in 1992. Hong Kong's i[illegible] of higher cost US [illegible]as been decreasing steadily ov[illegible] [illegible]e past few years.

- Although coal-fired power stations generated 97 percent of Hong Kong's power in 1992, coal's share of total electricity consumption is expected to decrease in the near future due to the start-up of a nuclear power plant and the import of natural gas by pipeline. The gas will come primarily from China's Hainan Island.

India

- Current levies on steam coal imports, and poor coal handling and transport facilities, continue to make importing steam coal difficult for Indian utilities. The government had been discussing the possibility of reducing the levy on steam coal imports, but instead chose to retain the levies and continue to protect state-owned Coal India Ltd (CIL). Domestic coal supplies consistently fall short of coal demand in India.

- The Indian government opened the electricity sector to foreign investors in 1992. Since then, foreign investors have expressed interest in over 40 power plant projects with 20 GW of capacity. These power plants would be developed under joint venture agreements and in the event that all were developed, would cost an estimated $16.1 billion.

Indonesia

- Indonesia's government has changed its recent policy that restricted investments in most remaining prospective areas for coal to Indonesian firms. Foreign firms will once again be permitted to explore and develop Indonesian coal through contract of work agreements with the government.

- The Indonesian government projects exports of 20 million tons in 1993, a 36 percent increase over 1992. Currently, sixty percent of production is exported. Exports are projected to increase to 36 million tons in 2000.

- Perusahaan Listrik Negara, PLN (Indonesia's state electricity company), has had difficulty arriving at an agreed electricity price with the consortium that will build Indonesia's first privately owned coal-fired power station. PLN will buy the electricity from the power station and distribute it to the public.

- Beginning in 1993, the Indonesian government has begun to promote briquettes as an alternative fuel for households and small-scale industry. The price is expected to be cheaper than that of kerosene and firewood. Demand for the briquettes is projected to be in the millions of tons.

Japan

- With the commissioning of several coal-fired power plants in 1993 and the approval of a large economic package to boost public works, Japanese imports of steam coal are expected to grow more rapidly than previously expected from 1993 to the year 2000.

- Japanese companies continue to invest in foreign mining operations, including coal-related infrastructure and coal handling facilities.

- Japan is actively developing new technologies as well as promoting exports of its proven Clean Coal Technologies. Technologies currently under development include bacterial desulfurization and production of low emission coal briquettes. Bacterial desulfurization involves utilizing bacteria to remove inorganic sulfur (pyrite) from PCI coal.

South Korea

- Consumption of coking coal is expected to rise in the near future following the expansion of Pohang Iron and Steel Company's production capacity. Korea is diversifying away from US low-volatile coking coal to lower cost coking coal.

- Anthracite production in South Korea has been decreasing over the past 4-5 years. Production fell by 20 percent in 1992, from 15 Mt in 1991 to 12 Mt in 1992. The downward trend is due mainly to public demand for cleaner, more efficient home heating fuels and the government rationalization policy for Korea's coal industry (meaning removal of subsidies). The EWC Coal Project estimates that Korea's coal production will fall to about 6 Mt in 2000 and 3 Mt in 2010.

- Utilities will account for the majority of the 20 Mt of additional steam coal imports to South Korea by the year 2000. Twelve new coal-fired power plants are planned each with a capacity of 500 MW.

New Zealand

- In order to expand its production of about 2 Mt/yr of coal, New Zealand's state-owned Coal Corp has established a new joint venture called Greymouth Coal Corporation on the West coast of New Zealand's South Island.

Philippines

- The Philippine power shortage continues with 13 of the country's 24 power plants being out of commission.

- Steam coal imports could increase rapidly over the next two decades, if power plants proposed by Hopewell Holdings (a Hong Kong corporation) and the National Power Corporation are built. Hopewell has obtained loans from Japan to build a 700 MW plant which would begin operations in 1996. Hopewell has also proposed building a 2 GW (4x500 MW) plant in the near future.

- Environmental objections are reportedly a major barrier to the expansion of coal-fired capacity in the Philippines. Pressure from environmental groups has resulted in the postponement of some coal-fired plants, and has resulted in the cancellation and replacement of one coal-fired plant with a gas-fired plant.

Taiwan

- About 70 to 90 percent of Taipower's coal imports will be purchased through long term contracts over the next several years. Taipower is continuing its policy to spread its long term contracts among more suppliers. Imports of coal from Indonesia tripled from 1991 to 1992.

- Taipower has faced major difficulties in siting coal-fired stations due to environmental objections. Because of these objections, two 750 MW units at Suao in northeastern Taiwan may be delayed.

- Taipower will install FGD equipment in four of the five new units installed at the Taichung power complex. The operation of the four units is scheduled during 1995-97.

Thailand

- The Electric Generating Authority of Thailand (EGAT) plans to involve the private sector in electricity generation. The first power project with private involvement is likely to be a lignite-fired plant at Mae Kam.

- The environmental aspect of power plant planning has greatly increased over the past year, since the environmental accident at Mae Moh.
- Thailand's government provided up to 10 billion Baht ($397 million) to install FGD equipment to units 8-11 at the Mae Moh lignite-fired power plant. Installation of the technology will take about four years.

United States

- According to the National Coal Association, 1993 coal exports are likely to fall by 6.6 percent from the 1992 export level. The organization cited the downward pressure on prices and a slow worldwide economic recovery as the main causes.

- Coking exports to Brazil may decrease up to 30 percent as the country is considering retaliation against the US imposition of punitive import surcharges for the alleged dumping of low price steel on the US market.

- USX and Inland Steel will begin operating PCI systems in 1993. The companies will together use about 2 Mt/yr of PCI coal.

Vietnam

- Vietnam is expecting to produce more anthracite in the coming years. Hongai Coal Company projects production of 2 Mt/yr beginning 1994.

- Coal consumption in Vietnam will not grow as quickly as previously expected due to the expansion of hydroelectric capacity in Vietnam. This should free more anthracite for exports.

AUSTRALIA

Production

- Australia's steam and coking coal exports are expected to reach 80 Mt and 70 Mt respectively by 2000. Exports in 1993 are projected to increase a maximum of 5 percent over 1992 levels. Production of both steam and coking coal totalled 171 Mt in 1992. Asia continues to be Australia's largest market led by Japan, South Korea, Taiwan, Hong Kong and India. [IBJ 2/93 and EWC Coal Project]

- Shipments from BHP's seven Australian coal mines reached 18.3 Mt for the six month period ending November 1992. Total revenues increased to $1.2 billion, up 6.6 percent from the same period in 1991. The low relative value of the Australian dollar compared to the US dollar was the primary reason for the revenue increase. [AJM 3/93]

Queensland

- Idemitsu Kosan has begun development of the Ensham deposit in central Queensland which is expected to produce 400,000 t/yr, dramatically down from the earlier projection of 4 Mt/yr.

- The Australian Supreme Court's decision in which Idemitsu Kosan would be forced to pay Pacific Coal and Agipcoal $19.8 million each in compensation and damages was overturned by an appeals court. However, the appeals court upheld the Supreme Court's ruling that Idemistu had made misleading claims in an attempt to obtain Agipcoal's interest in the Ensham deposit mentioned above. Idemitsu now owns 95 percent of the deposit. [ICR 2/19/93 and King's 4/15/93]

- Portman Mining and a group of Chinese (PRC) investors hope to begin development of a joint venture at the Burton Downs mine in Australia. The open pit mine is designed to produce 2 Mt/yr of coal. About 60 percent of the output is likely to be coking coal with the remainder being PCI and steam coal. [ICR 4/26/93]

- Full scale production at the North Goonyella deposit in Queensland is planned during 1993. Output will be 3 Mt/yr of high quality coking coal. [AJM Mining Yearbook 1993]

- The Barthrust coking coal deposit, owned by BHP Australia Coal, has been advertised for sale or joint development. The deposit contains about 300 Mt of high quality coal reserves. The deposit, located close to the coast and far to the north in Queensland, is well situated to export coal to the Asian market. However, the deposit may be subject to claims from local Aboriginal groups. [ICR 6/11/93]

New South Wales

- CRA succeeded in taking over Coal & Allied Industries, which is NSW's largest coal exporter with 11 Mt/yr of output. The control of Coal & Allied will make CRA Australia's second largest coal producer and exporter after BHP. This move places CRA in a strong competitive position to gain a larger share of the anticipated export growth in the Asia Pacific region. [ICR 4/19/93]

- The Hunter Valley Corporation intends to develop a new open pit mine at Mount Owen in Queensland, and Coal and Allied plans to expand its Hunter Valley mine to 4 Mt/yr of production. If these two projects go ahead, it is expected that up to 100 million tons of coal could be produced from the mines. [King's 1/21/93]

- The Boggabri deposit, which is wholly owned by Idemistu Kosan, is likely to produce 150,000-250,000 tons of coal in its first year. Idemitsu bought Boggabri from BHP Australia Coal and Agipcoal in 1991. [ICR 2/19/93]

- Oakbridge steam coal mines in the Hunter Valley intend to increase capacity from 9.3 Mt/yr to 13 Mt/yr. Cyprus Coal of the US took over 40 percent of the Oakbridge project from Australia's McIlwraith Mining. Cyprus is also interested in purchasing the shares of some of the Japanese interests in the mines. The Japanese shareholders are Tomen (25 percent) and Nippon Oil (23 percent). [ICR 4/5/93]

- After acquiring 100 percent ownership of an underground mine at Dartbrook in New South Wales's Upper Hunter Valley from Austen and Butta, Shell will develop the mine at a cost of $240 million. Shell expects to produce 3.5 Mt/yr of coal at the mine. [King's 4/29/93]

Trade

- It is estimated that on average, every one cent drop in the value of the Australian dollar implies an extra A$0.70/ton price increase. Thus, with the 127 Mt of total exports in 1992, producers would have theoretically gained an additional profit of about A$87 million (US$60 million) due to the weak Australian dollar in 1992. [ICR 1/8/93]

- According to the Australian Bureau of Agriculture and Resource Economics (ABARE), Australia's total exports of coal are expected to grow by 20 percent to 151 Mt by 1997-98. World thermal coal exports are projected to increase by 34 percent between 1992-93 and 1997-98. However, coking coal trade is expected to decline slightly over the period. [AJM 3/93]

- Australia achieved a new record of 127 Mt of coal exports, but growth of production declined from 13.4 percent in 1991 to 5.3 percent in 1992. Producers expect a further slowdown in 1993 because of current excess coal capacity in countries such as Indonesia and South Africa. [Mining Magazine 3/93 and AJM 3/93]

- ABARE expects total Japanese steam coal imports to reach 49.5 Mt in 1993 which is a 3 Mt increase over 1992 imports. ABARE expects this trend to continue with imports rising to 86 Mt over the next ten years. ABARE predicts that Australia will maintain 65 percent of the Japanese steam coal market through the next decade due to its competitive advantages in costs and coal quality. [ICR 2/8/93]

- Australian coal producers accepted a $2.55/ton FOB price reduction from Japanese utilities. Chubu Electric which acted as the lead negotiator in the contract talks was able to negotiate and set a base price of $36.25/ton FOB for 6,700 kcal/kg coal. [King's 2/11/93]

Transportation

- The South Coast producers, a group of NSW mining companies, have decided to expand the Port Kembla coal loader throughput capacity from the current 15 Mt/yr to 20 Mt/yr. The cost will be around A$15 million (US$10 million). Also there are plans to upgrade Dalrymple Bay in North Queensland to a capacity of 26.5 Mt/yr from the present 22.5 Mt/yr. [ICR 3/8/93 and ICR 4/19/93]

- The Gladstone Port Authority of Queensland plans to expand the existing Clinton Facility to provide 30 Mt/yr of throughput capacity. The port operates two export piers: Clinton Coal Facility which shipped 18.3 Mt in 1992 and Barney Point. When the project is completed in the second half of 1994, the Clinton Facility will be the world's largest coal export terminal. [IBJ 2/93]

Power Generation

- Asea Brown Boveri and the state government of Western Australia are discussing whether to build a 680 MW coal-fired station adjacent to the Collie coal field or to install gas-fired capacity. The coal-fired plant would cost $1.8 billion. [King's 2/18/93 and King's 2/25/93]

Companies and Foreign Investment

- Negotiations are being held between Chinese government officials and CRA Ltd. regarding a possible joint development of the Hail Creek deposit in MacKay, Queensland. Chinese officials have contacted most of the producers in the Bowen Basin region to seek possible investments in Australian coking coal mines. [King's 3/4/93]

- The Queensland state government is promoting foreign investment in the coal mining sector. In 1992, the government disclosed its plan to remove exploration restrictions and announced a two-stage release program covering 300,000 square kilometers of Central Queensland. [King's 4/22/93]

Technology

- At present, the Australian power industry has limited interest in Clean Coal Technologies (CCTs), and is unlikely to invest heavily in CCTs in the 1990s. Electric utilities have been able to meet emission standards through a combination of using lower sulfur coal and locating power plants away from population centers. [EWC Coal Project, 1993]

- Coal-fired power capacity is projected to increase from 22.4 GW in 1990 to 30 GW and 38 GW in 2000 and 2010 respectively, however, it is expected that the CCT market in the 1992-2000 period will be less than 3 GW and about 5 to 10 GW in the 1992-2010 period. [EWC Coal Project, 1993]

CHINA

Production

- Handan city in Hebei province, one of the China's 10 largest coal production bases, plans to expand its production capacity from 20 Mt/yr to 24.6 Mt/yr. Four coal mines scheduled for construction are: the Wutongzhuang mine ($40 million, 1.2 Mt/yr), the Dashucun mine ($42 million, 0.9 Mt/yr), the Yangdong mine ($47 million, 0.9 Mt/yr), and the Beilizhuang mine (1.2 Mt/yr). Average coal specifications are 6,000-8,000 Kcal/kg, 1.2 to 2.1 percent sulfur content and a relatively low ash content. [China Daily 5/10/93]

- The Chinese government opened its first national coal exchange with the purpose of linking mining companies concentrated in China's interior with consumers located in the coastal areas. The purpose of the exchange is to help balance coal supply and demand and eliminate the large financial losses brought about by black market competition. [Mining Magazine 1/93]

- The Chinese government plans to adjust state coal prices to correspond to prevailing market prices. The government's first step in freeing coal prices will be to cut the annual subsidy of Rmb1.3 billion ($227 million) to the China General Corporation. Energy ministry officials believe that allowing market prices to prevail will help reach the goal of 1.5 Bt coal production by 2000. [FEER 4/1/93]

- The China National Coal Corporation will lift price controls on 57 percent (190 Mt) of its total coal production in 1993. [New China Quarterly 5/93]

- The Huamei Coal Water Mixture Technology Center at the Beijing Coal Water Mixture Plant has begun operations. The mixture, composed of 65 percent coal powder, 34 percent water and one percent additive, is used as a substitute for crude oil. The plant has an output of 250,000 tons per year. [China Daily 3/2/93]

- A $690 million open-cut mine near the city of Shuozhou in Shanxi province in North China is expected to begin production by the year 2000. This mine will make Shuozhou the second largest coal producer in the province after Datong. Total production will be 60 Mt/yr. At present, the city has developed 251 mines. [China Daily 3/22/93]

- Coal production increased to 1.095 Bt in 1992 up 32.4 Mt from 1991. Coal production is forecast to reach 1.25 Bt by 1995 and 1.5 Bt by 2000. [ICR 3/9/93]

- China National Coal Corporation, which produces 370 million tons of coal annually, will lay off 400,000 of its 3 million workers by 1995. The company will obtain a $2 billion loan to diversify itself into service-oriented subsidiaries in an effort to absorb some of the laid-off workers put out of work by the closing of 30 coal mines. [FEER 1/7/93]

Trade

- The China National Coal Export-Import Corporation (CNCEIC) plans to increase exports by 2 Mt/yr over the next decade. The CNCEIC's goal is to export 35 Mt/yr by 2000. In FY1993, the CNCEIC accepted a $2/ton FOB price reduction on coking coal and $2.5/ton FOB on soft and semi-soft coking coal in its contracts with Japanese consumers. [King's 3/18/93]

- Japanese coal imports from Datong, China, for fiscal 1993/94 are estimated at 3.0 Mt. There is a 7 percent reduction in prices for FY 1992/93. The coal will be imported by Japanese power ities and cement manufacturers. [ICR 4/19/93]

- Minmetals, a state-run Chinese export-import company, delivered a test shipment of 20,000 tons of coking coal to Brazil recently, and plans to ship an additional 40,000 tons later this year. China is anticipating significant exports to Brazilian steel makers in the future. Trade relations between Brazil and the US, the largest coal supplier to Brazil, are strained due to Brazil's alleged dumping of low price steel on the US market. [ICR 6/11/93]

- For the first time, China has released a list of coal export and import data. The figures for 1992 are presented below.

China's Coal Trade in 1992

	Anthracite (Mt)	Coking (Mt)	Steam/Other (Mt)	Total (Mt)
Export	2.0	3.7	13.9	19.7
Import	0.8	0.4	-	1.2
Export-Import	1.2	3.3	13.9	18.5

[ICR 3/19/93]

Transportation

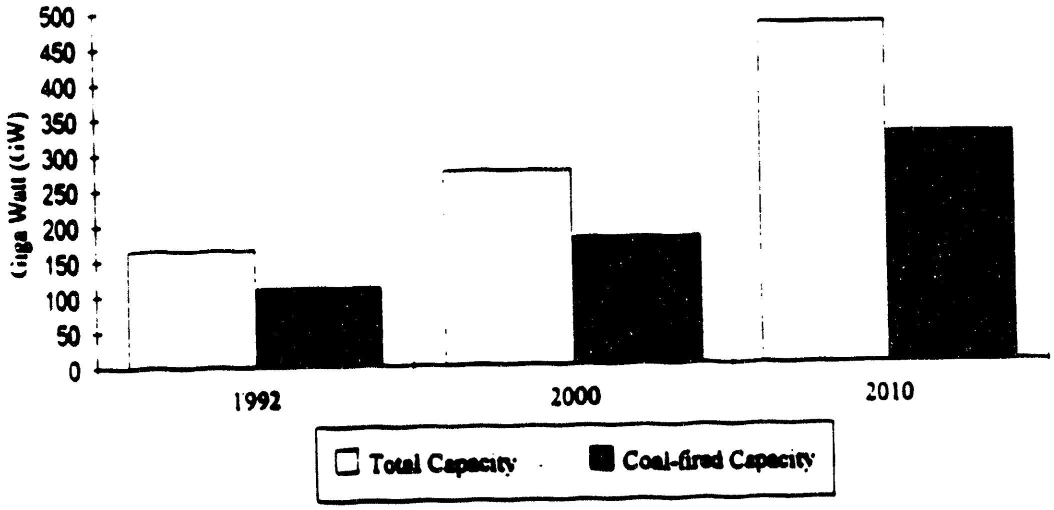
- China plans to export 25 Mt of coal by 1995 and 35 Mt by 2000. A new rail line between Datong and the port of Qinhuangdao has been built and a third phase of the Qinhuangdao port expansion has been completed. These facilities have an annual capacity of 75 Mt which will increase to 100 Mt after the fourth phase of the port expansion is completed in 1994. [Mining Magazine 6/93]

- As mentioned above, another berth with a capacity of 30 Mt will be added to the port facilities at Qinhuangdao. The port, located in Hebei province, handled 63 Mt coal in 1992. Sixty percent (12 Mt/yr) of the country's total coal exports go through Qinhuangdao. [New China Quarterly 2/93]

Power Generation

- Although China is promoting the use of energy alternatives in power plants, coal is projected to continue to account for approximately 70 percent of China's electricity market to 2010. The share of coal consumed in the electricity sector increased from about 20 percent in 1980 to 29 percent in 1990. This figure is projected to increase to about 40 percent in 2000 and to at least 50 percent in 2010. [EWC Coal Project 4/93]

China's Projected Electricity Capacity and Coal-Fired Electricity Capacity



- The Huaneng International Power Development Corporation plans to add 8,000-12,000 MW of thermal power capacity by 2000. Two new plants will be built and some existing plants will be expanded. The total cost of these projects is estimated at $7.0 billion which will be financed mostly by foreign sources. Huaneng is a pioneer in utilizing foreign funds to develop power projects. [China Daily 5/31/93]

- In 1993, 57 large and medium sized power generators with the capability of producing 11.4 GW per hour will begin operation. It is estimated that generating capacity must increase 73 percent in order to meet projected electricity demand in 2000. The government is currently attempting to attract more foreign investment for developing thermal and hydroelectric power plants. [China Daily 4/29/93]

- Wing Merill, a US based company, reportedly has agreed to build coal-fired power stations with a combined capacity of 1.4 GW in China's Henan province. The project will cost an estimated $500 million. [FEER 3/18/93]

- The Shajaio C power plant (3x660 MW coal fired-units) is now under construction and is due for start-up in 1995. The units are being built under a BOT agreement with Hong Kong based Hopewell Holdings. [ICR 6/11/93]

Companies and Foreign Investment

- The Export-Import Bank of Japan will provide a $400 million loan as part of a larger $6 billion energy loan package to China. The funds will be used to develop the Shenfu-Dongsheng coal mine in Shanxi province and Inner Mongolia. The loan funds will also be used to import advanced equipment. Total investment in the mine will be more than $5.26 billion of which $2 billion will be foreign capital. [China Daily 4/17/93]

Environment and Technology

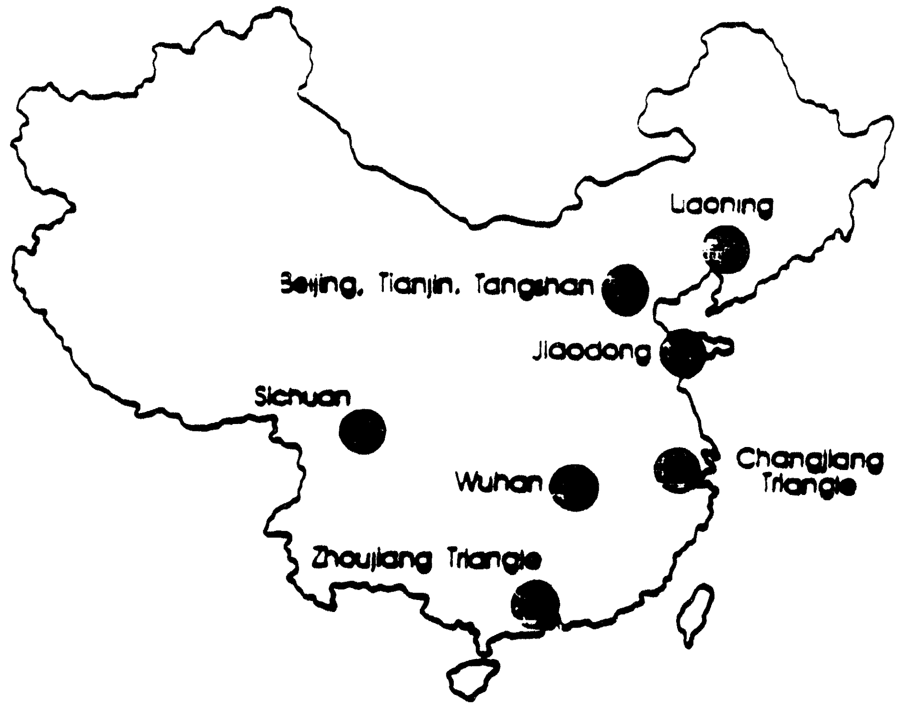
- Estimates of the potential size of the Clean Coal Technology market in China are highly speculative. However, recent research by the EWC Coal Project, estimates that China may become the largest user of Clean Coal Technology (CCT) in Asia after the year 2000. If this occurs, there should be opportunities for foreign technology companies to penetrate 15-25 percent of the market including power plants built under BOT contracts. The primary market for CCT's in China is for larger facilities (above 50-75 MW). [EWC Coal Project 4/93]

China's Potential Clean Coal Technology Market: 2000 and 2010[1]

Option	Percent SO_2 Reduction	2000 GW	2000 % of Market	2010 GW	2010 % of Market
Imported CCTs[2]	>80	13	7	65	20
Domestic CCTs	50-80	41	23	114	35
Low sulfur coal & fuel substitution	<50	90	50	114	35
Coal controls	0	36	20	32	10
Total		180	100	325	100

[1] The EWC Coal Project estimates in this table are preliminary, and are only useful as a plausible scenario for the Chinese CCT market.
[2] A portion of foreign CCTs will probably be manufactured in China.

- About 40 to 45 percent of China's electricity consumption is concentrated in seven geographic areas which make up less than 7 percent of the physical area of China. These seven areas are considered prime target area for CCTs. [EWC Coal Project 4/93]



The seven areas which are most likely to introduce CCT's

- **China plans to set stringent safety standards on mining operations to counter the country's rising mining related death tolls. There were 51 major mining mishaps in 1992 which caused more than 1,000 deaths. Coal mines in China employ more than 7 million workers. However, the implementation of effective safety standards will take decades. [King's 2/18/93]**

HONG KONG

Consumption

- An explosion took place in the hydrogen generating plant at China Light and Power's Castle Peak Station, but the company reports that coal-fired units at Castle Peak A and Castle Peak B power stations were undamaged during the incident. Electricity generation was affected for a short period directly following the explosion, and also later as a result of precautionary measures taken following the incident. *Revision for Asia-Pacific Coal News July 1992 through December 1992*. [China Light and Power Company Ltd.]

- Two 350 MW coal-fired units owned by the Hong Kong Electric Company are schedu[illegible] for start-up before 2000. The Lamma No. 7 unit will be completed by December 1995 and the Lamma No. 8 unit will come on stream by December 1997. These two units will consume 1.4 Mt/yr of steam coal. [World Coal 1/93]

- In 1993, China Light and Power plans to purchase 10 Mt of steam coal under a multi-sourcing policy. The expected suppliers are Australia (36 percent), South Africa (25 percent), China (16 percent), Indonesia (11 percent), and the US (3 percent). The remaining tonnages will be purchased on the spot market (about 10 percent). Coal specifications for the Castle Peak power plant are 6,200 kcal/kg, 36 percent volatile matter, 14.[illegible] percent total moisture, 12 percent ash and 0.6 percent sulfur. [King's 5/6/93]

- China Light and Power plans to double its contract purchases with South African suppliers to 3 Mt/yr. At present, the utility buys about 1.5 Mt/yr of South African coal. The coal will be used at the 4.1 GW Castle Peak coal-fired power station served by a terminal capable of handling two capesize vessels simultaneously. [King's 6/24/93]

- Total coal demand for Hong Kong's two utilities is expected to decline as a result of the start up of the nuclear power plant and the pipeline import of natural gas.

Hong Kong's Estimated Coal Demand (Mt)

	1993	1994	1995	1996	1997
Hong Kong Electric	3.1	3.2	3.4	3.6	3.85
	1992/93	1993/94	1994/95		
China Light and Power	9.2	7.9	7.[illegible]		

[World Coal 1/93]

- Higher cost imports of US coal have decreased in Hong Kong. Imports from the US dropped from 440 thousand tons in 1991 to 350 thousand tons in 1992, and no US coal purchases were reported in the first six months of 1993. This decrease in US imports reflects a trend toward responding to market forces rather than strategic considerations in making coal sourcing decisions. [King's 6/17/93]

Power Generation

- China Light and Power's (CLP) proposal to build 6,000 MW of coal-fired power capacity on the Hong Kong mainland has been changed. Now CLP plans to install a 2,500 MW combined cycled gas turbine plant. The plant, which is expected to begin operation in the mid-1990s, will import gas from China's Hainan island offshore field under a 20 year contract. Hong Kong's future coal consumption is projected by the EWC coal project to grow slowly over the next decade. [World Coal 1/93 and EWC Coal Project]

Environment

- Hong Kong Electric (HKE) will install Flue Gas Desulfurization (FGD) equipment along with low-NOx burners on its new coal-fired power stations. The first FGD plant will be commissioned in September 1993 on the Lamma No. 6 unit. Currently, none of HKE and CLP's existing plants are equipped with FGD technology, however both companies burn very low sulfur coal. [World Coal 1/93]

- Hong Kong's published pollution emission standards for coal burning are listed below.

Particulates	125	mg/m^3
SO_2	200	mg/m^3
NO_2	2,700	mg/m^3
Ash	16	percent max GAR[1]
Smoke Density	1	Ringlemann[2]
Sulfur	1	percent max GAR[1]

[1] Subject to 12 percent total moisture
[2] Zero indicates white smoke emitted from the stack and 5 indicates black smoke.
[World Coal 1/93]

Technology

- The combination of high income (GNP/capita = $16,400 in 1991), and the highest population density in Asia (5,182/km^2), have provided the economic base and incentives to introduce and enforce stringent environmental legislation. Government regulations are likely to require both 90 percent removal of sulfur and a limit of 1 percent sulfur content coals. If these regulations are implemented as expected, they will eliminate the option of using only low sulfur coal to meet environmental regulations. [EWC Coal Project, 1993]

- China Light & Power presently burns low sulfur coal with an average of 0.6 percent sulfur and 12 percent ash. The next coal-fired plant planned for 1996 will have FGD and low NOx burners. [EWC Coal Project, 1993]

- Hong Kong's total CCT market is projected in the range of 1 to 3 GW between 1992 and 2000 and 4 to 6 GW between 1992 and 2010. [EWC Coal Project, 1993]

INDIA

Production

- India's coal production increased from a level of 130.6 Mt in 1982/83 to 238 Mt in 1992/93 (an 82 percent increase). India's coal production target for FY 1993/94 is 249 Mt. The Chairman of state-owned Coal India ltd. (CIL) expects that production will grow to 291 Mt by 1996/97 and 367 Mt by 2001/02. However, demand for steam coal by southern India utilities continues to outstrip Coal India's ability to supply dependable coal tonnages, and this may result in pressure on the government to lift or reduce the substantial levy on steam coal imports. [Mining Magazine 3/93 and King's 5/6/93]

- Coal India's Rajmahal open-pit mine in the state of Bihar is being expanded. Output is expected to rise from 5.0 Mt/yr to 10.5 Mt/yr in order to reach production targets set by Eastern Coalfields Ltd (ECL). The turnkey project is being done by the Canadian Commercial Corporation through Met-Chem, a Canadian engineering company. [Mining Magazine 3/93]

- Six new coal mining projects were sanctioned by the Indian government. These projects are expected to produce 1.8 Mt/yr of coal. The projects include the Padampur and Gondegaon open pit mines of Western Coalfields Ltd., the Bakubla underground mines of Eastern Coalfields Ltd., the Samleshwqri open pit mines of Mahanadi Coalfields, the Selated Dhori open pit mines of Central Coalfields Ltd., and the Dudhichva open pit mine of Northern Coalfields Ltd. [King's 3/25/93]

Consumption

- Two Indian steel makers, the Steel Authority of India (SAIL) and Visakhapatnam, are seeking government approval to import about 6 Mt of coking coal in 1993-94. SAIL is seeking permission to import 4.5 Mt of coking coal and Visakhapatnam is seeking permission to import about 1.8 Mt. However, the government has not yet made a decision on the request. [King's 4/22/93]

- SAIL postponed the evaluation and award process of bids it received on a long-term contract for 2 Mt/yr of coking coal. Financial difficulties are the major factors impeding the decision. Two purchases in early and mid-1993 were financed by the World Bank. SAIL operates five coal-fired plants that consume 14 Mt/yr of coal, of which 4.5 Mt/yr is supplied by state-owned Coal India and the remainder is imported from foreign suppliers. SAIL usually purchases coking coal in 1.5 Mt lots on the spot market to meet coal demands. [King's 1/28/93 and King's 5/27/93]

Trade

- Over the past year, India's government has been considering the abolition or reduction of its 80 percent tax on steam coal imports. Recentl·· however, the government decided to follow its previous policy of protecting state-owned ·al India Ltd., thus the import tax remains. Because of this and the difficulties of securing credit lines in India, steam coal imports will be significantly limited until the policy is modified. [King's 4/29/93]

Transportation

- Ennore in Southern India will begin the construction of a new port facility for ships carrying up to 65,000 tons of cargo. The Asian Development Bank has approved a $200 million loan for the project which is expected to be completed by 1997. The new port will be able to handle 8 Mt/yr of coal for consumption in neighboring power stations. [King's 2/18/93]

- Inadequate port facilities in India discourage any attempt by the utilities to import steam coal on a large scale. An example is a recent solicitation from the Tamil Nadu Electric Board that required coal to be delivered in small handy size cargoes (35,000 tons). [King's 2/25/93]

- The Visakhapatnam steel plant put forth a plan to design, construct, commission, operate and maintain a port at Gangavaram outside its existing plant boundary. The plan entails upgrading the present port facilities to handle 4 Mt/yr of coal. Visakhapatnam is the newest integrated steel plant in India and will reach its 3 Mt/yr full capacity output in 1995-96. [ICR 4/19/93]

Power Generation

- In 1992, India's power minister opened the power generation sector along with the telecommunication and petroleum sectors to foreign and private Indian investment. The package offered to investors includes a two-part electricity tariff, a guaranteed 16 percent return on equity protected against exchange-rate risk, and an average load factor of 68.5 percent. The potential investments cover 40 projects totalling 20,000 MW of generating capacity at a projected cost $16.1 billion. [AWSJ Weekly 2/2/93]

- Only three of the 40 coal-fired power stations mentioned above are in the development phase. These are the first three projects listed in the table below. The other projects are still undergoing feasibility studies. [ICR 3/19/93]

Potential Investors for Coal-Fired Power Plants

Investors (joint venture)	Capacity (MW)	Location
Cogentric Inc. (U.S.) and GE (U.S.)	1000	Mangalore, Karnataka
Mission Energy Co. (U.S.) and Ashok Leyland Ltd. (India)	1000	Visakhapatnam, Andhra Pradesh
National Power (UK), and Jaiprakash Industries Ltd. (India)	300	Mangalore, Karnataka
Chalais Holding (UK)	300	Dharwar, Karnataka
North East Energy Services, NEES (US)	1000	Chamalapura, Karnataka
NEES (US)	500	Raichur Stage V, Karnataka
Hok Intercontinental (US)	500	Hospet, Karnataka
International Contracting and Marketing Corporation (US)	1000	Cuddalore, Tamil Nadu
Siemens, Deutsche Babcock, MAN GHH Takraf (Germany), McNally Bharat Engineering Ltd. (India), Tamil Nadu Industrial Development Corporation (India)	1500	Jayakomdan
Coleman Associates (Australia), Kalinga Power Development Corporation (India)	240	Barsingsar, Rajasthan
Coleman Associates (Australia), Kalinga Power Development Corporation (India)	500	Duburi, Orissa

The Asian Wall Street Journal Weekly February 2, 1993 and ICR 3/19/93

- Singareni Coal and Neyvelli Lignite of Coal India Limited (CIL) obtained World Bank loans for several projects which total about $3.2 million for several coal mining projects which will be developed before 1997. [King's 2/18/93]

Companies and Foreign Investment

- A proposed joint investment between the governments of India and China to develop Chinese coking coal deposits is being considered. The Indian government hopes to import the Chinese coal to meet its growing coking coal needs. India currently imports 8 Mt/yr of coal from

Australia and New Zealand. Such an investment in the near future appears speculative. [King's 2/18/93]

Technology

- Environmental problems associated with coal burning in this heavily populated country are serious, however major investments in emission control equipment have yet to be undertaken. Priority in the 1990s is on the control of particulate emissions and increasing power generation efficiencies. The installation of FGD systems is not a high priority. The poor quality of India's coal, and the smaller scale of most power plants, suggest a potential for the introduction of FBC technologies. The total CCT market is projected to be less than 3 GW between 1992 and 2000 and in the range of 10 to 20 GW between 1992 and 2010. These estimates are subject to considerable uncertainty. [EWC Coal Project, 1993]

INDONESIA

Production

- The Indonesian government re-opened the coal mining sector to foreign investment on February 23, 1993. The change in policy is due to the strong growth in the domestic coal market, higher coal demand projections for the intermediate and long-terms, and the need for capital investment. Coal reserves are primarily concentrated in West Indonesia where over 90 percent of the known coal exists. [EWC Coal Project and Prijono 1993]

- According to the president of state-owned PT Batubara Bukit Asam, coal production is expected to grow to 30 Mt by 1995 and double to 60 Mt by the end of the decade. However, accurate projections of coal production, consumption and trade are subject to considerable uncertainty at this early stage of coal expansion. Given this caveat, annual coal production is estimated by the EWC Coal Project to jump from 23 Mt in 1992 to 50 Mt and 80 Mt in 2000 and 2010 respectively. Exports are projected to increase from 16 Mt in 1992 to roughly 25 Mt in 2000. [Indonesia Development News Quarterly Winter 1993, IBJ 2/93 and EWC Coal Project 93]

- Indonesian coal production is expected to reach 28 Mt in 1993. Exports are expected to increase to 20 Mt in 1993. [Prijono, 1993]

- PT Batubara Bukit Asam has received a presidential decree to issue new exploration licenses for Indonesia's private non-contract mining companies. Presently, there are six private Indonesian non-contract mining companies situated around the Mahakam river in East Kalimantan. Production was 1.5 Mt/yr in 1990. These companies are expected to increase output to about 3 Mt/yr by 1994. Coal mine operations in Indonesia are divided into the state-owned company, private Indonesian non-contract mining companies, and coal cooperation contracts which are joint ventures between foreign and private Indonesian companies. [ICR 3/19/93 and Mining Magazine 3/93]

- PT Adaro's coal production is projected to double this year from 2 Mt in 1992 to 4 Mt in 1993. If the company's production goals are met, the mine's output will reach 20 Mt by 2000, and Adaro would become Indonesia's largest coal mine. [FEER 1/28/93]

- PT Berau began operations at its Lati mine in East Kalimantan with initial production of 0.5 Mt in 1993. Production is expected to rise to 0.7-0.8 Mt/yr which, for the most part, will be consumed by PLN's Paiton units 1 and 2 in East Java. PT Berau is owned by Nisho Iwai (40 percent) and PT Astra International (60 percent). [ICR 3/8/93]

- PT Arutmin, a BHP Indonesia subsidiary, is expanding its production into a third mine, East Senakin in Kalimantan, which will produce 1.2 Mt/yr of additional output. In 1993, PT Arutmin plans to export about 4.5 Mt of coal compared to 3.3 Mt of exports in 1992. The company is also building two washeries: one at East Senakin and the other at West Senakin. These new facilities will reduce the coal's ash content to 9-11 percent. Typical heat content of the coal is 6,700 kcal/kg. [ICR 2/19/93]

- Envirocoal, produced by PT Adaro, sells for about $24/ton FOB on the international spot market and $28/ton FOB in long-term contracts. Specifications are 5,900 kcal/kg, less than 0.1 percent sulfur, one percent ash, and 12 percent moisture. Many utilities worldwide (including the US) are purchasing trial shipments of the coal to determine how well it can be blended with high sulfur coal. [King's 2/18/93]

- The Indonesian government is promoting coal briquettes as an alternative source of energy for households and small-scale industry. Demand for briquettes is expected to be in the millions of tons because they are lower cost than kerosene or purchased fire-wood. State-owned coal producer PT Tambang Batubara Bukit Asam plans to produce 500,000 t/yr and three other private firms would also begin production. The use of briquettes will be widely introduced in 1994. This program is being carried out because of the government's concern to reduce the growth in liquid fuel consumption which will make the country a net oil importer by 2000. [The Jakarta Post 5/5/93]

- Depending on the processing method and the plant size, briquette production costs vary between Rp155 and Rp187/kg ($0.07 and $0.09/kg). At current coal prices, briquettes, which have a calorific value of 5,000 kcal/kg, are expected to sell at Rp220/kg ($0.11/kg). This price is competitive with the subsidized kerosene price at Rp350/l ($0.17). Kerosene has a calorific value of 11,000 kcal/kg. [NEDO 3/93]

- PT Multi Harapan Utama, a joint venture of New Hope Indonesia, PT Asminco and the Risjad Group will increase production to 2.5 Mt/yr by developing a new coal deposit close to its present mine in East Kalimantan. Current production at its Desa Bukit mine is 1.5 Mt/yr. [King's 6/3/93]

Consumption

- Power generation plants, cement plants, and paper and pulp mills account for the majority of domestic coal demand which is 5-6 Mt/yr. Demand is projected to increase to 9 Mt in the mid 1990s, due to the start-up of the Paiton I and II units (2x400 MW), and the expansion of the Semen Cibinong and Semen Gresik plants. Consumption will increase again in the late 1990s when several new power plants are expected to come onstream. [IBJ 2/93]

Trade

- Exports from Kaltim Prima, a joint venture between BHP and CRA, were 7.3 Mt in 1992 which is 3 Mt above original estimates. The company expects output to reach 8.5 Mt in 1993. [ICR 2/19/93]

Transportation

- PT Adaro revised its plan for the coal port facility in Pulau Laut. Stage I was re-configured as a shorter pier-large panamax facility rather than a full length deep-water pier for large capesize ships. This change reflects more emphasis toward the domestic market. Adaro will supply the coal for the two units of PT Paiton Energy beginning in 1995 under a 3 Mt/yr 30-year contract agreement. [ICR 3/8/93]

- PT Bukit Asam developed three coal port facilities in Sumatra. The facilities include Tarahan in Lampung province, Kertopati at Palembang in South Sumatra, and Telukbayur at Padang in West Sumatra. The company has also constructed a 400 km rail track from the Tanjungenim mine to Tarahan and a 200 km track from Tanjungenim to Kertopati. The Tarahan port is used primarily to ship coal to the Suralaya coal-fired power station in West Java and the Kertopati facility is used to export coal to Thailand, Japan and Malaysia. [Kompas 6/10/93]

Power Generation

- Indonesia's Investment Coordinating Board approved a joint venture company, PT Paiton Energy Co. to build two 610 MW power stations at Paiton in East Java. The consortium consists of Mission Energy BV (Netherlands), GE (U.S.), Mitsui (Japan) and PT Batu Hitam Perkasa (Indonesia). However, some uncertainties exist concerning the price that PLN (the State Electricity Company) will pay Paiton Energy for its power. PLN charges the customers in Rupiah and Paiton Energy will have to repay the loan in US dollars. [AWSJ Weekly 3/8/93]

- GEC Alsthom of France plans to construct two 100 MW generators at Ombilin in West Sumatra. The coal-fired power plants, which are scheduled to be completed by the end of 1996, reportedly will cost $372 million. [Warta Ekonomi 4/19/93]

- Indonesia's current electricity consumption is 31.5 trillion Watt-hours and the Indonesian government projects consumption to reach 112.9 trillion Watt-hours and 197.6 trillion Watt-hours by the end of 1999 and 2004 respectively. These projections, however are optimistic and assume a growth rate of almost about 15 percent per year over the 1993-2004. Indonesia's installed electricity capacity was 9,200 MW in 1991. The above consumption estimates could be met only by increasing power plant capacity to 25.9 GW and 41 GW by 1999 and 2004 respectively. [Editor 6/12/93]

Companies and Foreign Investment

- The Korea-Indonesia Resources Development Co. invested $142 million in a coal mine at Pasir in East Kalimantan with a capacity of 2.3 Mt/yr. In 1993, plans to export 1 Mt to the Korean Electricity Power Corporation (KEPCO). In the future, production is expected to rise to 4 Mt/yr. The mine has proven reserves of 455 Mt. [AJM 4/93]

- Endesa of Spain may take over a 20 percent share in PT Adaro which is presently held by Endesa's sister company Enesa. PT Adaro is likely to accept the proposal since Endesa is the company's largest customer. [ICR 4/5/93]

- The Mitsui Mining Company bought 20 percent of the Petangis steam coal deposit in Balik Papan Indonesia. The mine, developed by PT Kendilo Coal (owned by BHP Minerals), will extract 1 Mt/yr of coal mainly targeted to Japan. Coal characteristics are: 6,700 kcal/kg, 11 percent ash, 0.8 percent sulfur and 41 percent volatile matter. [ICR 4/19/93]

Environment and Technology

- Indonesia's emission air quality standards for stationary sources, spelled out in Ministerial Decree No. Kep-02/Men KLH/I/1988: *Environment Quality Standard Establishment Guidelines* are shown in the table below.

Emission Air Quality Standards for Stationary Sources

Parameter	Standards High	Standards Medium	Standards Low	Note
Sulfuric acid mist or Sulfur trioxide mist or both	0.2	0.25	0.3	g SO_3/Nm^3 from gas emission
Nitrogen oxide (NOx)	1.7	4.6	4.6	Clear gas emission g/Nm^3
Carbon monoxide (CO)	1.0	1.0	1.0	g/Nm^3
Solid particle	0.4	0.5	0.6	g/Nm^3

- Indonesia is an unlikely candidate for the early introduction of CCTs for the following reasons: (1) oil and gas accounts for the majority of total electricity generation; (2) Indonesia has ample reserves of low sulfur coal and substantial reserves of natural gas; (3) power plant expansions are well below the growth in demand, and this encourages investments in natural gas plants that can be brought into production more quickly than coal; and (4) The state utility (PLN) has serious constraints on available capital and is reluctant to make major investments in FGD equipment. [EWC Coal Project, 1993]

- Coal-fired power capacity is projected to increase from 1.8 GW in 1991 to 9 GW in 2000 and 22 GW in 2010. The total CCT market is projected at less than 4 GW between 1992 and 2000 and less than 8 GW between 1992 and 2010. [EWC Coal Project, 1993]

JAPAN

Consumption and Imports

- Japan's Central Electricity Council, in its medium-term energy outlook, estimates that coal's share of the total electricity generated in Japan will rise to over 20 percent by 2002. The increase will be the result of the start-up of new coal-fired facilities. [ICR 4/19/93]

- Imports of steam coal will increase from 36 Mt this year to 81 Mt in 2000. As stated above, the increase is the result of the start-up of several new coal-fired power stations before the year 2000. [ICR 4/26/93 and EWC Coal Project, 1992]

- Japan's steam coal imports will increase significantly in 1993. Three new power plants with 1,315 MW of capacity will account for additional coal imports of 2.7 Mt/yr. The projects include a 600 MW unit at Tohoku's Nodai No.1 plant and a 700 MW plant at the Hekinan complex. [ICR 2/19/93]

- Nippon Steel led a consortium of Japanese steel makers in renegotiating a 5 Mt/yr coking coal agreement with Siberian coal producers. It was agreed that the contract volume was more than the Russian suppliers could produce without additional investment in mines and equipment. Thus, the contract tonnage will be reduced to 3 Mt/yr. [King's 1/7/93]

- Japan's Electric Power Development Company (EPDC) purchased increased tonnages of coal from South Africa in 1992 at a price reduction of $2.50/ton. Total shipments were 780,000 tons, up 60,000 tons from 1991. EPDC operates seven power plants that consume 10 Mt/yr of coal. [King's 1/28/93]

- Tohoku Electric Power's coal demand will increase to 1.3 Mt/yr following the completion of a 600 MW unit at its Noshiro plant later in 1993. [King's 3/18/93]

- Chubu Electric plans to import about 400,000 tons of coal from South Africa and 400,000 tons from Indonesian suppliers for use at its Hekinan power station in 1993. [King's 5/20/93]

Power Generation

- Japan plans to add 32 coal-fired power plants with a total capacity of 18.9 GW by the year 2000. This additional coal-fired capacity will consume about 36 Mt/yr of coal. The Japanese government recently approved a $165 billion economic package to assist in the financing of public works. Part of these funds would be used for the development of up to 10 coal-fired power plants. [ICR 4/26/93]

- Kyushu Electric Power's 700 MW Reihoku No. 1 station will come on line in July, 1995. Other units at Reihoku will become operational later in this decade. Presently, Kyushu operates three coal-fired power plants that consume about 2 Mt/yr of coal. When Reihoku unit No.1 becomes operational, Kyushu Electric's coal consumption will be about 3.4 Mt/yr. [King's 5/27/93]

Foreign Investment

- Idemitsu's Ensham steam coal deposit in Australia will be scaled down from the previously planned capacity of 4.5 Mt/yr to about 900,000 t/yr. [ICR 4/26/93]

- Mitsui mining has increased its share in the Liddell joint venture in Australia from 10 percent to 27.5 percent. The venture, which produces steam and semi-soft coking coal, is located in New South Wales' Hunter Valley. [King's 4/8/93]

- Kanematsu, a Japanese investor, purchased 10 percent interest in Australia's Metropolitan Colliery, a subsidiary of Denehurst, for about $2.8 million. Kanematsu also agreed to provide Metropolitan with $23 million in credit and to act as a marketing agent in seeking new customers. [King's 6/24/93]

Environment and Technology

- The New Energy and Industrial Technology Development Organization (NEDO) is the key implementing agency of the Japanese government for Clean Coal Technologies. NEDO is examining options to promote the transfer of CCTs to developing countries - particularly in Asia. [EWC Coal Project 93]

- The Central Research Institute of Japan's electric power industry reports the use of bacteria to remove sulfur from coal before it is burned in thermal power plants and steel furnaces. The desulfurization process entails passing pulverized coal through a water tank full of bacteria. Reportedly, this process can remove 80 percent of the inorganic sulfur (pyrite particles) in just two to three minutes. The technology is still in the development stage. [IBJ 2/93]

- A new type of anthracite coal briquette has been introduced by Matsushita Electric Industry. The new briquettes reportedly release only one-fifth of the carbon monoxide and one-hundredth of the sulfuric acid produced by regular charcoal. [King's 4/8/93]

SOUTH KOREA

Production

- Korea's anthracite production decreased by 20.5 percent from 15.1 Mt in 1991 to 12.0 Mt in 1992. The EWC Coal Project estimates that coal production will fall to roughly 6 Mt in 2000 and 3 Mt in 2010. Production has been declining steadily since 1988, and the downward trend is mainly due to lower demand resulting from the Korean consumers' preference for cleaner, more efficient fuels, and the government's rationalization policy (removal of subsidies). All bituminous coal is imported. [Korea Energy Review Monthly 1/93 and EWC Coal Project]

Consumption

- Pohang Iron and Steel Company Ltd. expects to consume 22 Mt of coal in 1993. Of that tonnage, 2.5 Mt will likely be PCI coal. Pohang wants to limit its US coal imports to 3 percent of total volume and diversify purchases among other suppliers. [King's 5/27/93]

- KEPCO's (South Korean Electric Power Company) coal demand will reach 12 Mt/yr in 1994 if its two 500 MW units at Poryong and its 500 MW unit at Sanchanpo meet targeted start-up dates. If the company's long term expansion program to construct 12 new coal-fired power plants by 2006 is met, demand will increase to 19 Mt/yr in 1995 and 27 Mt/yr in 2000. [King's 1/7/93]

- KEPCO signed an eight-year contract to import up to 2.5 Mt/yr of steam coal from South Africa. The price will be $28/ton in 1993, but future prices will be negotiated annually. [King's 5/20/93]

- While Korea's total coal consumption (42 Mt) in 1992 decreased 8.0 percent from 1991, its total steam and coking coal imports rose 4.7 percent to 29.2 Mt. Coking coal accounted for 16.4 Mt of imports and steam coal accounted for 12.8 Mt. [Korea Energy Review Monthly 3/93]

- After adjusting for stocks, Korea's total steam and coking coal consumption was 26.4 Mt in 1992. 14.3 Mt were consumed by the iron and steel industries, 6.4 Mt by electric utilities, 4.4 Mt by the cement industry and 1.1 Mt by other users. [Korea Energy Review Monthly 3/93]

- In 1992, 79 percent of Korea's anthracite was used as a space heating fuel by households and the commercial sector, while electric utilities and the industrial sector consumed 17.4 and 4 percent respectively. [Korea Energy Review Monthly 3/93]

Power Generation

- Twelve new coal-fired power plants in Korea with a total capacity of 37 GW are expected to come on line by 2006. This extensive program is expected to cost $63.5 billion. KEPCO may face considerable difficulty in funding this program, and may depend, to some degree, on foreign investors and power companies to achieve its goals. [King's 1/7/93]

Foreign Investment

- Korea's Samsung Company entered a joint venture with Clutha of Australia. Samsung owns 50 percent of the Springvale Colliery mine. The venture plans to export up to 600,000 t/yr by 1996. The mine will also to supply the New South Wales government with 2 Mt/yr of steam coal for 20 years beginning in 1993. [ICR 3/8/93]

Environment and Technology

- South Korea plans to decrease maximum allowable sulfur emissions from the present 700 ppm to 270 ppm by 2000. KEPCO plans to meet these standards by installing FGD equipment on all new and possibly all existing coal-fired power plants. [EWC Coal Project, 1993]

NEW ZEALAND

Production

- The state-owned Coal Corporation of New Zealand, the largest coal producer in the country, produces 2.0 - 2.5 Mt/yr of coal. The measured resources of coal in New Zealand are 600 Mt of bituminous coal and 7,000 Mt of lignite. [Mining Journal 6/18/93]

- Greymouth Coal Corporation, a new joint venture (Coal Corporation - 33 percent, the Todd Group - 18 percent, and a Japanese company -18 percent) is considering the development of a mine on the West coast of New Zealand's South Island. The mine's output would most likely be exported to Japan. Mine capacity would be about 500,000 t/yr. Greymouth also plans to develop a coal handling facility at the site. [Mining Journal 6/18/93 and Mining Magazine 6/93]

PHILIPPINES

Production

- Domestic coal production in the Philippines is about 1.5 Mt/yr but the coal has a high moisture content and low calorific value. Production levels are expected to remain stagnant in the future. The EWC Coal Project projects production increases to about 4.0 Mt/yr could occur within a decade far short of the growth in coal consumption. [King's 5/20/93]

Consumption

- The goal of the Philippine National Power Corporation (Napocor) is for coal to make up at least 12 percent of the country's total energy mix. Currently, coal contributes 2.6 percent of The Philippines' total energy needs. By the year 2000, demand for coal is projected to be 14 Mt/yr. Present consumption is 4 Mt/yr. The surge in demand will be due, mainly to the government's energy plan in which 6 GW of coal-fired capacity is planned. [King's 3/4/93 & EWC Coal Project]

Power Generation

- The severe Philippine power shortage problem has increased with the shutdown of the 300 MW Calacca I plant. Thirteen units of the nation's 24 power plants are out of commission, and generating capacity is down by more than 1,000 MW. [King's 3/18/93]

- The Philippines will receive a $500 million loan from Japan to finance new power plants. An estimated $430 million in additional loans and grants are needed to carry out the government's power expansion program. [FBIS 3/16/93]

- Progress on the 200 MW Calacca II station in Batangas, scheduled to come on stream by late 1995, has been halted. The Japanese government through the Overseas Economic Cooperation Fund will not release a promised $320 million in funding until mid-February because of objections from an environmental lobby. The 600 MW coal-fired Masinloc plant in Zambales which will cost $662 million is also subject to delay for similar reasons. [EIU Country Report 2nd quarter 1993 - Philippines]

- The International Finance Corporation (IFC) and the Asian Development Bank (ADB) have granted Hopewell Energy Ltd. a $150 million loan to develop a 700 MW coal-fired power plant on the Quezon province South of Manila. Two other agencies, the Japan Export Import Bank and the US Export Import Bank will lend $335 million and $185 million respectively for the project. The plant which has a total cost of $880 million is expected to begin operations by 1996. However, start-up may be delayed because of environmental objections. [EIU Country Report 2nd quarter 1993 - Philippines]

- Hopewell has proposed building a 2,000 MW (4x500 MW) plant in the Philippines. [ICR 6/11/93]

- Major power projects will be jeopardized if the 18-centavo (0.6 US cent) per kilowatt hour rate increase proposed by Napocor is not approved by the Philippine Supreme Court. The court's decision could affect the development of the 700 MW Pabilao coal-fired plant which will be built by Hopewell Energy Ltd. which is mentioned above. [FBIS 4/2/93]

- The Mindanao (200 MW) and Sual (900 MW) coal stations are scheduled for commissioning ir ·96/97. [ICR 6/11/93]

Technology

- The Philippines will negotiate with the Japanese government to obtain funds under the Green Aid Plan for the construction of a 100 MW demonstration plant with sulfur removal technology. [FBIS 5/5/93]

- There are no plans to add FGD equipment to coal-fired power plants in the 1990s. Significant use of CCTs is unlikely before 2000. Although delays in power plant construction are often attributed to environmental concerns, the National Power Corporation is reluctant to introduce FGD because of the added costs. [EWC Coal Project, 1993]

TAIWAN

Production

- In 1992, Taiwan's coal production was an insignificant 0.3 Mt while imports grew 25 percent to 23 Mt. Coal production has been declining since 1984 following the removal of subsidies for domestically produced coal. Taiwan's coal production is now virtually non-existent. [EIU Country Profile 1993/1994 - Taiwan]

Consumption

- Taiwan Power Company (Taipower) plans to secure 70 to 90 percent of its coal needs through long term contracts. It plans to consume about 14 Mt in 1993, to 14.6 Mt in 1995 and 22.9 in 2000. There will be only small increases in imports to 1995. The completion of Taichung units 5-8 in 1995-97 will increase import demand to 18-19 Mt/yr by 1997. [ICR 3/8/93 & King's 5/20/93]

- Long term contract tonnages (5-7 years) recently awarded by Taipower were split between four countries - Indonesia, Australia, South Africa and the US. The contract tonnages average about 0.5 Mt/yr per supplier. No price data was released. [ICR 5/17/93]

Power Generation

- Plans are underway to privatize Taipower. Taipower operates six coal-fired power stations and three nuclear power plants with an estimated worth of $7.7 billion. The utility will be put up for sale in 1994 at the earliest. [King's 2/11/93].

- Taipower originally planned to install 5,500 MW of new coal-fired capacity at its Taichung power complex, however the project has been scaled back to 2,950 MW because of "environmental objections". The five units that will be built will have FGD technology built in. About 2,200 MW of coal-fired capacity in the complex has been equipped with FGD technology. [ICR 6/11/93]

- Two 750 MW units at Suao are planned as part of a four unit coal-fired station. Only the first unit is expected to be operating by the year 2000. The second unit is expected to begin operation in 2001. However, Taipower may encounter problems in securing site approval at Suao. Serious delays in approval can result in a Taipower decision to build a gas-fired station instead, as was the case at Hsinta where four planned 550 MW coal-fired units were cancelled due to siting problems. [ICR 6/11/93]

- Coal-fired power capacity is projected to increase from 4 GW in 1991 to 10 GW and 16 GW in 2000 and 2010 respectively. The CCT market is projected to be 5-8 GW between 1992 and 2000, and 10-14 GW between 1992 and 2010. [EWC Coal Project, 1993]

THAILAND

Production

- Ban Pu, one of Thailand's largest private mining companies has been awarded its third contract worth $461 million with the Electric Generating Authority of Thailand (EGAT) to mine lignite at the Mae Moh mine in Thailand's Lampang Province for the next ten years. [AJM 3/93 & Coal Project, 1993]

- Ban Pu plans to increase its own production from the present 1.7 Mt to 3 Mt in the next five years. The coal will be mined from open pit mines in two provinces - Lamphoon and Lampang. [AJM 3/93]

Power Generation

- Demand for electricity in Thailand is expected to increase about 10 percent annually over the next ten years. EGAT is planning to increase electricity generating capacity from 10,000 MW presently to more than 25,000 MW by about the year 2000. The EWC Coal Project projects electricity growth at a slightly lower rate of 8-9 percent per year in the 1990s. [AWSJ Weekly 1/11/93]

- Thailand is considering the privatization of certain power projects. The first private project is likely to be a lignite-fired plant at Mae Kham. The planned design consists of two fluidized bed boilers driving two 150 MW turbines. [ICR 6/11/93]

Environment and Technology

- A committee will be formed to set minimum environmental standards for electricity generating plants and to find ways to control power plant emissions. These minimum standards will first be applied at the Mae Moh lignite-powered plant which emits large quantities of sulfur dioxide. [Environmental News Briefing 12/92]

- The government is providing up to 10 billion Baht ($397 million) to install FGD systems at the Mae Moh lignite-fired power plant in the northern province of Lampang. The complete installation of FGD equipment may take up to four years. [EIU Country Report No.1 1993 - Thailand]

- At the invitation of the Thai government, a seminar on Clean Coal Technology will be held in Thailand in September 1993. The Seminar is under the APEC Experts' Group on Clean Coal Technology. [EWC Coal Project, 93]

USA

Production

- The United States' National Coal Association estimates that US coal production in 1993 will be about 900 Mt. However, total exports are expected to decline 6.6 percent from 1992 exports. Seaborne shipments are estimated at 29 Mt of steam coal and 50 Mt of metallurgical coal. [King's 2/18/93]

- A joint venture between Cyprus Coal and US Steel Mining will operate USSM's Cumberland coal mine and develop reserves owned by Cyprus in the Greene county area of south western Pennsylvania. Each party will own an equal share in the new venture. The companies will own a 20 year supply of minable steam coal with its coal reserves in Cumberland and the adjacent Cyprus deposit. The Cumberland mine produced about 3.5 Mt of steam coal in 1992. [King's 1/21/93]

Consumption

- US coal consumption in 1993 is expected to remain stagnant at about the 1992 level. Coal-fired utilities are projected to burn 721 Mt in 1993; 8.2 Mt above the 1992 level. Metallurgical coal use will remain constant at 30.8 Mt. Industry, residential and commercial use will also remain at the 1992 level of 74.4 Mt. [Mining Magazine 3/93]

- USX and Inland steel will begin operating PCI systems in 1993. USX expects to utilize 637,000 tons of low volatile matter and 0.7 percent sulfur coal as PCI coal in 1993. In 1994, Inland will consume 600,000 - 800,000 tons of PCI coal. Inland's facility will burn high volatile matter coal averaging 6,116 kcal/kg and 0.7 percent sulfur. Other companies likely to install coal injection equipment are Bethlehem Steel and LTV. [ICR 2/8/93]

- Mississippi Power received 69,000 tons of PT Adaro's Envirocoal from Indonesia in early March, 1993. The 0.1 percent sulfur and one percent ash coal will undergo testing at the company's Daniel plant. The company currently receives low sulfur coal from Wyoming's Powder River Basin, but company officials have indicated that the price of the Indonesian coal makes it an attractive alternative source. [King's 3/11/93]

- Jacksonville Electric Authority may purchase steam coal from South American suppliers. Steam coal is currently purchased from Ashland Coal's Hobet mine, but mine workers are presently on strike. The utility received about 600,000 tons from the Hobet mine in 1992. The price of the South American coal is being negotiated. [King's 5/20/93]

Trade

- US coal exports in 1992 were 82 Mt (30 Mt steam and 52 Mt coking coal) which represented an 8 percent drop from 1991. The National Coal Association forecasts that steam coal exports will decrease further in 1993 to 29 Mt with coking coal exports decreasing to 51 Mt. The reasons given were the slow worldwide economic recovery and competition from low cost producer: [IBJ 2/93]

- Exports of co..ng coal to Brazil may decrease as much as 30 percent this year as Brazil is preparing to retaliate from the US imposition of punitive import surcharges for the alleged dumping of steel on the US market. Brazil imports 11 Mt/yr of coal of which 50 percent is imported from the US. Brazil's other major suppliers are Australia (22 percent) and Poland ? percent). [ICR 2/8/93 and King's 3/18/93]

- average r of western US coal in the Asia-Pacific region is expected to decrease about rcent in The 1992 FOB price was in the range of $41-$43/ton which represents ./ton drop m 1991 prices. Western producers are also experiencing significant price pressure within the US. [King's 2/4/93]

- The export volume of US east coast ports declined from 61.9 Mt in 1991 to 56.4 Mt in 1992. Countries that imported less coal from east coast ports included Italy, the Netherlands, the UK Belgium, Brazil, Spain, Denmark, and Germany. [ICR 2/19/93]

- T.. .l coal exports from all US ports decreased significantly in 1992 to 78.9 Mt from 88.3 Mt in 1991. Both steam and coking coal shared the same volume decreases though steam coal represented a higher percentage decrease. [ICR 3/8/93]

- Japan's Sumitomo Co. purchased PCI coal from Sanborn Creek in Colorado which is owned by Pacific Basin Resources and Bear Coal. The price was set at $39.80/t FOB in 1992 with 38 percent volatile matter, 8 percent ash, 8.5 percent moisture, 0.5 percent sulfur, and a 12,000 Btu/lb (6,672 Kcal/kg) heat content. [ICR 1/8/93]

- US coke imports could remain at 1.8 to 2.7 Mt through 1995 because no new coke plants will be built. The largest suppliers will most likely be Japan and Australia. [ICR 2/8/93]

Transportation

- The proposed Port of Los Angeles coal terminal is in the final stage of its construction start-up. Planned capacity is 15 Mt/yr, but it will begin with a capacity of 2.2 Mt/yr. The consortium which finances the port's development is made up of investors from the US (51 percent) and Japan (49 percent). [ICR 2/19/93]

- The port of Anchorage, Alaska will be expanded to serve the expected increase in Alaskan coal production which is forecast to occur by mid-decade. As much as 13 Mt/yr of coal is expected to be available for export to Asian markets. [King's 1/7/93]

- The Clinton administration is planning to increase user-fees on the US inland waterway system (domestic river systems and intercoastal waterways). The plan calls for a phased increase of $1 from the current inland waterway fee of about 19 cents per gallon of diesel fuel consumption. [King's 5/6/93]

Companies

- Consol purchased Island Creek coal company in April, 1993. The merger brings together two of the three largest low-volatile matter metallurgical coal producers in US. The combined output of the two companies will be 65 Mt/yr, close to that of Peabody, the largest US producer, which produces 82 Mt/yr. [King's 4/15/93 and ICR 4/19/93]

- Several US companies reported gains in operating profits despite a slowdown in sales volumes. Massey's profits were $80.3 million in 1992 compared to $60.7 million in 1991. Ashland showed a slight increase in profits from $56.4 million to $58 million, and Pittston's profits were $36.9 million in 1992 compared to an operating loss of $84 million in 1991. [ICR 2/19/93]

- The UMW strike in the US caused prices to increase and supplies of certain types of coal to be scarce. The effect on export has been small so far but recently strikes in some Peabody export mines have caused exports of low volatile matter coking coal to decrease. Sweden's SSAB has recently replaced coal normally purchased from Peabody with coal from another suppliers. [ICR 6/25/93]

- Peabody reportedly is no longer interested in the acquisition of Naricual coal mine in Venezuela. It will, however, continue to explore other Venezuelan coal assets. Peabody has been active in acquiring equity in foreign mines over the past year. [King's 3/18/93]

Environment and Technology

- Tampa Electric Company is operating a 260 MW Integrated Gasification Combined Cycle (IGCC) generating plant. The system is equipped with hot gas clean-up (HGCU) and conventional gas clean-up (CGCU) technologies. The system will be used to test the efficiency of syngas cleaning and is expected to remove 96 percent of the sulfur present in the coal. [IBJ 2/93]

- The Tennessee Valley Authority has set up a 10 MW demonstration facility to test the applicability of gas suspension absorption in Flue Gas Desulfurization using high sulfur US coals. The unit is designed to remove up to 90 percent of sulfur dioxide in the flue gas. [IBJ 2/93]

- There are two compliance options under the Clean Air Act for companies operating coke plants. One applies to those plants planning to close by 2003 or earlier, and the other for companies willing to keep their plants operating beyond 2003. The options and emission time table are shown in the table below. [ICR 2/8/93]

US Emission Time Table

1993	MACT (mild) deadline for companies to close coke plants before 2003
1995	MACT deadline for companies planning to stay in operation beyond 2003
2003	LAER (intermediate) deadline for companies postponing highest "residual risk" level of compliance until 2020
2003	"Residual risk" deadline (stringent) for companies not meeting LAER standard
2020	"Residual risk" deadline for all remaining coke plants

[ICR 2/8/93]

VIETNAM

Production

- Vietnam's Hongai Coal Company is developing mining projects which are expected to produce 2 Mt/yr of anthracite targeted for both domestic and export markets. The commissioning is planned at the end 1993 [IBJ 2/93]

Trade

- Vietnam's state-owned coal trading company, Coalimex, exported 1.6 Mt of anthracite in 1992 and expects exports to increase to 2 Mt in 1993. The company's major customers are Japan, South Korea, Western Europe, Brazil and the Philippines. [IBJ 2/93]

- Vietnam's spot market exports to Japan have been falling recently. The Japanese industries that use anthracite have been scaling back because of the Japanese recession. [King's 4/8/93]

- Coalimex made an offer of $29/ton FOB for the sale of its anthracite to Japanese buyers, but sources estimate that Japanese buyers will require a $2-$3/ton price reduction. The anthracite is reportedly used mainly by the Japanese glass industry and by briquette producers. [King's 1/21/93]

- A Korean glass company bought two handy-size shipments of spot Vietnam steam coal in the $28/ton FOB range. The heat content of the coal was 5,600 kcal/kg. [King's 3/18/93]

Power Generation

- Domestic demand for coal has fallen with the large expansion of hydroelectric capacity (1,920 MW) in northern Vietnam. Excess coal is being exported. [EWC Coal Project 93]

- Vietnam's Ministry of Energy is considering the addition of new coal-fired generating units. The Pha Lai plant in the North and a new plant in the South have been tentatively considered as build-own-operate (BOO) projects with 200-600 MW of capacity. However, the expansion of hydroelectric and gas capacity, could delay major increases in coal use for electric generation for a decade or more. [ICR 6/11/93 and EWC Coal Project, 93]

- Vietnam's present coal-fired capacity of about 0.7 GW is not expected to increase significantly during the 1990's (a maximum of 1.0 GW by 2000, increasing to 2-3 GW by 2010). After 2010, growth in coal-fired capacity could be very rapid as hydro and natural gas reserves are expected to be fully committed. The CCT market is projected to remain quite small over the 1993-2010 period. [EWC Coal Project, 93]

WORLD

Production

- Worldwide steam coal trade is predicted to reach 366 Mt by 2000, and coking coal trade is expected to decline to 159 Mt by the year 2000 according to the Australian Bureau of Agriculture and Resource Economics (ABARE). Steam coal demand for Pacific Rim countries is expected to double by 2000, reaching 187 Mt. The decrease in coking coal trade will be caused mainly by the widespread use of pulverized coal injection (PCI) technology and depressed steel markets. [King's 2/18/93]

Trade

- Seaborne coal trade is expected to reach 275 Mt in 1997 and 320 Mt in 2000. A majority of the increase in import demand is projected for Pacific Rim countries notably Japan, South Korea, Taiwan and Hong Kong. Europe is also projected to account for a significant portion of seaborne coal trade growth. The growth in import demand will be due primarily to the start-up of new coal-fired power plants. [IBJ 1/93]

- The seaborne thermal coal price decreased during the first quarter of 1993. The average price of Australian thermal coal exports was $5/ton lower in March than in January, 1993, and the gap between Australian and US coals has broadened. U.S. railroads have been offering $2/ton rebates on freight in an attempt to maintain export shipment volumes. [Quarterly Review of Commodity Markets 3/93]

- The chairman of Germany's Krupp Fordertechnik forecasts European coal production to decrease 25 percent in 1993 and 50 percent by 2000. [King's 3/25/93]

Transportation

- National Power and PowerGen of Great Britain have invested in import facilities with a capacity of 15 Mt/yr. The average price of British Coal ($61.00/ton) still far exceeds the world market price even though suppliers to the above utilities have cut the price by 28 percent in real terms over the last five years. [IBJ 3/93]

Power Generation

- Malaysia's Ministry of Energy is considering the addition of coal-fired power plants by 2000. A 600 MW coal-fired plant at Port Klang is being considered for start-up in 1997/98. The ministry would like to arrange a BOO or BOT agreement for the plant. [ICR 6/11/93]

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ACRONYM

ABARE:	Australian Bureau of Agriculture and Resource Economics
AJM:	Australia Journal of Mining
AWSJ Weekly:	The Asia Wall Street Journal Weekly
Bt:	Bath (Thai currency)
Bt/yr:	Billion tons per year
EIU:	The Economist Intelligence Unit
FEER:	Far Eastern Economic Review
GW	Giga Watts
IBJ:	International Bulk Journal
kcal:	Kilocalorie
KEEI	Korea Energy Economics Institute
Mt:	Million tons
Mt/yr:	Million tons per year
PLN:	Perusahaan Listrik Negara (Indonesia's State Electricity Company)
Rmb:	Renmimbi (Chinese currency)
ton:	Metric units (1,000 kg)
t/yr:	Tons per year

OVERVIEW OF THE POTENTIAL FOR

CLEAN COAL TECHNOLOGY IN THE ASIA-PACIFIC REGION

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CONTENTS

FIGURES

I. INTRODUCTION[1]

The Asia-Pacific economies discussed in this chapter consume substantial amounts of coal for electricity generation and are potential important markets for clean coal technologies (CCTs). In this chapter CCTs are defined as those technologies that can substantially reduce emissions of SO_2 and NO_x resulting from the combustion of coal and lignite in electricity generating power plants. The rate of introduction of CCTs into Asia-Pacific economies varies widely and is broadly related to the level of economic development and environmental problems resulting from coal burning in individual economies. This chapter provides an overview of the trends in electricity generation in the Asia-Pacific region and estimates of the market for CCTs in electricity generation plants to 2010. There are other important markets for CCTs, such as in the iron and steel industry, that are not covered in this chapter.

Governments in all coal-consuming Asia-Pacific economies are examining options for maintaining high levels of economic growth and reducing environmental impacts associated with increased energy consumption. As shown in Figure 1, there is a correlation between the expansion in economic activity, commonly measured as the gross domestic product (GDP), and the growth in electricity consumption. In low-income economies the growth rate of electricity consumption usually exceeds the growth rate of GDP. However, in higher income, mature economies (such as Japan) the increase in electricity consumption is often substantially lower than the GDP growth rate. The anomalous lower income economy in Figure 1 is China, which has an electricity consumption growth rate lower than the GDP growth rate. This is probably partly because electricity supplies are increasing more slowly than the growth in demand and partly due to the structure of energy demand.

From an energy perspective, Asia is quite different from the rest of the world in the following two areas: the growth rate of electricity consumption is much higher than the rate in the rest of the world; and the region is twice as dependant on coal as the rest of the world (close to half of Asia's energy requirements are met by coal, compared to less than a quarter in the rest of the world). The combination of high growth rates in GDP and electricity consumption and the heavy reliance on coal means that Asia is adding to local and global environmental problems at a faster rate than the rest of the world. The high economic growth rates also mean that Asian economies will be able to invest increasingly in less polluting energy technologies.

As shown in Figure 2, coal consumption is projected to increase by about 1.3 billion tons over the 1993-2010 period. The expansion in coal consumption for electricity generation is the dominant factor in the large increase in coal consumption. Without effective control measures, the projected increase in coal consumption will have a serious impact on environmental quality in many countries in the region. Therefore, there is a need to develop sound policies and strategies at both national and regional levels to reduce the negative environmental effects of increased coal use in Asia. As discussed in this chapter, the introduction of appropriate CCTs is considered essential to achieving the twin goals of expanded use of coal and decreased environmental impacts.

[1]All figures are in constant 1992 US dollars.

II. ELECTRICITY GENERATING CAPACITY FORECASTS FOR ASIA

Figure 3 projects that total electricity generation capacity in the Asia-Pacific region will grow from 550 GW in 1992 to 850 GW in 2000 to 1,350 GW in 2010. The average growth rate over this period is projected at 5.1 percent per year. China is expected to account for the largest share of capacity additions -- accounting for about 40 percent of the projected capacity expansion over the 1992-2010 period.

Figure 4 shows the primary energy mix of electricity generation capacity in Asia in 1992 with projections for 2010. Coal's share of total capacity is projected to increase from approximately 39 percent in 1993 to 47 percent in 2010, even though governments and industry will continue to attempt to diversify away from coal where cleaner fuels are available at competitive prices. As shown in Figure 4, oil's share of capacity is projected to decline from 18 percent in 1992 to 10 percent in 2010. Nuclear power's share of generation capacity is projected to increase from 8 percent in 1992 to 13 percent in 2010. Even though increased attention will be given to expanding natural gas and hydroelectric supplies, neither of these energy options is expected to maintain its share of the electricity market over the 1992-2010 period. Other energy options, including solar, are projected to play an insignificant overall role in Asia's energy mix by 2010.

Requirements for Investment in Power Plants

Figure 5 shows that an estimated $750 billion dollars will be required to meet the requirements for investment in electricity generating plants in the Asia-Pacific region over the 1993-2010 period. As shown in Figure 5, China is expected to account for the largest share of investments, followed by Japan. Investments in coal-fired power plants are projected to account for about $300 billion or 40 percent of the total investments in power plants over the 1993-2010 period.

III. COAL AND THE ENVIRONMENT

The largest constraint on the continued expansion of coal-fired generating capacity is the impact that coal burning has on the environment. The main environmental pollutants are particulates, SO_2, NO_x and CO_2. In recent years the debate over global warming and the contribution of CO_2 to global warming has tended to dominate international environmental discussions. However, CO_2 is not a priority of most APEC governments according to a recent survey of APEC member governments (APEC, 1992). Figure 6 shows the relative importance of environmental issues according to the APEC survey of coal-consuming APEC members. Top priority is the control of SO_2 emissions, followed by particulates (ash) and NO_x, and, finally, CO_2. The lower priority given to CO_2 emissions reflects the immediate concern of most governments with reducing emissions of SO_2, particulates and NO_x that can have direct effects on the populations in the vicinity of power plants.

Figure 7 shows the estimated emissions of SO_2, NO_x and CO_2 in Asia (Kato, et al., 1987). These estimates should only be used as a general indicator of the percentage of emissions for Asian economies. China stands out as the largest contributor to the region's air pollution with about two-thirds of the total SO_2 emissions and roughly half of the NO_x and CO_2 emissions. Clearly, any strategy to reduce emissions of these gases in Asia will have to include increased attention on reducing these emissions in China.

Options for Reducing SO_2, NO_X and CO_2 Emissions from Coal Burning

Commercial CCTs are able to remove almost all emissions of particulates and SO_2 and the majority of NO_x emissions. The two primary commercial CCT options for controlling SO_2 emissions are flue gas desulfurization (FGD) systems added to conventional pulverized coal-fired power plants and atmospheric fluidized bed combustion (AFBC). These two technologies dominate the field of existing commercial technologies and are expected to be the main CCT choices of utilities in Asia during the 1990s. These technologies typically reduce SO_2 emissions by 85-95 percent. Beyond the 1990s, a wider range of CCT options are likely to become available that not only control emissions of SO_2 and NO_x, but will substantially increase efficiencies in energy conversion and therefore reduce CO_2 emissions per unit of electricity. No viable technology exists to reduce CO_2 emissions, except through increased efficiencies in fuel use, and switching to energy options that produce less CO_2 -- such as natural gas, hydropower and nuclear power.

Utilities do not necessarily have to use CCTs to meet environmental constraints. Almost all coal-fired plants being designed today have particulate recovery systems that recover in excess of 98 percent of the particulates, and at modest cost modifications can be made to the combustion system to substantially lower NO_x emissions. The reduction of SO_2 can be accomplished by substituting low-sulfur coals or installing CCTs (FGD or AFBC). A plant burning a high-sulfur coal (say 2.0 percent) could reduce sulfur emissions by 50 percent or more by substituting low-sulfur coal. Many utilities in the United States are following this strategy to substitute low-sulfur coal for high-sulfur coal. At present, there are abundant quantities of low-sulfur coal with sulfur contents in the 0.6-0.9 percent range being traded internationally in the Asia-Pacific region. To date, Australia is able to meet its emission standards using low sulfur coal and high stacks. In contrast, for high-sulfur lignites in Thailand and high-sulfur coals in various economies, including southern China, CCTs may be the most competitive alternative.

Where environmental legislation limits either power plant stack emissions or ground level concentrations, the use of low-sulfur coal and higher stacks can often meet environmental regulations. Some legislation requires specific percentage reductions in sulfur, regardless of the sulfur content of the coal being burned, therefore, in effect requiring the installation of CCTs. The trend in environmental legislation in a number of Asian economies is toward environmental quality standards that will effectively force many utilities to install CCTs by 2000.

A range of approaches to meeting environmental standards are being followed. Stated environmental goals and most environmental legislation in Asia have already established relatively high standards. An important problem in a number of economies is lack of enforcement of existing environmental standards, particularly for government-owned utilities.

IV. ECONOMICS OF CCT OPTIONS

Governments and utilities are faced with the problem of how to meet the growth in demand for electricity at the lowest possible cost while also meeting the demand for increased attention to reducing environmental impacts. There is no one energy option that is optimal for all economies. Each economy has different domestic energy options and, as a consequence, faces different levels of environmental pollution. The trend is toward establishing more stringent environmental standards, and allowing a greater role of market forces in determining the optimal energy mix.

The capital and operating costs of coal-fired power plants are usually higher than those for oil or gas-fired power plants. However, no government in Asia intends to rely heavily on oil for electricity generation in the future because of uncertainty about long-term prices and security of supply considerations. Clean-burning natural gas, where economically available, is increasingly the preferred choice. Unfortunately, most large gas reserves are far from markets, and long distance transportation is expensive. Nuclear power is competitive in selected situations; however, the much higher capital costs, longer construction lead times, and public opposition limit nuclear power's role in Asia's electricity market. Hydropower has potential in local areas of most Asian economies (particularly in China, Vietnam and Laos), but its high capital costs, long lead times, and environmental and social impacts limit potential expansions.

The addition of CCTs to power plants typically adds 15-25 percent to the capital costs and 10-20 percent to operating costs. For a power plant that costs $500 million, an additional $100 million for CCTs is considered too expensive by many utilities already facing serious problems in raising sufficient capital for conventional power plants. The added cost per kilowatt hour is roughly $0.01 for electricity that typically costs $0.05-0.07 per kilowatt hour in most Asian economies.

Figure 8 shows the projected market for CCTs in the Asia-Pacific region for the 1993-2010 period. These estimates are quite speculative, and are only useful as a broad guide to relative sizes of CCT markets. The estimates in Figure 8 assume that governments will continue to implement and enforce tighter environmental regulations over the forecast period. During the period 2001-2010, China is projected to be the dominant market for imported CCTs; however, the country is unlikely to add substantial CCT capacity before 2000.

Figure 9 presents an estimate of the plausible breakdown of technology and fuel options in China in 2010. Imported CCTs are projected to be used on about 20 percent of the total coal-fired capacity, with domestically produced CCTs and low-sulfur coal each accounting for 35 percent of capacity. Figure 9 assumes that during the 1990s there will be a substantial shift in government policies to encourage the introduction of CCTs.

A critical concern of most governments and utilities is how to finance the additional costs of CCTs. The problem of financing CCTs is large from an individual utility perspective; however, when considered in the context of investment requirements of the Asia-Pacific region, CCT investment needs appear more manageable. The total investment requirement for CCTs in the Asia-Pacific region over the period 1993-2010 is estimated at about 4 percent of the total investment requirements for power plants. Modest changes by bilateral and multilateral lending institutions in the terms of loans can allow utilities to add

CCTs at minimal added costs to the consumer for the additional borrowing. Increasingly, access to multilateral and bilateral loans for power plants may be contingent on meeting stricter environmental standards.

V. TRENDS

The 1992 APEC survey of coal-consuming Asia-Pacific economies demonstrated that governments are generally aware of the environmental problems associated with coal consumption. In addition, most governments are examining CCT options along with other alternatives to reduce the environmental impacts of coal consumption. The middle and higher income economies are further advanced in enforcing environmental regulations that will encourage the adoption of CCTs. Japan has already introduced CCTs throughout its utility sector and Japan and the United States are actively developing more advanced CCTs that can substantially increase energy efficiencies. Hong Kong, South Korea, Taiwan and Thailand are likely to install CCTs on the majority of all future coal-fired power plants, and China, Indonesia and the Philippines are considering CCTs. In China, considerable effort is under way to develop indigenous CCTs; however, a substantial market for high efficiency imported CCTs is projected, particularly after 2000. By 2010, CCTs are projected to account for 25-30 percent of coal-fired capacity in the Asia-Pacific region.

The goal of most Asian governments is to meet rapid increases in the demand for electricity at acceptable financial and environmental costs. Switching to low-sulfur coal is a viable option in the short to intermediate term for many utilities. However, as environmental legislation tightens, the introduction of CCTs on a wide scale in Asia is essential to achieving the twin objectives of acceptable costs and lower environmental impacts. Cooperation among governments and industry through organizations such as APEC will accelerate the timely dissemination of CCT information that can help governments make better long-term energy policy choices. The higher capital costs to introduce CCTs are believed to be within the capability of multilateral and bilateral institutions, but will require greater emphasis on environmental issues in making loans for power plants.

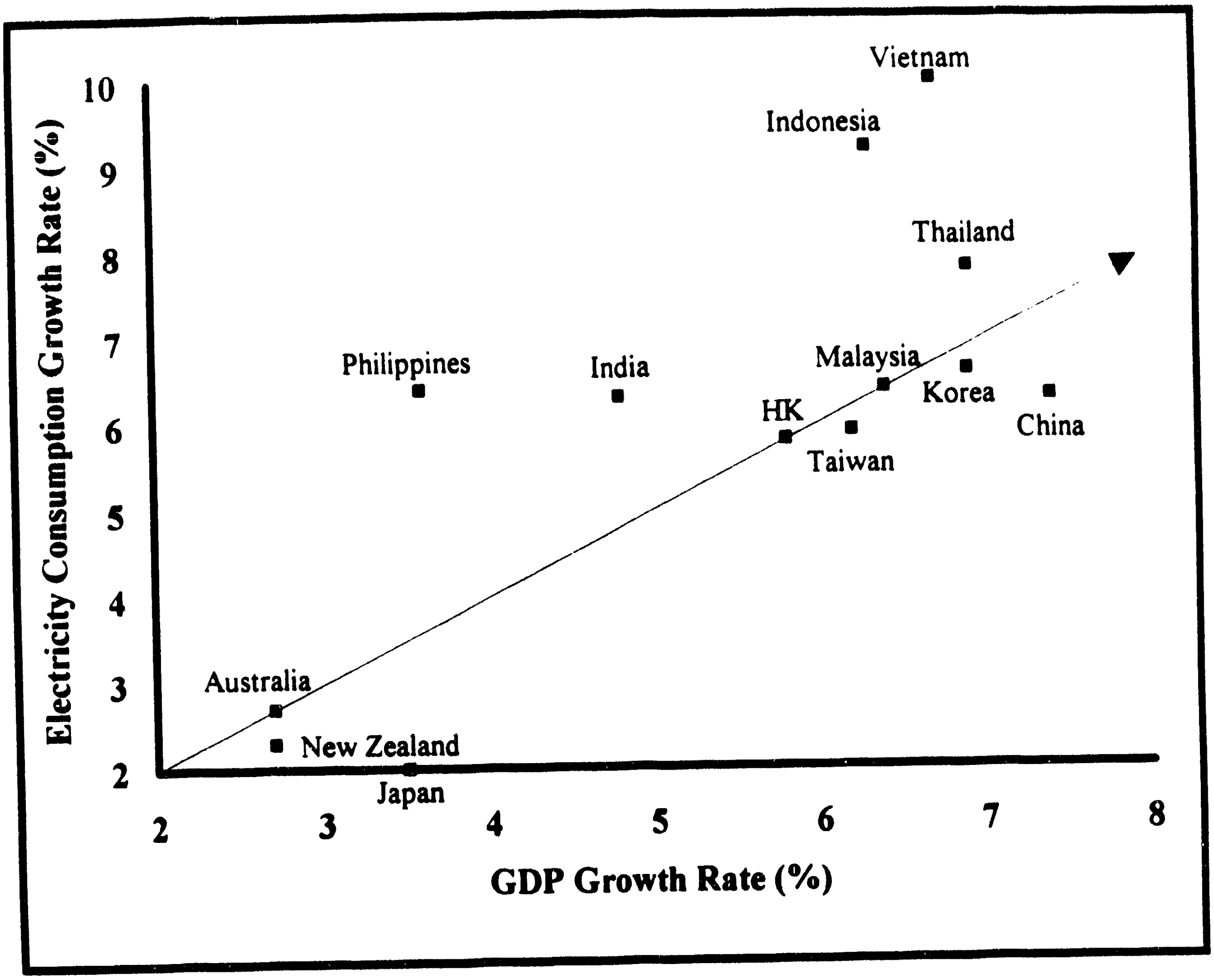

Figure 1. Projected growth rates of electricity consumption and GDP (1993-2010).
Note: Economies on the diagonal line have electricity consumption growth rates equal to GDP growth rates.

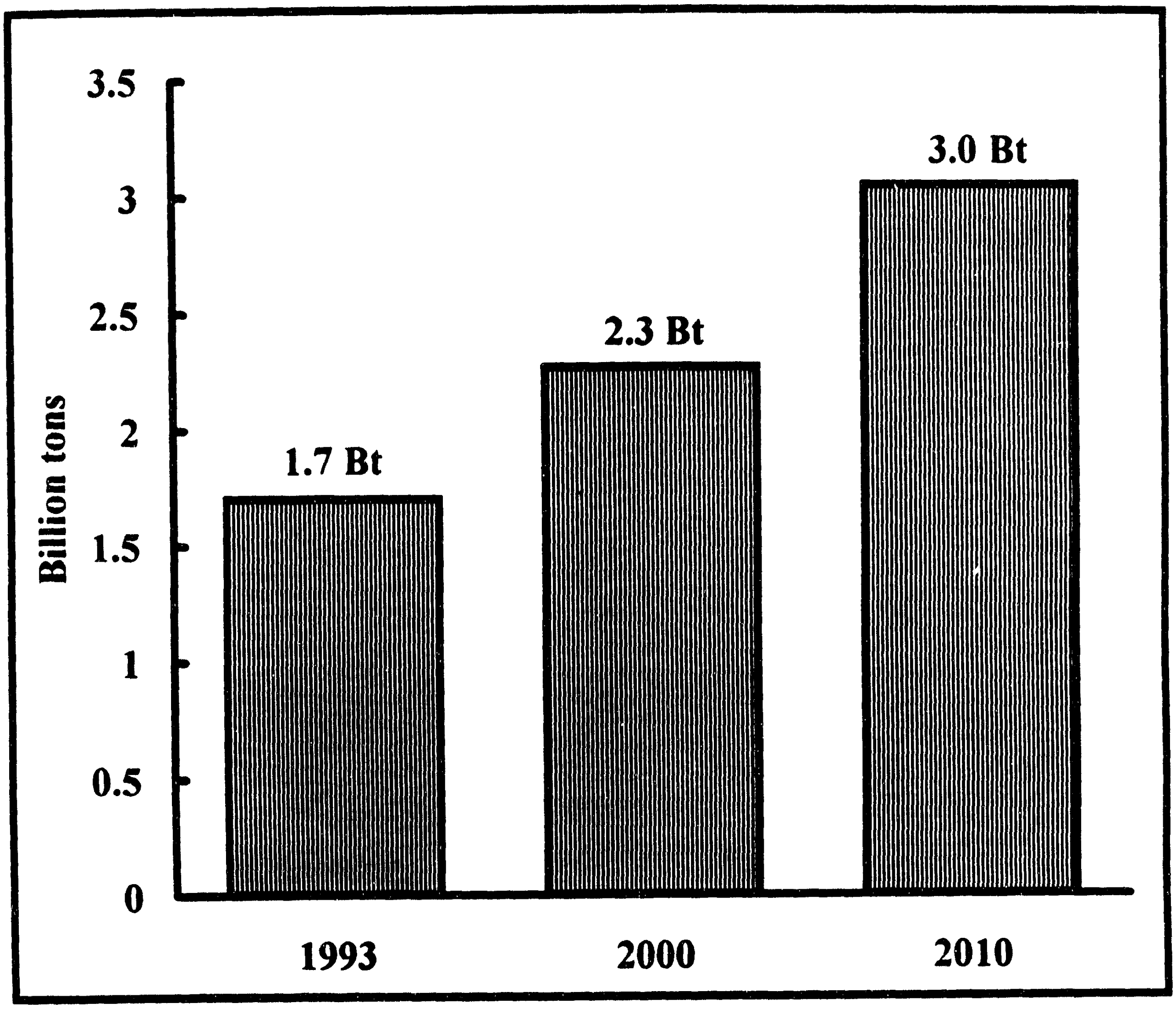

Figure 2. Coal consumption in Asia.

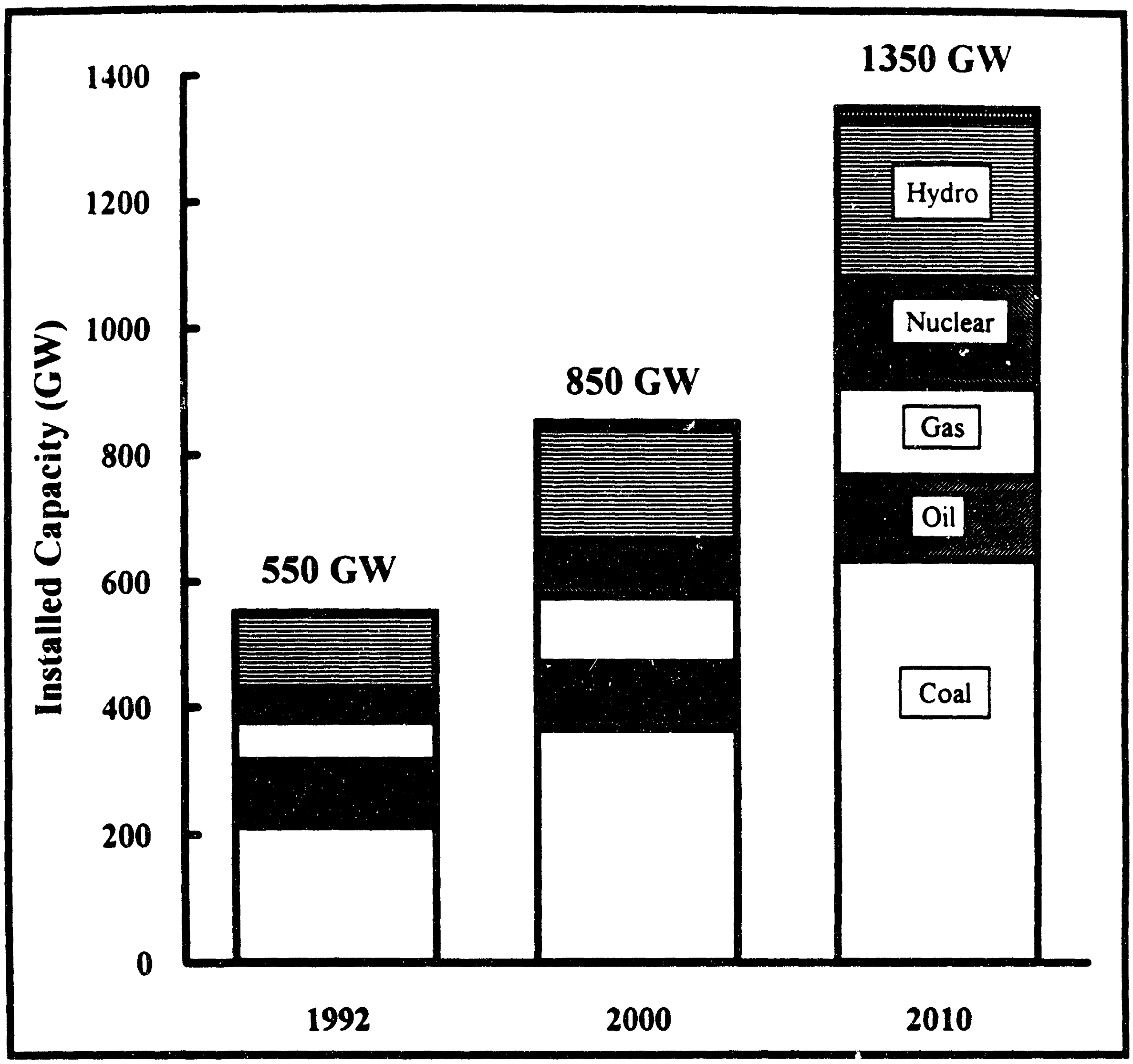

Figure 3. Projections of installed capacity in the Asia-Pacific.

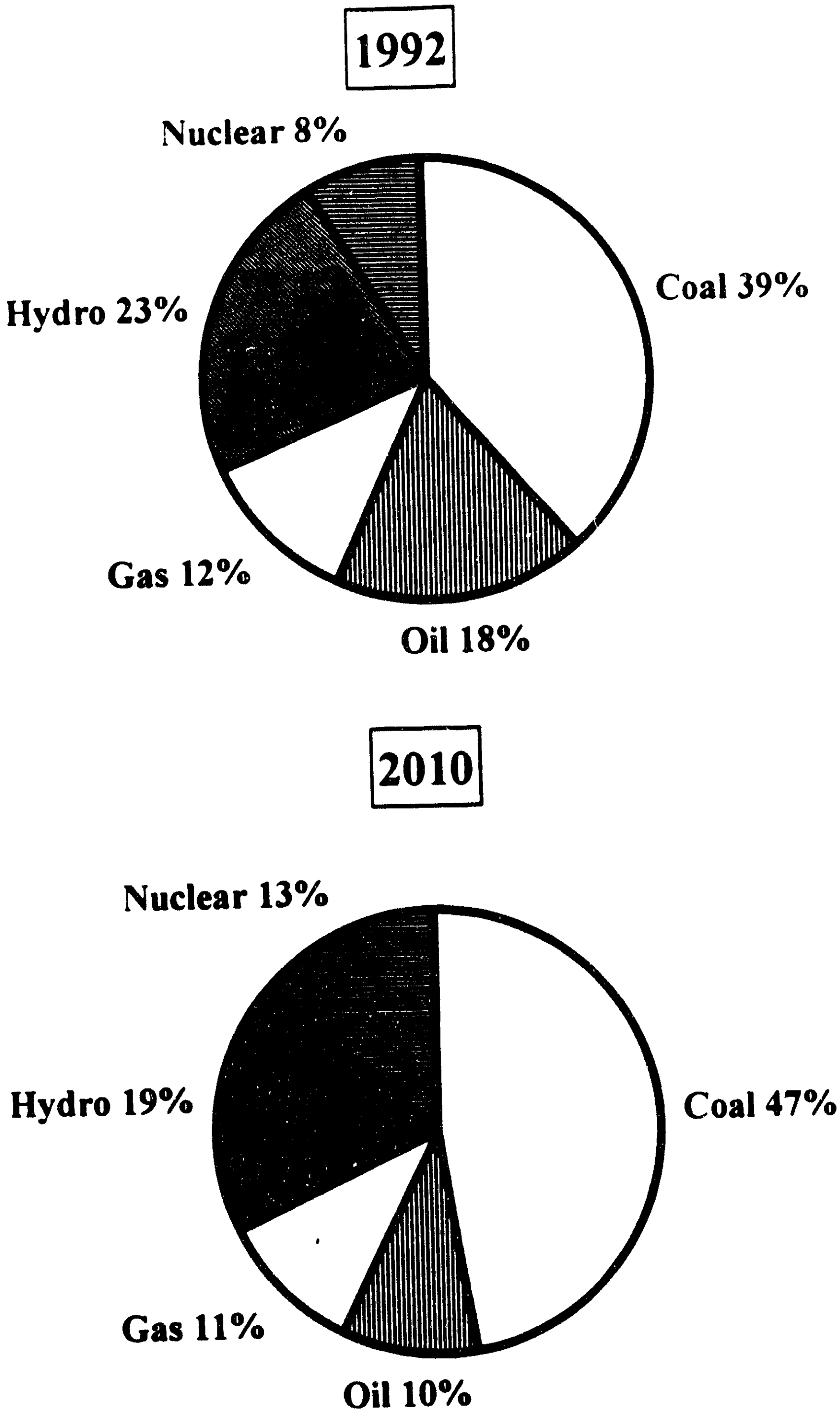

Figure 4. Distribution of generating capacity in the Asia-Pacific by energy type for 1992, and projections for 2010.

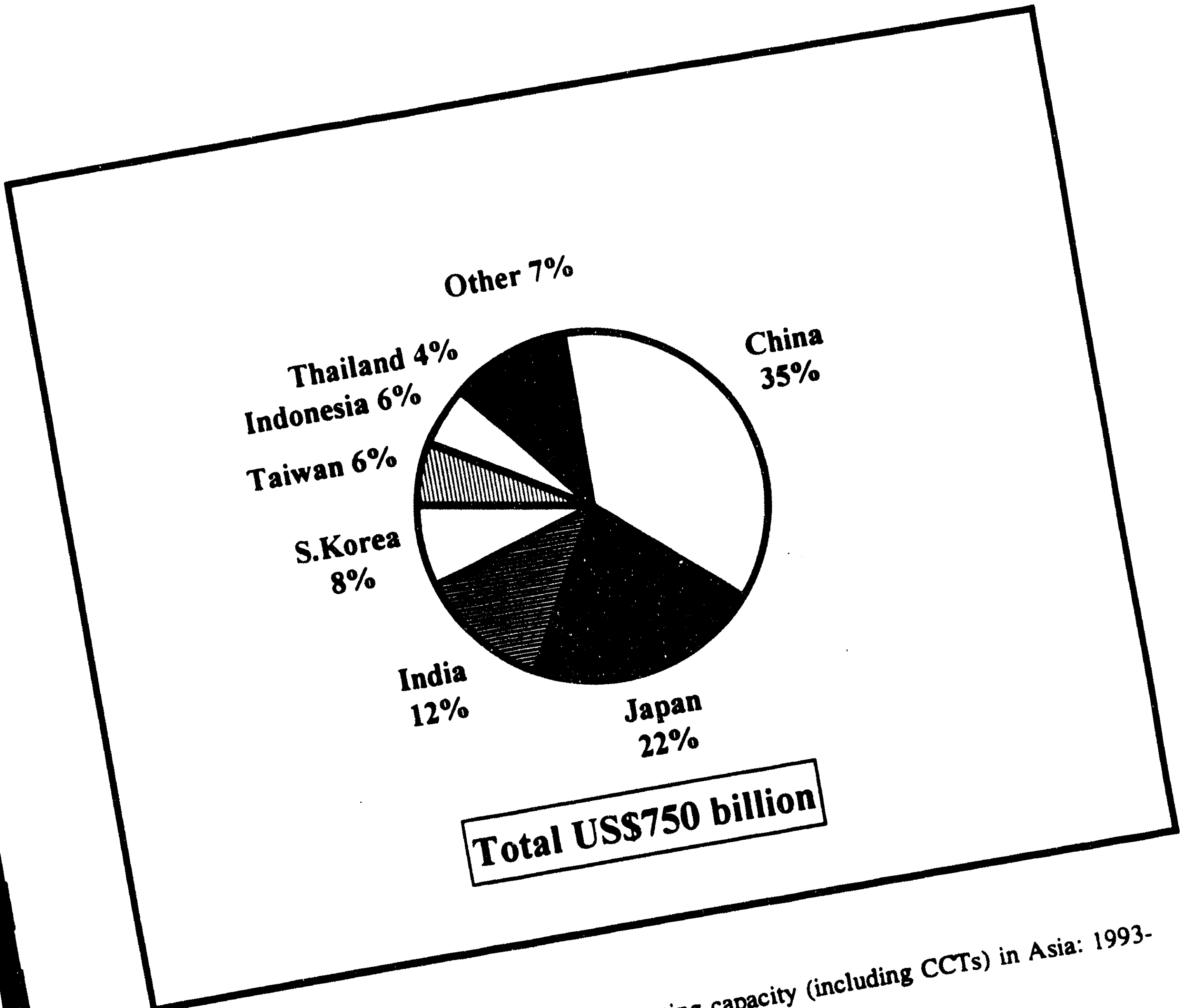

Figure 5. Investment requirements in generating capacity (including CCTs) in Asia: 1993-2010.

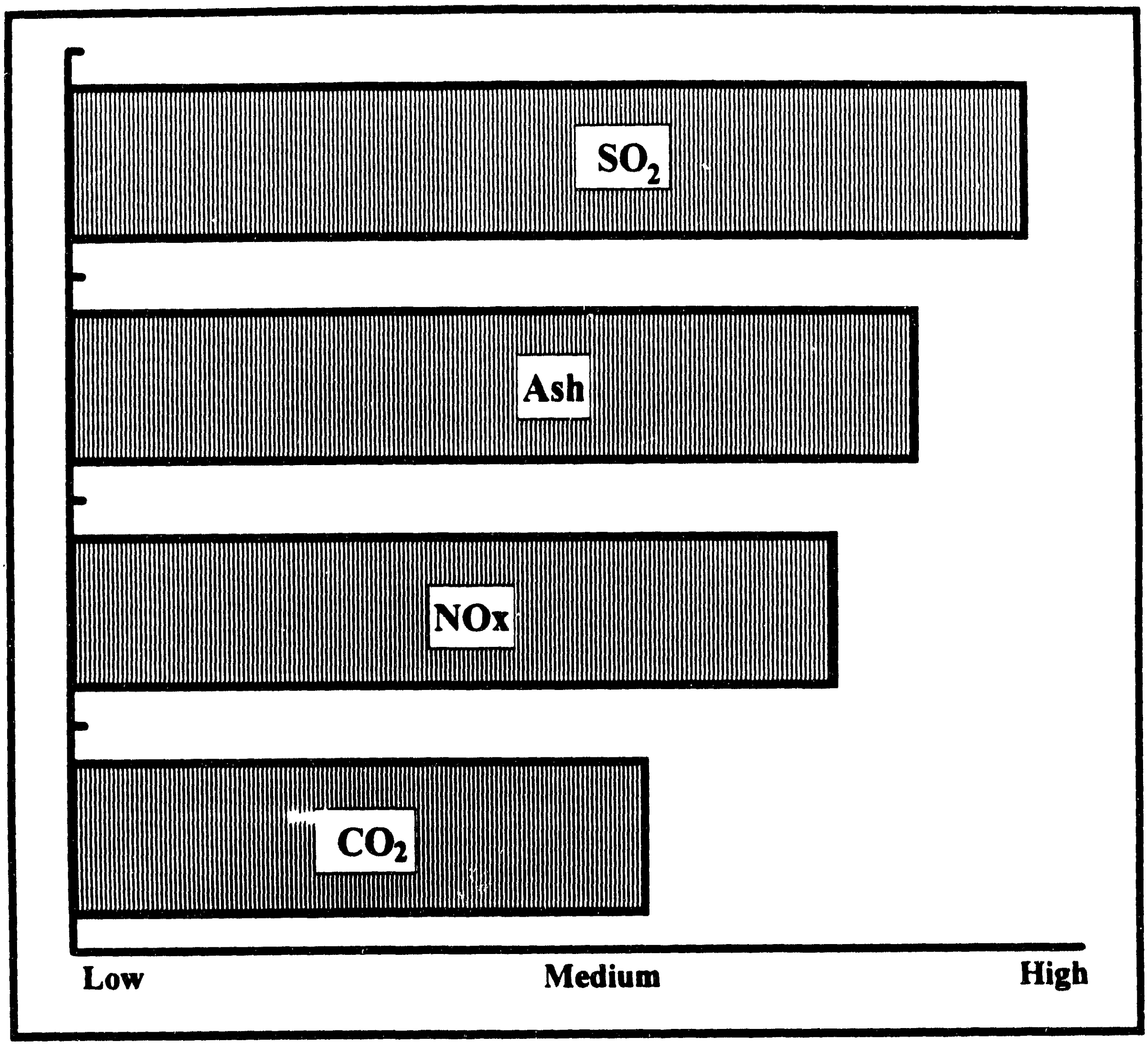

Figure 6. Emission control priority of APEC economies (weighted average of questionnaire responses).

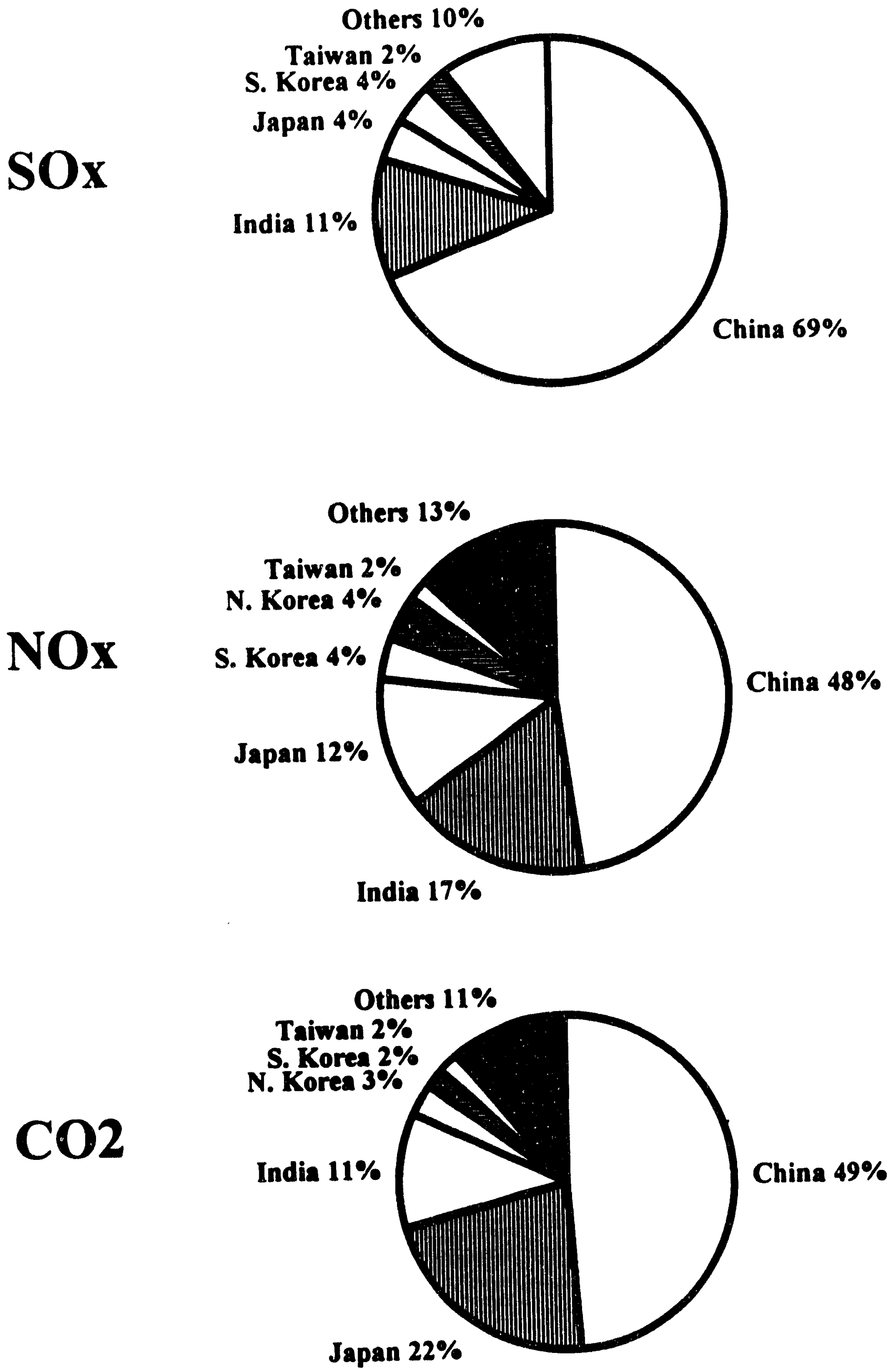

Figure 7. Asia emission shares.

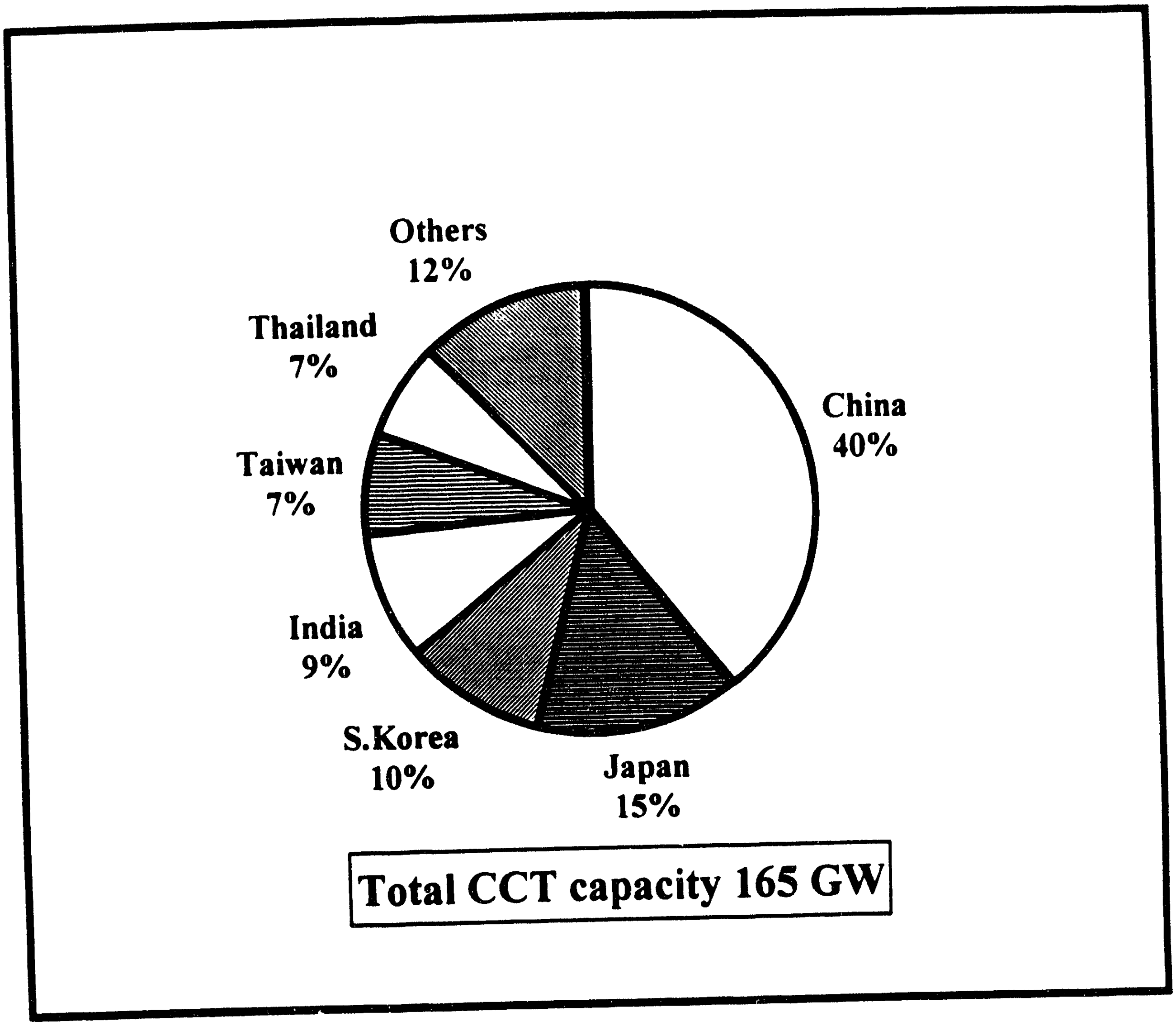

Figure 8. Estimated market for CCTs in the Asia-Pacific (1993-2010).

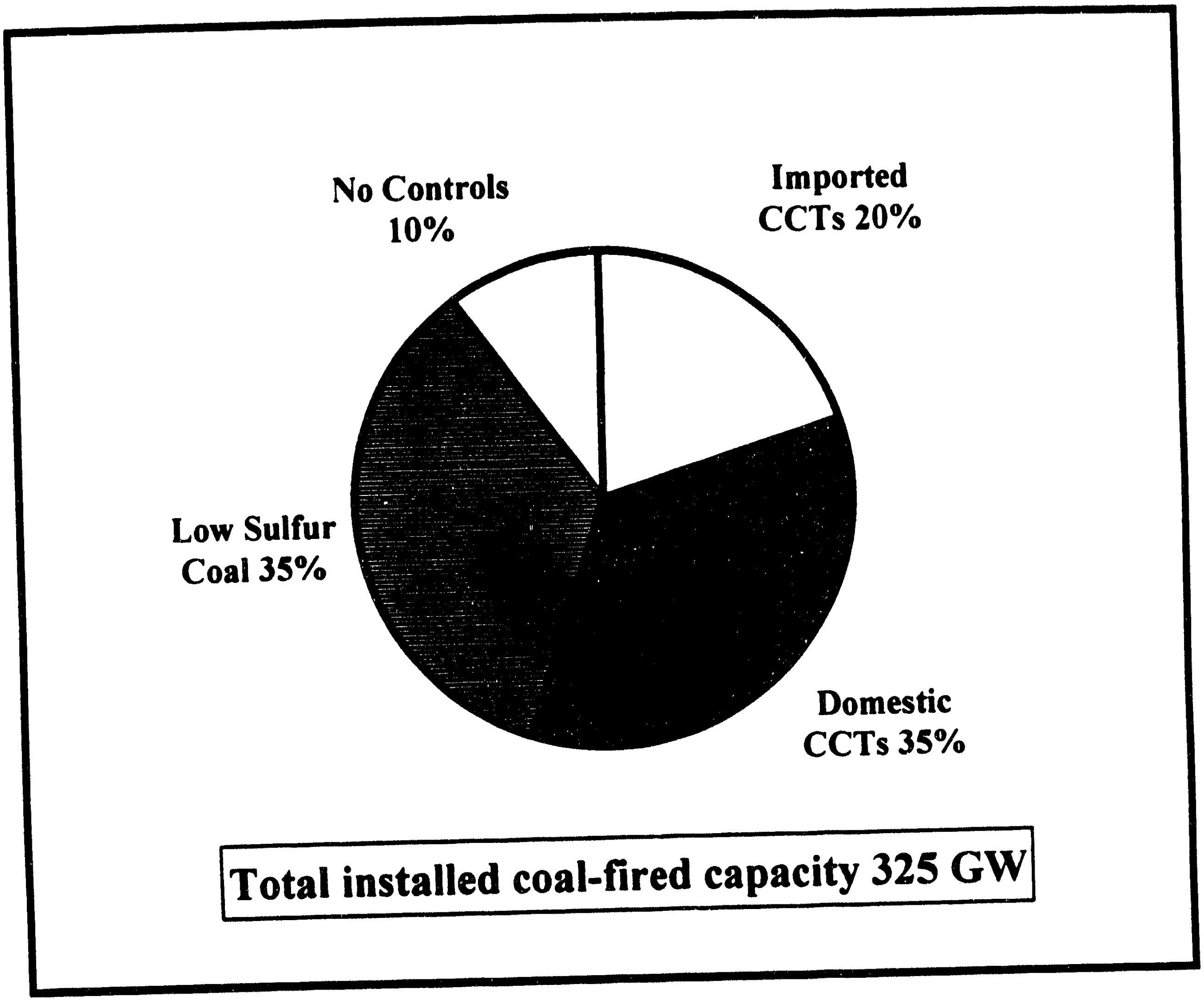

Figure 9. Estimated CCT use in China in 2010.

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Kato, N., et al., 1991, *Analysis of the Structure of Energy Consumption and the Dynamics of Emissions of Atmospheric Species Related to the Global Environmental Change (SOx, NOx &* CO_2 *in Asia).*

Asia Pacific Economic Cooperation Experts' Group on Clean Coal Technology, 1992, APEC *Clean Coal Technology Questionnaire.*

Section 2

Subtask B -- DOE Briefing Papers

BRIEFING MEMO

China's Clean Coal Technology Program and Future Market Potential[1]

To: U.S. Department of Energy, Fossil Energy Office

From: Charles J. Johnson and Binsheng Li
East-West Center's Coal Project

Introduction

China is presently a small market for Clean Coal Technologies (CCTs), even though it by far the largest source of coal related SO_2 and NO_x emissions in Asia. It is our view that China will become the largest user of CCTs in Asia after 2000.[2] The primary market for imported CCTs is projected to be for larger facilities (above 50-75 MW) in areas where reductions in sulfur emissions of over 80 percent are required.

This briefing memo provides: (1) estimates of the future growth in coal consumption and coal-fired electricity capacity, (2) estimates of coal related emissions of SO_2, NO_x and particulates, (3) estimates of the market potential for CCTs, (4) brief explanations of the roles of the key institutions involved in CCT research, and (5) a summary of the present status of CCT activities in China,

The number of institutions that claim to be active in the CCT area can lead to confusion in selecting the appropriate institutions to deal with, and can result in misleading assessments of the CCT outlook in China.

The combination of regulated low coal and electricity prices, limitations on available capital under the present state run system, and limited environmental enforcement mechanisms in China, result in a ***wide variance between stated policies to control pollution related to***

[1] Research partially supported by a grant from the Fossil Energy Office, USDOE.

[2] Refer to Appendix A for a quick reference to Chinese energy statistics and projections.

coal burning and the actual situation in China.

The structure of coal use in China is quite different from industrialized countries where the electricity sector is the dominant coal consumer. For example, 85 percent of coal use in the United States is in electricity production compared to 29 percent in China. In China, over half (53 percent) of coal goes to mostly smaller industrial users, followed by households with 18 percent.

United States CCT suppliers should give highest priority to China's electricity sector for three reasons: (1) it is more suitable for the larger scale CCTs developed in the United States; (2) the numbers of power plants is manageable (less than 150) compared to hundreds of thousands of users in the rest of the industrial sector; and (3) enforcement of environmental regulations is more likely at larger, more conspicuous power plants.

The reported capital costs of CCTs produced in China are far lower than CCTs that can be produced in the United States. A "rough" approximation of Chinese power plant technology costs is to divide U.S. power plant cost estimates in half.[3] But, the quality and reliability of Chinese power plant technologies and CCTs are substantially behind those of industrialized countries -- particularly at larger scales. Changing China's present strategy of relying on domestic CCT technologies will be difficult. ***CCT exporters will need an in-depth understanding of the Chinese power sector, and a long-term strategy to penetrate the critical 15-25 percent of the market that we believe will be available to imported CCTs.***

There appear to be major opportunities in selected provinces for BOT power plants, such as are being built by Hopewell Holdings in Guangdong Province.

Coal Production and Consumption

Coal accounts for about three-quarters of China's total energy consumption -- by far the highest share among all major coal consuming countries. Coal's share of energy is not expected to decrease below 70 percent over the 1993-2010 period. In 1992, China produced 1.1 billion metric tons (hereafter tons) of coal and exported under two percent (20

[3] Power plants built to the standards of industrialized countries are expected to have higher capital costs than reported for plants presently constructed in China.

million tons). Over the 1993-2000 period, we project coal consumption to grow at approximately 4 percent per year, reaching about 1.5 billion tons in 2000, then slowing to 1.6 (range 1.6-2.9) percent per year, reaching 1.8-2.0 billion tons in 2010. The projected slow down in growth rate in coal consumption is based on the assumption that the present pattern of inefficient coal use will shift more rapidly toward higher efficiency technologies. Our projections appear low when compared to the average annual growth rate in coal consumption of 5.5 percent over the previous 22 years.

Electricity Sector

The Chinese GNP is presently growing at over 10 percent per year, and we project an average GNP growth rate for the 1990-2000 period of 8.5 percent -- similar to recently revised Chinese government projections. Electricity consumption is conservatively projected to increase at 6.8 percent per year during the 1990-2000 period, then slow to 5.9 percent per year during the 2000-2010 period. Our estimates of future electricity and coal-capacity are based on these conservative estimates.

Even though, China is promoting expanded development of large hydroelectric projects, nuclear power and natural gas, ***coal is projected to continue to maintain approximately 70 percent of the electricity market to 2010.*** The reason that coal will continue to dominate is because the energy alternatives are limited by size, location and economics.

The share of coal consumed in the electricity sector increased from about 20 percent in 1980 to 29 percent in 1990, and is projected to increase to about 40 percent in 2000 and to at least 50 percent in 2010.

As shown in Figure 1, China presently has 160 GW of electricity capacity of which 110 GW is coal-fired. Figure 1, shows projected total electricity capacity reaching 275 GW in 2000 and 480 GW (range 440-500 GW) in 2010. Coal-fired electricity capacity is projected in Figure 1 to increase from 110 GW today, to 180 GW in 2000, and 325 GW (range 300-350 GW) in 2010.

SO_2, NOx, CO_2 and Particulate Emissions in China

There are a range of estimates of China's total emissions, however, all studies indicate that China is the largest contributor in Asia of SO_2, NOx,

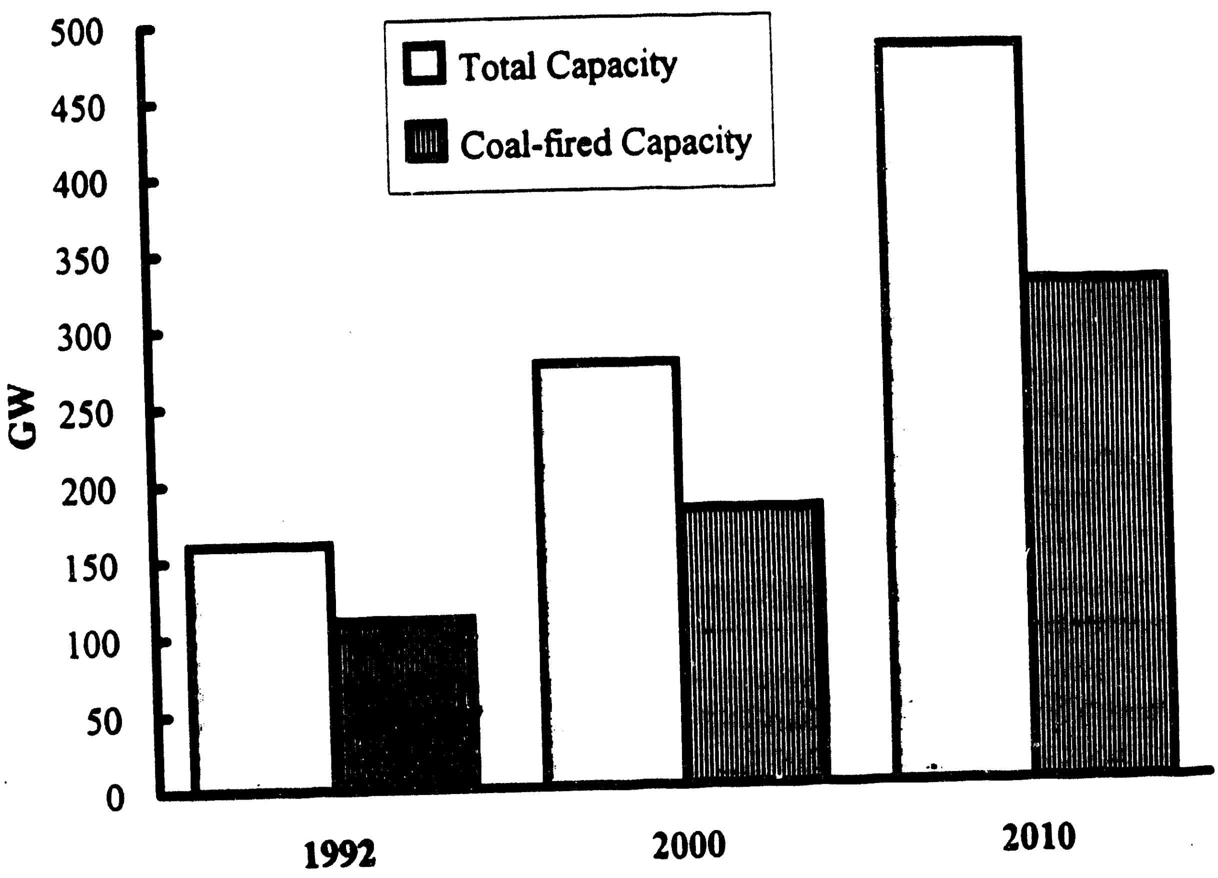

Figure 1. China's projected electricity capacity and coal-fired electricity capacity

CO_2 and particulates. Figure 2 shows China's share of Asia's total emissions of SO_2 and NOx for the period 1975-1987 with projections to 2000. At present China's share of Asia's total emissions is estimated at over 70 percent of SO_2 emissions and slightly under half of NO_x emissions. By 2000, China is projected to account for 75 percent of Asia's total SO_2 emissions. In addition, China emits about 13 million tons of particulates per year.

The focus of attention of the Chinese government has been on reducing particulate emissions and increasing energy efficiencies. During the past decade, China has made substantial gains in improving the efficiency of coal burning in power plants and in households, and in reducing particulate emissions per unit of electricity. ***During the early 1990s, increased attention is being given to the problems of reducing SOx and NOx emissions in selected areas,*** with more limited action to reduce CO_2 emissions.

The power sector contributes about half of the SO_2 emissions of the total industrial sector in China. At present, emission control technologies reportedly reduce SO_2 emissions by less than 6 percent in China's power sector. Increased attention is being given to pollution control options in major cities and industrial areas. Without effective control measures, emissions of SO_2 will increase by about 10 million tons over the next decade.

Beijing is being targeted for a major program in the 1990s to replace coal burning with natural gas (two natural gas pipelines are planned). A catalyst for China's plans to move away from coal use in Beijing is (apparently) the government's goal to attract the Olympic Games to Beijing.

Potential Clean Coal Technology Market in China 1993-2010.

No one, including Chinese experts, knows the longer term potential size and rate of introduction of CCTs into China. The estimates in Table 1 are based on discussions with Chinese experts, a review of recent research on CCTs in China, and modified by our estimates of changes expected to occur in the environmental and technology areas in China.

In preparing Table 1, we relied more heavily on the following two sources of information. A recent study by Feng Junkai (1993) of Tsinghua University in Beijing, examined 46, mostly large, power plants in China, and found that in order to meet a moderate emission control limit of 800

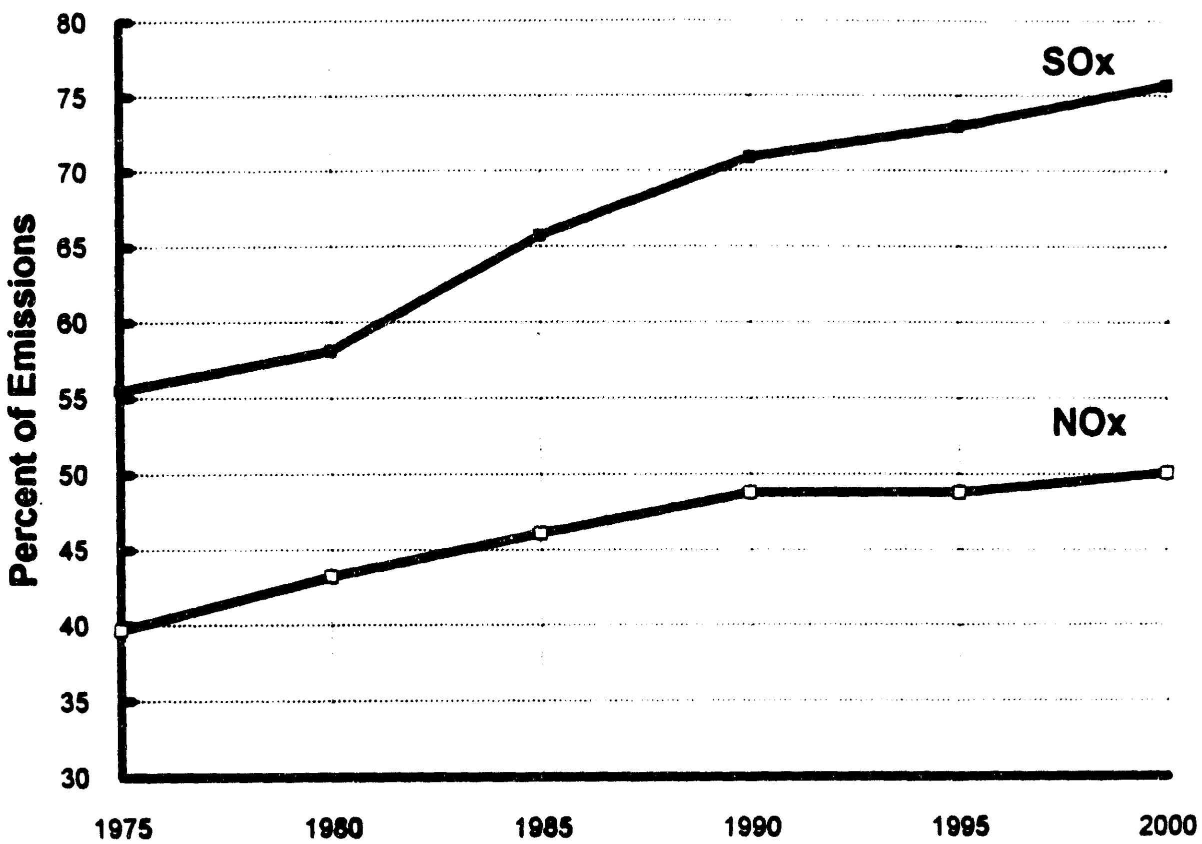

Figure 2. China's share of SOx and NOx emissions in Asia

mg/Nm³, 21 percent would need to achieve SO_2 reductions of over 80percent, 52 percent need reductions of 50-80 percent, and 26 percent would require less than 50 percent reduction. Feng's survey sample is small and may not be representative. However, recent discussions with Chinese CCT experts resulted in agreement that a reasonable assumption is that roughly 20 percent of China's coal-fired electric generating capacity plants are likely to require high performance CCTs to meet SO_2 emission goals.

Table 1

POTENTIAL CLEAN COAL TECHNOLOGY MARKET IN CHINA IN 2000 AND 2010[1]

Option	Percent SO_2 reduction	2000 GW	2000 Pct Mkt	2010 GW	2010 Pct Mkt
Imported CCTs[2]	>80	13	7	65	20
Domestic CCTs	50-80	41	23	114	35
Low sulfur coal & fuel substitution	<50	90	50	114	35
No controls	0	36	20	32	10
Total		180	100	325	100

[1]The EWC Coal Project estimates in this table are preliminary, and are only useful as a plausible scenario for the Chinese CCT market.

[2]A portion of foreign CCTs will probably be manufactured in China.

Table 1 assumes that imported CCTs will be installed in 7 percent (range: 5-10 percent) of coal-fired electricity capacity in 2000 and 20 percent (range: 15-25 percent) of capacity in 2010. Under these assumptions, China accounts for the largest growth in high performance CCTs in Asia during the 2001-2010 period.

We believe China will be able to produce the lower performance CCTs (roughly 50-80 percent SO_2 removal) at much lower costs than importing these technologies. For sulfur reductions less than 50 percent, substitution of low sulfur coal, coal washing, and other fuels are expected to be the preferred options.

The best opportunities for foreign suppliers of CCTs is expected to be the 20 percent of the facilities that are projected to need high performance CCTs (>80 percent SO_2 removal).

The seven geographic areas shown in Figure 3, account for less than 7 percent of the physical area of China, but consume between 40 and 45 percent of China's electricity. These seven areas are considered prime target areas for CCTs. An important advantage of locating power plants with CCTs within these areas is that they are also prime areas for cogeneration.

Foreign companies that can partially fabricate their CCTs in China will have an advantage in gaining market shares for both cost and policy reasons.

Status of SO_2 CCT Research in China

It is not possible to describe the full range of research because there are so many different institutions doing research on CCTs in China. The following summary specifies the more well known R & D activities on CCTs in China.

Advanced CCTs (IGCC and PFBC): Limited research is underway at very small scales on IGCC and PFBC technologies. These technologies have relatively low funding priority in China at this time. There is substantial interest in the R & D activities in the United States and other countries.

High Efficiency SO_2 Control (>80%): China appears to be leaning heavily toward dry scrubbers due to the lower capital costs. Dry limestone FGD technology has been added to the 20 MW Baima Power Plant in Sichuan Province. The FGD technology added 15 percent to the capital cost, and reportedly achieves an SO_2 reduction of 85 percent. Present plans are to scale up this technology to 200 MW by 2000. Most Chinese

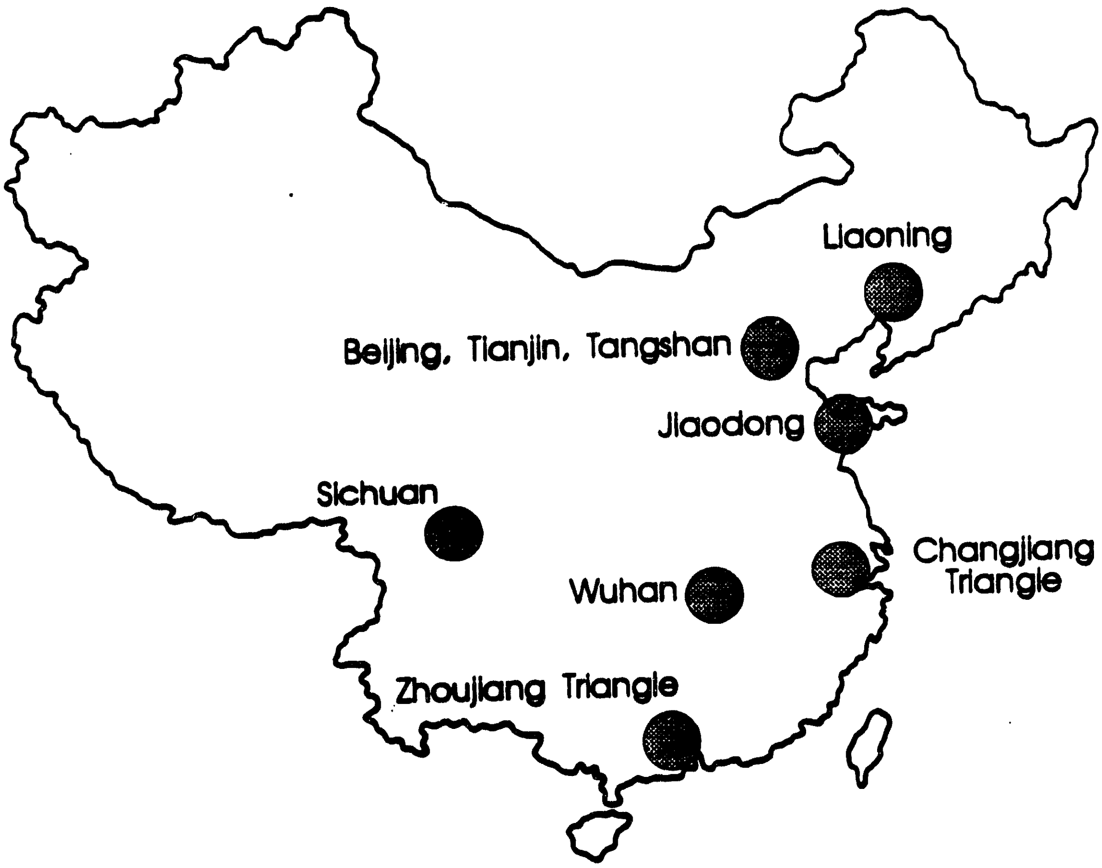

Figure 3. The seven areas which are most likely to introduce CCT's.

that we have talked to have strong reservations about wet scrubbers which are considered too expensive.

Mid-level Efficiency SO_2 Control (50-80%): Under development is a low cost, dry limestone injection system that is expected to reduce SO_2 emissions by 60-70 percent. A 125 MW demonstration plant is expected to begin operation in 1993. This project is listed as one of the ten key projects aimed at advancing China to a higher industrial level. Capital costs are estimated by the Chinese at a very low $15-20/kW. If this technology can be operated reliably at commercial scales at anywhere near the Chinese cost estimates, then the market potential within China is quite large, and might have market potential in some foreign countries.

There are over 400,000 industrial boilers in China, and the need for emission control is large. The majority of these boilers are located in industrial areas, close to population centers, and there is large potential for cogeneration facilities in the future.

The Chinese are particularly interested in FBC technologies because of three advantages: (1) they are commercial at the smaller scales common in China, (2) operate on the wide range of coal qualities common in China, and (3) can be easily modified to reduce SO_2 emissions. Currently, China has FBCs up to about 20 MW, but has ambitious plans to demonstrate FBCs of 50 MW (1995), 100 MW (1997) and 200 (MW) 2005. Without substantial foreign assistance these scale-up goals for FBCs appear optimistic.

Most of the FBCs in China are *bubbling bed* type. Chinese CCT experts report that China's priority is in developing the *circulating bed* type FBC. At present, the Chinese have only developed circulating bed technologies at small scales of less than 20 MW, and appear to need foreign assistance in scaling up to large units.

Low-Level SO_2 Control (Fuel preparation and substitution (<50%): With less than 20 percent of China's coal being washed there is a large potential to reduce ash, and moderate potential to reduce sulfur, through coal washing (beneficiation). There probably are substantial opportunities to expand production of low sulfur coals in some areas in northern China, given economic incentives (premium prices) that do not exist today.

Finally, both natural gas and hydroelectric developments are expected to receive much greater attention over the next decade. The impact on coal demand in the electricity sector is not expected to be more than a few percent by 2000. The impact after 2000 could be more significant if the massive capital investments are mobilized. China may have potential for large amounts of natural gas, which would probably be developed mostly for the non-utility sectors.

Key Government Organizations and Research Institutions

There is a complex system of organizations involved in coal and CCT activities in China. At the national level, State Commissions and Ministries have similar ranks but a different focus. State Commissions are closer to the planning functions of the national government, and coordinate ministry research activities. Ministries focus most of their attention on achieving the goals of the industries under their responsibility.

The five organizations most heavily involved with CCTs and related technologies are:

- **State Science and Technology Commission (SSTC)**
- **State Planning Commission (SPC)**
- **State Economy and Trade Office (SETO)**
- **Ministry of Energy (MOE) (Recent changes noted in text)**
- **Ministry of Machinery and Electronics Industry (MOMEI)**

The State Science and Technology Commission and the State Planning Commission are involved in long term technology planning, and manage State CCT projects, however neither Commission has research facilities. The actual R & D is conducted mostly at ministry research facilities, university laboratories and other institutions and enterprises listed at the end of this memo.

Although overlap exists, SSTC is primarily responsible for new and advanced technologies, and SPC is responsible for existing commercial technologies. In addition, the State Economy and Trade Office also supports some CCT projects that have reached the demonstration and commercialization stages.

The Ministry of Energy was established in 1988 through the merger of the Ministries of Petroleum, Coal, and the electric power portion of the Ministry of Nuclear Industry. The previous Ministry of Energy had limited interest in CCTs, and was primarily concerned with increasing energy supplies and efficiencies in electricity generation. In early 1993 the Ministry of Energy was reorganized to establish a Ministry of Electric

Power and a Ministry of Coal Industry. The Ministry of Coal Industry is basically the previously existing China National Coal Corporation, which is responsible for all links in the coal supply system, from production to utilization (excluding electricity).

The two Ministries with interests in CCTs are the Ministry of Electric Power and the Ministry of Machinery and Electronics Industry (MOMEI). MOMEI is broken down into two main subdivisions, Machinery (manufactures boilers, other utility equipment and CCTs), and Electronics.

CCT R & D can be broadly broken down into three levels:

Level 1: The highest level includes State R & D projects that focus on medium and long term technologies, and those technologies that fall between or across ministry responsibilities. State projects usually receive higher levels of funding and also tend to focus on more difficult technologies. These projects are selected, funded and regulated by the State Science and Technology Commission and the State Planning Commission.

Level 2: Ministry R & D projects tend to focus on more standard utilization technologies. There is heavy emphasis on commercial technologies.

Level 3: Local governments tend to support more limited R & D projects on simple technologies at smaller scales.

Institutions involved in R & D on Chinese CCTs

Ministry Research Institutions:

- Xian Thermal Power Engineering Research Institute (under MOE)
- Central Coal Mine Research Institute (under CNCC)
- Harbin Power Plant Equipment Research Institute (under MOMEI)
- Shanghai Electric Power Equipment research Institute (MOMEI)

University Laboratories:

- Tsinghua University (China's premier engineering university)
- Zhejiang University
- Harbin Polytechnical University
- South-East University

Other Research Institutions:

- Institute of Engineering Thermal Physics
- Academy of Science of China
- Shanxi Coal Chemistry Research Institute
- Academy of Science of China
- China Energy Research Society (an association)

Enterprises:

- Hangzhou Boiler Manufacturing Plant
- Wuxi Boiler Manufacturing Plant
- Jinan Boiler Manufacturing Plant
- Kaifeng Boiler Manufacauring Plant
- Sichuan Boiler Manufacturing PLant
- Guangzhou Boiler Manufacturing Plant
- Harbin Boiler Manufacturing Works

China

Economic Statistics

•*GNP/Capita: US$360 (1991)* •*GNP Growth Rate Per Year (1990 - 2000): 8.5 %*

•*Population (1992): 1,166 M (2010): 1,420 M*

Energy Statistics

•*Energy Mix (1991): Coal 76 %, Oil 17 %, Gas 2 %, Hydro 5 %*

•*Coal Fired Electricity Capacity (1992): 110 GW, (2000): 180 GW, (2010): 325 GW*

•*Electricity Growth Rate (1990 - 2000): 7.6 % per year, (2000 - 2010): 6.2 % per year*

	1992	*2000*	*2010*
•*Coal Production (Mt)*	*1110*	*1500*	*1920*
•*Coal Consumption (Mt)*	*1091*	*1485*	*1900*
•*Coal Exports (Mt)*	*19*	*15*	*20*

Environment & Clean Coal Technologies

•*Sulfur Emission Limits:* *Increased attention to control of emissions in major industrialized areas.*

	1993 - 2000	*1993 - 2010*
•*CCT Market Potential*[2]	*13 GW*	*65 GW*

•*Principal Organizations: Ministry of Electric Power Industry, State Science and Technology Commission (SSTC)*

Section 3

Subtask C -- Coal Advisories

The Booming Electricity Sector of China

--Its Opportunities and Challenges--

Binsheng Li and Charles J. Johnson

Program on Resources: Energy and Minerals

East-West Center

February 1, 1994

This paper was presented at the *AIC Power Generation in China* conference held in Atlanta on March 23-25th, 1994. The U.S. Department of Energy, Office of Fossil Energy provided financial support for the preparation of this report through the *Thermal Coal Requirements and Prospects for Clean Coal Technologies in the Asia-Pacific Region* grant no. DE-FG03-92SF19167.

CONTENTS

TABLES AND FIGURES

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I. INTRODUCTION

The continued high growth rate of the Chinese economy, and the large size of the market have placed China high on the investment list of most major multinational corporations. However, foreign investors have experienced mixed fortunes in the Chinese market. Uncertainties of government policies, regulations, Chinese business practices, and the accuracy of market information cause foreign investors to approach this major market with considerable trepidation.

Historically, the power sector was firmly regulated by the central government. Recent moves to deregulate this industry are opening large opportunities for foreign investors.

In this paper, the growth of the Chinese power industry is projected, the basic characteristics of this system are examined, and the investment requirements and capital availability are estimated. In addition to government investment plans, advantages and barriers to United States investors are also discussed. Profitable investments will continue to be uncertain for foreign investors that fail to fully understand the inner workings of the Chinese system, and do not take effective action to protect their interest.

II. ELECTRICITY DEMAND AND SUPPLY

As expected, the rapid economic growth in China has been accompanied by rapid electricity growth. Between 1980 and 1993, GNP growth averaged 9.4 percent per year, and total installed electricity generating capacity grew at an average of 8 percent per year. As shown in Table 1, total installed capacity increased from 66 gigawatts (GW) to about 178 GW, and total electricity generation increased from 301 billion KWh to 815 billion KWh. The elasticity of electricity to GNP was about 0.85.

Due to the uncertainties of future development, three alternative scenarios of electricity growth are developed, with the medium scenario reflecting the author's most likely projection. The three scenarios and the underlying assumptions are given in Table 2. Under the medium scenario, capacity growth is projected to average 7.7 percent in the rest of the decade and decline to 5.9 percent in the 2001-2010 period; total capacity is projected to increase from 178 GW in 1993 to 300 GW in 2000 and 530 GW in 2010.

Projection of China's Economic Growth

Electricity growth is highly correlated with GNP growth, therefore GNP growth rates are a useful predictor of electricity growth rates. Between 1991 and 1993, China's GNP growth rate averaged over 11 percent. GNP growth is projected in the medium case to average 8.5 percent per year for the 1994-2000 period, and 6.5 percent per year for the 2001-2010 period.

The driving forces behind China's high economic growth are dramatic increases in effective labor supply and effective capital stock due to the economic reforms and the shift towards a market economy. In the rest of the decade, effective labor supply is projected to increase rapidly due to: (1) the lay-off of millions of workers from over staffed state enterprises; (2) reforms of the Chinese wage systems that will lead to pay scales more closely related to employee productivity; (3) the relaxation of migration controls from rural to urban areas, that will accelerate the flow of labor to the more productive urban areas; and (4) China's personal income level is still very low, therefore high growth rates are easier to achieve. Effective capital stock will also continue to increase rapidly due to: (1) improvements in China's inefficient financial system; (2) continued increase in foreign investment;[1] and (3) a high national savings rate above 30 percent.[2]

Projection of Elasticity of Electricity

Unlike most developing economies, in the 1980s, China's average electricity growth rate was below its economic growth rate.

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[1] Between 1979 and June 1993, total actual foreign investment in China reached $50 billion, and $170 billion is planned (see People's Daily Overseas Edition 10/14/93). In 1993, foreign investment is expected to reach $100 billion (see China Daily 10/15/93).

[2] By the end of 1992, China's private bank savings reached 1.1 trillion yuan ($200 billion); private cash holdings reached 350 billion yuan ($60 billion); and total private financial assets reached 1.8 trillion yuan ($310 billion). In contrast, total private financial assets were only 38 billion yuan ($7 billion) in 1978 (see China Daily 3/22/93).

As shown in Table 3, the elasticity of electricity to GDP in the 1980s was only 0.83, the lowest among Asian economies, and also the lowest in the Chinese history (Table 4).

An important reason for the low elasticity of electricity is that electricity supplies have increased at a slower rate than demand. Some Chinese officials have estimated that electricity supply would have to increase by 20-30 percent in order to eliminate the present electricity shortages (Goldstein, 1992).

The cost of China's electricity shortages is very high. In 1993, total electricity generation was 815 TWh. Assuming the electricity shortage was 20 percent, evenly distributed among all sectors, then the electricity shortage in the industrial sector was about 140 TWh. According to Alan Burrell, manager of the Asia division (East) of the Asian Development Bank, in Asia the economic loss of each KWh of electricity demand that is not met, is about \$0.35. Assuming that the cost is half of this estimate, or \$0.175/KWh[3] then the cost of the electricity shortage in China in 1993 would be \$24.5 billion.[4] In contrast, in 1993 a total of \$6 billion was invested in China's power sector, about one-third of the cost of the shortage.

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[3] The exchange rate used in this paper is the current exchange rate (\$1=8.7 RMB) unless otherwise mentioned.

[4] Reportedly in the most serious situation in 1993, over 40 percent industrial production capacity was idle due to electricity shortage, and about 240 billion yuan (\$27.6 billion) worth of industrial value added was lost (China Times Weekly 9/19/93).

The second reason that China had a low elasticity of electricity in the 1980s was because growth in China's energy intensive heavy industry sector was slower than the less energy intensive light industry sector. Heavy industry consumes about three times as much electricity per unit of industrial output value as light industry. The share held by heavy industry decreased in the early 1980s from 56 percent to 49 percent, and returned to 53 percent in 1992. The share of heavy industry is not expected to decrease significantly over the next decade.

Third, due to low energy prices, energy efficiency was low with little incentive during the 1970s to reduce energy waste. Substantial reductions in unit energy consumption was possible from the movement toward greater energy conservation in the 1980s. However, the easy gains in reducing energy waste of the past decade are becoming more difficult in the 1990s.

For these reasons, official Chinese projection assume a higher elasticity of electricity to GNP of 1.1 for the rest of the 1990s. This elasticity is assumed in the high scenario of this paper. Under this scenario, total capacity will increase to about 345 GW in 2000 and 725 GW in 2010.

The elasticity of electricity supply to GNP could range from 0.9-1.1, with 0.9 assumed as a realistic elasticity given past performance and the higher than expected economic growth rates in the 1990s.

III. OVERVIEW OF THE CHINESE POWER SECTOR

Power Networks and Load Centers

China has five power networks, each covering 3 to 5 provinces, and 10 provincial power grids. In 1991, these 15 power networks and grids, shown in Figure 1 and Table 5, accounted for 90 percent of China's installed capacity and 95 percent of electricity generation.

Figure 1 shows the six major electricity load centers in China: (1) Liaoning province; (2) Beijing, Tianjin-Tangshan area; (3) Jiaodong area; (4) Changjiang Triangle; (5) Zhuojiang Triangle; and (6) Wuhan area. These six load centers account for about 5 percent of China's land area, 20 percent of the total population, and over 40 percent of total electricity consumption (Bi, 1992).

These load centers have limited coal and hydropower resources. About 70 percent of China's estimated coal reserves are located in a relatively small area in northern China referred to as the Coal Base (shown in Figure 2). The Coal Base includes portions of Shanxi, Ningxia, Inner Mongolia, Shaanxi, and Henan Province, with the best thermal coal reserves located in the north part of the Coal Base. Shanxi Province in the center of the Coal Base is the largest coal producing province in China. Figure 2 and Table 6 show China's hydropower resources which are mainly located in southwest China, 1000 to 2000 km away from load centers.

Figure 1 illustrates China's power development and distribution plans. Mine-mouth coal-fired power plants will be developed in east Inner Mongolia to send electricity to northeast China [1], in west Inner Mongolia to send electricity to Beijing [2], in north Shanxi Province to send electricity to Tianjin [3], in southeast Shanxi to send electricity to Shandong [4] and Jiangsu [5]. Hydropower will be developed at the Three Gorges Project to send electricity to East China [6], Central China [7], North China [8], and Sichuan Province [9]. Hydropower will also be developed in Guizhou [10], Yunnan [11], and Guangxi [12] to send electricity to Guangdong Province (Zhao, 1993).

It is uncertain whether this energy development and electricity transmission strategy will be successful as it will increasingly be influenced by economic factors and not rigid central government plans. Currently about 40 percent of the investment in the power sector comes from local sources (province and city level), and the share of local investment is projected to increase over time. Local governments of the major electricity consuming areas prefer to control their electricity supplies. Their main concern is that when electricity demand increases in the exporting provinces, exports to other provinces will be cut. Between 1980 and 1992, the share of central government (state investment and bank loans)[5] in total electricity investment decreased from about 90 percent to 30 percent, consequently central government control of the power sector has greatly decreased over the past decade.

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[5] Bank loans are controlled by the central government in China.

Installed Capacity by Fuel[6]

Table 7 shows that between 1980 and 1993, the share of coal-fired capacity increased from 51 percent to 66 percent, with decreases from 31 to 25 percent for hydro, and 18 to 8 percent for oil and gas. The share of coal and hydro capacity is projected to remain at about the same level during the 1990s. Between 2001 and 2010, coal's share of total capacity is projected to decrease gradually to about 60 percent due to the introduction of nuclear power in southeast China. It is important to note that China's large nuclear expansion plans may prove to be overly ambitious.

Thermal Power

China's thermal power plants are mainly coal-fired. According to the Chinese government, "hereafter, the fuel for thermal power stations will still be based on coal, while the existing oil burning units will be converted to coal-fired whenever possible. New oil burning power station will not be constructed in general." (Energy in China, 1992). Coal-fired capacity is projected to increase from 117 GW in 1993 to 195 GW in 2000 and 320 GW in 2010.

In 1991 the 82 large thermal power plants (600 MW and larger) shown in Table 8 accounted for about half of the total existing thermal capacity in China. Coal-fired plants accounted for more than 95 percent of the generation from large plants. All of the 19

[6] Available Chinese statistics only break total installed capacity down into hydro and thermal. Further break down of thermal capacity is only available for principal thermal power plants (600 MW and above). Coal-fired capacity is estimated through electricity generation by fuel.

GW large plants under construction are coal-fired.

Small oil, gas and diesel generators will probably be installed in the rapidly growing areas. For example in Shenzhen, the largest special economic zone in China, oil-fired power plants using imported oil have been constructed in recent years.

Natural gas is mainly consumed in the Chemical Industry in China. Power generation accounts for only about 6.6 percent of total gas consumption, but is projected to increase in the future. Table 9 shows that the share of gas in thermal electricity generation is insignificant (less than 1 percent).

Nuclear power development has progressed slowly in China, between 1982 and 1993, only two nuclear power plants were built in China, with 1.2 GW capacity in operation. The 300 MW Qingshan Nuclear Power Station in Zhejiang Province is domestically designed and constructed. The second is the imported Daya Bay Nuclear Power Station in Guangdong Province -- a joint venture with Hong Kong Light and Power.

Nuclear power development has recently gained momentum in China due to electricity shortages, continued coal transportation bottlenecks, and the Chinese desire to gain the international status associated with a nuclear power sector. China has ambitious plans to have 35 GW of nuclear power capacity installed by 2010. Table 10 shows the location, size, status and technology sources of China's plans.

Domestic nuclear technology is still in the demonstration stage, and imported nuclear power plants are very expensive. Electricity from Daya Bay will cost about 9 US cents per KWh, while residents in most cities only pay 2.5 US cents per KWh. The capital cost of Daya Bay Power Plant is about $2200/KW, and the capital cost of Yangjiang Nuclear Power Plant (an imported plant in Guangdong under planning) is estimated at $1727/kw.

Most nuclear capacity is planned for Guangdong Province, which is located far from both coal fields and hydro sites. The rapid economic growth rates of this export oriented province, and serious electricity shortages, increase the appeal of nuclear power. Although, the large planned nuclear expansions may occur, it is the author's view that coal-fired plants (using both domestic and imported coal) are a lower cost, and more realistic alternative for the majority of the power requirements of Guangdong Province. Therefore, the planned nuclear capacity shown in Table 11 is considered the maximum nuclear capacity that is likely to be installed by 2010.

By 2000, China's nuclear capacity is unlikely to exceed 7 GW. Most of the planned nuclear capacity will be installed after 2000. Total nuclear capacity in 2010 could be as high as 35 GW if China continues with its nuclear strategy. In the coastal areas of the southeast, coal-fired power plants, based on imported coal, appear competitive with nuclear power.

Hydropower

China's theoretical hydropower potential is almost 700 GW, of which the exploitable potential is estimated at about 400 GW. Currently only about 11 percent of exploitable hydropower resources are utilized, and an additional 5 percent are under construction.

Although Chinese officials would like to increase the share of hydro capacity to 30 percent in 2000, it is projected that the share of hydropower will not increase mainly because most of Chinese hydropower resources are less economic to develop than other energy alternatives (primarily coal). About half of the total investment in the power sector between 1953 and 1990 was in hydropower, yet hydropower accounts for only about one quarter of Chinese power capacity and supplies only 18 percent of the electricity. Historically the capital cost per KW of hydro capacity has averaged about 160 percent more than thermal plants. Even taking into account the potential costs of SO_2 emission controls on coal-fired plants and subtracting the costs of other benefits generated from the hydropower plants (such as irrigation and flood control), the capital cost of hydro plants is still over 100 percent higher than that of the coal-fired plants.

Figure 3 compares the total present value of costs between hydropower plants and coal-fired power plants. In China, the capital cost of coal-fired capacity (including associated power transformation and transmission equipment) is estimated at about \$400/kw; while the capital cost of hydro capacity is estimated at \$850/kw (\$700-1000), assuming the use of domestically manufactured equipment. Coal prices vary dramatically from place to place, with the highest prices ($25-35 per ton) in the eastern coastal areas.

Figure 3 shows that at a discount rate of 12 percent, coal-fired plants are cheaper than hydro plants at all coal prices, but at a lower discount rate of 8 percent most hydro plants are cheaper than coal. The typical discount rate used for Chinese power plants is 12 percent, therefore the economics of many of the planned hydro plants are questionable. Table 11 shows that as the share of central government investment decreased, the share of investment in hydro power plants decreased -- declining from 64 percent in 1981 to 42 percent in 1990.

As shown in Table 12, at the end of 1991, China had 41 hydropower stations with capacities of 250 MW and larger, with a total capacity of about 18.5 GW and an additional 16.2 GW under construction. Since large hydropower stations take about 7 years to construct, most of the new capacity to begin operation in the 1990s is already under construction. Total capacity of large hydro stations is projected to reach about 40 GW by 2000.

There was an extensive network of over 70,000 small hydropower plants (12 MW and smaller) in 1991, with a total installed capacity of 10 GW (Zhu, 1991). These small plants have played an important role in developing rural economies.

About one-third of the 2,300 Chinese counties rely on small hydropower plants to supply electricity. For many remote areas hydropower is the only alternative for electricity generation. China still has about 140 million rural people without access to electricity and small hydropower is expected to play an important role in providing electricity supplies to rural areas. It is projected that small hydro capacity will increase at about 10 percent per year in the 1990s and reach about 23 GW by 2000.

China had about 7.5 GW of medium-sized hydropower capacity (13 -249 MW) in 1991. By 2000, medium-sized capacity is projected to increase to 12 GW, and China's total hydro capacity is projected to reach 75 GW in 2000 and 140 GW in 2010. Given the high capital costs of hydro power, estimated capacity beyond 2000 is quite speculative.

Other Features of the Chinese Power Sector

Unit size

Table 13 shows that in 1991 about half of the thermal capacity was composed of units above 100 MW each, and half of the hydro capacity was above 40 MW each. The most common thermal generator sizes were 200 MW, 100 MW, and 125 MW. In 1992, the number of 600 MW units increased to six; the number of "principal units" (200 MW and above) increased to 241 (60 GW) and accounted for 36 percent of China's total capacity, compared to 24 percent in 1987.

Currently China has about 26 GW of low-efficiency coal-fired capacity, the specific coal consumption of these units is over 100 percent higher than that of the larger high-efficiency units. In the 1990s, China plans to replace 18.5 GW of the low-efficiency units with high-efficiency units.

Thermal Efficiency in Electricity Generation

Table 14 shows the trend in energy efficiency of the power industry. China's power plants (6 MW and larger) have an average efficiency of about 29 percent (419 g/KWh), up only modestly from 27.4 percent (448 g/KWh) in 1980. The overall average efficiency (including all power plants) is only 26 percent. Present efficiency is about 20-25 percent below modern power plants in other industrialized countries with efficiencies of 35-37 percent. China's goal is to increase the average efficiency to 33 percent (370 g/KWh) by 2000.

Selected other major features of the Chinese power industry are also listed in Table 14. Line (transmission) loss rates are rather stable at about 8 percent. Average annual operating hours are decreasing over time, with thermal plants averaging 5451 hours (62%) and hydro 3675 hours (42%).

IV. THE CHALLENGES OF THE CHINESE POWER INDUSTRY

Investment Requirements

Table 15 shows that China's total capital investment requirements for electricity development are conservatively estimated at about $95 billion between 1993 and 2000 (about $12 billion/year on average), and about $180 billion between 2001 and 2010 ($18 billion/year on average).

In 1993, China's total investment in the power sector was about $6 billion, about 50 percent above the 1992 level, of which only 30 percent came from the central government (Zhao, 1993). Investment in the power sector was about 6.7 percent of China's total investment in fixed assets. The power sector's share in total investment will have to increase to about 10 percent to meet the capital requirements of electricity development. If the share of the power sector investment remains the same, on average the capital available for electricity development will be about $8.3 billion/year between 1993 and 2000, about 30 percent short of investment requirement.

To close the gap between available capital and investment requirement, China plans to increase the share of foreign investment from 10 percent to 25 percent of total power sector investment requirements.

China's total foreign investment in the power sector to the end of 1992 is about $12 billion. Almost all of the foreign investment came from international financial institutions and foreign governments (Table 16). A shift to greater reliance on foreign private investment is underway in China, and will be critical to meeting the growth in demand for electricity in China.

Hong Kong firms are presently the largest investors in China's power sector followed by the US firms. Singapore, Malaysia and Thailand are also involved as shown in Table 17. As most private sector investments in China's power sector are still in the discussion/negotiation stages, the actual mix of foreign investment could be quite different from present expectations.

Electricity Tariffs

Before 1985, electricity tariffs were under strict government control, and were basically fixed. Increasing fuel prices appear to have been an important factor in the rapid decrease in profitability of the power industry in the 1980s. Between 1980 and 1991, profits decreased almost 40 percent (CESY, 1991). The profit rate of the power industry is now under 3.7 percent (Shi, 1993).

Since 1985, China has followed the following multi-rate system: (1) central government financed power plants, with "in-plan" coal supplies, sold their electricity at state fixed tariffs; (2) power plants purchasing high priced fuels were allowed to sell electricity at prices substantially above state fixed tariffs; and (3) some power plants simply charged a processing fee to convert fuels to electricity for their customers, and the customers were responsible for the fuel supplies. Currently a significant and increasing proportion of electricity is sold substantially above state fixed tariffs.

Most old power plants are able to make modest profits because of low capital charges due to state subsidies and/or low interest rates. However, under fixed electricity tariffs, new power plants are unable to cover their costs. Figure 4 shows the minimum electricity prices power plants have to receive under alternative coal prices to achieve 12 percent IRR. In most situations, the state fixed electricity prices are substantially below the minimum prices in Figure 4. Average state fixed electricity price is only about 2.5 US cents/KWh, the lowest in Asia (Table 18), and too low to achieve a 12 percent IRR under the full range of coal prices.

In order to attract foreign investors and local investors, a new tariff system called "old electricity-old price, and new electricity-new price" has been adopted in China. Tariff reforms have been introduced in Shenzhen, Guangdong Province. In Shenzhen, electricity tariffs are based on total costs plus 15 percent "social average profit rate," which results in an average tariff of about 6 US cents/KWh.

Currently, except for the central government invested power plants, other new power plants are allowed to sell at the prices which are able to cover costs, taxes, and "reasonable" profits. The definition of reasonable, however, is still vaguely defined.

In May, 1993, to protect the profitability of its over $1 billion investment in the power industry in Shandong Province, Hopewell Holdings of Hong Kong proposed to the Shandong provincial government that a 13 percent rate of return on equity should be guaranteed. The State Council in Beijing approved the application from the Shandong government for the higher rate, and a number of other provinces (including Sichuan, Hubei, Guangxi, Inner Mongolia, and Yunnan) have recently offered foreign investors a guaranteed rate of return on equity of 15 percent (China Times Weekly 9/19/93).

Foreign investors in Chinese power plants must establish electricity prices through negotiations. In price negotiations, the Chinese parties use the 15 percent rate of return on the foreign equity as the maximum return allowed by the Ministry of

Foreign Trade and Economic Cooperation (MOFTEC). However, the 15 percent ceiling is subject to negotiations. The 15 percent return is based on the assumption that annual operating hours will be 5500 hours (a plant load factor of 63%) -- typical of Chinese coal-fired plants. Foreign developers are accustomed to operating coal-fired plants at 7,000-7,500 hours (plant load factor of 80-86%) per year (Weber, 1993). If prices are set based on 5500 hours of operation to achieve the 15 percent return, then a much higher return can be achieved at the high operating rates of 7000-7500 hours.

For domestic investors, the State Council has agreed to increase electricity tariffs so that power plants will have the ability to repay their loans. A formula is now used to adjust electricity tariffs annually based on changes in fuel and transportation costs (Huang, 1993).

Environmental Problems and Clean Coal Technology Development

China's share of total emissions of SO_2, NOx and CO_2 is already the largest in Asia, and is growing at least twice the rate of other Asian economies. According to a 1991 Japanese study (Kato et al, 1991), between 1975 and 1987, the average annual growth rates of SOx, NOx, and CO_2 emissions in China were 5.8, 5.8, and 5.4 percent respectively, while the growth rates in emissions for the rest of Asia were only 1.0, 3.0, and 2.6 percent respectively. As shown in Figure 5, during the 1975-1992 period, the share of China's emissions in Asia increased as follows: SOx from 55 to 73 percent; NOx from 40 to 51 percent; and CO_2 from 41 to 52 percent.

The power sector is the fastest growing source of SO_2 emissions in China. In 1991, only 5.5 percent of total SO_2 emissions in the power sector were removed. Total emissions of SO_2 in the power sector was 5.28 Mt (million metric tons), and accounted for over 45 percent of total industrial SO_2 emissions. If China remains at the current SO_2 control level, SO_2 emissions from the power sector will almost double by 2000.

The rapid growth of SO_2 emissions is of increasing concern in the Chinese government. Emission Standards for coal-fired power plants were implemented in August, 1992. The National Environmental Protection Agency plans to issue tighter emission standards in 5 years (CEY, 1992). The primary problem is the difficulty in enforcing these standards.

Coal consumed in the power sector has an average sulfur content of 1.2 percent, however, sulfur contents vary widely from region to region. A 1991 survey of 46 coal-fired power plants with capacities from 125 to 1350 MW indicated that if SO_2 emission standards of a maximum of 600 ppm were enforced, all power plants in the survey sample would need to install desulfurization equipment (Feng and Yuan, 1991). If SO_2 emission standards of 800 ppm were enforced, about 90 percent of the power plants would need Clean Coal Technologies (CCTs), and about 20 percent of the power plants would require advanced CCTs which can reduce sulfur emission by over 80 percent.

To meet the increased demand on sulfur control technologies, China is actively working on a range of domestic CCTs, however, commercial scale introduction of CCTs is not envisioned for the power sector in the foreseeable future, and domestic CCTs are less than 25 MW.

China is struggling with the twin goals of how to reduce environmental pollution to acceptable levels and supply sufficient electricity to support rapid economic growth. To date, priority has been given to increasing electricity supply at the expense of environmental considerations. Although, technically foreign CCTs appear to be a viable option to achieve China's twin goals, the Chinese are resistant to investment in foreign CCTs which add 30-40 percent to the capital costs of domestically built power plants. However, the largest market for CCTs in Asia potentially exists in China. The key factors affecting the introduction of CCTs will be the enforcement of tighter environmental legislation, and joint ventures that allow for fabrication of most elements of CCTs in China which will reduce total costs.

A recent estimate by the authors in conjunction with collaborative discussions with Liu Deshun of Tsinghua University and Chen Shuoyi of the State Science and Technology Commission indicated the following plausible mix of CCTs in 2010: 13 GW of foreign CCTs and 52 GW of domestically produced CCTs.

V. THE OPPORTUNITIES AND BARRIERS OF THE UNITED STATES INVESTORS

Advantages to United States Investors

Due to insufficient domestic capital investments and the lack of efficient technologies, foreign investors are being actively solicited by the Chinese. So far Hong Kong companies are the most active investors in China's power sector. In terms of power plant technologies, there are a number of countries with advanced competitive technologies, and U.S. investors do not have a clear competitive edge in China. The U.S. is expected to be among the top three suppliers of power plant technologies to China. With respect to CCTs, U.S. companies appear to have a clear technical edge, but this advantage has yet to become apparent in the Chinese market place.

The power industry is generally risk averse in terms of technologies, and utilities are reluctant to bear the risk of technology development. Commercialization of new technologies in the power industry usually requires heavy government subsidies, which are unavailable in China. The decentralization of the overall Chinese system makes such subsidies increasingly difficult to obtain.

Unfortunately, due to limited capital availability, environment control is still a low priority in China, and demand for expensive CCTs is limited. However, in two areas, U.S. investors appear to have opportunities. The near term opportunity is the Circulating Fluidized Bed Combustion (CFBC) technology (particularly for co-generation), and in the longer term (after 2005), Integrated Gasification Combined Cycle (IGCC). China is presently unable to build the Circulating FBCs used in the United States. This technology is quite suitable for the typical power plant scales in China and variable qualities of coals being used.

China's total coal demand is projected to reach at least 1,500 Mt by the year of 2000, but domestic coal supply, based on current development plans, is unlikely to meet this demand. Coal shortages and imports are projected in the south-east coastal regions, and will result in export opportunities for other coal exporting countries in the Asian region.

China has over 400,000 industrial boilers which consume about 330 Mt of coal per year. The average efficiency is about 50 percent, compared to the potential of 65-70 percent. In addition, these boilers are major sources of air pollution. This size of the market for industrial boilers is large, however, with a large domestic industry, the share open to imports appears limited.

Although residential coal consumption only accounts for 16 percent of coal consumption, the largest share of coal related pollution in cities appears to come from home heating and small industrial boilers. Again, due to a large domestic industry, there appear to be limited opportunities for imported technologies.

The large demand of electricity and steam makes co-generation a very attractive option in China. Co-generation could provide both electricity and steam and raise overall energy efficiencies above 70 percent. Steam demand is mostly located in cities and industrial centers with high population densities, therefore emission controls are very important. Circulating FBC plants appear to have considerable promise in this area.

Barriers to United States Investors

The Risk of Devaluation of the Chinese Currency (RMB)

The most obvious risk to foreign investors is continued devaluation of the RMB. Since electricity generated in China will mainly be consumed by domestic consumers, most of the revenues generated from electricity sales are likely to be RMB. The two principal risks in this area are exchange rate risk and convertibility risk. The exchange rate risk can be handled by agreeing to a formula to correct for the relative devaluation of the RMB against the designated foreign currency. However, the Chinese may ask for a similar clause to correct for the possibility of appreciation of the RMB, which as previously discussed may occur.

With respect to the convertibility risk, the simplest solution is for the Chinese side to pay a pre-determined portion of the electricity revenue in hard currency. This approach has been utilized in (foreign exchange-rich) coastal province. In addition, in selected cases, utilities are beginning to charge some retail customers in hard currency. However, it is likely that most RMB will have to be converted to hard currencies in the swap market.

Compared to U.S. investors who focus on a few sectors, including the power sector, Hong Kong and other overseas Chinese investors have much broader business involvements in China, and can more readily use RMB profits within China. In the long term, the most successful equipment suppliers to the Chinese power sector is expected to be those foreign companies that develop power plant and

CCT manufacturing facilities in China through joint ventures with reputable Chinese companies.

In January 1994, China eliminated the official exchange rate, which at 5.7 yuan to the U.S. dollar was far from the black market (real) exchange rate of 8.5-9.0 yuan to the U.S. dollar. The current exchange rate of about 8.7 yuan to the U.S. dollar reflects the open market exchange rate. Currently, demand for the dollar is high due to: (1) speculative holding of dollars in expectation of high inflation rates and devaluation of the RMB ; and (2) high demand for imported goods. Under the assumption that reasonable economic and political stability is maintained in China, the outlook over the next few years is for only modest devaluation of the RMB, and toward the end of the 1990s, the RMB might appreciate against the U.S. dollar.

Competition From Low Cost Domestic Power Plants

The capital cost of China's domestically produced coal-fired power plants is presently about $400/kw, more than 50 percent below the capital costs of power plants from industrialized countries. Even assuming that the price of Chinese power plant technologies increases with the development of more advanced technologies, costs will still be far below imports. The long-term markets for technology exports to China will be for the most sophisticated technology and control elements for power plants that cannot be manufactured at the right scale and volume in China.

VI. CONCLUSION

The rapid economic growth in China is supported by fundamental economic factors that are expected to continue through at least the 1990s. High economic growth will lead to continued rapid growth in the power industry. The decreased share of state investment in the power sector will result in a shortage of available capital (a minimum of 30 percent) in the power industry during the rest of the 1990s. To close this gap, the electricity tariff system is being modified to improve power plant profitability and attract more investment from foreign and local investors.

Coal-fired plants will continue to dominate expansions in power generation. Coal-fired capacity is projected to increase from 117 GW in 1993 to 195 GW in 2000 and 320 GW in 2010. Coal related environmental pollution is very serious in China, and China is projected to become Asia's leading user of domestic and imported CCTs by 2010. The present U.S. technology edge in CCTs should result in substantial export opportunities to China, mostly after 2000.

The risk in exchange rates and hard currency repatriation is a barrier to foreign investors in China's power industry. However, it is likely that the rapid devaluation of the past is over, and a strengthening of the RMB may occur in the late 1990s.

Table 1. Installed Electricity Generating Capacity, Electricity Generation and Energy Mix in China: 1980-1993

	Installed Capacity				Elactricity Generation				GNP
	Total (GW)	Hydro (%)	Thermal (%)	Coal (%)	Total (TWh)	Hydro (%)	Thermal (%)	Coal (%)	Growth Index
1980	66	31	69	51	301	19	81	59	100
1981	69	32	68	51	309	21	79	59	105
1982	72	32	68	52	328	23	77	59	114
1983	76	32	68	54	351	25	75	59	125
1984	80	32	68	55	377	23	77	63	150
1985	87	30	70	58	411	23	78	65	162
1986	94	29	71	61	450	21	79	69	176
1987	103	29	71	62	497	20	80	70	194
1988	115	28	72	63	545	20	80	70	218
1989	127	27	73	64	585	20	80	70	224
1990	138	26	74	66	621	20	80	71	236
1991	151	25	75	66	678	18	82	72	253
1992	165	25	75	66	742	18	82	72	285
1993	178	25	75	66	815	18	82	72	322
Growth 80-93	8.0				8.0				9.4

Source: Electric Power Industry in China, 1991, 1992; Energy in China, 1992, and People's Daily Overseas Edition.

Table 2. Projections of Electricity Generating Capacity and Electricity Generation in China: 1994-2010

Year	Installed Capacity (GW)			Electricity Generation (TWh)		
	High	Medium	Low	High	Medium	Low
1992	**165**	**165**	**165**	**742**	**742**	**742**
1993	**178**	**178**	**178**	**815**	**815**	**815**
1994	196	192	188	890	876	865
1995	215	207	199	971	941	919
1996	237	223	210	1060	1012	975
1997	260	240	222	1157	1088	1036
1998	286	258	234	1263	1169	1099
1999	314	278	247	1379	1256	1167
2000	**345**	**300**	**261**	**1506**	**1350**	**1239**
2001	372	317	273	1611	1427	1294
2002	401	336	285	1724	1509	1351
2003	432	356	298	1845	1594	1411
2004	465	377	312	1974	1685	1473
2005	501	399	326	2112	1781	1538
2006	539	422	340	2260	1883	1606
2007	581	447	356	2418	1990	1677
2008	625	473	372	2587	2103	1752
2009	673	501	388	2768	2223	1829
2010	**725**	**530**	**406**	**2962**	**2350**	**1910**

Source: EWC Coal Project, 1994.

Assumptions

	High		Medium		Low	
	1994-2000	2001-2010	1994-2000	2001-2010	1994-2000	2001-2010
GNP Growth	9.0%	7.0%	8.5%	6.5%	7.0%	5.0%
Elasticity	1.1	1.1	0.9	0.9	0.8	0.8
Capacity Growth	9.9%	7.7%	7.7%	5.9%	5.6%	4.5%
Generation Growth	9.2%	7.0%	7.5%	5.7%	6.2%	4.4%

Table 3. Electricity Elasticity in Asia-Pacific Economies: 1980-1990

	GDP Growth Rate (percent)	Electricity Growth Rate (percent)	Electricity Elasticity
China	9.2	7.5	0.82
Japan	4.2	4.0	0.95
Taiwan	7.7	8.1	1.05
S.Korea	8.3	11.5	1.39
Hong Kong	7.0	8.6	1.23
Thailand	7.6	11.8	1.55
Australia	3.1	4.9	1.58
Malaysia	6.2	9.3	1.50
India	5.8	9.1	1.57
New Zealand	1.9	3.2	1.68
Indonesia	6.0	12.0	2.00
Philippines	1.9	3.9	2.05

Source: Coal Information 1992, International Financial Statistics, and UN Energy Statistics Yearbooks, 1983-1990.

Table 4. Electricity Elasticity in China

	Economic Growth Rate* (percent)	Electricity Growth Rate (percent)	Electricity Elasticity
1952--1970	6.2	16.6	2.68
1971--1980	5.8	10.0	1.73
1981--1990	9.0	7.5	0.84
1991--1993	10.9	9.5	0.87

Note: National income growth rates before 1980 and GNP growth rates after 1980.

Source: China Statistical Yearbook, 1992; Energy in China ,1992; People's Daily (Overseas Edition) 9/25/93.

Table 5. Electricity Capacity and Generation of 15 Networks (in 1991)

		Installed capacity			Electricity Generation			Load
		Total	Share of Hydro		Total	Share of Hydro		Factors
		(MW)	China	(%)	(TWh)	China	(%)	(%)
Northeast Power Network	NEPN	23013	15	17	103	15	11	86
North China Power Network	NCPN	18836	12	5	97	14	1	90
East China Power Network	ECPN	23757	16	11	119	18	6	90
Central China Power Network	CCPN	22004	15	37	102	15	34	91
Northwest Power Network	NWPN	9406	6	47	46	7	34	83
Shandong Provincial Grid	SDPG	9064	6	1	49	7	0	87
Fujian Provincial Grid	FJPG	3238	2	49	14	2	35	83
Guangdong Provincial Grid	GDPG	8937	6	24	38	6	13	86
Guangxi Provincial Grid	GXPG	2747	2	52	12	2	44	84
Sichuan Provincial Grid	SCPG	7006	5	32	32	5	32	85
Yunnan Provincial Grid	YNPG	2936	2	57	12	2	61	82
Guizhou Provincial Grid	GZPG	2198	1	42	10	2	32	87
Hainan Provincial Grid	HNPG	626	0	30	1	0	39	
Xinjiang Autonomous Region	XJAR	2142	1	24	8	1	19	
Xizang Autonomous Region	XZAR	167	0	73	0	0	74	
Total of 15 Networks		136074	90	23	643	95	17	88

Source: Electric Power Industry in China, 1992.

Table 6. Distribution of Exploitable Hydropower Resources

		Capacity (MW)	Share of China	Generation (TWh)	Share of China	Annual Operating Hours
Northeast Power Network	NEPN	12045	3.1	38.4	2.0	3187
Liaoning		1633	0.4	5.6	0.3	3419
Jilin		4379	1.1	11.0	0.6	2502
Helongjiang		6032	1.6	21.9	1.1	3623
North China Power Network	NCPN	6920	1.8	23.2	1.2	3356
Beijing, Tianjin, Hebei		1837	0.5	4.2	0.2	2274
Shanxi		2640	0.7	10.7	0.6	4053
Inner Mongolia		2443	0.6	8.4	0.4	3418
East China Power Network	ECPN	5634	1.5	17.5	0.9	3103
Shanghai, Jiangsu		98	0.0	0.3	0.0	3179
Zhejiang		4655	1.2	14.6	0.8	3128
Anhui		882	0.2	2.6	0.1	2960
Central China Power Network	CCPN	60971	15.7	228.5	11.9	3748
Henan		2929	0.8	11.2	0.6	3811
Hubei		33095	**8.5**	149.4	**7.8**	4514
Hunan		19838	**5.1**	48.9	**2.5**	2464
Jiangxi		5109	1.3	19.1	1.0	3730
Northwest Power Network	NWPN	33403	8.6	144.5	7.5	4327
Shaanxi		5507	1.4	21.7	1.1	3941
Gansu		9110	2.4	42.4	2.2	4659
Qinghai		17991	4.6	77.2	**4.0**	4292
Ningxia		795	0.2	3.2	0.2	3977
Shandong Provincial Grid	SDPG	108	0.0	0.2	0.0	2200
Fujian Provincial Grid	FJPG	7051	1.8	32.0	1.7	4541
Guangdong Provincial Grid	GDPG	6390	1.6	24.0	1.2	3753
Guangxi Provincial Grid	GXPG	14183	3.7	63.9	3.3	4509
Sichuan Provincial Grid	SCPG	91665	**23.7**	512.3	**26.7**	5589
Yunnan Provincial Grid	YNPG	71168	**18.4**	394.5	**20.5**	5543
Guizhou Provincial Grid	GZPG	12918	3.3	65.2	3.4	5051
Xinjiang Autonomous Region	XJAR	8535	2.2	46.0	2.4	5387
Xizang Autonomous Region	XZAR	56593	**14.6**	330.0	**17.2**	5832
Total		387582	100.0	1920	100.0	4955

Source: Electric Power Industry in China, 1992.

Table 7. Installed Power Capacity by Fuel

	1980		1993		2000		2010	
	GW	Share	GW	Share	GW	Share	GW	Share
Total	66	100	178	100	300	100	530	100
Coal	34	51	117	66	195	65	320	60
Hydro	20	31	45	25	75	25	140	26
Oil & Gas	12	18	14	8	20	7	30	6
Nuclear	0	0	1	1	7	2	35	7
Other	0	0	1	1	3	1	5	1

Source: Energy in China, 1992; Electric Power Industry in China 1991-1992; People's Daily Overseas Edition, and EWC Coal Project estimates.

Table 8. Principal Thermal Power Plants (600MW and above) as of end 1991

NO.	Name	Location	Network	Capacity (MW) Design	Existing	Fuel
Total				74317	55307	
1	Qinghe	Liaoning	NEPN	1300	1300	coal, oil
2	Jinzhou	Liaoning	NEPN	1200	1200	coal
3	Liaoning	Liaoning	NEPN	1050	1050	coal, oil
4	Dalian	Liaoning	NEPN	700	700	coal
5	Tieling	Liaoning	NEPN	1200	0	coal
6	Changshan	Jilin	NEPN	693	693	coal
7	Jilin	Jilin	NEPN	850	850	coal, oil
8	Fularji No.3	Heilongjiang	NEPN	1200	1200	coal
9	Mudanjiang	Heilongjiang	NEPN	820	820	coal
10	Shuangyashan	Heilongjiang	NEPN	820	610	coal
11	Harbin No.3	Heilongjiang	NEPN	1600	400	coal
12	Daqing	Heilongjiang	NEPN	600	200	coal
13	Yuanbaoshan	Inner Mongolia	NCPN	900	900	coal
14	Tongliao	Inner Mongolia	NCPN	1200	800	coal
15	Fengzhen	Inner Mongolia	NCPN	600	400	coal
16	Gaojing	Beijing	NCPN	600	600	coal
17	Shijingshan	Beijing	NCPN	600	600	coal
18	Dagang No.1	Tianjin	NCPN	640	640	oil
19	Dagang No.2	Tianjin	NCPN	640	640	coal
20	Junliangcheng	Tianjin	NCPN	840	640	coal,oil
21	Douhe	Hebei	NCPN	1550	1550	coal
22	Xingtai	Hebei	NCPN	1290	1090	coal
23	Matou	Hebei	NCPN	850	850	coal
24	Shang'an	Hebei	NCPN	700	700	coal
25	Shalingzi	Hebei	NCPN	1200	300	coal
26	Xibaipo	Hebei	NCPN	1200	0	coal
27	Shentou	Shanxi	NCPN	1300	1300	coal
28	Shentou No.2	Shanxi	NCPN	1000	0	coal
29	Datong No.2	Shanxi	NCPN	1200	1200	coal
30	Zhangze	Shanxi	NCPN	1040	1040	coal
31	Shidongko	Shanghai	ECPN	1200	1200	coal
32	Shidongko No.2	Shanghai	ECPN	1200	0	coal
33	Wujing	Shanghai	ECPN	950	750	coal
34	Minhang	Shanghai	ECPN	818	818	coal
35	Baoshan	Shanghai	ECPN	700	700	coal,BFG
36	Jianbi	Jiangsu	ECPN	1625	1625	coal
37	Xuzhou	Jiangsu	ECPN	1300	1300	coal
38	Wangting	Jiangsu	ECPN	1100	1100	coal,oil
39	Nantong	Jiangsu	ECPN	700	700	coal
40	Ligang	Jiangsu	ECPN	700	0	coal
41	Nanjing	Jiangsu	ECPN	600	0	coal
42	Changshu	Jiangsu	ECPN	1200	0	coal
43	Beilungang	Zhejiang	ECPN	1200	0	coal
44	Zhenhai	Zhejiang	ECPN	1050	1050	coal, oil
45	Taizhou	Zhejiang	ECPN	750	750	coal
46	Pingwei	Anhui	ECPN	1200	600	coal

Table 8. Principal Thermal Power Plants (Continue)

NO.	Name	Location	Network	Capacity (MW) Design	Existing	Fuel
47	Huaibei	Anhui	ECPN	950	750	coal
48	Huainan	Anhui	ECPN	600	600	coal
49	Luohe	Anhui	ECPN	600	600	coal
50	Fuzhou	Fujian	FJPG	700	700	coal
51	Zouxian	Shandong	SDPG	1200	1200	coal
52	Shiheng	Shandong	SDPG	735	735	coal
53	Shiliquan	Shandong	SDPG	625	625	coal
54	Huangtai	Shandong	SDPG	925	925	coal
55	Longkou	Shandong	SDPG	600	600	coal
56	Xindian	Shandong	SDPG	600	600	oil
57	Huangdao	Shandong	SDPG	670	670	coal
58	Hualu	Shandong	SDPG	1200	600	coal
59	Weifang	Shandong	SDPG	600	0	coal
60	Yaomeng	Henan	CCPN	1200	1200	coal
61	Jiaozuo	Henan	CCPN	1224	1024	coal
62	Hanchuan	Hubei	CCPN	1200	600	coal
63	Qingshan	Hubei	CCPN	674	674	coal, oil
64	Jingmen	Hubei	CCPN	600	600	coal
65	Yangluo	Hubei	CCPN	600	0	coal
66	Yueyang	Hunan	CCPN	700	700	coal
67	Jinzhushan	Hunan	CCPN	600	600	coal
68	Jiujiang	Jiangxi	CCPN	650	450	coal
69	Ginling	Shaanxi	NWPN	1050	1050	coal
70	Weihe	Shaanxi	NWPN	1200	300	coal
71	Jingyuan	Gansu	NWPN	800	600	coal
72	Daba	Ningxia	NWPN	600	300	coal
73	Luohuang	Sichuan	SCPG	700	700	coal
74	Chongqing	Sichuan	SCPG	696	696	coal
75	Jiangyou	Sichuan	SCPG	660	660	coal
76	Qingzhen	Guizhou	GZPG	658	658	coal
77	Huangpu	Guangdong	GDPG	1100	1100	coal, oil
78	Shajiao A	Guangdong	GDPG	1200	600	coal
79	Shajiao B	Guangdong	GDPG	700	700	coal
80	Shaoguan	Guangdong	GDPG	624	624	coal
81	Zhujiang	Guangdong	GDPG	600	0	coal
82	Shenzhen	Guangdong	GDPG	600	0	coal

Total existing capacity (MW)	55307		
Total design capacity (MW)	74317		
Capacity under construction	19010		
Share in thermal (existing)	49	There is no duel-fired or oil-fired under construction	
Oil-fired	1240	Dual-fired (coal-oil)	7764
Share of oil-fired in design.	1.7	Share of duel-fired in design.	10.4
Share of oil-fired in existing.	2.2	Share of dual-fired in existing.	14.0

Table 9. Fuel Consumption of Thermal Power Generation

Year	Coal (Mt)	Oil (Mt)	Gas (BCM)	Coal (MTOE)	Oil (MTOE)	Gas (MTOE)	Total (MTOE)	Share of fuel (%) Coal	Oil	Gas
1979	106.7	16.4	0.17	53	16.4	0.2	70	76	23	0.2
1980	109.7	16.3	0.21	55	16.3	0.2	71	77	23	0.3
1981	109.9	15.8	0.18	55	15.8	0.2	71	77	22	0.2
1982	117.1	15.2	0.22	59	15.2	0.2	74	79	21	0.3
1983	125.6	14.5	0.20	63	14.5	0.2	77	81	19	0.2
1984	140.8	13.8	0.28	70	13.8	0.3	84	83	16	0.3
1985	156.6	13.5	0.36	78	13.5	0.3	92	85	15	0.4
1986	192.5	13.5	0.55	96	13.5	0.5	110	87	12	0.5
1987	196.5	13.4	0.57	98	13.4	0.5	112	88	12	0.5
1988	223.9	14.3	0.42	112	14.3	0.4	127	88	11	0.3
1989	274.3	17.1	0.94	137	17.1	0.9	155	88	11	0.6
1990	291.0	15.5	0.97	146	15.5	0.9	162	90	10	0.6
1991	325.9	15.0	1.06	163	15.0	1.0	179	91	8	0.5

Source: Energy in China, 1992.
Note: Heat content of Kgce is 7000 Kcal (Kgoe is 10,000 Kcal)
Heat content: Coal 5000 Kcal/kg, Oil 10,000 Kcal/kg, Gas 9310 Kcal/CM.

Table 10. Nuclear Power Development Plans

Plant Name	Location	Capacity (MW) Design	Existing	Schedule Status	Technology Options
Total in 2010			35000		
Total in 2000			7000		
Total in 1993			1200		
Qingshan I	Zhejiang	300	300	82-91	Domestic
Qingshan II	Zhejiang	1200	0	Construction	Domestic
Qingshan III	Zhejiang	1200	0	Planning	Domestic
Zhejiang II	Zhejiang	2000	0	Planning	Imported
Daya Bay	Guangdong	1800	900	87-93 (94)	France
Shantou I	Guangdong	2000	0	Planning	Imported
Shantou II	Guangdong	4000	0	Planning	*na*
Yangjiang I	Guangdong	4000	0	Planning	Imported
Yangjiang II	Guangdong	2000	0	Planning	*na*
Guangdong IV	Guangdong	6000	0	Planning	*na*
Wentuozi	Liaoning	2000	0	Planning	Russia
Dongfang I	Hainan	350	0	Planning	Domestic
Dongfang II	Hainan	350	0	Planning	Domestic
na	Fujian	*1200*	0	Site Selection	*Domestic*
na	Jiangsu	*1500*	0	Site Selection	*Domestic*
na	Jiangxi	*900*	0	Site Selection	*Domestic*
na	Shandong	*1200*	0	Site Selection	*Domestic*
na	Southwest	*1200*	0	Site Selection	*Domestic*
na	Other	*1800*	0		*Domestic*

Note: Numbers and technology options in italics are estimated by the author.
Source: China Daily, Asian Energy News, China Newsletter, and Energy in China 1992.

Table 11. Investment in Power Basic Construction Projects

Year	Investment (100 million yuan)			Share of Investment (%)	
	Total	Thermal	Hydro	Thermal	Hydro
1953	2.6	1.6	1.1	59	41
1954	3.9	2.2	1.7	56	44
1955	5.4	3.8	1.6	71	29
1956	7.2	4.9	2.4	67	33
1957	10.7	7.4	3.3	69	31
1958	20.5	11.5	9.0	56	44
1959	27.6	16.6	10.9	60	40
1960	29.6	15.5	14.1	52	48
1961	7.6	3.7	3.9	49	51
1962	3.6	1.2	2.4	34	66
1963	3.9	1.8	2.1	46	54
1964	6.5	3.1	3.4	48	52
1965	11.7	6.3	5.4	54	46
66--70	68.6	32.7	36.0	48	52
71--74	98.7	46.0	52.7	47	53
1975	30.7	15.1	15.6	49	51
1976	34.0	18.8	15.2	55	45
1977	34.7	17.5	17.2	51	49
1978	50.9	23.3	27.6	46	54
1979	51.0	20.5	30.5	40	60
1980	48.1	19.1	29.0	40	60
1981	40.1	14.6	25.6	36	64
1982	46.2	18.2	28.1	39	61
1983	57.5	25.1	32.3	44	56
1984	77.0	38.3	38.7	50	50
1985	109.5	50.0	59.4	46	54
1986	161.6	85.3	76.3	53	47
1987	210.9	106.7	104.2	51	49
1988	249.7	146.2	103.5	59	41
1989	267.9	153.0	114.8	57	43
1990	334.6	195.2	139.3	58	42
Total	**2112**	**1105**	**1007**	**52**	**48**

Source: China Energy Statistical Year Book, 1991.

Table 12. Large Hydropower Stations (250 MW and above) as of end 1991

NO.	Name	River	Location	Capacity (MW) Total	Existing	Generation (TWh)	Operating Hours
1	Shuifeng	Yalujiang	Liaoning	630	630	3.93	6238
2	Fengman	Songhuajiang	Jilin	639	639	1.96	3067
3	Yunfeng	Yalujiang	Jilin	400	400	1.75	4375
4	Baishan	Songhuajiang	Jilin	1500	1500	2.04	1360
5	Laohushao	Yalujiang	Jilin	390	390	1.20	3077
6	Panjiakou	Luanhe	Hebei	390	390	0.56	1446
7	Xin'anjiang	Xin'anjiang	Zhejiang	663	663	1.86	2808
8	Fuchunjiang	Qiantangjiang	Zhejiang	297	297	0.93	3129
9	Jinshuitan	Quijiang	Zhejiang	300	300	0.49	1633
10	Wan'an	Ganjiang	Jiangxi	500	500	1.05	2100
11	Shaxikou	Shaxi	Fujian	300	300	0.96	3200
12	Shuikou	Mingjiang	Fujian	1400	0	4.95	3536
13	Zhaxi	Zishui	Hunan	448	448	2.20	4916
14	Fengtan	Youshui	Hunan	400	400	2.04	5100
15	Dongjiang	Laishui	Hunan	500	500	1.32	2640
16	Wuqiangxi	Yuanshui	Hunan	1200	0	5.37	4475
17	Danjiangkou	Hanjiang	Hubei	900	900	3.83	4256
18	Gezhouba	Changjiang	Hubei	2715	2715	14.10	5193
19	Geheyan	Qingjiang	Hubei	1200	0	3.04	2533
20	Sanmenxia	Huanghe	Henan	250	250	1.31	5240
21	Xinfengjiang	Xinfengjiang	Guangdong	293	293	1.17	4000
22	Guangzhou	Tributary of Liuxi River	Guangdong	1200	0	2.38	1983
23	Dahua	Hongshuihe	Guangxi	400	400	2.05	5125
24	Yantan	Hongshuihe	Guangxi	1100	0	5.37	4882
25	Gongzui	Daduhe	Sichuan	700	700	4.12	5886
26	Baozhusi	Bailongjiang	Sichuan	640	0	2.28	3563
27	Tongjiezi	Daduhe	Sichuan	600	0	3.21	5350
28	Ertan	Yalongjiang	Sichuan	3300	0	17.00	5152
29	Wujiangdu	Wujiang	Guizhou	630	630	3.34	5302
30	Tianshengqiao-II	Nanpanjiang	Guizhou/Guangxi	880	0	4.92	5591
31	Tianshengqiao-I	Nanpanjiang	Guizhou/Guangxi	1200	0	5.38	4483
32	Lubuge	Huangnihe	Yunnan/Guizhou	750	750	2.75	3667
33	Dongfeng	Wujiang	Guizhou	510	0	2.42	4745
34	Manwan	Lancangjiang	Yunnan	1000	0	5.48	5480
35	Yanguoxia	Huanghe	Gansu	396	396	2.15	5429
36	Liujiaxia	Huanghe	Gansu	1225	1225	5.58	4555
37	Bikou	Bailongjiang	Gansu	300	300	1.46	4867
38	Qingtongxia	Huanghe	Ningxia	272	272	1.04	3824
39	Ankang	Hanjiang	Shaanxi	1000	1000	2.86	2860
40	Longyangxia	Huanghe	Qinghai	1280	1280	5.98	4672
41	Lijiaxia	Huanghe	Qinghai	2000	0	5.90	2950
Total/Average				34697	18467	142	4085
Total Capacity Under Construction (MW)			16230				
Share of China's Total Hydro Capacity (%)			49				

Source: Electric Power Industry in China, 1992.

Table 13. Major Generating Units in 1991

Fossil-Fired Units (100 MW and above)

Rating (MW)	No.of units	Capacity Total (MW)	Capacity Share (%)	Generation Average (MWH)	Generation Total (TWh)	Generation Share (%)	Annual Operating Hours	PLF %	Weighted Average EAF (%)	Weighted Average EFOR (%)
100	105	10500	18	587017	62	18	5870	67	87.86	1.97
110	6	660	1	730862	4	1	6644	76	82.32	2.19
120	2	240	0	557684	1	0	4647	53	65.49	12.84
125	68	8500	15	789630	54	16	6317	72	86.19	4.10
200	112	22400	39	1191425	133	39	5957	68	80.57	7.28
210	6	1260	2	1074632	6	2	5117	58	70.71	13.20
250	2	500	1	1910778	4	1	7643	87	92.75	0.92
300	28	8400	14	1745572	49	14	5819	66	81.01	8.62
320	2	640	1	1120885	2	1	3503	40	75.22	12.12
330	1	330	1	540788	1	0	1639	19	48.52	28.88
350	10	3500	6	1760540	18	5	5030	57	78.14	6.14
600	2	1200	2	2316610	5	1	3861	44	57.18	18.03
Sub-total	299	58130	100		338	100	5782	66	82.24	6.15
Share of thermal		51			61					

Hydropower Units (40MW and above)

Type	No.of units	Capacity Total (MW)	Capacity Share (%)	Generation Average (MWH)	Generation Total (TWh)	Generation Share (%)	Annual Operating Hours	PLF %	Weighted Average EAF (%)	Weighted Average EFOR (%)
Axial	53	4748	27	423438	22	34	4727	54	93.07	0.41
Francis	134	12701	73	329642	44	66	3478	40	92.17	0.43
Sub-total	187	17448	100		67	100	3818	44	92.47	0.42
Share of hydro		46			53					

Source: Electric Power Industry in China, 1992.

EAF: Equivalent availability factor. EFOR: Equivalent forced outrage rate.

Table 14. Main Indicators of Power Industry (6 MW and above)

	1980	1985	1986	1987	1988	1989	1990	1991	1992
Net Coal Cons. (g/kwh)	448	431	432	432	431	432	427	423	419
Efficiency	27.4	28.5	28.4	28.4	28.5	28.4	28.8	29.0	29.3
Plant use (%)	6.44	6.4	6.5	6.7	6.7	6.8	6.9	6.9	6.9
Thermal	7.65	7.8	7.8	7.9	7.9	8.1	8.2	8.1	8.1
Hydro	0.19	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Line Loss Rate (%)	8.93	8.2	8.2	8.5	8.2	8.0	8.1	8.2	8.2
Utilization Hours	5078	5308	5388	5392	5313	5171	5036	5030	na
Thermal	5775	5893	5974	6011	5907	5716	5413	5451	na
Hydro	3293	3853	3882	3771	3710	3691	3800	3675	na

Source: Energy in China, 1992.

Table 15. China's Investment Needs for Electricity Development

Installed Capacity (GW)

	Total	Coal-fired	Hydro	Nuclear	Other	CCTs (I)	CCTs (D)
1992	165	110	41	0.3	13.7	0.7	0
2000	300	195	75	7	23	13	41
2010	530	320	140	35	35	65	114

New Capacity (GW)

	Total	Coal-fired	Hydro	Nuclear	Other	CCTs (I)	CCTs (D)
1993-2000	135	85	34	6.7	9.3	12.3	41
2001-2010	230	125	65	28	12	52	73
1993-2010	365	210	99	35	21	64	114
Average (93-2010)	20.3	11.7	5.5	1.9	1.2	3.6	6.3
1993-2000	16.88	10.63	4.25	0.84	1.16	1.54	5.13
2001-2010	23.00	12.50	6.50	2.80	1.20	5.20	7.30

Capital Cost of New Capacity ($billion)

	Total	Coal-fired	Hydro	Nuclear	Other	CCTs (I)	CCTs (D)	Total CCTs
1993-2000	89.3	42.5	30.6	10.1	3.7	1.0	1.4	2.4
2001-2010	174.6	62.5	58.5	42.0	4.8	4.4	2.4	6.8
1993-2010	263.9	105.0	89.1	52.1	8.5	5.5	3.8	9.2
Average (93-2010)	14.7	5.8	5.0	2.9	0.5	0.3	0.2	0.5
1993-2000	11.2	5.3	3.8	1.3	0.5	0.1	0.2	0.3
2001-2010	17.5	6.3	5.9	4.2	0.5	0.4	0.2	0.7

Retrofitting of Existing Coal-fired Capacity

	Capacity (MW)	Cost ($billion)
1993-2000	28.05	4.66
2001-2010	37.95	6.30
1993-2010	66.0	11.0
Average (93-2010)	3.7	0.6
1993-2000	3.5	0.6
2001-2010	3.8	0.6

Capital Cost of New Capacity and Retrofitting Capacity ($billion)

	Total	Coal-fired	Hydro	Nuclear	Other	CCTs (I)	CCTs (D)	Total CCTs
1993-2000	93.9	47.2	30.6	10.1	3.7	1.0	1.4	2.4
2001-2010	180.9	68.8	58.5	42.0	4.8	4.4	2.4	6.8
1993-2010	274.9	116.0	89.1	52.1	8.5	5.5	3.8	9.2
Average (93-2010)	15.3	6.4	5.0	2.9	0.5	0.3	0.2	0.5
1993-2000	11.7	5.9	3.8	1.3	0.5	0.1	0.2	0.3
2001-2010	18.1	6.9	5.9	4.2	0.5	0.4	0.2	0.7

Note: dollars ($) refer to constant 1994 US dolars

Assumptions of Table 16		
Hydro	900	$million/GW installed
Nuclear	1500	$million/GW retrofitted
Coal-fired	500	$million/GW installed
Other	400	$million/GW installed
	17	% coal-fired retrofitted within 8 years
	40	% coal-fired retrofitted within 18 years
Retrofite	166	$million/GW retrofitted
CCTs (Imported)	85	$/KW
CCTs (Domestic)	33	$/KW
Exchange rate	8.7	yuan per US dollar

Table 16. Power Projects Using Foreign Loans

Project	Capacity (MW)	Schedule	Loan ($million)	Source	Location
Total	36270		9336		
Hydropower	20970		4110		
Lubuge	600	84--90	141	World Bank	Yunnan
Shuikou	1400	87--92	240	World Bank	Fujian
Yantan	1210	84--93	52	World Bank	Guangxi
Ertan (Phase I)	3300	91--2000	380	World Bank	Sichuan
Tianhuangping	1800	93--97	300	World Bank	Zhejiang
Longtan (Phase I)	4200	94--2002	1300	World Bank	Guangxi
Hongjiadu*	540	94--2001	200	World Bank	Guizhou
Wuqiangxi	1200	88--96	200	OECF (Japan)	Hunan
TSQ-II	880	84--93	478	OECF (Japan)	Guizhou
Shisanling PS	800	90--95	100	OECF (Japan)	Beijing
TSQ-I*	1200	91--98	160	OECF (Japan)	Guizhou
Guangzhou PS (P-I)	1200	88--94	200	France	Guangdong
Geheyan	1200	88--93	108	Canada	Hubei
Guangzhou PS (P-II)*	1200	93--97	200	ADB	Guangdong
Lingjintan*	240	94--99	50	ADB	Hunan
Thermal Power	15300		4767		
Beilungang	1200	86--93	390	World Bank	Zhejiang
Wujing	600	88--92	190	World Bank	Shanghai
Zouxian	1200	92--96	310	World Bank	Shandong
Yanshi	600	92--95	200	World Bank	Henan
Yangzhou*	1200	93--97	300	World Bank	Jiangsu
Ligang	700	88-92	246	Spain & Italy	Jiangsu
Ezhou*	600	92--95	250	OECF (Japan)	Hubei
Sanhe*	600	93--96	250	OECF (Japan)	Beijing
Jiujiang*	600	93--96	250	OECF (Japan)	Jiangxi
Hejin*	600	94--97	250	OECF (Japan)	Shanxi
Nanjing	600	89--92	241	Former USSR	Jiangsu
Jixian	1000	89--93	430	Former USSR	Tianjin
Suizhong	1600	90--95	650	Former USSR	Liaoning
Yimin	1000	90--95	430	Former USSR	Inner Mongolia
Wentuozi	2000	Agreed	na	Former USSR	Liaoning
Shidongkou No.2	1200	88--92	380	EDC, USA	Shanghai
Power Transmission			460		
TSQ-II-Guangzhou	500kv 1050km	88--93	116	OECF (Japan)	
TSQ-II-Guiyang	500kv 285 km	88--92	24	OECF (Japan)	
TSQ-I-Guangzhou*	500kv 1100km	94--98	140	OECF (Japan)	
Outgoing Lines for* Ertan Hydro*	500kv 2500km	94--98	180	World Bank	

Note: *Project financing is still in the process of negotiation
Source: Electric Power Industry in China 1992, China Daily, Asian Energy News.

Table 17. Power Projects Invested by Foreign Private Investors

Name	Capacity (MW)	Schedule Status	Investment ($million)	Foreign ($million)	Foreign Firms	Location	Fuel
Zhuhai	3720	Contract	3180	*1590*	Three HK firms	Guangdong	Coal
Daya Bay	1800	87--93	4000	1000	China Light&Power HK	Guangdong	Nuclear
Taishan	4920	93--97	2240	*1120*	na	Guangdong	Coal
Shajiao C	1980	93--95	1850	1850	Hopewell HK	Guangdong	Coal
Shajiao B	700	85-87	513	513	Hopewell HK	Guangdong	Coal
Nansha	1200	88-94	380	190	New World HK	Guangdong	Coal
Yinglongshan	2400	Contract	952	476	Sembawang Singapore	Zhejiang	Coal
Jiangsu	2400	Contract	2400	1680	Wing Merrill US	Jiangsu	LNG
Anhui	600	94-97	600	600	United Engineers US	Anhui	Coal
Qinzhou	1320	Contract	1250	750	Hopewell HK	Guangxi	Coal
Beihai	600	Contract	692	346	New World HK	Guangxi	Coal
Mixian	1400	94--97	500	*250*	Wing Merrill US	Henan	Coal
Dengfeng	1400	94--97	500	*250*	Wing Merrill US	Henan	Coal
Meizhouwan	1200	93--97	1000	1000	HK, US, Singapore	Fujian	Coal
Shengli	600	Contract	500	250	Cathay HK	Shandong	Coal
Zouxian	1200	Contract	600	180	Goldman Sachs US	Shandong	Coal
Other Shandong	na	Contract	2000	*1000*	China Light&Power HK	Shandong	Coal
Lianyuan	250	Contract	230	115	Time Berhad Malaysia	Hunan	Coal
Yangcheng I	2000	Contract	1700	400	Strategic US	Shanxi	Coal
Negotiation -	37230		30950				
Yangcheng II	*2000*	Negotiation	1700	na	na	Shanxi	Coal
Changzhi	*2000*	Contacting	1700	na	US or HK	Shanxi	Coal
Yangquan	*2000*	Contacting	1700	na	US or HK	Shanxi	Coal
Hequ	*2000*	Open	1700	na	na	Shanxi	Coal
Seven Others	*14000*	Open	11900	na	na	Shanxi	Coal
Jinghong	1350	Contract	na	na	Thailand	Yunnan	Hydro
Other Hopewell	6680	Approached	6250	na	Hopewell HK	5 Provinces	Coal
Huhhot	7200	Approached	6000	na	na	Inner Mongo.	Coal
Sichuan 3 Plants	na	Contract	na	na	HK	Sichuan	Hydro
Guizhou 2 Plants	na	Intent	na	na	HK and US	Guizhou	Hydro
Total	29690		25087	13560			

Note: This list is incomplete. Numbers in italics are estimated.
Source: China Daily, Asian Energy News, People's Daily Overseas Edition.

Table 18. Major Indicators of Power Industry in Asian Economies

	1990		
	Price USc/KWh	Load Factor (%)	System Losses
China	2.07	89.2	14.4
India	4.42	62.1	28.1
Viet Nam	6.00		26.8
Indonesia	6.14	67.5	20.4
Malaysia	6.65	67.7	16.3
Thailand	7.01	69.5	14.6
Hong Kong	7.18	54.3	11.8
Taiwan	7.22	68.1	9.7
S.Korea	7.48	71.2	10.2
Philippines	7.59	72.1	19.2
Japan	13.36	57.5	10.7

Source: Electric Utilities Data Book 1993 (ADB); Electric Power Industry in Japan 1991/92.

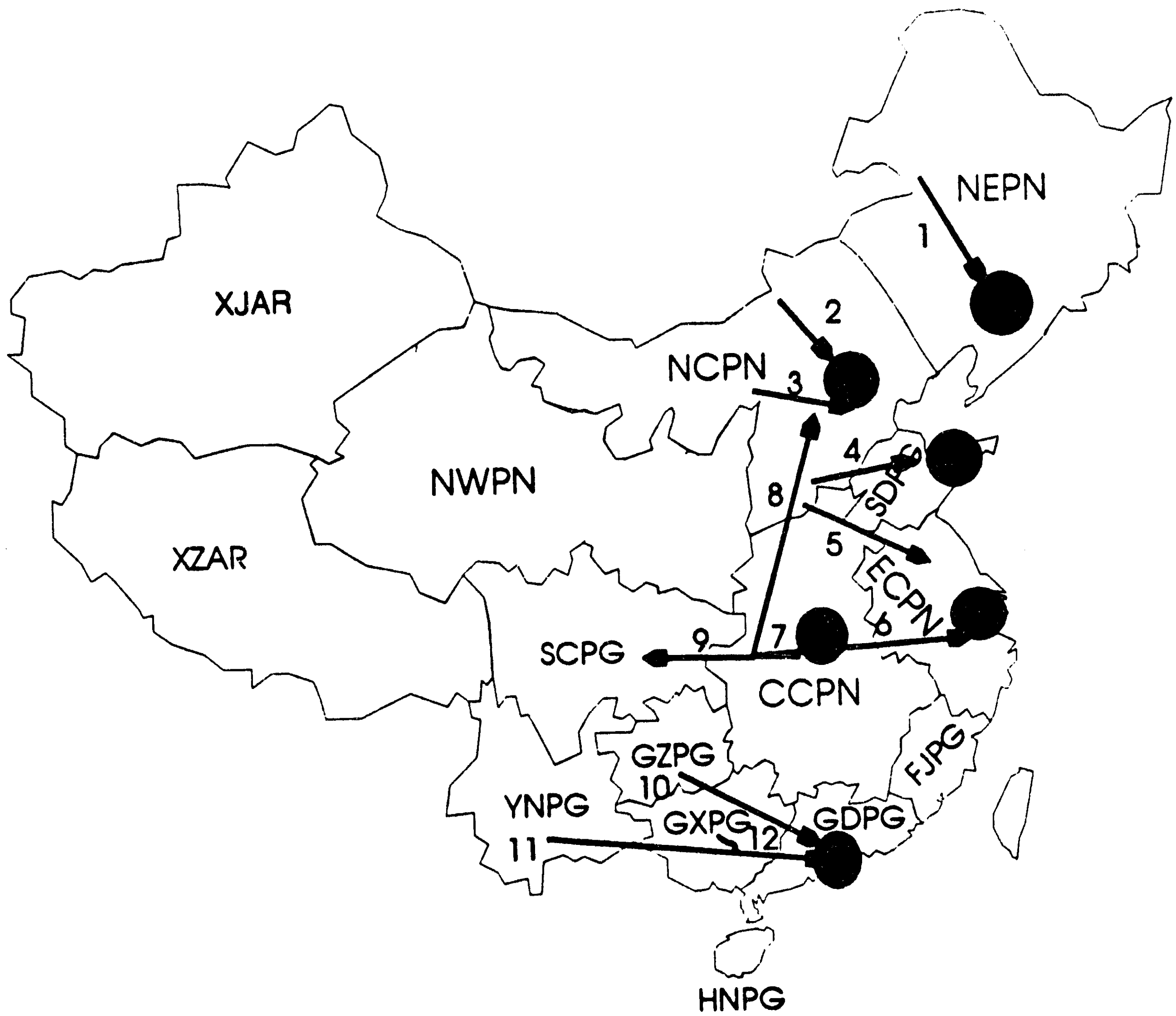

Figure 1. Planned major electricity transmission movements from coal and hydroelectric facilities to the six major load centers

Major Power Load Centers

Electricity Transmission

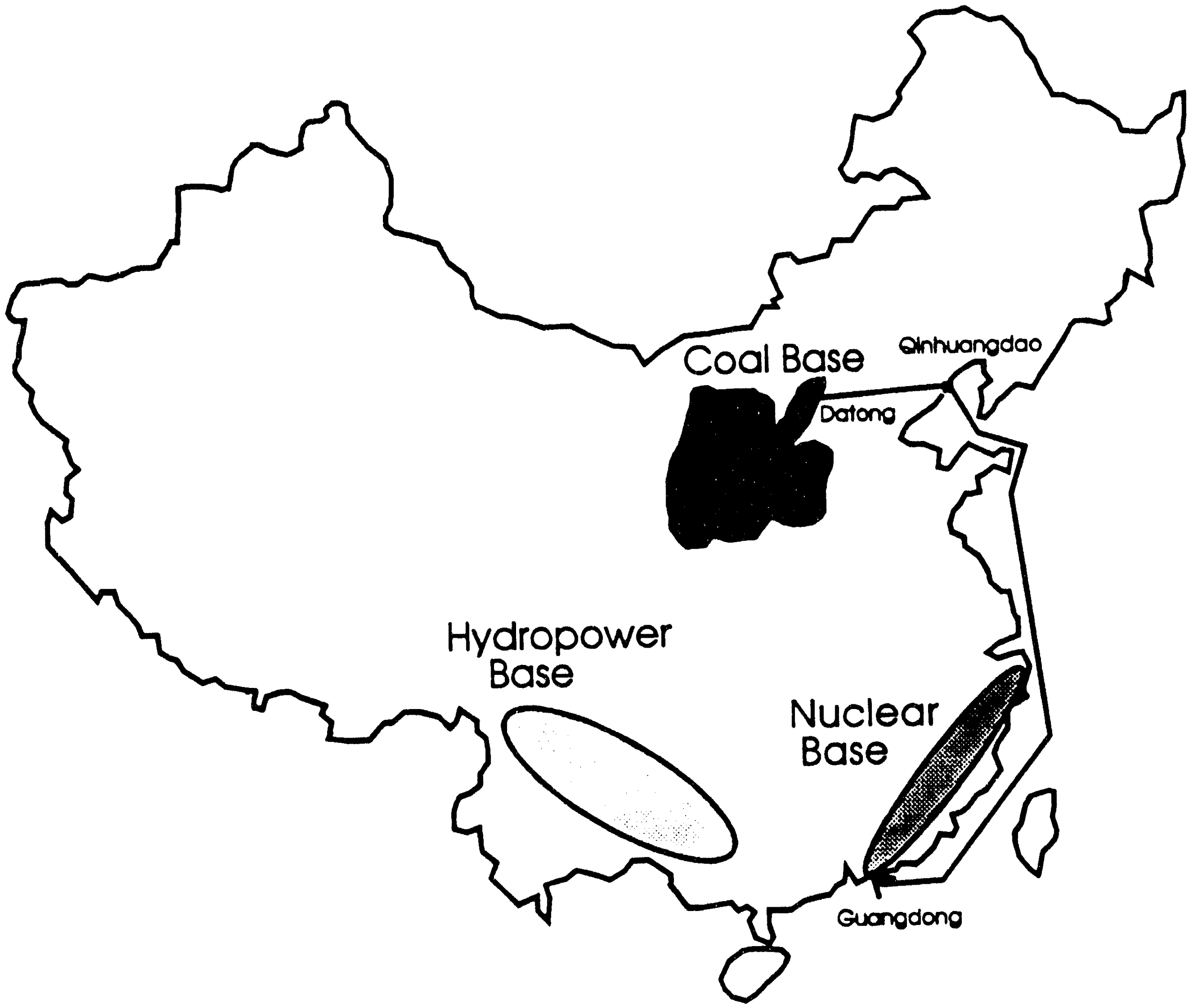

Figure 2. Energy Bases In China

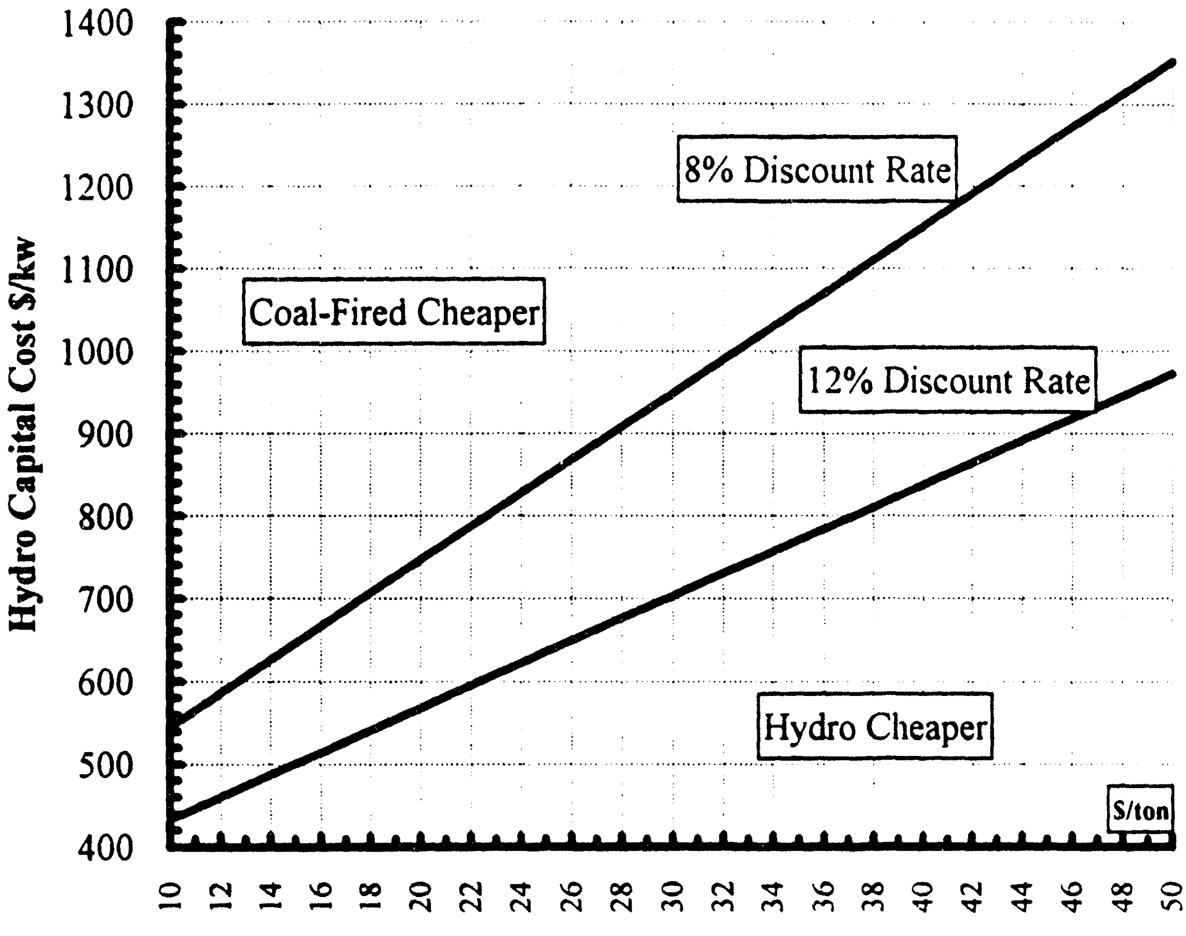

Figure 3. Hydro and coal-fired power plant economics

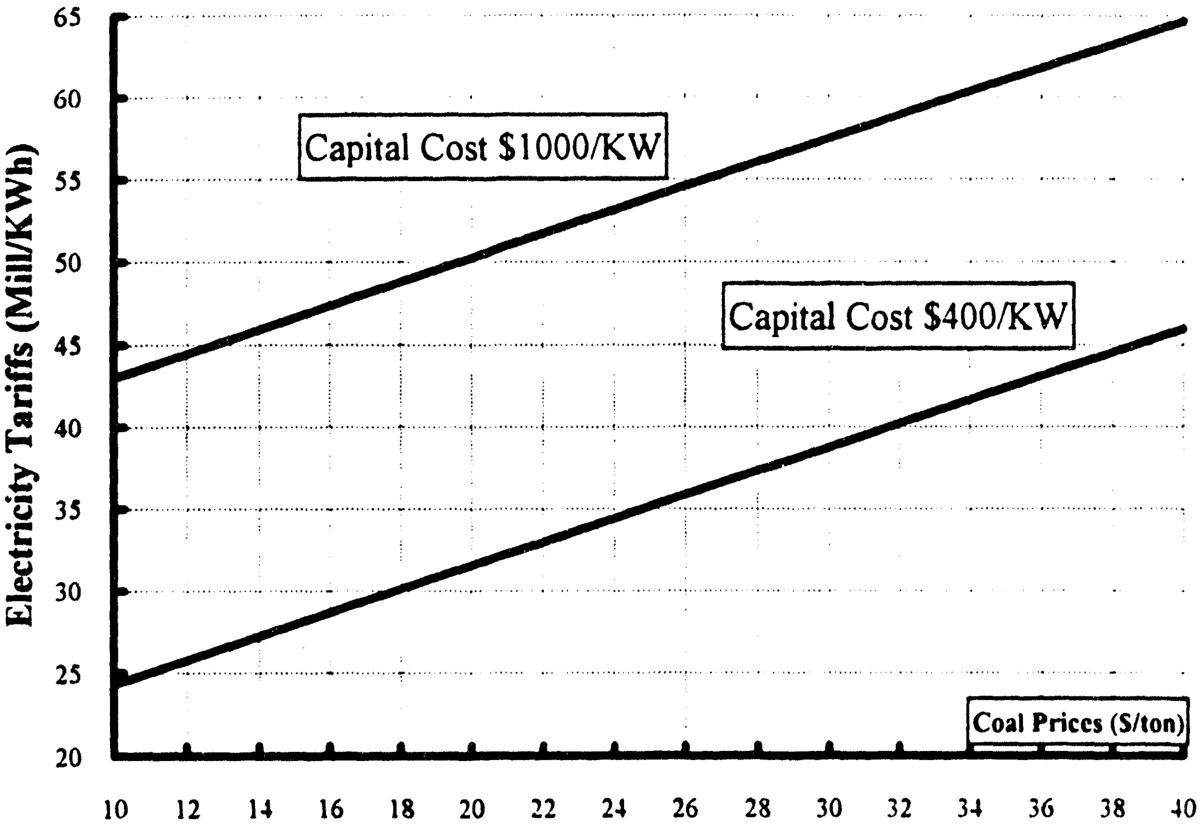

Figure 4. Minimum tariffs at alternative coal prices (12% IRR)

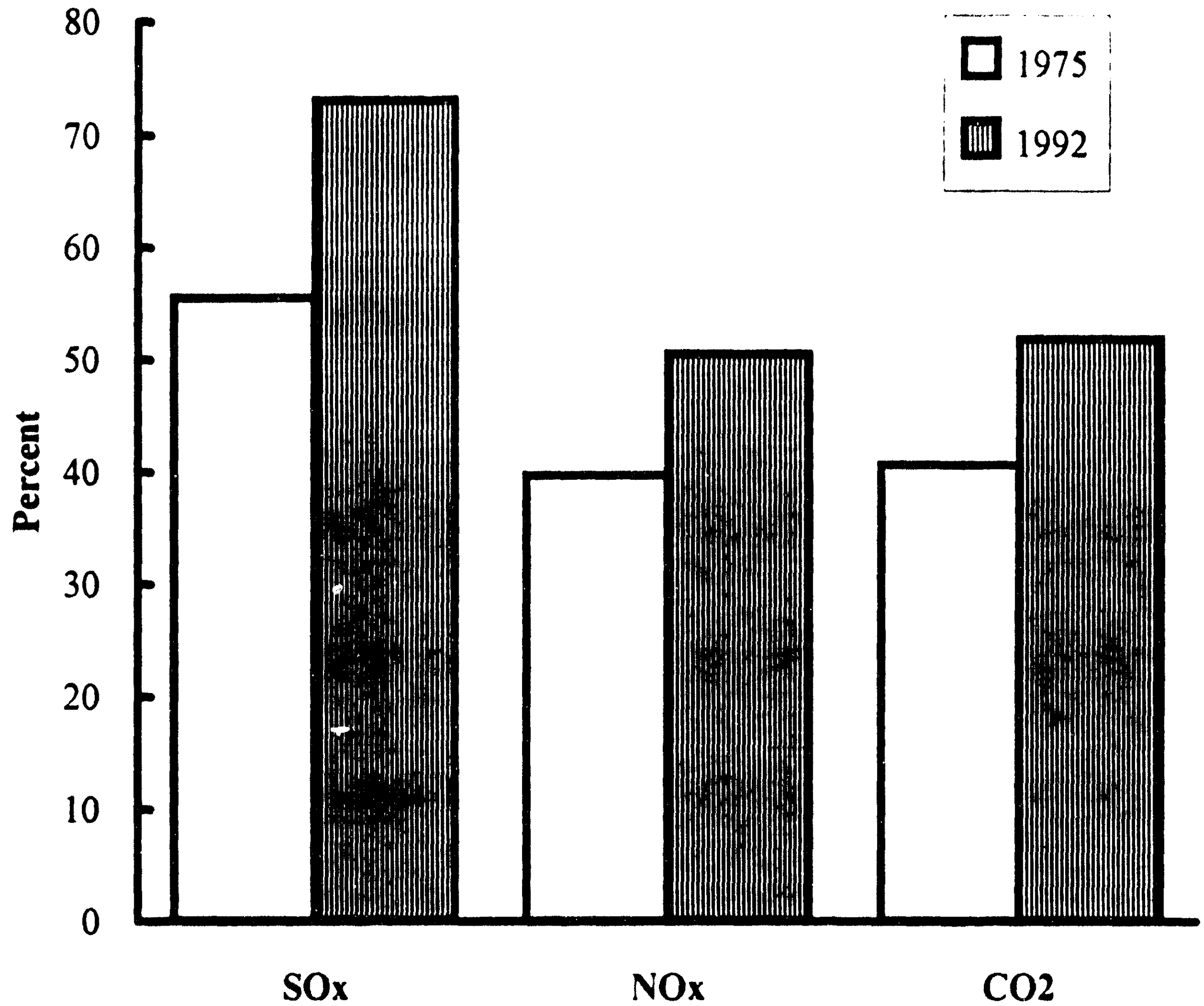

Figure 5. China's shares of emissions in Asia

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Coal Outlook in Asia[1]

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1. Introduction

The future of coal is dependent on the interaction of a range of government policy, environmental and market forces that are discussed in this paper. Revised projections of coal supply and demand for the 1992-2010 period are provided that reflect a combination of an evaluation of economic and energy trends and subjective assessments of factors influencing the future of coal in Asia.

The role of coal in Asia is more important than in the rest of the world, with Asia dependent on coal for almost 50 percent of its energy needs compared to less than 25 percent in the rest of the world. In fact over the 1982-1992 period coal consumption in Asia grew at about 7 percent per year compared to no growth in the rest of the world (BP, 1993). Falling coal production in the former Soviet Union and Eastern Europe contributed to the wide difference between Asia and the rest of the world.

However, after adjusting for anomalous conditions over the last decade, Asia is projected to account for 60-70 percent of the total growth in coal consumption in the world over the 1992-2010 period. The recognition that the Asian region will remain the dominant growth area for coal consumption, is attracting increased investments in the region from major international coal companies, as well as the attention of equipment suppliers (including coal mining, coal-fired power plant and related environmental technologies).

2. Determinants of Coal's Future Role in Asia[2]

Six important factors that determine future changes in coal production, consumption and trade are: (1) coal resources and energy alternatives, (2) government policies, (3) environmental factors, (4) economic and electricity growth rates, (5) competition and prices, and (6) strategic factors.

(1) Coal Resources and Energy Alternatives

Coal is the dominant energy resource of Asia. Asia's coal reserves are equivalent to about 250 years of Asia's coal production, compared to 55 and 20 years reserves/production ratios for natural gas and oil. (British Petroleum, 1993, and Coal Project 1993).

Coal is the most abundant energy resource in Australia, China, India, Russia and Vietnam. In contrast resources of oil and gas are relatively limited, and Asia is already heavily dependent on oil imports. Therefore, most Asian economies have policies to promote the use of coal - particularly for electricity generation. The oil crises in the 1970s resulted in a shift in government policies to support increased steam coal use for electricity generation in Hong Kong, Indonesia, Japan, South Korea, Philippines, Taiwan and Thailand. This trend toward greater coal use in electricity generation is projected to continue over the 1992-2010 period.

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[1] Australia is included with Asia because of it close proximity and extensive coal trade in Asia. Tons are metric tons and dollars are US dollars.

Dr. Johnson is Head of the EWC Coal Project. Mr. Scott Long and Dr. Binsheng Li of the East-West Center assisted in preparing the projections in this paper. The EWC Coal Project's coal and Clean Coal Technology research is partially supported by the Fossil Energy Office of the U.S. Department of Energy.

[2] The list of determinants is a revised list from the author's paper "Coal Demand in the Pacific Rim", 1992, and a Report of the Experts Group on Clean Coal Technology, 1992.

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(2) Government Policies

Most governments of Asia have the two key energy objectives to reduce the environmental impacts of coal burning, while also maintaining high levels of economic growth. Ensuring that energy supplies expand smoothly to meet economic growth is a high priority, even in some cases where this results in some deterioration of the environment.

Governments have considerable influence on energy choices through policies, tax incentives and environmental legislation. This is particularly true in electricity generation in Asia where most utilities are state corporations. The trend in Asian governments is to encourage their state utilities to adopt private sector management practices. In addition, most governments in Asia are now encouraging some private power, commonly on a build-operate-transfer (BOT) basis.

(3) Environmental Factors

The most important factor influencing the long term growth potential of coal consumption is the environmental effect of coal burning. The impact of environmental trends on coal use should be divided into two categories. The first category includes traditional pollutants (particulates, SO_2 and NO_x) that can be controlled with existing technologies. All Asian economies are projected to substantially reduce these pollutants as they expand and modernize their power plants. Before 2000, environmental legislation and government policies are expected to result in the addition of sulfur removal technologies to most new coal-fired power plants in Hong Kong, South Korea, Taiwan and Thailand.

The second category of pollutants are greenhouse gases, dominated by CO_2, that are very costly to control with known technologies. The response of most Asian governments to the greenhouse gas problem, is to promote greater efficiency in power generation, therefore reducing the amount of CO_2 per unit of electricity generated. Concern about coal's contribution to greenhouse gases has not caused developing economies of Asia to turn away from coal use, because there are limited economic energy alternatives for most of these economies.

(4) Economic and Electricity Growth Rates

The growth rates of electricity consumption are higher than the growth rates of gross domestic product (GDP) in most Asian economies. Table 1 shows the average annual growth rate of GDP and electricity consumption of Asian economies over the 1981-1990 period, with projections to 2010. As shown in Table 1 for most developing

Table 1 GDP and Electricity Growth Rates and Projections For Coal Consuming Asian Economies 1980-2010

	GDP Growth (%)		Electricity Growth (%)	
	1981-1990	1991-2010	1981-1990	1991-2010
China	9.2	7.5	7.5	6.8
South Korea	8.3	7.0	11.5	6.7
Thailand	7.6	7.0	11.8	6.5
Vietnam	4.8	6.7	8.7	10.0
Malaysia	6.2	6.5	9.3	6.5
Indonesia	6.0	6.3	12.0	9.4
Taiwan	7.7	6.3	8.1	5.7
Hong Kong	7.0	5.7	8.6	5.7
India	5.8	4.8	9.1	6.2
Japan	4.2	3.5	4.0	2.0
Philippines	1.9	3.5	3.9	6.4
Australia	3.1	2.7	4.9	2.7

Source: International Financial Statistics, 1992, U.N. Energy Statistics Yearbook, 1983-1990, and EWC Coal Project estimates, October 1993.

Table 2 Coal Production in Asia[1]: 1990-2010
(Million metric tons)

Country	1992	2000	2010	Change 1992-2010
China	1,110	1,500	1,920	810
India	211	345	550	339
Australia	180	225	305	125
Korea (North)	29	40	50	21
Korea (South)	12	8	5	−7
Indonesia	23	58	90	67
Japan	8	2	1	−7
Vietnam	4	8	15	11
Other	4	10	15	11
Philippines	2	3	5	3
Total	1,583	2,199	2,956	1,370

[1] Asia includes Australia but excludes Russia; excluding lignite, EWC Coal Project projections, 1993.

Table 3 Coal Consumption in Asia[1]: 1990-2010
(Million metric tons)

Country	1992	2000	2010	Increase 1992-2010
China	1,091	1,485	1,900	809
India	219	360	575	356
Japan	119	142	155	36
Australia	53	60	70	17
Korea (North)	31	45	60	29
Korea (South)	42	56	80	38
Taiwan	23	35	57	34
Hong Kong	10	13	16	6
Indonesia	7	33	65	58
Vietnam	2	4	9	7
Philippines	4	13	22	18
Thailand	1	6	15	14
Other	10	16	22	12
Total	1,612	2,268	3,046	1,370

[1] Asia includes Australia but excludes Russia; excluding lignite; consumption includes coal stocks; EWC Coal Project projections, 1993.

Table 4 Coal Trade in Asia[1]: 1990-2010
(Million metric tons)

Net Exporters	1992	2000	2010	Change 1992-2010
Australia	127	165	235	108
China	19	15	20	1
Russia (Eastern)	6	11	13	7
Indonesia	16	25	25	9
Vietnam	2	4	6	4
Net Exports	170	220	299	129
Net Importers				
Japan	111	140	154	43
Korea (South)	30	48	75	45
Taiwan	23	35	57	34
Hong Kong	10	13	16	6
India	8	15	25	17
Korea (North)	2	5	10	8
Philippines	2	10	17	15
Thailand	1	6	15	14
Other	6	6	7	1
Net Imports	193	278	376	183
Net Trade	−23	−58	−77	

[1] Asia includes Australia; This table includes exports from eastern Russia into the Pacific, but Russia is not included in the production and consumption tables; excluding lignite; EWC Coal Project projections, 1993.

about 20 percent from 2000 to 2010. These projections of increasing net imports to the Asian region are particularly uncertain, because Australia, China and Indonesia have relatively large reserves, and might increase exports above the estimates in this paper.

4. Review of Asian Economies with a Significant Role in Coal

(1) Australia

Australia is projected to account for more than 80 percent of the growth in exports from economies in the Asia over the 1992-2010 period. Australia's dominant position in coal exports results from the combination of large, high quality coal reserves, mostly within 300 kilometers of deep water ports, and the most stable investment environment in the region. Australian coal exports in 1993 are expected to increase by about three million tons to 130 million tons. Moderately low coal prices improve Australia's export opportunities by preventing the large capacity, higher cost, North American producers from increasing exports to Asia, and slowing China's development of a large export capability.

(2) China

China has sufficient coal reserves to meet the projected growth in domestic consumption, plus expand exports. However, the uneven distribution of higher quality, low sulfur coals, and the serious lack of sufficient rail transport capacity, limit China's ability to smoothly meet increased domestic demand and increase net exports.

The largest economic deposits are located in northern China, centered around Shanxi Province, referred to as China's "Energy Base". The Energy Base is 600-900 kilometers from deepwater ports. China's high growth coastal areas are short of coal, and over the 1992-2010 period, are expected to supplement the shortfall in Chinese coal supplies with imported coal. Without government restrictions, imports could exceed 50 million tons by 2010. The lower projections in this paper of imports of 10 million tons in 2000 and 20 million tons in 2010, reflect the belief that Chinese government will not allow large coal imports, and the expectation that large investments will be made to improve China's coal distribution system.

Although China has ambitious plans to expand nuclear power and hydroelectric capacity, coal's share of total electricity is projected to remain in the 65-70 percent range over the 1990-2010 period. China's coal-fired electricity generating capacity is projected to increase from 110 GW in 1992 to 180-200 GW in 2000 and 300-350 GW in 2010.

(3) Hong Kong

The rapid growth in coal consumption in the 1980s is over, and gradual growth is projected over the 1992-2010 period. The shift to pipeline imports of gas for the next 2,500 MW of power for the Black Point Power Plant, and the start-up of the two 900 MW units at the Daya Bay nuclear plant are expected to keep the total growth in coal imports to a modest 2-4 million tons between 1990 and 2000. After 2000, the combination of more pipeline gas imports, and reliance on coal-fired plants located in Gaungdong Province are expected to result in continued low growth rates in coal consumption in Hong Kong.

(4) India

India is the second largest coal producer and consumer in Asia, and is projected to have the region's second largest growth in consumption over the 1992-2010 period. Domestic reserves of coal are substantial, however most coal is high in ash, and lower quality than internationally traded coal. The ash in many Indian coals is particularly difficult to remove by washing. In addition, transport systems are generally poor, and need major investments to increase capacities to handle the growth in coal demand. The growth in domestic supplies of coal and of electricity are typically below the growth in demand. Imports of coal (presently at about 8 million tons per year) would grow rapidly if the government removed import restrictions. Imports of coal are projected to increase from 8 million tons in 1992 to 25 million tons in 2010. Liberalization of the terms for foreign investment are necessary to attract the needed levels of investment in India's energy sector.

(5) Indonesia

Indonesia's relatively large steam coal export potential was not recognized until the 1980s. Rapid expansion of surface mine production from large deposits in Kalimantan is underway, and is expected to continue over the 1992-2010 period. Some producers, such a Kaltim Prima, appear to be among the lowest cost suppliers in the world, and are penetrating international markets.

Although Kalimantan has some premium quality steam coal (such as Kaltim Prima), most of the reserves have one or more quality deficiencies that may constrain its market potential. Typical Kalimantan coals have low sulfur contents, low to medium energy contents, and relatively high moisture. Some coals are hard (low HGI) and will have grindability problems, and others have low fusion temperatures that may cause slagging problems. On the positive side, Kalimantan contains some of the lowest sulfur and ash content coals in the world that are expected to be in high demand as environmental standards become more stringent.

The largest constraint on the rate of growth in exports is expected to be the rapid growth in domestic coal consumption for electricity generation. Official Indonesian estimates of the growth in domestic coal consumption have tended to be optimistic. If domestic consumption falls substantially below the projections in Table 3, then exports could be larger than the 25 million tons projected for 2000 and 2010.

(6) Japan

Japan will easily retain its position as the largest coal importer in the world over the 1992-2010 period. The growth is in steaming coal with a substantial decline projected for coking coal consumption. The ranges in net imports are projected to be 135-145 million tons in 2000 and 150-160 million tons in 2010. Changes underway in the structure of the Japanese economy and economic growth rates, and government efforts to reduce CO_2 emissions, result in considerable uncertainty in coal projections beyond 2000. Japan is expected to play an important role in the introduction of clean coal technologies to reduce the negative environmental impacts of coal burning in Asia.

(7) Korea, North

No accurate publicly available information exists on coal production and consumption in North Korea, except that North Korea is believed to be a substantial producer and consumer of coal, mostly anthracite. Estimates range from about 30-50 million tons per year, with recent estimates near the low end.

It is assumed that deposits are similar, but larger than South Korean deposits, and that mining has been heavily subsidized by the government. When the economy is eventually opened to market forces, a substantial share of North Korean production may prove to be uneconomic, as occurred in the former East Germany.

The conservative projections in this paper assume 5 and 10 million tons of coal imports for 2000 and 2010.

(8) Korea, South

Over the 1992-2010 period South Korea is projected to account for the largest increase in quantity of coal imported in Asia, marginally larger than the growth in imports to Japan. High cost domestic production of anthracite has declined rapidly from 24 million tons in 1988 to 12 million tons in 1992, and is projected to decrease to 5 million tons in 2010.

Nuclear power plays a key role in South Korea's electricity mix, accounting for over 40 percent of total electricity generation. Coal-fired capacity is projected to increase from 15 percent of total electricity capacity in 1992 to 25-30 percent of capacity in 2010. All growth in coal consumption is projected to come from imported coal. The main uncertainty with respect to the growth rate in coal consumption are environmental regulations that are expected to force utilities to install sulfur removal technologies by 2000.

(9) Taiwan

Taiwan has very limited energy resource, and has no alternative to increased energy imports. Almost all growth in coal consumption is projected to be for steam coal. Coal-fired electricity capacity is projected to remain in the 25-30 percent range over the 1992-2010 period. Sulfur control technologies are projected for all new coal-fired power plants.

(10) Thailand

Since the 1970s, Thailand has had an active program to develop its lignite deposits, most of which are located at Mae Moh in northern Thailand. Thailand's lignite cannot meet the projected growth in demand for electricity beyond the late-1990s, therefore most growth in energy needs after 2000 will be from imports. Environmental problems associated with burning high sulfur lignite at Mae Moh have caused the government to re-evaluate its long term energy policies and strategies. It now appears that the growth rate in lignite capacity additions will be slower than previous projections of the state utility (Electricity Generating Authority of Thailand) and that all future lignite-fired plants will have SO_2 control technologies.

Plans for imported coal for electricity generation have been delayed for both environmental reasons and the resistance of coastal residents to siting plants along the coast. Imported coal appears to be quite competitive to alternative energy options, and imported coal is expected to range from 12 to 24 million tons in 2010. The level of imports depends on government policies, economic growth rates, and the amount of natural gas that can be imported by pipeline from neighboring countries (Myanmar, Malaysia, Cambodia and possibly Vietnam). In addition, hydropower development in neighboring countries (particularly Laos) are expected to supply electricity to Thailand.

(11) Vietnam

Vietnam has substantial energy resources of coal (mostly anthracite), oil, gas and hydro. More than 90 percent of the economic reserves of anthracite are located in northern Vietnam, near the coast, in the Quang Ninh Basin. Economic reserves are probably 0.5-1.5 billion tons with much larger resources. More than 75 percent of production has historically been used domestically, mostly for electricity generation. Recent expansions in hydroelectric capacity have greatly reduced the domestic coal market, and emphasis has shifted to increasing exports, projected at about 1.5-1.7 million tons in 1993.

Modernization of mining and port facilities, and management changes could reduce costs by perhaps 25-35 percent, and increase the export potential. However, Vietnam's large hydroelectric and natural gas potential is expected to slow the developments of coal capacity for domestic electricity generation over much of the 1992-2010 period.

(12) Non-Asian Suppliers

Increased competition from mines within the Asian region, and reduced demand for premium quality coking coal have weakened the competitive position of North American coals in Asia. North American producers are increasingly the swing suppliers for Asia, expanding exports mostly during periods of coal shortages and higher coal prices. At present prices, most North American steam coal is only marginally competitive in the Asian region. Large U.S. companies are increasingly looking for coal deposits within the Asian region (Australia, Indonesia and China) that will be more competitive in the region. In addition, the large projected growth in coal consumption in Asia is attracting coal-related technology companies (mining, power plant and environmental control technologies).

South Africa is the lowest cost coal exporter to Asia, and even with expected higher costs in the future, is expected to increase the total amount of coal exported to Asia over the 1992-2010 period.

5. Conclusions

Asia continues to lead the world in growth of production, consumption and trade. There are limited options for most Asian economies to shift away from coal, and the region is projected to account for 60-70 percent of world growth in coal consumption over the 1992-2010 period. Three factors that could have the largest impact on the projections in this paper are; (i) adoption of stringent environmental regulations that limit coal burning in Asia; (ii) serious political and economic instability in one or more of the major coal economies of Asia, or (iii) stagnation in the economic growth rates of major Asian economies.

The conclusion of this paper is that the combination of diversity of coal suppliers, the competitive nature of the industry, and the introduction of technologies to burn coal more efficiently with lower environmental emissions, will ensure stable growth in competitive coal supplies over the 1992-2010 period. There is no convincing evidence for sustained shortages of coal supplies and high prices over the 1993-2010 period. The average increase in coal prices over the 1992-2010 period is projected at between -0.5 and 1.5 percent per year in constant dollars. However, premium prices may occur for coals having superior environmental performance.

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Section 4

Subtask D -- Meetings and Cooperation on Asia

During the contract the Coal Project staff communicated with coal, power, and CCT experts in most of the APEC member economies including Australia, China, Hong Kong, Indonesia, Japan, the Philippines, South Korea, Taiwan, and Thailand, and the United States. Visits were made to China, Indonesia, Japan, the Philippines, and Thailand.

Thailand underwent a fundamental policy shift during the year, and now requires SO_2 control technology on all new lignite-fired power plants. FGD units are being installed at the main lignite-fired power plant in Mae Moh. In addition, FBC's are being considered for the lower quality lignites.

Indonesia's interest in CCTs is primarily in the area of coal preparation and not in SO_2 emissions control technology.

Japan's international CCT program is most active in China, with smaller projects in Indonesia and the Philippines. International activities are primarily divided between Japan's New Energy and Industrial Technology Development Organization and the Electric Power Development Corporation.

Section 5

Subtask E -- APEC Experts' Group on CCTs

APEC Experts' Group on Clean Coal Technologies Activities

The Coal Project actively assisted the U.S. Department of Energy in coordinating the APEC Experts' Group on Clean Coal Technologies Technical Seminar held in Bangkok and Chiang Mai, Thailand in September 1993. The Coal Project was responsible for coordinating with the Thai government on seminar organization, paper preparation, meeting records, and publishing the seminar papers. The final proceedings document is titled the *APEC Experts' Group on Clean Coal Technologies Technical Seminar Proceedings.* A total of 225 copies were distributed to various individuals and organizations. Copies of the proceedings volume were sent to the Department of Energy, Office of Fossil Energy and can be obtained from either Lowell Miller (Tel: 301-903-9451, Fax: 202-586-8488) or Jean Lerch (Tel: 202-586-7320, Fax: 202-586-7085) and to the APEC Secretariat in Singapore. The Coal Project also prepared and presented a paper at the Seminar reviewing the Clean Coal Technology potential of the APEC region.

A questionnaire designed to gauge the interest of member economies in various activities was sent to Experts' Group members and is included in this section. Based on the results of the questionnaire, another Technical Seminar and a Clean Coal Technology Training Course are planned for late 1994. The Technical Seminar will be held October 11-13, 1994 in Indonesia, and the Training Course will be held November 28th to December 7th, 1994 in Sydney, Australia. The EWC coal project is actively involved in these projects.

The Japanese government, through the New Energy and Industrial Technology Development Organization, contributed US$500,000 to the East-West Center to be used in accordance to directions form the APEC Experts Group on CCTs to further the goals of the experts group.

A notable weak link in the APEC Experts Group is China's participation. Although China is sending capable engineers to the meetings, none have had a broad understanding o the potential role of CCTs in the economy. Because of the huge importance of China as a future market for CCTs, it is important to seek participants from China that have a broader understanding of CCTs in China's future. For example, both the State Science and Technology Commission and Tsinghua University are known to have scientists with a broader understanding of CCT issues.

QUESTIONNAIRE ON FUTURE APEC EXPERTS' GROUP ON CLEAN COAL TECHNOLOGY ACTIVITIES

RESPONSES AND SUMMARIES

December 1993

1994 TECHNICAL SEMINAR

1. Participant evaluation of the September 1993 Technical Seminar in Thailand:

(a) Was the subject matter adequately covered?

- Yes. Coverage of subject matter depends very much on APEC economies being able to nominate experts willing to present papers.
- In the Thailand seminar, we were ambitious and tried to cover all technologies at all stages of the coal chain but with emphasis on combustion. For the most part, I think we accomplished this.
- Yes, the subject matter was covered on pre- during and post combustion.
- Yes it was. As the first technical seminar, it provided some guidance on how to present CCT option to those who are interested.
- Yes. But, if we have focused on the pollution problems more intensively, it would be better for the Thailand people and for other countries.
- Yes. Maybe too much cover.
- Yes, coverage was good, considering that this was the first technical seminar, and presentations from many different economies had to be integrated into the seminar. The experience of this seminar can be used to improve future seminars.

Summary

Coverage was broad as planned for the first technical seminar. In the future, more attention should be given to selected areas.

(b) Were the sessions of the correct length?

- Yes. A two-day seminar is considered adequate, unless the paper contributions are of a sufficiently high standard to maintain active participation of delegates over a third day.

- Several papers were rushed. Therefore, in future, recognizing some of the problems in cutting off speakers we should space things out a little to allow for more discussion when warranted.

- Yes, 2-3 days are enough for the seminar and one day for site visit to the related subject.

- Yes, they were, as a whole. There was close exchange of questions and answers between panelists and the floor, however, a little more time in each session would be needed to have more discussion between panelists.

- One week is adequate for the seminar. Otherwise it is very hard to encourage people to participate in the seminar.

- Yes, 2-3 days is the right length. Senior government officials and company executives have difficulty getting enough time to attend longer conferences, and will tend to send substitutes. Fewer topics can be covered at each seminar in the future, and this will allow more time for discussions.

Summary

The length of 2-3 days is generally supported. The problem of not enough time to discuss individual topics is best addressed by covering fewer topics at each seminar.

(c) Were there particular papers or presentations that stood out as good models for future seminars?

- Yes, e.g., Advanced FGD Technology (R. Conley, Pure Air), Nitrogen Oxide Removal Processes (W. VanNieuwenhuizen, B&W), Fludizied Bed Combustion (K. Reed, Foster Wheeler).

- Most of the papers were well prepared and presented.

- I am not sure, but a compilation of those papers presented at the seminar would be good enough as a CCT textbook.

- On the whole, they were of similar standard.

- Most presentations are good and can be the good models for future Seminar; for example Dr. Charles Johnson's presentation on the "Overview of the Potential for CCT in the Asia-Pacific Region." However, few are not satisfactory because the speakers could not communicate well in English and some presentations did not provide fruitful information.

- Some speakers had more experience in preparing and presenting papers, particularly in English. However, a mix of speakers from the region is desirable, and we should be prepared to give more detailed guidelines on papers, and assist authors with special needs, perhaps including transparencies.

Summary

A relationship exists between the backgrounds of participants and the papers they favored. Some speakers could benefit from additional assistance in the preparation of their papers and transparencies.

(d) Did the Technical Seminar achieve its objectives?

- Yes.

- Assuming the goal of information exchange, I think it was successful. In some cases, the biases of the author with respect to a given technology were obvious, but I think all we can do is ensure all technologies are aired. Country distribution of papers was good.

- Yes, we got many information which we need by direct discussion with the experts.

- We think so. It was especially useful to have a bird's-eye view of CCT from the research and development stage to the commercial stage.

- Relatively the seminar achieved its objective. But I doubt whether policy makers understand the issues or not.

- Partly only as it succeeded in educating on various CCT processes available but not enough impact for regularizing or acceptance.

- Yes.

- Yes. The CCTs technologies, at least, had been discussed among the APEC economies. The information or knowledge gained from the Seminar will support them to formulate more appropriate polices and measure for coal utilization. In the case of Thailand, the result of the Seminar is very beneficial because it confirms that the chosen CCT technology is currently the most appropriate for Thai people.

- Yes. An important objective of this seminar was to assist one of the members, Thailand, in its consideration of CCTs. The response of Thai policy people at the seminar and in this questionnaire confirmed that the seminar met their expectations. Overall, the seminar achieved the agreed goals.

Summary

All respondents agreed that the seminar achieved the planned objectives.

(e) How can we do a better job in future technical seminars?

- There needs to be a greater emphasis on comparative economics of CCT options, if the seminars are to assist with policy making. Some presentations tended to focus on domestic developments and activities and these needs to be related to broader APEC interests by authors.

- In preparation for this seminar the topics were general in that they were not directed specifically at one country or at a given problem. In future, we may wish to consider a balance between focusing on perhaps host country situations and providing general information to all economies. In this context, perhaps the first sessions of some future seminars could be papers from the host country outlining their energy/environmental policies and issues. I still think we are weak on the policy side.

- I think it will be important to identify the audience seminars are directed at and ensure appropriate participation particularly from Asian economies. In Thailand, we obviously had good representation from the Thais and key but limited participation from most other countries. Perhaps in some instances, the seminars should focus on issues and technologies relevant to the host country. This was not the original goal in the Thailand seminar.

- It is better if the Technical Seminar accompanies by an exhibition which has relation to the subject matter.

- A problem-oriented approach would be useful to stimulate more intensive discussion between experts and policy makers. Mae Moh's case is a good example. Similar case studies are possible.

- Coal is considered as a pollution source by most policy makers. It is necessary to educate them that coal is not as dirty as they think. So it is necessary to encourage them to participate in this kind of seminar. There should be some method how to encourage the policy makers to participate in the seminar.

- Focus should be the idea. Too many subjects around the concept can be unnecessary.

- It was well organized.

- Since there are tremendous difference in degree of industrialized among APEC's member, I believe the demand for Technical Seminar will be a lot of different. Hence, I suggest it should be divided into two or three working groups, each member include industrialized, nearly industrialized and developing members, and come to more proportional selected topics before biannual meeting is held. This should be able to respond to the demand of technology input and output among members. For every alternative year, the group members can be rearranged.

- In order to prevent the communication problem which may occur, some speakers, if necessary, should bring their own interpreter.
- We need to focus more attention on selected CCT options, and present information in terms that can be used by the policy maker. Economic, and performance comparisons between CCT types is important to the policy maker.

Summary

Give greater focus on selected CCTs, include economic analysis and address issues that the policy makers want to know.

(f) Other suggestions to make the APEC Experts Group on CCT more effective?

- It is important to encourage participation by utilities which have experience with different CCT options so that a perspective additional to that of the technology vendors is presented.
- It would also be worthwhile to seek EPRI CRIEPI involvement.
- Depending on the seminar, more participation from the host country in the planning to ensure relevance of seminar to their situation (only if we decide to put some focus on issues in the host country).
- No suggestion for the time being.
- It is needed to include at least a government official in the APEC's Group on CCT.
- Do not put too much emphasis on the term of experts. You would risk needless alienation. Reduce number of salesmen on the experts' list.
- The site visit did not allow enough time to see the plant. A dialogue session with the plant operator would have been useful.
- At the end of each Technical Seminar, i.e., from the panel discussion, the chairman concludes and address the selective topics, and assign working group to evaluate in order to come to a conclusion in the next steering committee meeting.
- The seminar participants should be selected carefully in order to make sure that they are qualified and represent all the concerned organization.
- There is a need to review how we can ensure that each country is sending participants that will be active members of the APEC experts group on CCTs. In one or two cases, there are excellent CCT groups within an economy that would enhance the contribution of their economy to the APEC activities.

Summary

Three participants suggested more attention in the selection of experts that will present objective CCT information. It should be ensured that key CCT groups are represented.

2. **What topics and emphasis should be included in the 1994 Seminar?**

- Economic comparisons of CCT options, steps involved in commercialization of CCT options, and impact of environmental regulations (for existing and new plant) on CCT choice.

- This depends on the location and more on the views of the Asian countries. However, as I said before, I do not think there is enough emphasis on the policy side. We may want to narrow or give focus to the seminar to make them more manageable by identifying issues or problems to be addressed.

- The same as in the 1993 Seminar, but economic issue must have more portion.

- Laws, regulations, and standard to prevent air pollution; citing of major CCT facilities (projections and plans); and international cooperation activities other than APEC activities.

- Coal briquetting. Pollution control.

- The role of developed countries in the implementation of CCT and priority given to it. The cost for developing countries to adopt CCT.

- Clean coal technology option (advanced), environmental issues including climate change, and financing clean coal technology developments.

- Availability, reliability and efficiency data of proven CCT plant.

- The safety in handling pulverized coal, i.e., shipping and storage.

- It should include the following topics: 1) transportation, handling and distribution of coal and 2) selecting of coal for CCT power plant.

- There are a range of important areas for focus. One important area is a seminar that focuses on comparisons of CCT options -- including cost comparisons, efficiency comparisons and emission comparisons. In addition to a seminar proceedings volume, a small working group could prepare a small handbook CCT guide to policy makers (30 pages), plus another proceedings volume.

Summary

Economics of CCTs, financing CCTs, environmental regulations, coal handling, and related policy issues are the areas suggested for the 1994 Seminar.

3. **How much of the Seminar should be on technical discussion, and how much on economic and policy issues?**

- A 50:50 split between technical discussions and economic/policy issues may be appropriate, with technical discussions setting the scene.

- Could vary depending on the seminar topic, but I think we need more on the policy side than we had in Thailand (Anywhere from 25/75 to 75/25 depending on the topic).

- Technical=60%, Economic=25%, and Policy=15%.

- It is difficult to keep the proper balance between issues of technical and economic/political. However, close linkage between these issues should always be kept in mind.

- To understand each other side, it should be covered both fields at same time. 1/3 is economic and policy issues and 2/3 is to technical discussions.

- All factors are of equal importance thus should have equal emphasis.

- The seminar should cover all three aspects.

- Half of technical and the rest on economic and policy issues.

- The ratio is suggested as 40:30:30.

- The seminar should place emphasis equally on economic and policy issues as well as the technical discussions.

- The 1993 Seminar gave about 75 percent to technical issues and 25 percent to economics and policy. The 1994 Seminar should emphasis economic and policy issues (suggest 2/3 economics and policy, and 1/3 technical). This will require inviting a different mix of speakers (more economists and planners involved with CCTs).

Summary

There was a clear consensus to increase economic and policy issues in the 1994 Seminar to at least 50 percent.

4. **Where should the 1994 Seminar be held? Would your organization be willing to host the 1994 Seminar? Do you have a preference for the Seminar dates?**

- An Asian location is considered appropriate for the seminar. Preferred timing is late September/early October.
- I think we should stick to the Asian economies for another year and then perhaps start to include N.A., Japan and Australia. I think it is important to have activities move around and not try to centralize them in any location. This contributes to the education process.
- It is better the 1994 Seminar should be held in a country which has developed CCT and at the beginning of September is a good preference dates.
- It would be held better by the country (economy) who volunteers to host the seminar.
- 1994 seminar should be in a developed country. Seminar should be in Summer or Spring.
- In a country which will be undertaking significant coal based developments in the next 10-15 years.
- Any of the coal consuming APEC member.
- Nearly industrialized members are more properly, i.e., South Korea or Taiwan. My organization, Industrial Technology Research Institute, is willing to be considered candidate. The seminar shall last for three days including one field trip.
- It should be held in the countries where these technologies had been successfully installed.
- As Seminars will probably be held over many years, all economies should have a chance to host a seminar. At the September APEC meeting in Bangkok, Indonesia offered to host the next seminar, and there were no dissenting votes. For the longer term, China has the largest coal-related environmental problem in Asia, and should be an important priority for one or more Seminars. However, it may take another year to get the best organizational setup to ensure the Seminar is most effective.

Summary

Most suggestions are to hold the 1994 Seminar in Asia. Two suggestions are for the September/October period. Both Indonesia and Taiwan have offered to host the Seminar. Indonesia was the first to offer to host the 1994 Seminar.

5. How should speakers be selected for the Seminar?

- Ideally, speakers should be selected by invitation. However, in initial stages, we may need to be content with volunteers.

- The selection process for the 1993 seminar worked fairly well. It is important in a multilateral organization to ensure participation from as many member economies as possible.

- Full experience in the application.

- Ideally, purely voluntary participation is the best. In fact, however, proper contributions by responsible agencies from each country will probably be needed for the right nomination of experts.

- It is necessary to participate many companies as possible. So participants have opportunity to compare each technology and judge what technology is suitable to their unique situation.

- More policy makers and implementors and less salesmen.

- Invited by the steering committee on the basis of reputation and seminar objectives.

- Preferable some speakers with hands-on experience in the subject of their papers.

- The topics of invited speakers are suggested to focus on policy and economy, i.e., the experience in environmental assessment and the period of capital return. United States and Australia are right candidates.

- As same as the last method of speakers selection, the invitation letter should be sent to each economies for nomination of the speakers. The organizer, then choose the most appropriate speaker for each topic. However, the speakers should be directly involved in practicing the technologies in their home countries and should be able to communicate well in English.

- In order to continue to develop the APEC CCT group as a true team activity, we must ensure that various members play a real role in selecting both Seminar topics and speakers. The method used in 1993 achieved these goals with most speakers. In practice it is difficult to reject a speaker after he/she has been nominated by a government. I believe more discussion and guidance needs to be given to governments about the qualifications of speakers, and the scope of their talks.

Summary

Continue to select speakers through a nomination process of the APEC members. Although opinions varied, there is a need for experts with commercial experience as well as those with policy and economics backgrounds.

6. **What types of people (policy, engineers, economists, etc.) should participate in the Seminar? Should the Seminar focus on a particular group?**

- All should be able to participate. A focus on a particular group is not warranted.

- The type of people will depend on the topic - but it is likely a valuable contribution could be made from participants with a variety of backgrounds.

- Engineers and Economists are more dominant and it is not necessary the Seminar focus on a particular group.

- All three types of people will be needed. A better mixture of people will be realized by setting topics properly.

- It is good to participate all types of people to understand their fields.

- Focus on environmental groups and regulating bodies on pollution control.

- As wide a range as possible of persons involved in making decisions about CCT.

- Engineers, planners, and policy makers.

- No comment on the participants, but the Seminar is better to focus on a particular group in order to have the meeting more fruitful, and new or state-of-art technology should be included.

- The senior government officers concerning in the policy level and people from NGO as well as the technical/policy analysts and engineers from utilities should participate in the seminar. In some cases, the seminar for a particular group should be held separately for instance the technical group for specific CCT technology to discuss the detail of technology in question.

- All types of people have an important role. The mix will vary depending on the scope of a particular Seminar. Mixing government, industry and academics together will result in greater differences in discussions, and will ensure that there is a broader and useful exchange of information on CCTs. Perhaps we should remind all participants in our invitation letters that they are expected to maintain high professional standards in presenting their views at the Seminar.

Summary

All types of people should be included. The mix of policy makers, engineers and economists can vary with the scope of a specific seminar.

7. Should the Seminar include a field trip in the host country?

- Yes. The field trip should be related to a technology demonstration and/or issues facing the host country.
- Yes, if it is reasonable convenient and is relevant.
- Yes. One day trip to project or manufacture which has developed CCT.
- It will depend upon willingness of the host country.
- Yes.
- Yes. Go for worst case of pollution.
- Yes.
- Yes. Sufficient time should be given for the field trip.
- Yes. One coal-fired power plant and one of concerned research institute, one day is suggested.
- Yes. The field trip in the host country is an essential part of the seminar. The participants will have a chance to see the application of the technology.
- Yes. A field trip to a demonstration plant not only increases the knowledge about the status of CCT use in the economy, but also ensures that participants have a day to get to know each other before the seminar. This greatly facilitates discussions, and potential for follow up exchanges.

Summary

Yes (unanimous)

8. Other suggestions that will help make the Seminar a success?

- The host country may wish to present an overview paper, identifying the issues for coal and CCTs. Authors should be encouraged to address these issues during the presentations, thus complementing their papers.
- Uses of coal other than electricity generation should not be ignored. The appropriate mix will depend on the location of the seminar, e.g. the Thai seminar was properly targeted.
- The Seminar accompanied by an exhibition of the subject matter.
- Identify resources required to host a seminar and ensure host country has adequate resources.
- Play down the environmental or prototype methods and go for the established and proven technologies.
- The seminar should include industrial as well as power generation utilization of coal, including small industries cofiring of coal and biomass.
- More participants from plant operations and provision of more opportunities for interpersonal discussions with the speakers.
- The activities of accompanying persons should be arranged.
- The seminar should be arranged by professionals for example the private consultant company to ensure the success of the seminar. In case of the seminar in Thailand, the reason of the success stems mainly from the seminar professionals.
- The reimbursement of seminar budget should be flexible for the host country and not be rigid to regulations and rules of the APEC Secretariat office.
- The financial support for the seminar should also come from organizations other than APEC Secretariat, no matter public or private organizations.
- The financing of the seminar was difficult, and the seminar would have encountered a severe financial situation without the last minute intervention of an member economy to supply conference funds. Funds for seminars must be available in advance to cover costs, and there must be more flexibility to meet different requirements among economies in the region.

Summary

The range of suggestions was wide. The key concern of the 1993 host government was that funding needs to be more flexible, and that funding needs to also come outside of APEC.

1994 TRAINING COURSE

1. **What topics and emphasis should be included in the Training Course?**

- Comparative evaluation of CCT options (coal preparation, processing and emissions control), including technologies, environmental performance and economics.

- The question of how one makes economic comparisons and technology choices is one which has been repeated at various meeting. This could involve demonstration of some modelling package which address this area but I would exercise caution because this may have a limiting influence on your audience. The other major question is should the course focus on general needs of all countries or one country. Secondly, if it focuses on general needs, do you hold it once or do you hold it more than once at different locations. The answer to this may depend on who gives the course (paid consultants or non-paid industry/association people).

- I think case studies from the various economies could enhance any seminar or training course.

- How to select the CCT options and other energy options due to coal characteristic and the condition of the site location.

- For example, case studies which present problems in which political, technical, and economical solutions are needed.

- Efficient operation of power plants.

- Global uniform regulations for pollution control. Hard economics on CCT proven technology.

- Criteria for selection of appropriate advanced CCT.

- Coal sampling and analysis, coal preparation and beneficiation, pulverization, combustion technology, ash handling and disposal.

- The experience to set a coal-fired power plant, environmental assessment, capital investment, operational and maintenance cost.

- The following topics should be included: 1) the economies and financial analysis, 2) transportation, handling and distribution of coal, and 3) selecting of coal for CCT power plant.

- Topics that received the most attention at the seminar in Thailand.

- Course might include: (i) an introduction to CCTs (technical description, efficiencies and costs); (ii) review evaluation techniques for CCTs; (iii) one or more case studies of CCTs, (iv) evaluation of CCT options using computer models; and (v) policy issues related to the selection of CCTs.

Summary

The training course should include analysis of CCTs from the perspectives of costs, efficiencies, and environmental performance. A number of other topics were suggested.

2. **How much of the Training Course should be technical discussions, how much on economic and policy issues, and how much work with computer models?**

- The course needs to be practically oriented, with participants engaging in analysis and interpretation, including use of computer modeling. A 25:25:50 split between technical discussions, economic/policy issues, and analysis (including computer modeling) may be appropriate.

- Depends on what the purpose of the course is and the audience it is designed for.

- Technical=50%, Economic=30% and Policy=20%

- Proper balance between these issues will be needed, even if policy issues are the most important. So far as computer models are concerned, it is difficult to make comments because we simply don't know what that would be.

- It is needed to separate issues needed to be covered.

- 30:30:30:10 (in order of the question)

- Mainly technical issues, but some economic and policy. Hands on computer model sounds useful as well.

- Three-quarters on technical and the rest on economic policy and computer modelling.

- 80% of technical discussions and 20% of computer models.

- Technical discussions and economic and policy issues should be equally discussed. The computer models should be held separately for specialists.

- 1/3 economic/policy issues and 2/3 technical (include computer in here as applicable.

- Approximately 50% technical and 50% economic and policy. Computer modelling activities (40-60%).

Summary

Training Course should have the heaviest emphasis on technical aspects of CCTs (at least 50%), but include economic and policy analysis. Computer model work recommended, but would not dominate the Course.

3. **Where should the training course be held. Would your organization be willing to host the Training Course? Do you have a preference for the Training Course dates?**

- An Asian location is considered appropriate for the Training Course.

- No preference for location or timing but keep in mind a training course could be given more than once and in various locations if there is a demand.

- We prefer the Training Course will be held in USA or Japan and the preference dates are around August.

- We haven't had any specific idea about the location yet at this moment.

- In a country (developing) which is going to have a major need for CCT in medium term.

- We do not have coal training facility. No preferential date.

- Coal export members are suggested. The agenda for four days including one day field trip is recommended.

- The Training Course should be held in the country which CCT's has successfully established for example in the U.S.A. NEPO is not ready to host the Training Course.

- Suggest Brisbane, Australia October 9-12, 1994 is 10th Triennial ICCR Conference; Richard Lawson is chair. Good to connect with this high level group from 15 countries.

- The Training Course can be successfully held in any APEC economy that wants to sponsor the course. However, it will be easier to hold the first course in one of the industrialized economies where there will be greater access to expertise and computing facilities.

Summary

No consensus among recommended locations. At the September APEC meeting, Australia tentatively offered to host the Training Course.

4. How should speakers/teachers be selected for the Training Course?

- Speakers/teachers should be professional lecturers with proven experience in industry/policy work or industry professional experienced in teaching or training.
- There is a need to ensure that the courses are not biased towards science or a particular technology, yet technologically oriented to addressing and analyzing the economic and policy issues involved.
- You will always be trying to get knowledgeable people in the subject area to provide the training. Depending on the subject, the training source may be obvious. We may decide to give a course which has already been prepared and tested by someone. Consideration may have to be given to dividing the course among various economies although this may not always be practicable.
- Full experience in the application.
- Policy issues - government officials (both central and local), University Professors.
- Technical/economic issues - engineers from enterprises and economists who are interested in technology and environment.
- Instead of professors, field engineers are good to share their experiences.
- Policy makers and implementors of CCT.
- Selected by a steering committee to cover the objectives of the course.
- From a mix of academic and experienced plant operators.
- Qualified shift supervisors, plant managers, equipment designers as well as local commissioner.
- The speakers/teachers should be directly involved in practicing the technologies and should come from various countries in order to share their experiences.
- Selected by host.
- Members of the steering committee should assist in putting together a list of potential speakers/teachers. It is essential that speaker/teachers have considerable experience in training. There is no set number but a suitable mix for a one to two week course: 2-4 engineers, 2 economists, 1 computer specialist, 1-2 government policy persons; total 6-9 lectures. At least three lecturers should have experience working with CCT technologies.

Summary

Speakers/teachers should be professionals that understand the subject area and are experienced in training.

5. **What types of people (policy, engineers, economists, etc.) should participate in the Training Course? Should the Training Course focus on a particular group?**

- A focus on a particular group is not warranted.
- Depends on the topic and audience identified.
- Engineers are more dominant.
- Young government officials (central and local) and engineers of energy related industries.
- Training course should focus on a particular group.
- All types. Focus on industries or users.
- Mainly engineers, but could include policy and economic people.
- Operating engineers and planners.
- Engineers are recommended.
- The people concerned: policy makers, engineers, economists and environmentalists should participate in the Training Course. The Training Course should focus on the policy makers and economists.
- Could have one topic focus. Could hold one with multiple focuses to include all interests.
- The focus should change from year to year in response to the needs of the user group. The first Training Course should have a goal to provide a solid understanding of the basic techniques of evaluating CCTs, and include some hands on computer experience.

Summary

A range of groups were suggested, with engineers and policy people mentioned most often.

6. **Should the Training Course include a field trip in the host country?**

- Yes. Field trips should be related to a technology demonstration in the host country or issues facing the host country.
- Yes, if relevant.
- Yes. One day trip for comparative study.
- Yes. Site visits would be useful to know actually what CCTs are.
- Yes.
- Yes. Visit an established CCT user and nonuser.
- Yes.
- Yes. Visit to plant as well as short attachments.
- Yes. It would be better to select two sites with same capacity, the old plant retrofits to meet air quality regulation as the new plant.
- Yes. The field trip in the host country is an essential part of the seminar. The participants will have a chance to see the application of the technology.
- Yes, if directly relates to the topic of the Training Course.
- Yes. Visit to a related CCT facility. Need to take into consideration in selecting the location for the Training Course.

Summary

Yes (unanimous)

7. **Other suggestions that will help make the Training Course a success?**

- Preparation of a manual, including lectures, inclusion of case studies, and greater emphasis on hands-on analysis of issues rather than lecturing.
- Course duration will be important in that it must provide enough training time but too long a course limit participation. We will need some feedback on this from the Asian economies.
- A relatively short-term course would be better to start with. Two weeks is adequate.
- Focus.
- Advantages in running it after the seminar. Selection of technology based on coal quality.
- Designate an experienced engineer in the plant to impart his knowledge on operation and maintenance of the coal aspects of the plant to the trainees.
- The last day of the Training course should have the attendants present the assigned works with separated groups.
- The Training Course should be arranged by professionals to ensure the success of the Training Course. The financial support for the Training Course should come from public and private organizations other than APEC Secretariat and the reimbursement budget should be flexible.
- Check calendar of events and set in conjunction with other meetings: before or after; not in conflict with.
- Because most participants will not have time to read the materials prior to the course, the first day could be set aside to read the materials. From the readings, each participant should provide a check list of the items of greatest interest.

Summary

Suggestions varied: prepare a manual; include case studies; duration two weeks or less; have assignments for participants.

LONGER TERM PROGRAM PROPOSALS
1995-1996

1. Activities other than Technical Seminars or Training Courses?

- Coal/CCT information brochures (for dissemination to the public), studies on coal/CCT use in the region (e.g., update of the October 1992 report, up-take of specific CCTs in the region, etc.), and country specific coal/CCT studies (if desired by one or more APEC economies).

- Technical tours of technology producing countries.

- There will be an ongoing need to have coal supply/demand information and to keep abreast of technology implementation/costs, power plant development, and environmental energy policy requirements in the various economies. To this end, reports similar to our last report providing country specific information should be an ongoing part of the work plan.

- We could include an information exchange as part of the Experts' Group meetings.

- To establish CCT data base center.

- There will be themes for study and analysis which have common interest to APEC economies. The steering committee is hoped to identify such themes.

- Forum and invite non-APEC countries. Form a team that can assist in specific problems on a costs basis, i.e., nonprofit making. Form a study group to look at new CCT and submit input.

- A study group to consider financial and political barriers to advanced CCT use.

- A newsletter to keep members informed.

- Exchange of researchers and engineers in short-term (one to three months). consultant or joint venture program with industrialized members commercialized technologies exhibition.

- The information network concerning the progress of Clean Coal Technologies should be installed to ensure that members can follow the advancement of these technologies. The publicity of the technology should be encouraged for the acceptance of the public at large.

2. Technical Seminars - Post 1994

(a) What topics and emphasis should be included in the Technical Seminars?

- See answers to 1994 Technical Seminar.

- In addition to combustion technologies/economics, courses or seminars could also focus on specific topics such as mining techniques, processing blending, energy policies, pricing and environmental policies/regulations. They could also focus on specific environmental topics such as options for reducing SO_2 emissions and cover both the technological and policy options.

- Canada would be willing to host a seminar as early as the fall of 1995, possibly prior to or following the Coal Association of Canada's biennial conference. Although open to suggestions, the seminar could focus on environmental policies that impact technology choices associated with coal mining operations and combustion, and the processes used to develop these policies in the various APEC economies. The linkages could be made between policy development and the requirements for future technology development. In conjunction with the seminar, technical visits to mines/power plants could be arranged. For this purpose and considering travel distances, the most suitable location would be western Canada, possibly the Jasper-Edmonton area.

- A development of CCT.

- Policy issues concerning coal and the environment. (Pollution and damage, environmental standards and countermeasures, and technology options).

- General or global regulations for CCT that require to be adopted by all countries that is fair for all.

- Too early to decide.

- Developing CCT Technologies and time frame to commercialization.

- NOx reduction to 50 ppm, what types of technical combination is more cost effective. CO_2 reduction, the effect of economic growing and controlled technologies.

- The application of CCT in sectors other than power.

3. Training Courses - Post 1994

(a) What topics and emphasis should be included in the Training Course?

- See answers to 1994 Training Course.
- See seminar topics.
- Emission Control Management.
- If not immediately, Japan will be one of the countries to host a training course in the future. We would like to learn about the experience of other countries who have offered training courses.
- Role of developed countries in assisting developing countries in implementing CCT.
- Too early to decide.
- Besides technical topics, the Training Course can cover economic, regulatory and planning issues.
- How to regulate a reasonable emission standard among developing, nearly industrialized members? The effect of regulations on the industry and how to deal with?
- Utilization of ash from coal fired power plant.

Section 6

Subtask F -- China Focus

China Focus

The Coal Project has been giving greater attention to energy and environmental developments in China because this is considered the largest long term market for CCTs. China is by far the most complex market to assess, due to the wide range of institutions involved in power developments and conflicting policy statements on the terms and conditions for foreign investment in China.

Three key institutions involved in power plant planning and CCTs are:

(1) The State Planning Commission is the highest level planning organization in China. It is responsible for China's five-year economic plan, and is responsible for allocating funds for major projects, including power plants. The role in funding projects is changing with the establishment of the State Development Bank of China. Minister: Chen Jinhua.

(2) The Ministry of Electric Power is the highest level government organization responsible for formulating and implementing electricity policies. It reports directly to the State Council. The Ministry of Electric Power and the State Planning Commission work together to guide power plant developments. Minister: Shi Dazhen. The provincial power groups -- some of which are quite powerful(i.e. Guangdong Power Company) fall under the jurisdiction of the Ministry of Electric Power.

(3) The State Science and Technology Commission is involved in long-term technology planning. Minister: Dr. Song Jian. In charge of CCT: Mr. Shi Dinghuan, Director General, Department of Industrial Science and Technology.

In addition to those listed above, there are at least twenty other institutions involved in various aspects of CCT research in China. The main academic research institution in China is Tsinghua University -- China's equivalent of MIT in the United States. Clean Coal Technology researchers from the State Science and Technology Commission and Tsinghua University spent approximately one month at the East-West Center. See the Briefing Paper under Subtask B.

AIIM

Association for Information and Image Management
1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202

Centimeter

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 mm

1 2 3 4 5

Inches

1.0 1.1 1.25 1.4 1.6 1.8 2.0 2.2 2.5 2.8 3.2 3.6 4.0 4.5 5.0 5.6 6.3

In addition to meeting with officials from the above-mentioned institutions, meetings were held with Qu Geping, Chairman of the Environmental Protection Committee, National People's Congress. There is considerable awareness of environmental problems in China. However, the environmental movement and related institutions are still relatively weak.

QUARTER TECHNICAL PROGRESS REPORT
FOR THE OFFICE OF FOSSIL ENERGY, US DOE

Contractor:	East-West Center
Grant Number:	DE-FG03-89FE61811
Services:	Potential for Thermal Coal and Clean Coal Technology (CCT) Export in the Asia-Pacific
Period:	1st Quarter, 1993 (January-March)
Co-Principal Investigators:	Charles J. Johnson and Fereidun Fesharaki

OBJECTIVES OF THE CONTRACT

The overall purpose of this contract is to provide general support and advice to the Department of Energy, Office of Fossil Energy (DOE/FE) on likely thermal coal and Clean Coal Technology trading opportunities in the Asia-Pacific region. The primary objectives of the contract are to:

a)Identify the qualitative and quantitative supply and demand constraints and trends in the trade of thermal coal in the Asia-Pacific region.

b)Assess the U.S. competitive position in thermal coal trade and identify potential impacts on and opportunities for U.S. Clean Coal Technology exports.

c)Function as a catalyst for U.S. industry and government representatives to access high level planning and decision-making authorities from Asia-Pacific countries that have or are likely to have an interest in thermal coal and/or Clean Coal Technologies.

SUMMARY OF QUARTER ACTIVITIES AND PRODUCTS

(1) A series of brief overviews of the coal, electricity, and technology situations in the Asia-Pacific region was completed and distributed to DOE and to Asian contacts. These Information sheets were designed to give planners and policy makers a quick reference and update of important trends affecting the coal and technology markets in the region.

(2) The EWC Coal project was responsible for coordinating the Asia-Pacific Economic Cooperation Steering Committee meeting held in Bangkok, Thailand in February 1993. The main purpose of the meeting was to finalize plans for the APEC Seminar on CCTs. It was agreed at this meeting that Thailand would host the seminar, and that it would be held on September 6-10, 1993. The stated purpose of the seminar was to provide accurate technical and economic information to those interested in Clean Coal Technologies.

(3) A preliminary Agenda was prepared for the APEC Technical seminar in Thailand, and economies were asked to provide a list of potential experts from their respective economies to prepare papers to be presented at the seminar.

(4) The *Asia-Pacific Coal News Biannual Summary and Outlook* for July 1992 through December 1992 was completed and distributed to DOE and throughout Asia. The summary outlined major developments in coal, technology and coal-related news occurring in the second half of 1992.

QUARTER TECHNICAL PROGRESS REPORT
FOR THE OFFICE OF FOSSIL ENERGY, US DOE

Contractor:	East-West Center
Grant Number:	DE-FG03-89FE61811
Services:	Potential for Thermal Coal and Clean Coal Technology (CCT) Export in the Asia-Pacific
Period:	2nd Quarter, 1993 (April-June)
Co-Principal Investigators:	Charles J. Johnson and Fereidun Fesharaki

OBJECTIVES OF THE CONTRACT

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SUMMARY OF QUARTER ACTIVITIES AND PRODUCTS

(1) Prospective authors recommended by APEC representatives from a number of the APEC member economies were invited to attend the APEC Technical Seminar in Thailand. A preliminary list of participants and presenters for the Seminar was completed. Sample tables, figures and headings were sent to each prospective author as guidelines in order to ensure a standardized format.

(2) Work began on the *Asia-Pacific Coal News Biannual Summary and Outlook* for January through June 1993. The biannual summary series outlines the most recent trends in coal, electricity and technology issues in the Asia-Pacific region.

(3) Briefings on China power and CCT opportunities were held at the Department of Energy in Washington, D.C.. In addtion, East-West Center briefings on energy and environmental problems in China were made to staff of the U.S. Congress in a U.S. Senate Hearing room.

(4) Research on China energy problems was expanded to include a review of key Chinese language publications.

QUARTER TECHNICAL PROGRESS REPORT FOR THE OFFICE OF FOSSIL ENERGY, US DOE

Contractor:	East-West Center
Grant Number:	DE-FG03-89FE61811
Services:	Potential for Thermal Coal and Clean Coal Technology (CCT) Export in the Asia-Pacific
Period:	3rd Quarter, 1993 (July-September)
Co-Principal Investigators:	Charles J. Johnson and Fereidun Fesharaki

OBJECTIVES OF THE CONTRACT

The overall purpose of this contract is to provide general support and advice to the Department of Energy, Office of Fossil Energy (DOE/FE) on likely thermal coal and Clean Coal Technology trading opportunities in the Asia-Pacific region. The primary objectives of the contract are to:

a)Identify the qualitative and quantitative supply and demand constraints and trends in the trade of thermal coal in the Asia-Pacific region.

b)Assess the U.S. competitive position in thermal coal trade and identify potential impacts on and opportunities for U.S. Clean Coal Technology exports.

c)Function as a catalyst for U.S. industry and government representatives to access high level planning and decision-making authorities from Asia-Pacific countries that have or are likely to have an interest in thermal coal and/or Clean Coal Technologies.

SUMMARY OF QUARTER ACTIVITIES AND PRODUCTS

(1) The papers written for presentation at the APEC Technical Seminar in Thailand were received at the East-West Center. The papers which needed pre-conference editing were retyped and edited prior to the Seminar.

(2) The EWC Coal Project, together with the National Energy Policy Office of Thailand, coordinated the September APEC Technical Seminar in Thailand. Each participant was given a spiral bound copy of the proceedings of the Seminar and will receive a higher quality bound copy of the proceedings in late December, 1993.

(3) Post-conference editing of all papers submitted for the APEC Technical Seminar was begun.

(4) The *Asia-Pacific Coal News Biannual Summary and Outlook* for January 1993 through June 1993 was completed and distributed. The summary outlined major developments in coal, technology and coal-related news occurring in the first half of 1993.

(5) Detailed discussions were held with Thai officials about the extent of coal related environmental problems in Thailand, and about options for addressing these problems. As a result of these meetings and ongoing research on energy alternatives(future gas imports from Myanmar, Cambodia and Vietnam and electricity imports from Laos), coal imports to Thailand are expected to be less than previously projected by the Electricity Generating Authority of Thailand.

QUARTER TECHNICAL PROGRESS REPORT FOR THE OFFICE OF FOSSIL ENERGY, US DOE

Contractor:	East-West Center
Grant Number:	DE-FG03-89FE61811
Services:	Potential for Thermal Coal and Clean Coal Technology (CCT) Export in the Asia-Pacific
Period:	4th Quarter, 1993 (October-December)
Co-Principal Investigators:	Charles J. Johnson and Fereidun Fesharaki

OBJECTIVES OF THE CONTRACT

The overall purpose of this contract is to provide general support and advice to the Department of Energy, Office of Fossil Energy (DOE/FE) on likely thermal coal and Clean Coal Technology trading opportunities in the Asia-Pacific region. The primary objectives of the contract are to:

a)Identify the qualitative and quantitative supply and demand constraints and trends in the trade of thermal coal in the Asia-Pacific region.

b)Assess the U.S. competitive position in thermal coal trade and identify potential impacts on and opportunities for U.S. Clean Coal Technology exports.

c)Function as a catalyst for U.S. industry and government representatives to access high level planning and decision-making authorities from Asia-Pacific countries that have or are likely to have an interest in thermal coal and/or Clean Coal Technologies.

SUMMARY OF QUARTER ACTIVITIES AND PRODUCTS

(1) Editing was completed on papers presented at the September APEC Technical Seminar held in Thailand. The papers were retyped and reformatted in order to acheive a consistent set of chapters to insert into a bound Seminar proceedings volume. A total of 225 volumes were completed and distributed in lateDecember and January.

(2) A questionnaire designed to gauge APEC member economy opinions on future APEC Experts' Group on Clean Coal Technology activities was created by the Department of Energy and the EWC Coal Project. The questionnaire results were compiled, analyzed and presented to a small group of APEC Experts' Group members in December (described below). The questionnaire results will be presented to the entire Experts' Group in February.

(3) A coordinating meeting of the APEC Experts' Group on Clean Coal Technology, hosted by the EWC Coal Project, was held at the East-West Center on December 8 & 9, 1993. The purpose of the meeting was to direct future Experts' Group activities and to coordinate the transfer of a $500,000 contribution from the Japanese Government through the New Energy and Industrial Technolgy Development Organization to the East-West Center Coal Project which will be responsible for administration of the contribution. Results of an APEC activities questionnaire were reviewed and sites were discussed for a Technical Seminar and a Training Course in late 1994.

QUARTER TECHNICAL PROGRESS REPORT FOR THE OFFICE OF FOSSIL ENERGY, US DOE

Contractor:	East-West Center
Grant Number:	DE-FG03-89FE61811
Services:	Potential for Thermal Coal and Clean Coal Technology (CCT) Export in the Asia-Pacific
Period:	No Cost Contract Extension (January-May 1994)
Co-Principal Investigators:	Charles J. Johnson and Fereidun Fesharaki

OBJECTIVES OF THE CONTRACT

The overall purpose of this contract is to provide general support and advice to the Department of Energy, Office of Fossil Energy (DOE/FE) on likely thermal coal and Clean Coal Technology trading opportunities in the Asia-Pacific region. The primary objectives of the contract are to:

a)Identify the qualitative and quantitative supply and demand constraints and trends in the trade of thermal coal in the Asia-Pacific region.

b)Assess the U.S. competitive position in thermal coal trade and identify potential impacts on and opportunities for U.S. Clean Coal Technology exports.

c)Function as a catalyst for U.S. industry and government representatives to access high level planning and decision-making authorities from Asia-Pacific countries that have or are likely to have an interest in thermal coal and/or Clean Coal Technologies.

SUMMARY OF QUARTER ACTIVITIES AND PRODUCTS

(1) An APEC Experts' Group on Clean Coal Technologies meeting was held February in Indonesia. The purpose of the meeting was to finalize plans for the $500,000 NEDO contribution to the Experts' Group which is to be administered by the EWC. Also, budgeting and planning for the upcoming Technical Seminar in Indonesia and the Training Course in Sydney Australia was discussed. The results of an APEC Activities Questionnaire were further reviewed to aid the group in planning for the Seminar, Training Course and future Experts' Group activities.

(2) Charles Johnson and Binsheng Li participated in the AIC *Power Generation in China* Conference held in Atlanta on March 23-25 where a paper entitled *China's Booming Electricity Sector: The opportunities and Challenges* was presented. The paper outlined the electricity and Clean Coal Technology situations in China as well as opportunities for US investors in these sectors. Discussions were held with senior Chinese officials about the power sector of China, particularly with respect to the range of problems delaying power plant expansions.

(3) The Coal Project participated in a series of briefings held at the Metropolitan Club, and Johns Hopkins in Washington D.C. and the Council on Foreign Relations in New York City in late April. Presentations were given on coal and Clean Coal Technology issues in China. In addition, Coal Project staff participated in round table discussions on China's energy sector at the Aspen Institute.

(4) The last of the APEC Experts' Group on Clean Coal Technology Technical Seminar proceedings were mailed to Seminar participants, Experts' Group members, Energy Official Group members, and other APEC members in January 1994. Extra copies were sent to the APEC Secretariat in Singapore.

(5) Meetings were held with senior officials of China's Environmental Protection Agency on coal related environmental problems. Meetings wre also held with executives from major U.S. and Japanese energy corporations.

QUARTER TECHNICAL PROGRESS REPORT
FOR THE OFFICE OF FOSSIL ENERGY, US DOE

Contractor:	East-West Center
Grant Number:	DE-FG03-89FE61811
Services:	Potential for Thermal Coal and Clean Coal Technology (CCT) Export in the Asia-Pacific
Period:	June-July 1994
Co-Principal Investigators:	Charles J. Johnson and Fereidun Fesharaki

OBJECTIVES OF THE CONTRACT

The overall purpose of this contract is to provide general support and advice to the Department of Energy, Office of Fossil Energy (DOE/FE) on likely thermal coal and Clean Coal Technology trading opportunities in the Asia-Pacific region. The primary objectives of the contract are to:

a)Identify the qualitative and quantitative supply and demand constraints and trends in the trade of thermal coal in the Asia-Pacific region.

b)Assess the U.S. competitive position in thermal coal trade and identify potential impacts on and opportunities for U.S. Clean Coal Technology exports.

c)Function as a catalyst for U.S. industry and government representatives to access high level planning and decision-making authorities from Asia-Pacific countries that have or are likely to have an interest in thermal coal and/or Clean Coal Technologies.

SUMMARY OF QUARTER ACTIVITIES AND PRODUCTS

(1) Preparations commenced for the APEC Experts Group on Clean Coal Technology's Technical Seminar to be held in Indonesia October 10-14, 1994. Coal Project staff began pre-conference editing of the papers.

(2) A review of Japan's export program on Clean Coal Technology was carried out in June.

(3) The China energy database is being updated to include regional energy data. In addtion, a file is being developed on organizational responsibilities in China with respect to the power sector.

DATE
FILMED
9/23/94

END