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Final Technical Report

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Thermal Coal Requirements and Prospects for Clean Coal Technologies in the Asia-Pacific Region

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Charles J. Johnson
Coal and Environment Project

East-West Center
1601 East-West Road
Honolulu, Hawaii 96848

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Introduction

The overall goal of the Cooperative Agreement (October 1994 to September 1997) was to provide general support and advice to the U.S. Department of Energy, Office of Fossil Energy (DOE/FE) on the likely opportunities for U.S. coal trade and potential for U.S. Clean Coal Technologies in the Asia-Pacific Region.

Over the three year Cooperative Agreement, assistance evolved toward greater emphasis on support for the U.S. Department of Energy's role as chair of the *Asia-Pacific Economic Cooperation's (APEC) Experts' Group on Clean Fossil Energy*. Responsibilities included assistance in arranging for all Technical Seminars, technical papers for these seminars and final editing, publishing and distribution of 500 copies of the proceedings. In addition, the East-West Center was called upon to host annual APEC Subcommittee Meetings, and periodic ad hoc planning meetings. The East-West Center played an active role in working with counterpart APEC and energy policy people throughout Asia, and advising the U.S. Department of Energy on options to enhance energy and Clean Coal Technology cooperation with various Asian nations, particularly People's Republic of China (hereafter China) Towards the end of the Cooperative Agreement, increased emphasis was placed on the potential for gas fuels in Asian markets (natural gas, coalbed methane and gasification of coal).

Much of the research on Asian coal and Clean Coal Technology in the Coal and Environment Project of the East-West Center, was partially supported by this Cooperative Agreement, both directly through support of research activities, and in use of the data and analyses resulting from the Cooperative Agreement.

Summary of Major Findings

- The APEC Experts' Group on Clean Fossil Energy has produced more major publications than any other APEC experts group. This group is the leading group within APEC in addressing the advanced technology and fuel options to meet the twin needs of increased energy consumption in Asia and reduced emissions that damage the local, regional and global environment. The U.S. role in chairing this APEC experts group has

been essential to balancing different views among member APEC economies, and promoting cooperation on important clean fossil energy issues.

- Research under this Cooperative Agreement showed that the growth in coal consumption in Asia is slowing, however coal consumption is still expected to double by 2020. Coal consumption in Asia is projected to grow at between 2.3 and 3.3 percent per year to 2020. Consequently, environmental problems in Asia will become much more severe in the early part of the 21st Century, unless there is increased efforts to introduce Clean Coal Technologies along with substitution of cleaner gaseous fuels where these are competitively available.

- During the 1990s, all APEC Asian economies, including China, have tightened their emissions legislation pertaining to coal use in power plants. By 2000, a substantial share of new coal-fired power plants in most Asian economies will include SO_2 control technologies. In the largest coal consuming economy, China, SO_2 control technology is expected to be more gradually introduced, first in the most polluted, heavily populated areas, and in richer coastal provinces. However, expanded use of low sulfur coal, as has occurred in the U.S., will also play a prominent role in China in the future. New power plants in China are required to include SO_2 control technologies if they plan to burn coal with above 1.0 percent sulfur content. More stringent local regulations exist in numerous areas of China. The issue of lack of effective enforcement of emissions regulations will remain a problem for many years in a number of developing Asian economies.

- The outlook for U.S. coal exports to Asia is for a continued decline in the share of coal from the United States. Changes in coal quality requirements in the steel industry, and the rapid expansion of lower cost thermal and metallurgical coal supplies from Australia, Indonesia and to a lessor extent China have increasingly made U.S. coal exports not competitive in Asia. There are no indications that this trend will be reversed, except during short term. The key problem faced by U.S. coal exporters is the cost disadvantage resulting from the long transport distances to Asian markets.

- The potential is promising for U.S. technology exports to Asia's rapidly growing power industry. However, competition for power plant equipment supplies is intense, and concessional financing arrangements by other governments is a continued threat to US technology export competitiveness in Asia. In addition, in the longer term, a strong equipment manufacturing industry will emerge in Asia, capable of supplying advanced power plant technologies. Such a capacity already exists in Japan, but other Asian economies, including China, are improving their manufacturing capability.

- Our 1995 investment survey of foreign companies involved in the power sector in Asia provided useful insights into market opportunities for Clean Coal Technologies, and perceived risks to investors. The two largest potential markets for Clean Coal Technologies, China and India, received relatively low ratings for their "investment climates" -- an indication of the need to improve the investment terms in these economies. Selected problems, contributing to the 1997-1998 economic crisis in Asia were revealed in the 1995 survey, but no company accurately predicted that a crisis was eminent. However, the survey results for both Indonesia and Thailand were anomalous in having expected returns on investments that were above realistic expectations.

- The largest polluter in Asia for coal related SO_2 is China, which accounts for 63-68 percent of Asia's total emissions. The range of estimates is due to considerable differences in estimates of emissions for China. With China likely to double coal consumption by about 2015, acid rain problems will become much more severe unless SO_2 control technologies are introduced aggressively, along with substitution of cleaner fuels (lower sulfur coal and natural gas).

- The potential long term role of coal-gasification in China is the largest in the world. China has limited reserves and resources of oil and natural gas, but very large reserves of coal. The government is quite concerned about growing oil imports, and has a policy to promote gasification of coal. China already has about 23 Texaco gasification plants for the manufacture of chemicals. The government has been interested in a demonstration IGCC plant since the early-1990s, and was disappointed when the U.S. government halted plans to (partially) support a

demonstration IGCC plant. Even without U.S. government, China is likely to proceed with the development of an IGCC facility within a decade. There appear to be considerable potential benefits to both China and the U.S energy relations in cooperation to build and operate a demonstration IGCC plant in China.

- China is the most important Asian economy needing U.S. department of Energy assistance in introducing advanced Clean Coal technologies over the next decade. In addition, China is the fastest growing producer of greenhouse gases among major economies of the world. There is a need to support research and cooperation in China to evaluate options for reducing the rate of growth in greenhouse gases.

- The U.S. is the world leader in commercial recovery of coalbed methane. China is known to have large coalbed methane resources, but limited commercial development. Some estimates place China's recoverable coalbed methane at more than their total recoverable natural gas reserves. Preliminary investigations into markets for coalbed methane in China show that consumers are likely to be willing to pay prices that could support a viable coalbed methane industry in China. The present modest level of U.S. - China cooperation needs to be expanded and developed into an integrated long term coalbed methane assistance program for China. The greenhouse gas benefits and opportunities for U.S. investors justify an expanded program of cooperation.

- The information on the quality and quantity of coal and natural gas reserves and resources in Asia varies widely between economies, and is in need of revision. A key problem is that technical estimates by geologists often do not account for location and market factors which determine whether deposits should be classified as reserves. Second, exploration has been biased toward oil and not natural gas in a number of Asian economies, particularly China -- therefore the potential appears to be underestimated. The situation with coal reserves is also of concern, with reserves estimates that are widely divergent from the probable size of economic deposits in some economies. These deficiencies in data contribute to greater uncertainty in estimating the future energy mix in Asia, investment opportunities, and environmental impacts of future energy use.

Attached Publications

The papers and reports included in this final report were either directly funded (in part), under this Cooperative Agreement or were heavily based on data and analyses produced under this Cooperative Agreement. All reports listed on the Contents page, are in this report with the exception of the 300 plus page China Power Report which is bound as a separate volume.

It is important to note that the views in the attached reports are those of the authors, and do not necessarily reflect the views of the U.S. Department of Energy

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conf papers cycled separately.

- **"Outlook and Challenges to Coal in Asia: 1994-2015,"** by Charles J. Johnson and Binsheng Li, presented at JAPAC International Symposium "Coal Flow '96" The Role of Coal in the 21st Century—Over the Uncertainty," held February 8-9, 1996 in Tokyo, Japan. conf paper cycled separately. Section 9
- **"Indonesian Energy Outlook: Coal and Electricity Focus,"** by the Coal Project, Program on Resources: Energy and Minerals, East-West Center, June 1995. cycled separately as DOE/FE/63313--T - Pt. 2 Section 10
- **"1995 Asia Investment Survey: Coal, Private Power, and Technology,"** by Charles J. Johnson and Binsheng Li, Coal Project, Program on Resources: Energy and Minerals, June 1995. DOE/FE/63313--T -Pt.3 Section 11
- **"China's Current Anti-Inflation Measures is Nurturing an Electricity Supply Crisis,"** by Binsheng Li and Charles J. Johnson, Program on Resources: Energy and Minerals, East-West Center, June 1995. DOE/FE/63313--T -Pt.4 Section 12
- **"South Korean Energy Outlook: Coal and Electricity Focus,"** by the Coal Project, Program on Resources: Energy and Minerals, East-West Center, March 1995. DOE/FE/63313--T -Pt.5 Section 13
- **"Environmental and Economic Challenges to Coal's Future in China,"** by Charles J. Johnson and Binsheng Li, presented at AIC China Power Conference, November 8-10, 1994. conf paper cycled separately. Section 14
- **"APEC Trends in Coal and Clean Coal Technologies,"** presented by Charles J. Johnson to the APEC Experts' Group on Clean Coal Technology, October 11-13, 1994, Jakarta, Indonesia and published in its Proceedings, pages 27-40. conf reprint removed. Section 15
- **"Role of Coal in the World and Asia,"** by Charles J. Johnson and Binsheng Li, presented at the First APEC Coal Flow Seminar, October 4-6, 1994, Tokyo, Japan. Section 16
- **"Challenging Opportunities in China's Power Sector,"** by Charles J. Johnson and Binsheng Li, published in *World Coal*, October 1994, p. 18-29. reprint removed Section 17
- **"China's Macro Economic Trends and Power Industry Structure,"** by Binsheng Li, Charles J. Johnson and Ronald Hagen, September 1994. DOE/FE/63313--T -Pt.6 Section 18
- **"Hong Kong's Macro Economic Trends and Power Industry Structure,"** by Binsheng Li, Charles J. Johnson and Ronald Hagen, September 1994. DOE/FE/63313--T -Pt.7 Section 19
- **"China's Clean Coal Technology Program,"** China Energy Research Society, Sponsored by the State science and Technology Commission and the State Economic and Trade Commission,, translated by Binsheng Li, East-West Center, June 1994. DOE/FE/63313--T -Pt.8 Section 20