CONF-891185
Dist. Category UC-101

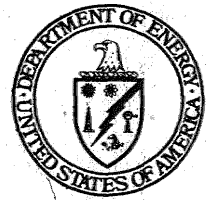
The Asia-Pacific Coal Technology Conference

November 15-16, 1989
East-West Center
Honolulu, Hawaii

Sponsored by:
Resource Systems Institute East-West Center
and
U.S. Department of Energy
Assistant Secretary for Fossil Energy
Washington, DC 20585

Under Grant No. DE-FG03-89FE61811

February 1990



DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Program Agenda
ASIA-PACIFIC COAL TECHNOLOGY CONFERENCE
Hawaii Imin International Conference Center at Jefferson Hall
East-West Center, Honolulu, Hawaii
November 14-16, 19819

TUESDAY, NOVEMBER 14, 1989

5:30 - 7:00 pm **Welcoming Reception,** Jefferson Hall Lanai

WEDNESDAY, NOVEMBER 15, 1989--Keoni Auditorium, Jefferson Hall

8:00-9:00 **Registration, Coffee, Tea & Pastries**

Morning Session

9:00-9:30 **Opening Remarks** Ms. Denise Swink, Director, Office of Planning and Environment, Office of Fossil Energy, U.S. Department of Energy--**Conference Co-Chairperson**

Dr. Fereidun Fesharaki, Energy Program Leader, East-West Center--**Conference Co-Chairperson**

9:30-10:00 **Keynote Address: Expanded Horizons for U.S. Coal Technology and Coal Trade**
Ms. Denise Swink

10:00-10:30 **Photo Session**--outside of Jefferson Hall
Coffee Break

10:30-12:30 **Overview of the Asia-Pacific Energy Outlook**
Dr. Fereidun Fesharaki

Asian Presentations I

Chairperson: Dr. Kuntoro Mangkusubroto, President Director
PT. Tambang Batubara Bakit Asam, Jakarta, Indonesia

Taiwan Presentation
Mr. Si-Min Chang, President
Taiwan Power Company

Future Coal-Fired Generation and Capacity Requirements of the Philippines
Mr. Ernesto Aboitiz, President
The Philippine National Power Corporation

Korean Presentation
Mr. Kun Jeong, General Manager of Electricity Economics Department, Korean Electric Power Corporation

Hong Kong Future Coal Requirements
Mr. Howard Au, Fuel Supply Engineer
China Light & Power Company, Limited

12:30-2:00 **Luncheon--University of Hawaii Campus Ballroom**
Video messages from U.S. Senator Frank Murkowski (R-AK), U.S. Senator Mitch McConnell (R-KY), and Representative Ralph Regula (R-OH)

Afternoon Session

2:00-3:30 **Asian Presentations II**

Chairperson: Mr. Wenceslao R. De La Paz, Executive Director, Office of Energy Affairs, Office of the President of the Republic of the Philippines

Indonesian Presentation
Mr. Aloysius Andoyo, Director, Electric Power Planning and Development, Ministry of Mines and Energy

Electric Power System in Thailand
Mr. Charmon Suthiphongchai, Deputy General Manager, Thermal Power and Mine Development, Electricity Generating Authority of Thailand

Coal in Malaysia - A Position Paper
Mr. Mohd Ariffin bin Abdul Rahman, Deputy General Manager, Corporate Planning, National Electricity Board of the States of Malaysia

3:30-3:45 **Break**

3:45-4:15 **The U.S. and Asia: Pacific Partners in Coal and Coal Technology**
Mr. Thad Grundy Jr., Deputy Assistant Secretary for International Affairs, U.S. Department of Energy

4:15-5:15 **U.S. Presentations**

Chairperson: Dr. Tony Churchill, Director, Energy & Industry
The World Bank

U.S. Coal Production and Export
Mr. Alan M. Dunn, Deputy Assistant Secretary for Basic Industry, International Trade Authority, U.S. Department of Commerce

U.S. Clean Coal Technologies
Dr. E. Allen Womack, Vice President, Research and Development
Babcock & Wilcox

6:00-9:00 **Cocktail Reception**
Sponsored by Babcock and Wilcox

THURSDAY, NOVEMBER 16, 1989

8:00-8:30 **Coffee, Tea & Pastries**

Morning Session

8:30-10:00 **Developments in Coal Transport and Utilization**

Chairperson: Mr. James Heller, President, Fieldston Company, Inc.

Alternative/Innovative Transport
Introduction: Mr. Peter Cover, Program Manager, Coal & Technology Exports, Office of Planning & Environment, Office of Fossil Energy, U.S. Department of Energy
Mr. Geoff Uttmark, President, TransTech Marine Company and
Mr. Henry Brolick, Vice President, Williams Technologies, Incorporated

Electricity Generation in Asia and the Pacific: Power Sector Demand for Coal, Oil and Natural Gas
Dr. Hossein Razavi, Senior Energy Economist, Asian Region
The World Bank

10:00-10:30 **Break**

10:30-12:00 **Environmental Issues**

Chairperson: Dr. James Sullivan, Director, Office of Energy, U.S. Agency for International Development

Role of Clean Coal Technology in the Energy Future of the World
Mr. Jack Siegel, Deputy Assistant Secretary for Coal Technology, U.S. Department of Energy

Global Climate Change: A Fossil Energy Perspective
Mr. Robert Kane, Environmental Protection Specialist, Office of Planning & Environment, Office of Fossil Energy, U.S. Department of Energy

12:00-1:30 **Luncheon**--University of Hawaii Campus Ballroom

Speaker: The Role of Coal in Meeting Hawaii's Power Needs
Mr. Richard K. McQuain, Vice President, Engineering, Hawaiian Electric Company, Inc.

Afternoon Session

1:30-3:30 **Workshops on Critical Issues Associated with Coal Usage**

Chairpersons: Mr. Robert Lee Kessler
Western Coal Transportation Association

Dr. Manfred Raschke, President
International Strategic Information Service

Mr. Daniel Gerkin, Senior Vice President
National Coal Association

3:30-4:00 **Coffee Break**

4:00-5:00 **Workshop Summaries**
Mr. Morgan Greenwood, President, Williams Technologies, Inc.

5:00 **Closing Remarks by Conference Co-Chairpersons**

Adjournment

CONF-891185
Dist. Category UC-101

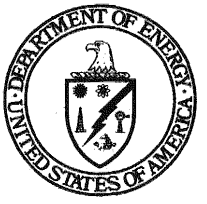
The Asia-Pacific Coal Technology Conference

November 15-16, 1989
East-West Center
Honolulu, Hawaii

Sponsored by:
Resource Systems Institute East-West Center
and
U.S. Department of Energy
Assistant Secretary for Fossil Energy
Washington, DC 20585

Under Grant No. DE-FG03-89FE61811

February 1990



DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED



Program Agenda
ASIA-PACIFIC COAL TECHNOLOGY CONFERENCE
Hawaii Imin International Conference Center at Jefferson Hall
East-West Center, Honolulu, Hawaii
November 14-16, 19819

TUESDAY, NOVEMBER 14, 1989

5:30 - 7:00 pm **Welcoming Reception,** Jefferson Hall Lanai

WEDNESDAY, NOVEMBER 15, 1989--Keoni Auditorium, Jefferson Hall

8:00-9:00 **Registration, Coffee, Tea & Pastries**

Morning Session

9:00-9:30 **Opening Remarks** Ms. Denise Swink, Director, Office of Planning and Environment, Office of Fossil Energy, U.S. Department of Energy--**Conference Co-Chairperson**

Dr. Fereidun Fesharaki, Energy Program Leader, East-West Center--**Conference Co-Chairperson**

9:30-10:00 **Keynote Address: Expanded Horizons for U.S. Coal Technology and Coal Trade**
Ms. Denise Swink

10:00-10:30 **Photo Session**--outside of Jefferson Hall
Coffee Break

10:30-12:30 **Overview of the Asia-Pacific Energy Outlook**
Dr. Fereidun Fesharaki

Asian Presentations I

Chairperson: Dr. Kuntoro Mangkusubroto, President Director
PT. Tambang Batubara Bakit Asam, Jakarta, Indonesia

Taiwan Presentation
Mr. Si-Min Chang, President
Taiwan Power Company

Future Coal-Fired Generation and Capacity Requirements of the Philippines
Mr. Ernesto Aboitiz, President
The Philippine National Power Corporation

Korean Presentation
Mr. Kun Jeong, General Manager of Electricity Economics Department, Korean Electric Power Corporation

Hong Kong Future Coal Requirements
Mr. Howard Au, Fuel Supply Engineer
China Light & Power Company, Limited

12:30-2:00 **Luncheon**--University of Hawaii Campus Ballroom
Video messages from U.S. Senator Frank Murkowski (R-AK), U.S. Senator Mitch McConnell (R-KY), and Representative Ralph Regula (R-OH)

Afternoon Session

2:00-3:30 **Asian Presentations II**

Chairperson: Mr. Wenceslao R. De La Paz, Executive Director, Office of Energy Affairs, Office of the President of the Republic of the Philippines

Indonesian Presentation
Mr. Aloysius Andoyo, Director, Electric Power Planning and Development, Ministry of Mines and Energy

Electric Power System in Thailand
Mr. Charmon Suthiphongchai, Deputy General Manager, Thermal Power and Mine Development, Electricity Generating Authority of Thailand

Coal in Malaysia - A Position Paper
Mr. Mohd Ariffin bin Abdul Rahman, Deputy General Manager, Corporate Planning, National Electricity Board of the States of Malaysia

3:30-3:45 **Break**

3:45-4:15 **The U.S. and Asia: Pacific Partners in Coal and Coal Technology**
Mr. Thad Grundy Jr., Deputy Assistant Secretary for International Affairs, U.S. Department of Energy

4:15-5:15 **U.S. Presentations**

Chairperson: Dr. Tony Churchill, Director, Energy & Industry
The World Bank

U.S. Coal Production and Export
Mr. Alan M. Dunn, Deputy Assistant Secretary for Basic Industry, International Trade Authority, U.S. Department of Commerce

U.S. Clean Coal Technologies
Dr. E. Allen Womack, Vice President, Research and Development
Babcock & Wilcox

6:00-9:00 **Cocktail Reception**
Sponsored by Babcock and Wilcox

THURSDAY, NOVEMBER 16, 1989

8:00-8:30 **Coffee, Tea & Pastries**

Morning Session

8:30-10:00 **Developments in Coal Transport and Utilization**

Chairperson: Mr. James Heller, President, Fieldston Company, Inc.

Alternative/Innovative Transport
Introduction: Mr. Peter Cover, Program Manager, Coal & Technology Exports, Office of Planning & Environment, Office of Fossil Energy, U.S. Department of Energy
Mr. Geoff Uttmark, President, TransTech Marine Company and
Mr. Henry Brolick, Vice President, Williams Technologies, Incorporated

Electricity Generation in Asia and the Pacific: Power Sector Demand for Coal, Oil and Natural Gas
Dr. Hossein Razavi, Senior Energy Economist, Asian Region
The World Bank

10:00-10:30 **Break**

10:30-12:00 **Environmental Issues**

Chairperson: Dr. James Sullivan, Director, Office of Energy, U.S. Agency for International Development

Role of Clean Coal Technology in the Energy Future of the World
Mr. Jack Siegel, Deputy Assistant Secretary for Coal Technology, U.S. Department of Energy

Global Climate Change: A Fossil Energy Perspective
Mr. Robert Kane, Environmental Protection Specialist, Office of Planning & Environment, Office of Fossil Energy, U.S. Department of Energy

12:00-1:30 **Luncheon**--University of Hawaii Campus Ballroom

Speaker: The Role of Coal in Meeting Hawaii's Power Needs
Mr. Richard K. McQuain, Vice President, Engineering, Hawaiian Electric Company, Inc.

Afternoon Session

1:30-3:30 **Workshops on Critical Issues Associated with Coal Usage**

Chairpersons: Mr. Robert Lee Kessler
Western Coal Transportation Association

Dr. Manfred Raschke, President
International Strategic Information Service

Mr. Daniel Gerkin, Senior Vice President
National Coal Association

3:30-4:00 **Coffee Break**

4:00-5:00 **Workshop Summaries**
Mr. Morgan Greenwood, President, Williams Technologies, Inc.

5:00 **Closing Remarks by Conference Co-Chairpersons**

Adjournment

DENISE SWINK
Director, Office of Planning and Environment
Office of Fossil Energy
U.S. Department of Energy

Education: B.A. in Mathematics, American University
M.A. in Environmental Sciences, Johns Hopkins University

Ms. Swink has been in the Director's position since March 1988. The Office of Planning and Environment is a staff office of a dozen senior analysts which report directly to the Assistant Secretary. All aspects of technology, regulatory, and economic impacts on the extraction and utilization of fossil fuels are analyzed, the results being input to national policy decision-making and the strategies for Fossil Energy research, development and demonstration program. Issues/activities that are addressed include natural gas deregulation incentives for enhanced oil recovery, deployment of innovative technologies in the utility, industrial, commercial, and transportation sectors, fossil fuel reserve definition, fossil fuel distribution system capabilities and capacities, U.S. coal technology export, technical and economic performance of innovative gas and coal-fired technologies, implications of proposed environmental regulations on the fossil fuel resource base and utilization patterns, changes to, or development of, fossil fuel leasing programs, and ES&H oversight of FE's facilities. Ms. Swink represents FE as chairman of the task group on Emissions and Control of the National Acid Precipitation Program, observer to the Outer Continental Shelf 5-Year Leasing Plan Policy Committee, program contact for National Coal Council and National Petroleum Council Study activities, and member of the Interagency Steering Committee for U.S. Coal and Coal Technology Export. In addition, representing the Assistant Secretary or herself, Ms. Swink makes speeches and gives presentations to international, national, state, and local organizations, both private and public, regarding fossil fuel extraction and utilization conditions and situations, including administration policies, current activities and trends.

Previous to her current position, Ms. Swink was the Special Assistant to the Deputy Assistant Secretary for Clean Coal, Combustion and Conversion Systems. The Office of Clean Coal, Combustion and Conversion Systems was responsible for the clean coal demonstration program, and combustion and conversion systems research and development programs, which include fluidized-bed combustion, advanced combustors, alternative fuels, coal gasification and liquefaction, gas stream cleanup, waste management and coal-fired diesels and turbines. She worked in coal technology research, development, and demonstration beginning in 1983. Major emphasis during her tenure was on program development, planning and management, and crosscutting technology initiatives such as integrated gasification combined cycle and nonutility sector coal applications.

Ms. Swink's previous experience included thirteen years with the U.S. Environmental Protection Agency in the Office of Research and Development, the Office of Water Programs and the Office of Toxic Substances, in both management and analytical positions.

FOSSIL ENERGY SPEECHES

U.S. DEPARTMENT OF ENERGY OFFICE OF FOSSIL ENERGY

Fossil Energy

U.S. and the Pacific Rim: Fueling Tomorrow's Progress

Remarks by Denise Swink Acting Principal Deputy Assistant Secretary for Fossil Energy U.S. Department of Energy to the Asia-Pacific Coal Technology Conference in Honolulu, Hawaii November 15, 1989

On behalf of the U.S. Government, let me welcome each of you here. I hope the remarks I will deliver this morning on behalf of the Department of Energy underscore the importance we place on our economic ties to the countries of the Pacific Rim.

This conference has one single focus — to strengthen those ties. And I, as a representative of President Bush's Administration, have a single purpose in my remarks this morning and that purpose is to reinforce our government's policy of free and open trade — a policy that can work to the benefit of countries on both sides of the Pacific.

The currents of change are dramatic throughout the world. But in terms of economic growth, no change is more dynamic than the industrial momentum of the Pacific Basin.

Over the last decade and a half, annual economic growth in the Pacific region has averaged about six percent. This is all the more significant when one realizes that it has been accomplished despite rising oil prices and social changes. The dynamic energy and enterprise so evident in the Pacific Rim is changing the world's economic center of gravity. The United States and our neighbor Canada now exchange more goods with Asia and the Pacific than with Europe. Almost one-third of the total U.S. trade now flows west.

The last five U.S. Presidents have all recognized — and emphasized — that the continued growth and security of the Pacific Basin is of vital importance to the economic and political stability of the globe. And no commodity plays a greater role in that stability than energy.

We have had a decade now in which to regroup from a time in which a small band of nations transformed the global flow of crude oil into a political weapon. The lessons we, as consuming nations, learned in the 1970s were painful. But hopefully, they have stayed with us. We saw the paramount importance of restoring diversity to world energy markets — and inherent in that diversity, greater stability.

We saw the paramount importance of restoring diversity to world energy markets — and inherent in that diversity, greater stability. That's why the world reopened its eyes in the late 1970s to coal.

That's why the world reopened its eyes in the late 1970s to coal.

And the American coal industry delivered. New mines were opened and new production capacity was brought into operation — not only to fuel American boilers, but to meet the expanding European steam coal market and to be transported to our trading partners across the Pacific.

Today, we have — or should have — a much greater appreciation for the dangers of over-dependence on any single energy resource. And yet, even with energy supplies relatively unthreatened in the 1980s, world oil markets have been anything but stable — particularly when it comes to price.

Our nations have ridden a roller coaster during the past decade — first with escalating oil prices and then with steep price drops. Today, we have been given a brief opportunity to catch our economic breath. But the fact remains: The world's energy economy remains fragile. A sense of uncertainty remains in the Persian Gulf. Social and political unrest continues in South Africa. Recent events in the Peoples' Republic of China have raised serious questions about that country's progress in joining world trading circles. And of course, we have the remarkable changes occurring in the Soviet Union that, as promising as they are, still must cast some uncertainty over that nation's impact on world energy markets.

Throughout all of this, U.S. coal — with its more than 3,000 privately owned, independent coal companies and with a government policy of removing trade obstacles — has remained a stable, reliable energy resource.

Productivity in American mines continued upward, so that the price of American coal is actually lower today — in real terms — than it was in 1980. And it is expected to retain its competitive advantage. Looking through the year 2010, oil and gas prices are expected to increase more than eight times as fast as coal.

...the dramatic growth in electricity demand in the Pacific Rim in the last few years — coupled with a move to reduce oil demand — could raise coal-fired electricity from the 12,000 megawatt capacity levels of 1986 to as much as 50,000 megawatts by the year 2000.

Again speaking for the U.S. Government, I can give you our assurances that the U.S. is determined to play an active role in the international coal market — and in the global market for new, more efficient, cleaner coal technology.

That's why this conference is important. That's why we have endorsed it and supported it. And that's why this kind of conference is only a predecessor to an intensified effort on our part to bring buyer and seller together and to create opportunities for market initiatives that can meet future energy demands without returning to past energy dangers.

We know that when it comes to coal, energy growth translates very closely into electricity growth. And the dramatic growth in electricity demand in the Pacific Rim in the last few years — coupled with a move to reduce oil demand — could raise coal-fired electricity from the 12,000 megawatt capacity levels of 1986 to as much as 50,000 megawatts by the year 2000.

Already, the Asian Pacific Basin receives one-third of the world's steam coal exports. By the turn of the century, that share could be significantly greater.

We believe U.S. coal can compete in this growing market. For years, the school-of-thought was that the U.S. would remain a marginal, or "swing," supplier in the Pacific Basin. High inland transportation costs, combined with the relatively low-Btu value of some western coals, would combine to keep prices above world market levels.

That has been the case in recent years. Will it be the case in the future? I think some analyses we've done recently calls that into question.

The Energy Department funded a recent study of innovative transport modes for moving U.S. coal to the Pacific Rim — you'll hear more about this later in this conference. The purpose was to see what type of alternative transport methods might be used to bring down our inland transport costs and restore a higher degree of competitiveness to U.S. coal exports.

Looking at the Pacific coal market in general — and Australian deliveries specifically — we concluded that the benchmark for economic competitiveness was something in the range of $1.80 to $2.05 per million *Btus* — equivalent in today's APB steam coal market to $43.90 to $50 per ton of 12,200 Btu coal, or $28.80 to $32.80 for 8,000 Btu per pound coal.

...there is no fundamental reason why western U.S. coal can't be economically competitive today — even with current rail shipment as the standard mode of transport.

Then we looked at current U.S. competitiveness and how that competitiveness might be enhanced by such transport modes as slurry pipelines. The results were, at the very least, intriguing.

They told us, for example, that there is *no* fundamental reason why western U.S. coal can't be economically competitive today — even with current rail shipment as the standard mode of transport. The study told us that there appears to be *no* reason why Powder River Basin coal can't be delivered to the Pacific Rim at costs equivalent to $1.78 to $2.04 per million Btu. In other words, at economically competitive costs today.

Now, assume that Powder River coals were someday moved by slurry pipeline to Puget Sound, shipped via tanker, and burned as coal-water fuel upon delivery.

We see delivered costs in the range of $2.42 to $2.90 per million Btus — costs that compare very favorably to current delivered fuel oil prices of $17 to $19 per barrel.

The same can be said for certain coals in Utah. Coal from the Four Corners region looks competitive when moved by slurry pipeline — both as a dewatered fuel and as a slurry substitute for fuel oil. Beluga coals also look competitive today — probably not in competitive with fuel oil — but certainly compared to other coal suppliers. And Alaska's inland transportation costs are expected to decrease as coal production and coal exports increase.

So the message we see coming out of this analysis is that the U.S. is *not* destined to remain the perpetual swing supplier. And, as you hear more about this analysis later today and tomorrow, the question we ask you is: Are we right? And if so, what do we need to do to turn economic projections into export realities?

One of the things I think we can do is to think more in terms of "packages." The bulk commodity is clearly important, but we must also recognize that the Pacific Basin's growing industrial momentum places new demands on end-use technology. The coal supply and the technology to use it should be viewed as a package — each enhancing the other's value.

...we must also recognize that the Pacific Basin's growing industrial momentum places new demands on end-use technology. The coal supply and the technology to use it should be viewed as a package — each enhancing the other's value.

The U.S. government and industry have joined in a national commitment to expand the menu of environmentally clean, cost-effective coal technology. We call the program the "Clean Coal Technology Demonstration Program" and its purpose is to put into place a new generation of "showcase" coal plants, each demonstrating advances in pollution control and power generating technology.

To date, we have 28 active projects, valued at more than $2.3 billion. Next month, we will add another 10 to 20 projects, totaling well in excess of another $1 billion. By the time this single initiative is completed, we should have more than $5 billion worth of projects — commercial scale projects — up and running.

The advantages of these showcase plants are multi-fold. First and foremost, they can break the historical linkage between coal use and environmental concerns. We have technologies in the program that can produce electricity with the same sulfur emission levels of natural gas. We have technologies that can accommodate a variety of coal ranks and qualities without compromising efficiency or environmental performance. We have technologies that show marked reductions in CO_2 output due to their enhanced efficiencies. And we have technologies that do not carry with them the burden of difficult waste disposal.

We are convinced that these technologies will play an increasingly important role both in the U.S. and in other countries as the world is taking on a new environmental con-

sciousness. Nations that wish to expand their economies will need to do so in a manner consistent with this global environmental responsibility.

But the advantages of these technologies extend well beyond the environment. In large measure, they offer economic benefits that clearly look attractive for future capacity investments.

Many of these technologies — which you will be hearing about as this conference progresses — offer a modular approach to capacity additions. Building a power plant in modules, without sacrificing efficiencies, offers benefits in terms of standardization, easier off-site fabrication, faster construction times, and, most importantly, lower costs. Many of these concepts offer ways of extending the lifetimes of aging power plants, at the same time boosting their power outputs.

No longer will companies have to speculate about the potential economic and environmental advantages of these new concepts. Instead, they can view first-hand actual operating hardware that is functioning in a commercial environment...

Five or 10 years ago, these concepts were still on the drawing boards or, at best, in small-scale testing. Today that is changing. No longer will companies have to speculate about the potential economic and environmental advantages of these new concepts. Instead, they can view first-hand actual operating hardware that is functioning in a commercial environment and generating hard data on costs, performance, and reliability.

As you will hear, our goal is to put these technologies into operation not only for U.S. interests but for the world to see and assess. That goal is but one segment of a much larger mosaic. We can adopt national initiatives, we can put into place major demonstration efforts, and we can pursue major new national strategies and policies. But ultimately, we must function within — and as part of — a world community.

Together, the combined economies of the Pacific Rim and the U.S. account for half the output of the Free World. We cannot escape our global responsibilities. We must rely on free and open trading markets and we must recognize that the economic and political security of each of our nations is inseparable from that of its neighbor.

It is in that spirit that I am pleased to open this conference, and to extend a very special welcome to our distinguished guests from across the Pacific.

FEREIDUN FESHARAKI
Energy Program Leader
East-West Center

Dr. Fereidun Fesharaki is the Leader of the Energy Program at the Resource Systems Institute, East-West Center, Honolulu, Hawaii. Born in Iran, he received his Ph.D. in Economics from the University of Surrey in England. During 1977-78 he attended the OPEC Ministerial Conferences in his capacity as Energy Adviser to the Prime Minister of Iran. After completing a Visiting Fellowship at Harvard University's Center for Middle Eastern Studies, he joined the East-West Center in 1979.

His area of specialization is oil and gas market analysis and the downstream petroleum sector, with special emphasis on the Asia-Pacific region, Middle East, Caribbean and United States. He has been a consultant to a number of major oil companies, independent oil companies, utilities, mining companies, shipping/storage firms and governments in the Middle East, Pacific basin and the Caribbean, as well as the U.S. government. He has been awarded research grants exceeding 1.5 million dollars by the U.S. Department of Energy and international organizations.

Dr. Fesharaki is the author of more than 50 papers and has authored or edited twelve books, the latest of which are *The Oil Market in the 1990s: Challenges for the New Era* (Westview Press, 1989), *OPEC and Lower Oil Prices: Impacts on Production Capacity, Export Refining, Domestic Demand and Trade Balances* (U.S. Department of Energy, 1989), *Electricity in Asia and the Pacific: Power Station Fuel Demand to 2000* (Economist Intelligence Unit, 1989), *Deregulating Australia's Oil* (Economist Intelligence Unit, 1987), *Spot Oil, Netbacks and Petroleum Futures* (Economist Intelligence Unit, 1987) and *China's Petroleum Industry in the International Context* (Westview Press, 1986). He is also Vice President for International Affairs of the International Association for Energy Economics and serves on the editorial board of the *Energy Policy Journal*. In 1989 Dr. Fesharaki was elected a member of the Council on Foreign Relations.

A DECADE OF CHANGE IN THE ASIA-PACIFIC REGION: The Energy Outlook and Emerging Supply/Demand Imbalance

by

Fereidun Fesharaki
Nancy D. Yamaguchi

Energy Program
Resource Systems Institute
East-West Center

Prepared for
The Asia-Pacific Coal Technology Conference
Honolulu, Hawaii

November 1989

A DECADE OF CHANGE IN THE ASIA-PACIFIC REGION:
The Energy Outlook and Emerging Supply/Demand Imbalance

Fereidun Fesharaki and Nancy D. Yamaguchi
Energy Program, East-West Center

1. Introduction

The 1980s ushered in what many analysts enjoy calling the "Pacific Century." The region is seen as the emerging center of gravity for the world economy, and even if economic growth slows during the 1990s, there is wide acceptance of the idea that the region will continue to be one of the fastest-growing in the world. The 1980s witnessed spectacular growth rates in the Asia-Pacific region, the rising economic power of Japan, an unprecedented opening of China's economy, the emergence of the "Four Tigers" or the "Little Dragons" (Singapore, South Korea, Taiwan, and Hong Kong), a rapid growth of exports from the region--in short, remarkable economic success and an increase in entrepreneurialism and the free-market philosophy. Even the United States, which historically has been Atlantic-oriented, sat up and took notice.

While the relationship between economic growth and energy consumption is not necessarily one-to-one, energy is a required input for economic activity and trade. Energy demand growth in the Asia-Pacific region has been accordingly rapid. At this point in history, oil and economic growth are so interrelated that changes in one invariably have major repercussions on the other. During the coming decade, continued economic growth is foreseen for the Asia-Pacific

region, coupled with the fastest rate of oil demand growth of any region on earth. Pressure will come to bear on the regional oil and gas markets, since demand growth will take place concurrently with a decline in the availability of local, low-sulfur crudes. The region will become even more dependent on imports of Middle Eastern crude, which will result in a higher-sulfur crude slate. Moreover, we anticipate that the existing and planned refinery complex will lack the capacity and the flexibility to fully satisfy product demand. The consequence will be a higher level of refined product imports.

The problem facing the regional market is one of both quantity ***and*** quality. Petroleum product specifications are tightening significantly, due in part to a rising environmental consciousness. Octane requirements are increasing, not merely because of demand for premium gasoline but because the regular grades in many nations are significantly underpowered (some have research octane numbers in the low-eighties) and the long-term costs to the motor vehicle fleet are becoming all too apparent. At the same time, many countries are phasing in low-lead and unleaded gasoline grades, which places additional pressure on the octane pool. Additionally, the higher-sulfur crude slate will correspond with a tightening of sulfur standards for middle distillates and fuel oil. The 1990s should prove exciting for the regional oil and gas industry.

In this paper, we examine the Asia-Pacific energy situation and the outlook for the regional oil and gas market, beginning with a look at the structure of demand, the extent of the regional oil and gas resource, and the prospects for

crude oil production through the year 2000. Following this is our assessment of the Asia-Pacific supply/demand balance (or imbalance, as the case may be), and the future of the regional refining sector.

2. Structure of Energy Demand: World Versus Asia-Pacific

The world energy markets consumed 160.6 million barrels per day of oil equivalent (MMBDOE) in 1988, of which two-thirds was consumed in the non-Communist world. As shown in Table 1, 38 percent of world energy consumption was supplied by oil, 20 percent by gas, 30 percent by coal, 7 percent by hydro, and 5 percent by nuclear power. If only non-Communist countries are considered, the share of oil in energy demand rises--primarily because the use of natural gas and coal in the Communist world is higher than it is in the non-Communist world.

When comparing the Asia-Pacific region with the world, the size of China's energy market poses a serious problem. Since China's coal consumption accounts for nearly 80 percent of her total commercial energy demand, the total Asia-Pacific picture is affected. As a result, oil consumption in the region is shown to be only 33 percent, gas 6 percent, and coal 52 percent. Since China's inclusion in the table distorts the regional picture, we have constructed a table excluding China. The emerging picture actually makes the region not all that different from global economy--except for gas. The Asia-Pacific region depends on oil for 47 percent of its energy demand, coal for 31 percent, hydro and

Table 1
PRIMARY ENERGY CONSUMPTION BY FUEL 1988
(million barrels per day of oil equivalent)

	Total World		Asia-Pacific**		Asia-Pacific (excluding China)	
	MMBDOE	%	MMBDOE	%	MMBDOE	%
OIL	60.1 (47.5)	38 (45)	11.2	33	9.3	47
GAS	32.5 (19.0)	20 (18)	2.2	6	1.9	10
COAL	48.6 (23.6)	30 (22)	17.7	52	6.1	31
HYDRO	10.6 (8.3)	7 (8)	1.8	5	1.2	6
NUCLEAR	8.8 (7.6)	5 (7)	1.3	4	1.3	6
TOTAL	160.6 (106.0)	100 (100)	34.2	100	19.8	100

*East, South East, and South Asia plus Australasia.
Brackets denote Non-Communist World.

nuclear for 6 percent each, but gas is used for only 10 percent of energy demand in the Asia-Pacific region. In contrast, global energy demand is supplied 20 percent by gas.

Indeed, the role of gas in the supply of energy in the Asia-Pacific region is lower than in any other part of the world (see Table 2). In the Soviet Union, gas makes up 39 percent of energy demand, in the United States 24 percent, and in the Middle East 28 percent. Even Latin America and Africa consume more gas than the fast-growing Asia-Pacific region. It is only natural to expect that the share of gas consumption will rise dramatically in the region by the year 2000.

Our own assessment of the future Asia-Pacific energy demand is shown in Table 3. The share of different energy sources clearly varies by oil price. If we assume an oil price of around $23 per barrel by the year 2000 (in real 1988 prices), we expect the share of oil to decline to 42 percent (though in absolute terms oil demand will rise significantly), the share of coal to decline to 26 percent; the share of gas to rise dramatically to 16 percent, and the share of nuclear power to rise to 9 percent. A higher oil price would reduce oil demand to 37 percent and result in higher demand for other energy sources. In both price scenarios, however, the share of gas will expand significantly. In fact, we believe that current economics already warrant increased gas use in many parts of the region. Gas use will expand with additional discoveries and, even more importantly, with progressive development of a "gas utilization culture." Use of gas is

Table 2
SHARE OF GAS IN THE STRUCTURE OF ENERGY DEMAND 1988 (%)

USA	24
WESTERN EUROPE	15
ASIA-PACIFIC (CHINA)	6% TO 10%* (2%)
USSR	39
MIDDLE EAST	28
LATIN AMERICA	19
AFRICA	12
WORLD	20

*6% including China and 10% excluding China.

Table 3
CURRENT AND FUTURE ASIA-PACIFIC* ENERGY DEMAND STRUCTURE
(TWO SCENARIOS)

	1988 (%)	2000** I (%)	2000** II (%)
OIL	47	42	37
GAS	10	16	17
COAL	26	26	29
HYDRO/OTHER	6	7	7
NUCLEAR	6	9	10
TOTAL	100	100	100

*excluding China.

**corresponding to our Low Price Scenario I of $23 per barrel and High Price Scenario II of $35 per barrel of oil in the year 2000.

new in the region. As the governments and industries become familiar with established and new uses of gas, and as they prepare to make the heavy start-up investments in infrastructure and distribution, the consumption of gas is sure to rise by leaps and bounds. Assuming an annual energy demand growth of 3.5 to 5 percent annually, we are likely to see demand for gas of 5 to 6 MMBDOE in the year 2000, compared to 1.9 MMBDOE in 1988. And still, we may well be on the conservative side.

Insofar as nuclear power is concerned, our forecasts do not include any nuclear power production in Indonesia, China, Pakistan, and the Philippines. In fact, we assume that there will be no additional nuclear development in nations outside of the few already with current involvement in nuclear power generation. Most of the projected additions are for the power plants already under construction or firmly planned. Nuclear power generation in Taiwan has faced severe political opposition and faces a moratorium. At most, two new power plants may be built in Taiwan by the end of the century. In Japan, already up to 10,000 MW of new generation capacity from nuclear power has been postponed. In Korea, as yet there is no active opposition, but it will be surprising if the environmental concerns already surfacing do not extend to nuclear power as well. Essentially, after a jump in nuclear capacity between 1990-1995 because of facilities already firm or under construction, we do not see many prospects for growth of nuclear power in the region.

3. Asia-Pacific Oil and Gas Reserves

In the global context, the Asia-Pacific region has only a small oil and gas resource base. Proven oil and gas reserves are shown in Table 4. The Asia-Pacific region contains around 45 billion barrels of proven oil reserves equivalent to only 4.5 percent of world proven reserves, with a reserve-to-production ratio of 21 years. Indonesia and China together account for over 70 percent of the regional oil reserves.

Gas reserves in the Asia-Pacific region account for nearly 7 percent of proven world reserves and indicate a reserve-to-production ratio of 57 years. There are many more countries with gas resources than with oil reserves, and the outlook is generally brighter.

If we were to look at an updated version of Table 4 in, say, 5 years, we would probably see very little change in the oil picture, but a substantial change in the gas picture. Oil reserves will not change dramatically, but both gas reserves and R/P ratios will be very different. We are only in the early stages of finding gas and learning how to use it in the Asia-Pacific region. In addition, we do not believe there will be any new LNG importers. Therefore, new gas discoveries will be used domestically on a much wider scale in almost every country with significant gas reserves.

Table 4
PROVEN OIL AND GAS RESERVES
(as of January 1, 1989)

Oil	Billion Barrels	Share of Total (%)	R/P Ratio
TOTAL WORLD*	992.5	100.0	45.0
OPEC**	764.7	77.0	100.0+
ASIA-PACIFIC	45.1	4.5	21.0
--Brunei	1.4	0.1	27.5
--Indonesia	8.3	0.8	19.6
--Malaysia	2.9	0.3	14.8
--India	6.4	0.6	26.6
--Australia	1.7	0.2	9.1
--China	23.6	2.0	23.0

Gas	Trillion Cubic Feet	Share of Total (%)	R/P Ratio
TOTAL WORLD	3,953.3	100.0	55.9
OPEC	1,498.3	37.9	100.0+
ASIA-PACIFIC	272.4	6.9	57.0
--Brunei	11.6	0.3	37.9
--Indonesia	83.6	2.4	68.3
--Malaysia	51.7	1.5	100.0+
--India	17.7	0.5	40.3
--Australia	16.6	0.5	30.7
--China	31.7	0.9	44.4
--New Zealand	5.2	0.1	32.0
--Bangladesh	12.7	0.4	60.7
--Pakistan	17.7	0.5	40.3

*Includes more than 300 million barrels of official "paper" increase by the Persian Gulf countries--half of which probably do not as yet exist.
**As of March 1, 1989.

4. Declining Crude Production and Export Availability

The Asia-Pacific region has four net oil exporters: Indonesia, China, Malaysia, and Brunei. Burma, an oil exporter until 1986, is now a minor importer, and Vietnam's exports of 15-20 mb/d are less than her 30 mb/d demand.

The net oil exporters in the region exported 1.8 mmb/d of oil in 1985. Additional discoveries and enhanced recovery techniques have succeeded in maintaining a fairly steady level of exports to the present time. However, beyond 1990 the outlook is for a decline. Exports will drop to 1.2 mmb/d in 1995 and to only 0.45 mmb/d by the turn of the century. Two key factors will be responsible for the dramatic drop: rising demand in the four net oil exporting nations, and a drop in the oil production capacity of each country with the exception of Brunei. China is likely to witness a major decline in crude oil availability from 450 mb/d in 1990 to 200 mb/d in 1995. Coupled with additional large-scale product imports, China may well be a net importer by 1995.

In the early 1990s, significant new sources of heavy sweet crudes will come on line in Indonesia. Duri production (Caltex) will jump from 100 mb/d in 1988 to 250 mb/d in late 1990 and to 300 mb/d by 1992/93. Production of Intan (Maxus) began in June 1989 and reached 45 mb/d in September. Widuri (Maxus) will begin production in 1990. By 1992, the Intan and Widuri fields will produce 220 mb/d. As a result, significant additional LSWR supplies may become available during the period from 1990 to 1992/93. However, by the turn of the century, Indonesian crude production will fall to approximately 800 mb/d,

the bulk of which will be used domestically. Malaysia will experience a similar though less-pronounced trend, with the result being that Indonesia and Malaysia will become very small players in the crude export market. Of the four net oil-exporters, only Brunei will be able to continue exports at current rates into the 21st century.

Meanwhile, Australian production is expected to decline slowly. The decline of Gippsland crude production will be offset partially by new production in the Timor Sea, which is expected to reach 100 mb/d by December 1989. Still, we expect that the Australian market will absorb virtually all domestic crudes.

Very few nations in the region are moving to fill the void that will be created as the traditional oil-exporters enter into production decline. By the year 2000, new sources may include perhaps 50-75 mb/d from Papua New Guinea and 30 mb/d from Burma. Papua New Guinea's Iagifu/South Hedonia crude is a light, Gippsland-type material. Production of Minas-type material from Vietnam (Bach Ho crude) is expected at 20 mb/d in 1990 and may reach 50 mb/d by 1995. By then, we expect that domestic processing will keep exports out of the regional market.

The conclusion is that the availability of Asian low sulfur crudes will be seriously reduced due to rising domestic demand and lower production. The decline of low sulfur crude will occur simultaneously with changing sulfur standards requiring reduction of sulfur in fuel oil and middle distillates. Shorter supplies of light sweet crudes are likely to result in sulfur premiums, since

additional Middle Eastern crudes will be used. At the same time, we may see a widening differential between light sweet and heavy sweet crudes by the early 1990s.

5. The Asia-Pacific Oil Balance

The Asia-Pacific oil balance, 1980-2000, is displayed in Table 5. Regional demand will grow dramatically by 2 mmb/d between 1990 to 1995 and 1 mmb/d to the year 2000. It is to be noted that our demand forecast, which is aggregated from two dozen sources, is very conservative--almost 50 percent lower than an individual country-by-country forecast would indicate. Demand could easily be 1-2 mmb/d higher in each of the two periods. At the same time, regional production is declining moderately. Dependence on outside sources of oil will rise to unprecedented levels. Imports from sources outside the Gulf will rise but will be almost insignificant when compared to the volumes of Middle Eastern oil. Indeed, it is the Persian Gulf which will be the chief supplier of oil. As discussed above, exports from Asia-Pacific oil producers will drop sharply, from approximately 1.8 mmb/d in 1990, to 1.2 mmb/d in 1995, and to less than half-a-million barrels per day by the year 2000. Assuming that all of this goes to other nations in the region--a generous assumption--imports from the Persian Gulf are likely to rise to over 7.6 million b/d in 1995, an increase of more than 80 percent over the 1985 level of 4.2 million b/d. Dependence on the Persian Gulf for imports into the region may rise from a 1985 low of 67 percent to 73

Table 5
ASIA-PACIFIC OIL BALANCE
(thousands of barrels per day)

	1980	1985	1990	1995	2000
Regional Demand	10,735	10,140	11,965	13,937	14,942
Regional Production	4,885	5,790	5,910	5,880	5,480
Net Oil Required From Outside the Region	5,850	4,350	6,055	8,057	9,462
Imports from Regional Oil Exporters	1,255	1,874	1,797	1,213	450
Imports from Persian Gulf	5,525	4,170	5,705	7,657	8,962
Imports from Other Regions	325	180	350	400	500
Total Imports	7,105	6,224	7,852	9,270	9,912
Import Dependence On Persian Gulf	78%	67%	73%	83%	90%

percent in 1990, 83 percent in 1995, and perhaps to *90 percent* by 2000, making the Asia-Pacific region the most import-dependent region of the world. This trend is likely to hold whether Asian refining expands to meet demand or not, since the Mideast is the most likely swing source of products as well as crude.

6. The Boom in Asia-Pacific Oil Demand

During the mid-80s, the future of oil-demand growth was the most frequent topic of debate at energy conferences. Those who forecasted increasing demand were hard-pressed to identify where such growth would take place; both Europe and the United States were seen as stagnant or declining markets. Developing-country demand was often invoked as the variable that would balance the equation, but careful observation of Third World oil consumption showed that the total volume of consumption was growing at only moderate rates from a relatively modest base. By the late 1980s, many analysts were inclined to dismiss the idea of demand surges in the developing world.

As so often happens in the world of oil, about the time that a possibility is dismissed, it begins to occur. Lower oil prices and booming economic activity are leading to rapid increases in oil demand in the majority of Asia-Pacific countries. Between 1987 and 1995, current forecasts suggest average annual growth of 3.6 percent per year. Although a massive economic turnaround or another oil-price shock could stem this growth, most of the current forecasts are reasonable given today's economic and price outlook; some, indeed, may be too

low. Our 1987-1995 product demand forecast by region is included as Table 6. Most of the forecasts used in this paper are the most recent forecasts by the relevant ministries in the Asian countries (except for many of the small economies, where our own forecasts have been employed); where possible, however, these have been compared with the internal forecasts of oil companies operating in the countries, and there is remarkably little divergence between the industry perspective and the predictions of individual governments. In each country in question, there is general agreement that a demand boom is occurring. What is not generally noticed is that the boom is pandemic; virtually every major Asian country is facing rapid growth in demand that is likely to send Asian oil consumption well above historical levels.

Much of the growth can be accounted for by continued demand increases in the traditional high-oil-growth exporting countries such as Indonesia and China, but more surprising is the surge in growth in the traditionally demand-controlled economies of East-Asia. Taiwan is experiencing rapid increases in demand, Korea's consumption is surging forward at record rates, and even Japan is experiencing an increase that is very large in absolute terms. Between 1987 and 1995, oil demand in the Asia-Pacific region is likely to increase by 3.5 million b/d. China alone accounts for about 1 million b/d of this increase and four countries--China, Japan, India, and Korea--account for 2.6 million b/d, or nearly three-quarters of the total additional demand. A bar chart displaying the absolute increases in oil demand by nation is provided as Figure A.

Table 6

Asia-Pacific Forecast Petroleum Product Demand, 1987-1995

('000 barrels per day)

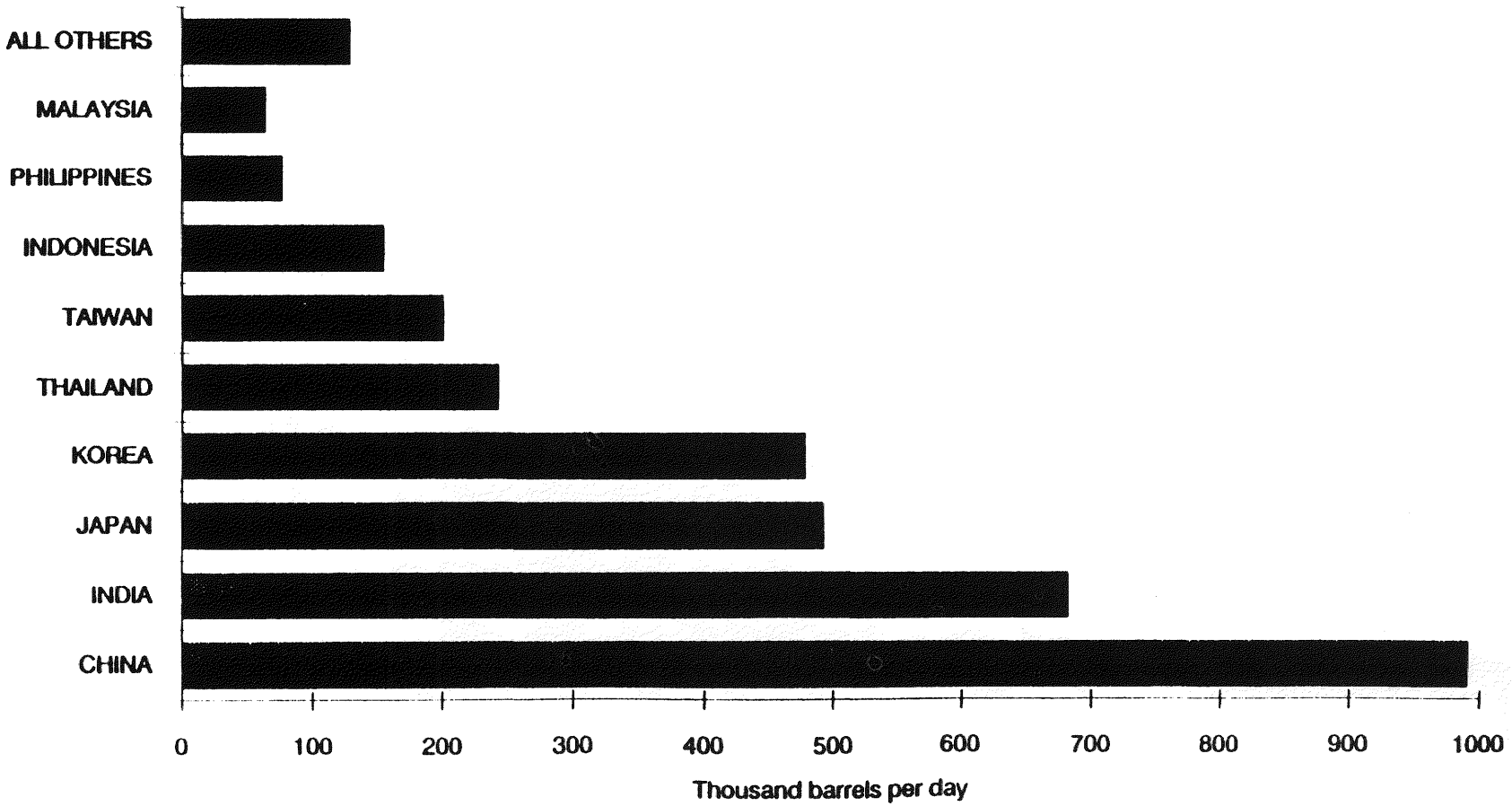
REGION	Year	LPG	Light*	Medium	Heavy**	TOTAL
East Asia	1987	651.1	1,840.4	2,326.9	2,398.9	7,217.3
	1990	707.4	2,098.8	2,801.0	2,623.2	8,230.4
	1995	779.4	2,554.8	3,298.7	2,746.0	9,378.9
Southeast Asia	1987	55.4	231.6	642.9	433.1	1,362.9
	1990	63.1	332.3	776.6	476.1	1,648.0
	1995	78.2	388.5	919.9	515.4	1,902.0
South Asia	1987	33.9	162.1	689.3	319.3	1,204.6
	1990	20.4	191.8	837.9	337.0	1,387.1
	1995	22.4	277.1	1,135.8	507.0	1,942.2
Australasia	1987	40.7	339.6	237.4	68.0	685.6
	1990	42.3	339.6	247.1	70.1	699.1
	1995	43.4	337.1	275.2	57.8	713.5
1987 Total		**781.0**	**2,573.7**	**3,896.4**	**3,219.4**	**10,470.5**
1990 Total		**833.1**	**2,962.5**	**4,662.5**	**3,506.4**	**11,964.6**
1995 Total		**923.4**	**3,557.5**	**5,629.5**	**3,826.2**	**13,936.7**

*Note: Includes naphtha, solvents, and petrochemical feedstocks

**Note: Includes crude burned as fuel.

Figure A

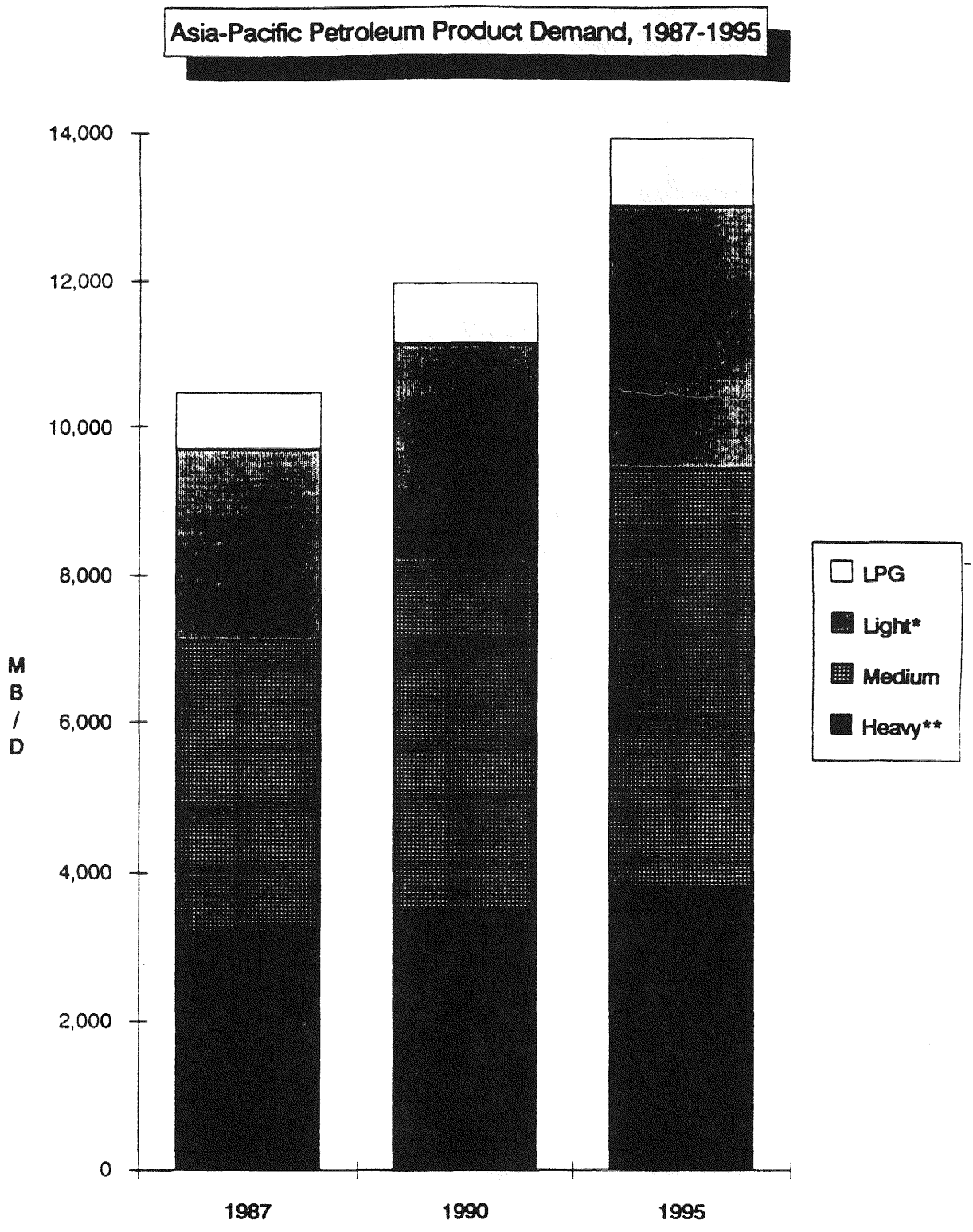
Increase in Oil Demand in the Asia-Pacific Region, 1987 to 1995



The initial drop in prices seemed to spur little increase in consumption. In part, this is because it takes a considerable period for consumers to readjust their behavior, and even longer to change perspectives on the future availability of energy. An even more important factor in Asia, however, is the adjustment of government policies. Most Asian governments continued to control oil demand tightly even after the initial price collapse; only in late 1987 through 1988 did most of them begin to relax their taxes, quotas, and administrative controls. At present, a wave of liberalization is sweeping the petroleum industry in the Far East; from Australia and New Zealand to Japan and Korea, privatization and free-marketeering are the watchwords of the day. The perceived lack of danger from future shortages in the oil market are a contributing factor to this change in outlook, but the most compelling force has undoubtedly been the price decrease; coupled with the general weakness of the dollar and expanding Asian economic success, the real price of oil is at one of its lowest levels in many domestic currencies, and its price relative to income levels has diminished rapidly.

Figure B displays the regional demand growth in absolute terms by product from 1987 to 1995, while Figure C depicts the demand barrel in relative terms. Unlike the outlook of previous years, when rapid growth was seen for middle distillates, with only slow growth for light products and declining demand for fuel oil, the regional picture now shows more rapid growth at both the top and the bottom of the barrel. Although middle distillates' share of the demand barrel is

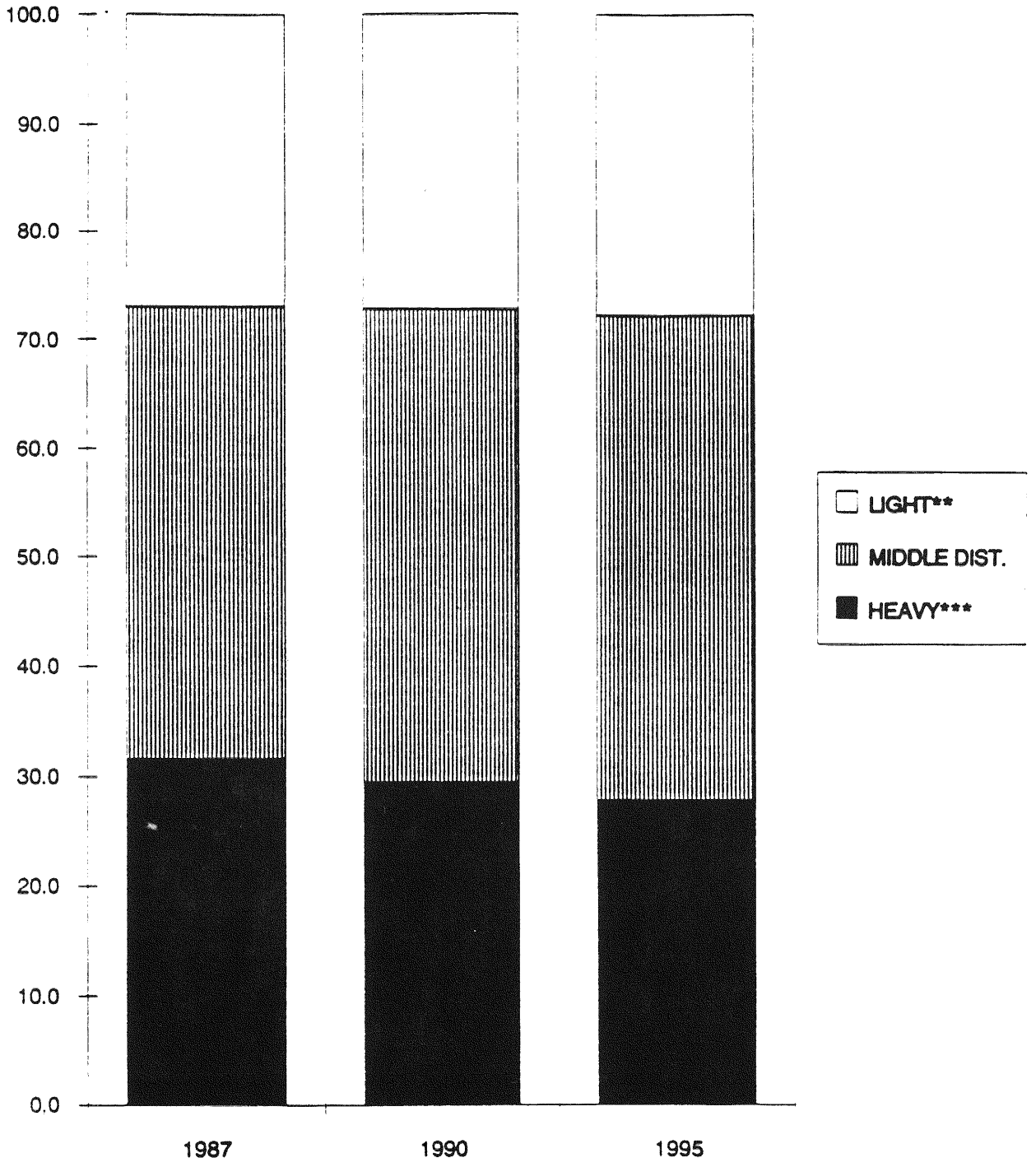
Figure B



*Includes solvents and petrochemical feeds. **Includes crude burned as fuel.

Figure C

Asia-Pacific Product Demand Barrel, 1987-1995*



*Excluding LPG and direct-burned crude. **Mogas, naphtha, etc. ***Fuel oil, asphalt, lubes, etc.

increased at the expense of fuel oil, the share of mogas and naphtha also increase, and all cuts of the barrel increase substantially in absolute terms. Although middles distillates will continue to be under some degree of stress, the outlook now, in terms of refinery capabilities, is far less grim than the drastically unbalanced barrel that earlier trends suggested. Moreover, the increase in gasoline demand, coupled with new environmental restrictions on lead content in many countries, suggest that octane may become a more important Asia-Pacific issue than in past years. In the mid-80s, hydrocracking was seen as the only feasible solution to the region's supply/demand imbalance; now catalytic cracking technologies, particularly resid cat cracking (RCC), appear to have considerable promise in helping to overcome the mismatch.

7. The Asia-Pacific Refining Sector

Of the 14.2 million b/d of demand (including bunkers) projected for 1995 in the region as a whole, substantial quantities are from non-refinery sources. About 300,000 b/d of this amount is crude oil burned directly in Japanese power stations, and about 775,000 b/d of LPG will be provided from natural gas and LNG facilities; thus the actual demand for refined products in the region will be about 13.1 million b/d. This is still well above the region's total installed distillation capacity of 12.2 million b/d. The gap between demand and refinery capacity is even more marked when it is noted that a substantial fraction of the region's capacity is idle in Japan, which is unlikely to become a major exporting

center unless Japanese policies and Japanese refinery economics change dramatically.

If all regional demand were to be met from regional refineries, this would demand a crude throughput of at least 13.6 million b/d, implying a utilization rate of 96 percent for the region's refineries, including currently idle Japanese capacity.

Plans are already moving ahead to add substantial new refining capacity in the Asia-Pacific region. Current plans call for the addition of more than 2 million b/d of new distillation capacity before 1995, which will raise the regional total to 14.2 million b/d. The configurations of the current and planned Asia-Pacific refining complex, by nation, are provided in Tables 7, 8, and 9. Graphic depiction follows in the form of a nation-by-nation comparison of "Asia-Pacific Crude Distillation Capacity, 1987 and Minimum Likely 1995" (Figure D).

Substantial additions to upgrading capacity are also being made, including 160,000 b/d of hydrocracking and 375,000 b/d of new RCCs. Figure E, titled "Asia-Pacific Current and Planned Upgrading Capacity," provides a look at planned capacity by unit type. Nonetheless, these additions are almost certain to be inadequate to the task of balancing the barrel. To meet 1995 demands, about 2.5 million b/d of fuel oil will have to be cracked into light and middle products. The region's planned 2.7 million b/d of FCC, RCC, hydrocracking, and coking capacity still falls short of the ability to convert 2.5 million b/d in net terms, even if fully utilized. Thus, the region will either have to expand refinery

Table 7

Asia-Pacific Refinery Configuration, 1989

('000 barrels per day)

COUNTRY	CDU	VDU	VBR	COKING	FCC*	HDC	CAT REF	RESID DS	VGO DS	HDF	HDT	ALKY/ POLY	BTX	ISOM	LUBE	ASPH	H2 (mmcfd)
Australia	644.1	154.0			190.3		159.6		11.0	22.7	250.0	32.9		13.8	13.2	16.4	
Bangladesh	31.2	3.5					1.7			2.4	1.9					1.2	
Brunei	10.0																
Burma	26.3	4.8	1.7														
China	2251.0	n.a.	40.0	111.0	606.0	90.0	85.0				109.0	24.0	n.a.		51.0	n.a.	n.a.
India	1051.4	333.0	73.8	36.9	134.0	6.0	26.0			13.8	70.6		4.3		15.0	37.2	9.5
Indonesia	812.0	288.0	65.6	35.2	35.0	110.8	73.3			18.0	51.5	0.6			5.0	7.5	130.8
Japan	4111.0	1563.0	60.0	22.8	522.9	91.0	531.1	386.5	610.9	298.9	1880.5	24.4	48.6	10.5	48.6	58.5	850.8
Malaysia	209.3	7.2					22.0			60.9						1.7	
New Zealand	88.4	36.6				21.5	21.9		6.5		47.4					2.3	44.0
Pakistan	130.1	14.2					5.5				24.8		1.3		3.8	4.1	0.1
Philippines	254.0	58.6			23.1		39.4		5.0	18.0	91.2				3.4	5.0	
Singapore	852.0	256.1	137.7			48.1	58.3		44.6	36.0	11.0				12.8	12.0	79.0
South Korea	855.0	59.0	50.0	19.0		29.0	68.0			21.0	175.0		11.9		4.2	11.2	68.0
Sri Lanka	50.0	2.4	12.5				3.8		2.1		15.3					1.0	
Taiwan	600.0	123.5		15.0	25.0	20.0	62.5	60.0	58.5	54.9		3.2	29.7	13.5			100.0
Thailand	202.7	38.7	19.5		8.1		26.3			17.6	69.0					1.1	4.7
Total	12178.5	2942.6	460.8	239.9	1544.4	416.4	1184.4	446.5	738.6	564.2	2797.2	85.1	95.8	37.8	157.0	159.2	1286.9
Total excl. Japan:	8067.5	1379.6	400.8	217.1	1021.5	325.4	653.3	60.0	127.7	265.3	916.7	60.7	47.2	27.3	108.4	100.7	436.1
Total excl. Japan & China:	5816.5	n.a.	360.8	106.1	415.5	235.4	568.3	60.0	127.7	265.3	807.7	36.7	n.a.	27.3	57.4	n.a.	n.a.

*Note: China's FCC capacity includes 108 mb/d of resid cat cracking (RCC)

Table 8

Asia-Pacific: Refinery Construction Planned

('000 barrels per day)

COUNTRY	CDU	VDU	VBR	COKING	FCC*	HDC	CAT REF	RESID DS	VGO DS	HDF	HDT	ALKY/ POLY	BTX	ISOM	LUBE	ASPH	H2 (mmcfd)
Australia							22.0				18.7			10.0		3.0	
Bangladesh			13.0														
Brunei																	
Burma																	
China	360.0				140.0		36.0										
India	498.8	139.7	11.4			75.0	8.1				5.3				7.9		
Indonesia	485.0				166.8												
Japan	10.0	4.5									29.0						
Malaysia	100.0						28.5				26.5						
New Zealand																	
Pakistan	34.0	22.2	14.7			19.4	4.1				4.1						
Phillippines	46.0	12.0									14.8					5.0	
Singapore			50.0		30.0	23.0					9.6			12.0			
South Korea	210.0	45.0	25.0			27.0	22.5	27.0			31.5		9.1				
Sri Lanka	2.9																
Taiwan	120.0				25.0		60.0	105.0		11.0	28.2	2.5	12.0	6.0		46.8	
Thailand	170.0				14.0	17.0											
Total	**2036.7**	**223.4**	**114.1**		**375.8**	**161.4**	**181.2**	**132.0**		**11.0**	**167.7**	**2.5**	**21.1**	**28.0**	**7.9**	**54.8**	
Total excl. Japan:	**2026.7**	**218.9**	**114.1**		**375.8**	**161.4**	**181.2**	**132.0**		**11.0**	**138.7**	**2.5**	**21.1**	**28.0**	**7.9**	**54.8**	
Total excl. Japan & China:	**1666.7**	**218.9**	**114.1**		**235.8**	**161.4**	**145.2**	**132.0**		**11.0**	**138.7**	**2.5**	**21.1**	**28.0**	**7.9**	**54.8**	

*Note: Planned FCC units are resid cat crackers (RCC)

Table 9

Asia-Pacific: Future Refinery Capacity

('000 barrels per day)

COUNTRY	CDU	VDU	VBR	COKING	FCC	HDC	CAT REF	RESID DS	VGO DS	HDF	HDT	ALKY/ POLY	BTX	ISOM	LUBE	ASPH	H2 (mmcfd)
Australia	644.1	154.0			190.3		181.6		11.0	22.7	268.7	32.9		23.8	13.2	19.4	
Bangladesh	31.2	3.5	13.0				1.7			2.4	1.9					1.2	
Brunei	10.0																
Burma	26.3	4.8	1.7														
China	2611.0	n.a.	40.0	111.0	746.0	90.0	121.0				109.0	24.0	n.a.		51.0	n.a.	n.a.
India	1550.2	472.7	85.2	36.9	134.0	81.0	34.1			13.8	75.9		4.3		22.9	37.2	9.5
Indonesia	1297.0	288.0	65.6	35.2	201.8	110.8	73.3			18.0	51.5	0.6			5.0	7.5	130.8
Japan	4121.0	1567.5	60.0	22.8	522.9	91.0	531.1	386.5	610.9	298.9	1909.5	24.4	48.6	10.5	48.6	58.5	850.8
Malaysia	309.3	7.2					50.5			60.9	26.5					1.7	
New Zealand	88.4	36.6				21.5	21.9		6.5		47.4					2.3	44.0
Pakistan	164.1	36.4	14.7			19.4	9.6				28.9		1.3		3.8	4.1	0.1
Philippines	300.0	70.6			23.1		39.4		5.0	18.0	106.0				3.4	10.0	
Singapore	852.0	256.1	187.7		30.0	71.1	58.3		44.6	36.0	20.6			12.0	12.8	12.0	79.0
South Korea	1065.0	104.0	75.0	19.0		56.0	90.5	27.0		21.0	206.5		21.0		4.2	11.2	68.0
Sri Lanka	52.9	2.4	12.5				3.8		2.1		15.3					1.0	
Taiwan	720.0	123.5		15.0	50.0	20.0	122.5	165.0	58.5	65.9	28.2	5.7	41.7	19.5		46.8	100.0
Thailand	372.7	38.7	19.5		22.1	17.0	26.3			17.6	69.0					1.1	4.7
Total	**14215.2**	**3166.0**	**574.9**	**239.9**	**1920.2**	**577.8**	**1365.6**	**578.5**	**738.6**	**575.2**	**2964.9**	**87.6**	**116.9**	**65.8**	**164.9**	**214.0**	**1286.9**
Total excl. Japan:	10094.2	1598.5	514.9	217.1	1397.3	486.8	834.5	192.0	127.7	276.3	1055.4	63.2	68.3	55.3	116.3	155.5	436.1
Total excl. Japan & China:	7483.2	n.a.	474.9	106.1	651.3	396.8	713.5	192.0	127.7	276.3	946.4	39.2	n.a.	55.3	65.3	n.a.	n.a.

Figure D

Asia-Pacific Crude Distillation Capacity, 1987 and Minimum Likely 1995

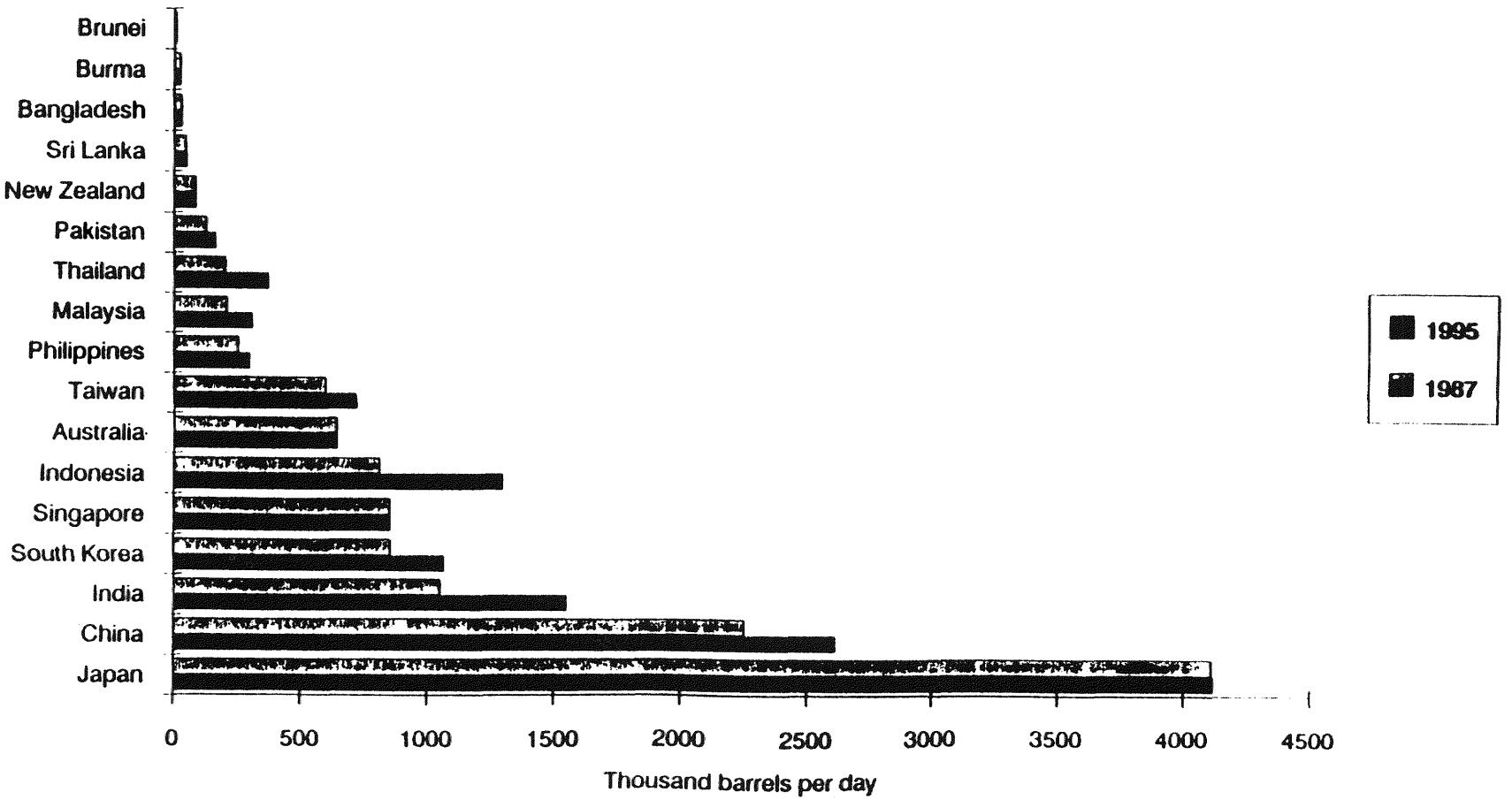
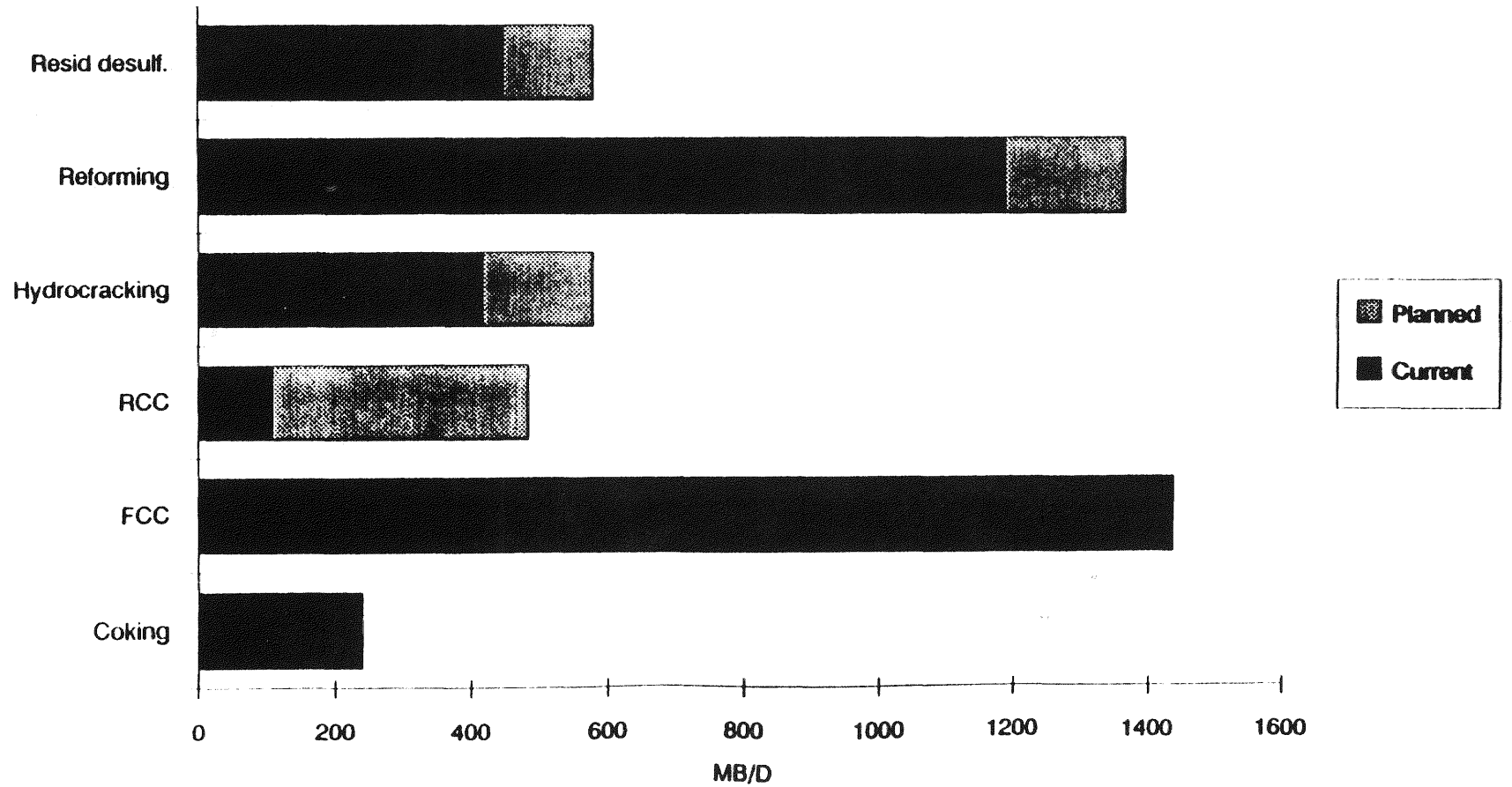


Figure E

Asia-Pacific Current and Planned Upgrading Capacity



construction well beyond current plans, or anticipate substantial product imports from the Mideast.

8. Impacts of Changing Product Specifications

Product specifications are likely to become a greater problem for Asian refiners than ever before. In Korea, where gasoline demand is growing at 20 percent annually, the government has initiated a 5-year phasedown of lead that will eliminate leaded gasoline in the early 1990s; the growth rate in octane demand is thus even higher than the 20 percent growth in gasoline. Some countries, notably Korea and Taiwan, have stiffened sulfur standards on fuel oil and diesel substantially, and further tightening should be expected. One of the most surprising developments in Asia is the rapid spread of environmental concerns within national governments and the populace as a whole. Many countries that have previously paid only lip service to environmental protection are now seriously considering changes in sulfur and leading specifications. Although this does not go nearly as far as in the US, where reduction of benzene in gasoline is being advocated, a significant tightening of specifications at a time of soaring demand will confront Asian refiners with increasingly difficult problems.

9. Product Trade and Gasoline Export Availability

In the key refining center, total gasoline production reached 1.75 mmb/d in 1988. Imports of 172 mb/d and exports of 123 mb/d resulted in a consumption of 1.81 mmb/d. The key refining center in this context is defined as Australia, China, Indonesia, India, Japan, Malaysia, New Zealand, Philippines, Singapore, South Korea, Taiwan, and Thailand. The 1988 petroleum product balance for these nations is provided in Table 10.

In 1988, diesel production of 2.3 mmb/d and imports of 384 mb/d were observed, with exports accounting for 287 mb/d. Fuel oil production of 2.7 mmb/d was supplemented by 605 mb/d of imports. Fuel oil exports averaged 562 mb/d, most of which was shipped from Singapore and Indonesia.

The four net exporters of gasoline in 1988 accounted for 65.8 mb/d of exports, with China and Singapore accounting for almost the entire volume. The region as a whole is a net-importer of gasoline; however, we have calculated the potential for gasoline exports from the four current and two prospective net-exporters in the region. Our findings are included as Table 11. For 1995, our low range gasoline export availability is 67 mb/d, and high range export availability is 140 mb/d. China and the Philippines drop out of the picture entirely, and Singapore and Indonesia account for virtually all exports. We expect all net exports to be easily absorbed in the Asia-Pacific region.

Table 10

Key Refining Centers* Petroleum Product Balance, 1988

('000 barrels per day)

	Production	Imports	Exports	Consumption
LPG	429.9	480.5	57.7	846.9
Gasoline	1,751.7	172.1	123.2	1,811.6
Naphtha	711.8	456.1	215.4	897.3
Kero/Jet	1,148.8	227.0	205.2	1,170.2
Diesel/Gasoil	2,265.4	383.7	287.1	2,373.0
Fuel Oil	2,716.9	605.3	562.0	2,776.2
Other	452.2	22.4	47.5	438.5
TOTAL	9,476.7	2,347.1	1,498.2	10,313.7

*Key centers are Australia, China, India, Indonesia, Japan, Malaysia, New Zealand, Philippines, Singapore,South Korea, Taiwan, and Thailand

Table 11

Potential Gasoline Exports in the Asia-Pacific Region

('000 barrels per day)

Net Exporters:	1988	1995 Lower	1995 Upper
Australia	0.0	0.0	0.2
China	24.1	0.0	0.0
Indonesia	0.0	25.0	74.1
Philippines	3.6	0.0	0.0
Singapore	38.0	42.0	64.8
South Korea	0.1	0.0	1.4
Total	65.8	67.0	140.5

10. Conclusion

A substantial amount of the demand increase projected between 1987 and 1995 has already taken place. Based on preliminary statistics for 1988 and 1989, it appears that regional demand will reach 12 million b/d in 1990, an increase of about 1.5 million b/d over 1987. Thus, over 40 percent of the total growth of 3.5 million b/d in Asian demand over the 1987-95 period is likely to have been completed by next year. Even if demand does not grow as rapidly as anticipated, even modest increases from the 1990 base, seen against a background of declining Asian crude exports, points to a tighter market, a prolongation of high refinery margins, an increased reliance on supplies of oil from the Mideast and, more surprising, an unforeseen rate of firming in the crude market. OPEC is likely to resume its pivotal role in the oil market, and the Persian Gulf will once again be the focus of political and economic attention. The increase in demand in Asia, in concert with the levels of demand increase worldwide, may return the global economy to a situation where a disruption or political instability in the Middle East can give rise to sudden price shocks and market dislocations.

There are many factors that could alter this outlook. Those who believe that we learn from history might suggest that OPEC will be more moderate in its pricing behavior during a new tightening of the market. The "Yamani strategy" of slow and steady price increases, at low enough levels to discourage major shifts away from oil, may carry the day with oil ministers who remember the

debacle following the rise to $34/b. Downstream integration, especially the moves by Venezuela, Saudi Arabia, Kuwait, and Indonesia, may act as a force in favor of market stability; those countries with extensive joint ventures and overseas marketing outlets have much more to lose from market disruptions than in the past.

Near-term price increases could also have a constraining effect on demand growth, not only through direct price effects, but also from their effects on perception. Both policymakers and end-users appear to be more sensitive to the *rate* of price increases than to the absolute levels of price. A steady increase in price might do little to discourage demand growth, but a near-term price spike owing to a supply disruption could have a dramatic effect on the policies of both governments and consumers. In Asia in particular it would be easy for governments to reinstate the control systems that governed petroleum in the mid-70s through mid-80s. Furthermore, conservation measures are now more widely understood by both industry and residential customers than after the previous two oil shocks. A sense that oil is a point of vulnerability, which has largely vanished, could result in a curtailment of demand much more rapidly than has occurred in the past.

Finally, the economic position of the Asian economies must be considered. Recessions could dramatically affect the demand outlook. Some analysts simply feel that the recent booming growth cannot be sustained. Demand growth could be set back somewhat if political or social strife postpone or derail national

development plans. The recent events in China could result in a major change in Chinese consumption. Since China accounts for nearly 1 million b/d of the projected demand increase from 1987 to 1995, a slump in Chinese demand growth would have a massive impact on the overall regional forecast. (However, reduced Chinese demand might not fully alleviate the pressure on refined product supply, since it is possible that some planned refinery construction projects might be cancelled or postponed). Similarly, India's always-precarious economic growth could be reversed; India accounts for over 680,000 b/d of the incremental demand projected.

In closing, we would like to emphasize very briefly some key points to be kept in mind and examined.

- Is the pace of demand growth likely to continue higher than our forecasts? If so, then the biggest pressure on oil prices in the 1990s will come from the Pacific basin.

- Japan's crude burning practice is the most important *single* determinant of crude prices in the Asia-Pacific region.

- The Asia-Pacific refining sector is still far behind the rest of the world in terms of its capacity and sophistication. Product imbalances are virtually inevitable and will necessitate significant growth in product trade. Increasingly, nations will have to look outside the region for marginal supplies of product. The implications for freight markets are potentially enormous.

- The four most critical product imbalance centers are likely to be India, China, Japan, and U.S. West Coast. These pressure points are likely to

cause significant changes in the regional crude and product flows. For example, the U.S. West Coast will make the transition from crude-surplus region to crude-deficit region. We anticipate that the West Coast refiners will look to the Asia-Pacific region for additional supplies of crude, product, or both.

- Changing environmental standards on sulfur and lead will result in much stronger premiums for Far East crudes. With low sulfur crudes declining in availability, hydroprocessing will be relied upon more and more to reduce sulfur and increase yields of transport fuels.

- Refining will remain profitable even for less-sophisticated refineries. Since the imbalance in the region will be a question of both quantity *and* quality, straight run products from simple hydroskimming plants will be highly valued--cracking improves yields, but cracked stocks (particularly thermally-cracked stocks) are generally poorer in quality. This is not to say that a sophisticated refiner will ever find himself at a disadvantage--the added element of flexibility will remain at a premium. Experienced refining/-trading centers such as Singapore will be admirably poised for the coming decade.

In short, the 1980s brought many changes to the Asia-Pacific region, and the coming decade is sure to pose continual challenges. The region will undergo major structural changes; dynamic demand growth and impending product imbalances offer many exciting opportunities to buyers, sellers and shippers alike. The unusual complexities of the regional system will make planning an essential tool. Those who have learned from the past and can project their experience into the future stand to do very well in the "Pacific Century"--or at least in part of it, since the "century" may very well outlast our lifespans. In contrast, for

those who cautiously stand back and catch only the tail end of the coming cycles in building, buying, or selling, the future may be full of pitfalls and unpleasant surprises.

KUNTORO MANGKUSUBROTO
President Director
PT Tambang Batubara Bukit Asam
(Persero)

Professor Industrial Engineering Dept.
Bandung Institute of Technology (ITB)

Chairman
Graduate School of Transportation Systems, ITB

Education:

1. Bandung Institute of Technology (ITB)
   -- Engineering degree in Industrial Engineering
   -- Doctor degree in Industrial Engineering
2. Stanford University, Industrial Engineer
3. Stanford University, Civil Engineer

Professional Background:

1972 - 1979	Assistant and Associate Professor in Industrial Engineering, ITB
1979 - present	Chairman of Graduate School of Transportation Systems, ITB
1983 - 1988	Assistant to the Secretary of State of the Republic of Indonesia
1988 - present	President Director, PT Tambang Batubara Bukit Asam (Persero)

Professional Association:

1. Persatuan Insinyur Indonesia (Indonesian Engineer Association)
2. Institute of Management of Science, (TIMS)
3. Institute of Industrial Engineers (IIE)
4. Chairman, Ikatan Sarjana Teknik dan Manajemen Industri Indonesia (ISTMI) (Indonesian Association of Industrial Engineers)

SI-MIN CHANG
President
Taiwan Power Company

Education: BSEE, National Taiwan University, 1953
Reserve Navy Officer, Chinese Navy, 1954

Training Abroad:

Mar - Oct. 1960	Distribution Engineering Practice, Public Service Co. of Indiana and Boston Electric Co., USA
Nov. 1964 - Feb. 1965	Rate Structure, Ebasco Service Co., USA
June 2 - June 14, 1985	Modeling and Analysis of Modern Power System, The University of Texas at Arlington, Texas, USA
June 8 - July 3, 1987	Top Management Program, Asian Institute of Management, Baquio City, Philippines

Present Position: President, Taiwan Power Company

Working Experience:

Distribution Engineer, Section Head, Division Head, Business Dept., TPC

Deputy Manager, Tao-Yuan District, TPC in charge of Sales and Management

Deputy Manager, Taipei District, TPC in charge of Distribution System Planning and Construction

Manager, Tao-Yuan and Taipei Districts, TPC

Chief Engineer, Distribution, TPC, Vice President, Taiwan Power Company

Foreign Service:

Jan. - Apr. 1966	Member, China Power Mission to Vietnam
Feb - Apr. 1972	Member, China Power Mission to Thailand
Mar 1975 - Apr 1976	Member, China Power Mission to Saudi Arabia

Part-time Teaching Experience:

1969 - 1975	Associate Professor, EE Dept., National Taiwan University

FUTURE COAL-FIRED GENERATION PLAN OF TAIWAN POWER COMPANY

SI-MIN CHANG
PRESIDENT
TAIWAN POWER COMPANY

NOV. 1989

FUTURE COAL-FIRED GENERATION PLAN OF TAIWAN POWER CO.

I am very pleased to have this opportunity to be here with you to report the coal-fired power generation plan of Taiwan Power Company. Taiwan Power Company, also known as Taipower, is a state-owned electric utility managed and operated as a business entity under the general supervision of the Ministry of Economic Affairs(MOEA). As the sole electric utility in Taiwan, Taipower is responsible for developing, generating, supplying and marketing electric power to the whole Taiwan island and its offshore islets. Today, I would like to present an overall picture of the current status and long range power development program, with the focus on coal-fired projects, as designated by the Executive Committee of the conference, and I will then conclude today's presentation with Taipower's coal procurement policy.

1.0 THE PRESENT GENERATION CAPABILITY

Taipower's present power generation system consists of a well-balanced mix of fossil-fired, hydro and nuclear. As today it is, we have a total installed capacity of 16,589 MW, as shown in Table 1-1, of which 15.4% is hydro, 53.6% thermal, and 31.8% nuclear. The net peaking capacity is 15,884 MW. As compared with the peak load of 13,422 MW on July 21 this year , the system reserve margin once declined to an untolerably low level of 14%.

Since the load demand is characterized by a very high load factor,the bulk power requirement has primarily stemmed from

the base load. Fossil-fired and nuclear facilities have been rapidly expanded, and are being operated mainly to supply base load. Storage, pondage and pumped storage hydro plants as well as gas turbines have been assigned mainly to meet peak load demands.

Table 1-2 gives a historic electricity production and its composition over the past 5 years (1984-1988). Figurel-1 further illustrats the fluctuation of the composition during the same period.

2.0 LOAD FORECAST AND GENERATION EXPANSION PLAN

(I) Economic Growth and Electricity consumption

The economy in the Republic of China is trade-oriented, with the United States being the leading trading partner, followed by Japan, West Germany and other countries. We have experienced rapid growth of GNP and modernization of economic structure in the past years. Taipower's growth has been strongly interrelated with these processes, and will continue to be so in the future. During the period 1971 to 1980, electricity consumption on an average increased at a remarkable rate of 12.2% per annum. In 1981 and 1982, we experienced a lowest record level of -1.3% and 1.9%, respectively. In 1987 and 1988, the rate of increase came back to two-digit numbers, 11.6% and 10.2%, respectively, due to strong economic recovery resulting from a great step toward economic internationalization and liberalization,

which are highly important to strengthening a sound foundation for the economy of our country.

It is no doubt that sufficient electricity is an indispensable driving force to economic developments. And, the GDP growth rate renders the most important paramater in predicting future electricity demand. when we reviewed the historic statistics, a high positive correlation between GDP growth and electricity consumption growth was found as shown in Table 2-1. If we further compare these two figures by a seasonal split as shown in Figure 2-1, it gives us a even stronger impression about their correlation.

(II) Load Forecast

The latest load forecast was made by Taipower in Octerber this year. It is revised basically on an annual GDP growth rate of 6.10% for the period 1989 to 2000, as projected by the Council For Economic Planning and Development in March 1988.

The results of the forecast show that, after taking into account the enhancement of load management, the average load and peak load are predicted to increase at a moderate rate of 5.3 and 5.4 per annum, respectively. The year-by-year figures are shown in Table 2-2.

The prediction also indicates that the economic structure in Taiwan is now in a transition period. The share of industrial

power consumption declines primarily due to the change of industrial structure from labor-& energy-intensive to technology-& capital-intensive operations and service sectors are playing an increasingly important role. And at the same time, because of the improvement of living standard, electrical appliances and air conditioners are widely used in Taiwan. This trend has made the gap between peak load and average load become bigger and bigger.

(III) Strategies and Measures for System Expansion:

In programming system expansion, Taipower has never relaxed its efforts in meeting the grand goal of achieving the reasonable power service cost, with adequate measures in environmental and ecological protection and energy supply security.

Thus, the present system is to be improved and potential energy supply sources are to be developed to meet the future power demand with following strategies:

(1) Achieving reasonable power generation cost by:

- Optimal mix of various generation units, using nuclear units as base load, coal-firing as intermediate and base load, and hydro as peak load unit.
- attaining regional demand and supply balance.
- maintaining adequate reserve capacity.
- standardizing unit size to sale investment and facilitate

operation and maintenance.
- multiunit installation at each developed site.
- obtaining adequate profit to cover debt service and return.

(2) Emphasizing environmental and ecological protection by:

- conducting thorough environmental impact assessment before project proposal submittal.
- allocating adequate budget to cover measures needed to comply with environmental protection standard.
- inviting public participation in order to reach consensus in formulating protection measures.

(3) Ensuring energy supply security by:

- diversifying form and source of energy.
- maintaining adequate fuel inventory.
- utilizing domestic resources.
- developing and utilizing new energy resources.

(IV) Generation Expansion Programme (1989-2000)

The present long-range power development programme covers a period of 12 years from 1989 to 2000. some projects are under construction, some are in the process of securing goverment approval, while others are at the stage of feasibility study.

In summary, by the end of 2000, it is anticipated that the system will increase from the present 16,589 MW to 30,801 MW.

The net increase of 14,212 MW during this timeframe will comprise 2,075 MW from hydro, 11,078 MW from fossil-fired, 2,000 MW from nuclear, and the deduction of 941 MW for scheduled retirement.

Figure 2-2 & 2-3 show a brief contrast of projected installation and generation between 1988 and 2000.

3.0 NEW COAL-FIRED POWER PROJECTS

As we can see from the generation expansion program, the most significant increase will come from coal-fired power.

Table 3-1 summarizes the status of existing 11 coal-fired units with a total installed capacity of 3,750 MW. All these units are of dual-fired design and can burn either coal or oil.

Table 3-2 illustrates the coal-fired expansion programme. 13 new units with a total installed capacity Of 7,750 MW will successively join the system before the year of 2000. AS a result, the coal-fired installed capacity in the system will increase from the present share of 23.9% to 37.1%, and coal-fired units are going to play a more important role in Taipower's system.

Figure 3-1 demonstrates the locations of coal receiving ports and coal-fired power plants.

In developing new coal-fired power projects, major concerns are sites/terminals availability, direct and smooth coal handling, and adequate environmental protection measures.

Due to these reasons, the candidate site of Taichung, Su-Ao and the existing site of Hsin-Ta are all in the area of seaside adjacent to or near the existing commercial harbors.

An exclusive coal terminal with modern unloading facilities for each specific project will be constructed within the existing commercial harbor or just adjacent to the site of power stations.

Each associated coal yard will have the capability of stocking at least three-month coal requirements to comply with government regulations.

Of course, all the proposed coal-fired units will be designed and equipped with the modern flue gas emission reduction devices such as electrostatic precipitator or bag house filter, FGD and DeNOx, etc., to reduce the pollutants to the practicably minimum level. The designed emission limits for SOx, NOx and particulate are more stringent than those stipulated by our government. Such investmentsare somewhat beyond economical consideration. However, as a state-owned utility, Taipower is in duty bound to be a paragon of environmental protector.

As for fly ash and FGD sludge, we plan to dispose in the

seaside ash pond just adjacent to the plant sites. These ash ponds will be large enough to accommodate all the ash to be disposed during the lifetime of the power plants.

Table 3-3 shows the associated facilities, such as terminal, ship unloader and coal yards which are planned to be built for the new coal-fired power projects.

4.0 COAL PROCUREMENT POLICY

With the current installed capacity of 3750MW for coal-fired units, around 8 million metric tons of steam coal are consumed by Taipower. The expansion plan, as mentioned above, will add to the system 13 units with an additional installed capacity of 7,750 MW. This will boost steam coal consumption up to 20 million metric tons per annum by the year of 2000. Figure 4-1 shows the statistics of Taipower's coal consumptions for the past and Figure 4-2 gives the Taipower's projected coal requirement.

As you are aware, not only Taipower but also other major electric utilities in the Far East have similar plans to significantly expand their coal-fired power generation capacity in the future. Recent reports indicate that the annual coal consumption in the power sector in Japan, South Korea, and Hong Kong will rapidly increase to 46, 24 and 18 million metric tons, respectively, by the end of this century. Those countries with the same background of lacking indigenous energy resources will form an increasingly

important and dominant importing center in the international seaborn coal market. After carefully reviewing its particular circumstances, experiences in coal purchasing activities and common practices adopted by other electric utilities, Taipower has formulated the basic procurement policy as follows :

(1) Diversification:

Electric utilities bear the responsibility of furnishing sufficient electricity to their customers. Especially for those utilities such as Taipower who must import virtually all of its fuel requirement from overseas , fuel supply reliability is of vital importance. There is a general consensus that supply diversity is the cornerstone of security. With the perception of internatonal coal market situations, we plan to have our coal supply sources portofolio as follows:

Origin countries	Percentage
United States	20 ---40 %
South Africa	20 ---40 %
Australia	20 ---40 %
Others (Canada, Indonesia etc.)	10 ---30 %

In addition to the diversification of supplying countries, we will also undertake to diversify loading ports, inland transportation routes, and producing areas within a country.

(2) Acquisition Approaches:

The fundamental objective of coal procurement of electric utility is not in pursuit of short term gains, but rather of longer term stability. In our opinion, spot purchase will be utilized only to serve as a means of examining new coals and evaluating new suppliers, a buffer for variations in short term demand, a step of making up delivery loss from Force majeure or other reasons, or a means of observing market situations. Basically, we would maintain the following pattern:

Approaches	Percentage
Long-term contract and overseas investment	70 ---90 %
Spot purchase	10 ---30 %

As for the long-term contract arrangement which is the main approach that Taipower secures its coal requirements, several guidelines would also be followed:

(a) Term of Contract:

Within a range from 5 to 10 years.

(b) Price Mechanism:

Among various kinds of price clauses, market price is our preference. Though it might not result in the lowest cost, yet it provides both the buyer and the supplier with a more pleasant and satisfactory business relationship to maintain a long contract in line with the market trend.

(C) Quantity:

Base contract tonnage from any single supplier will be limited to 10% of Taipower's annual requirement and one-third of the supplier's annual production capacity. An adequate annual quantity flexibility will also be required in order to meet future demand uncertainty.

(3) Quality of coal supplied:

Coal quality significantly affects plant design, plant investment, operating and maintenance cost,and output efficiency. We plan to design our new coal-fired units to accommodate a wider range of coal quality. Coal blending facilities will also be equipped so that we may have considerable flexibility in coal supply sources, while maintaining a stable and consistent quality of coal to

our power plants.

(4) Purchasing Procedures:

We shall sign contracts directly with coal producers or owners, without any brokers or intermediaries. We will also maintain direct contacts with our suppliers including potential suppliers so as to bring a better understanding and maintain a friendly and mutually beneficial working relatiohship. On the other hand, prior to entering long-term contracts, prudent selection of reputable producers through competitive process is deemed crucial, and emphasis will be placed on production capability, coal quality, economical viability, performance record and delivered cost per Btu to Taipower CIF basis.

TABLE 1-1 PRESENT GENERATING CAPABILITY

Item	Installed Capacity		Net peaking Capacity	
	(MW)	(%)	(MW)	(%)
Hydro	2,558.0	15.4	2,254.8	15.0
Fossil-fired	8,886.8	53.6	8,009.4	53.4
Nuclear	5,144.0	31.0	4,740.0	31.6
Total	16,588.8	100.0	15,004.2	100.0

TABLE 1-2 HISTORIC ELECTRICITY PRODUCTION AND ITS COMPOSITION

YEAR	HYDRO		OIL-FIRED		COAL-FIRED		NUCLEAR		TOTAL
	TWH	%	TWH	%	TWH	%	TWH	%	TWH
1984	4.4	9	9.4	19	11.9	24	23.6	48	49.3
1985	6.9	13	5.0	10	13.1	25	27.5	52	52.5
1986	7.4	13	7.1	13	18.6	31	25.8	44	59.2
1987	7.1	11	6.0	11	20.7	31	31.8	48	66.7
1988	6.1	9	15.0	21	21.1	29	29.4	41	71.6

Fig. 1-1 Composition of Production

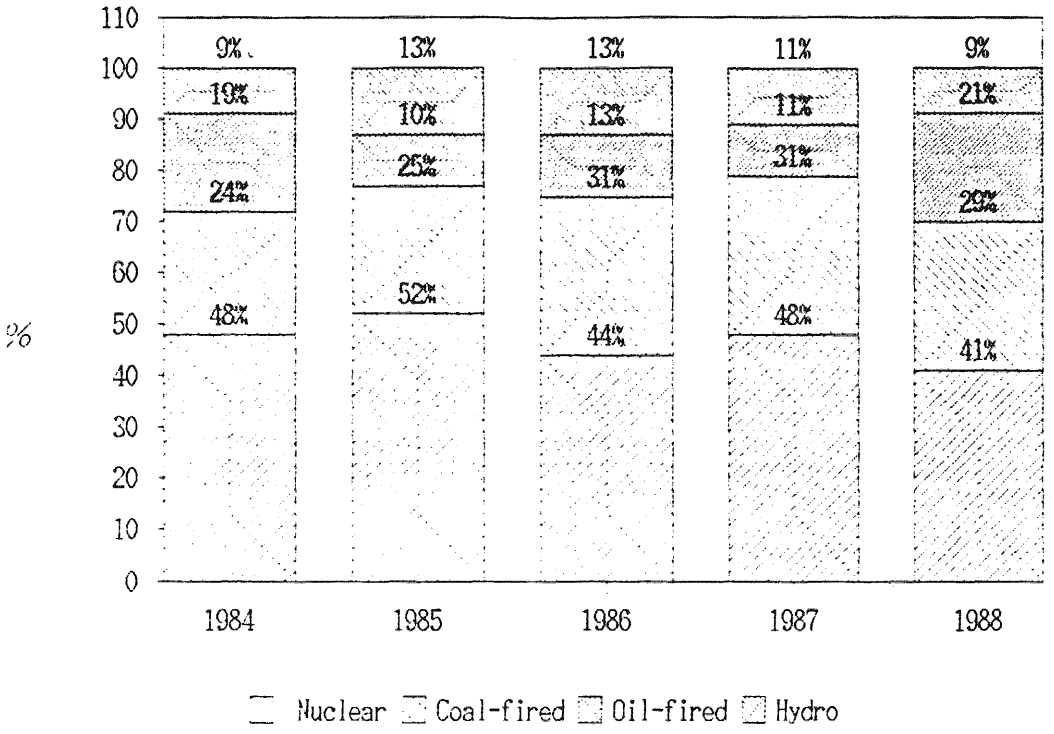


Table 2-1 ECONOMIC GROWTH AND ELECTRICITY CONSUMPTION

ITEM	70's (1961-70)	80's (1971-80)	90's (1981-88)
1.GDP real growth rate	9.6	9.7	7.5
2.electricity consumption	14.3	12.2	7.0
3.elastic coefficient	1.49	1.26	0.93
4.average load	13.8	11.9	6.9
5.peak load	12.9	12.1	7.9

FIG 2-1

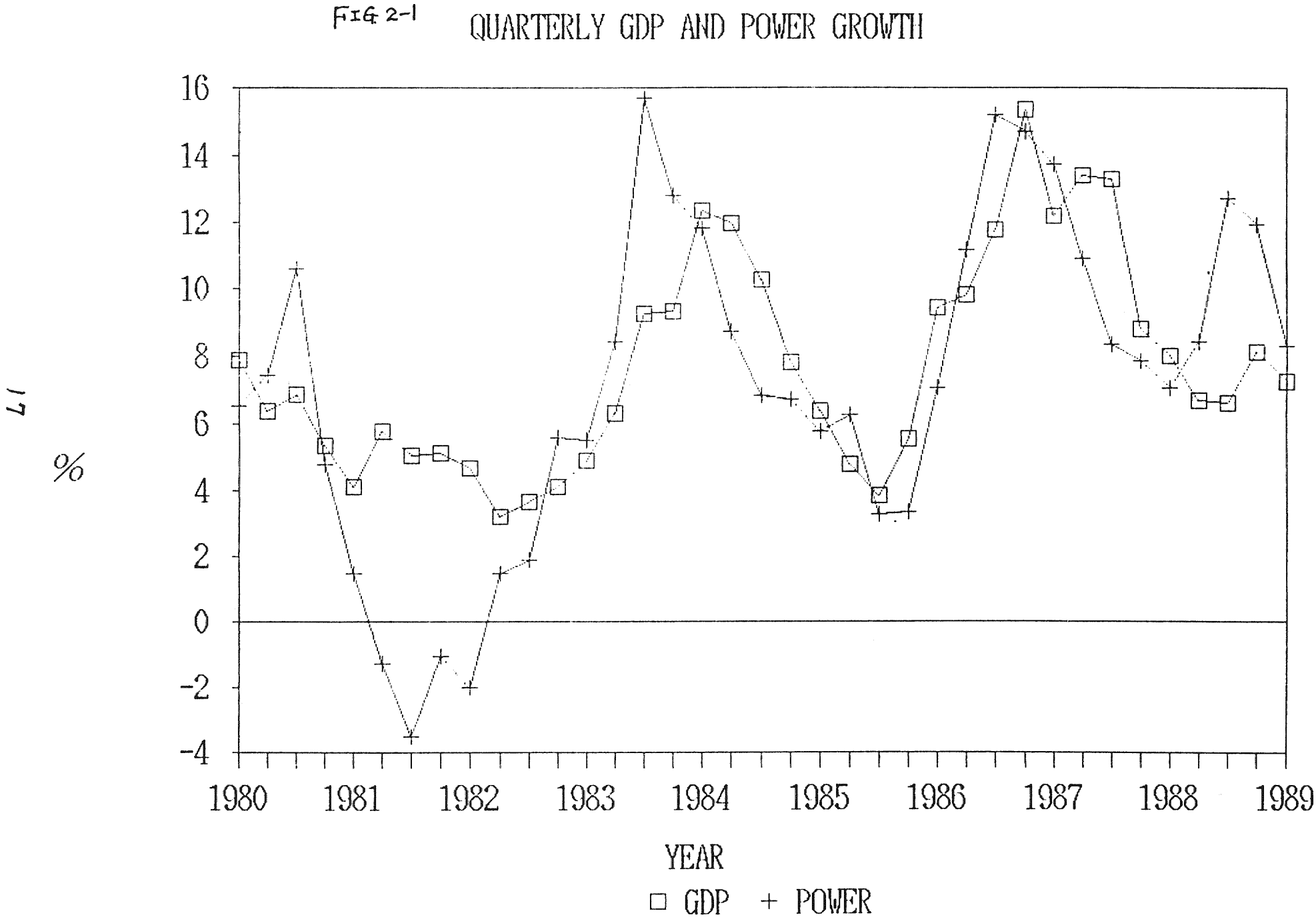

QUARTERLY GDP AND POWER GROWTH
%
16
14
12
10
8
6
4
2
0
-2
-4
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
YEAR
□ GDP + POWER

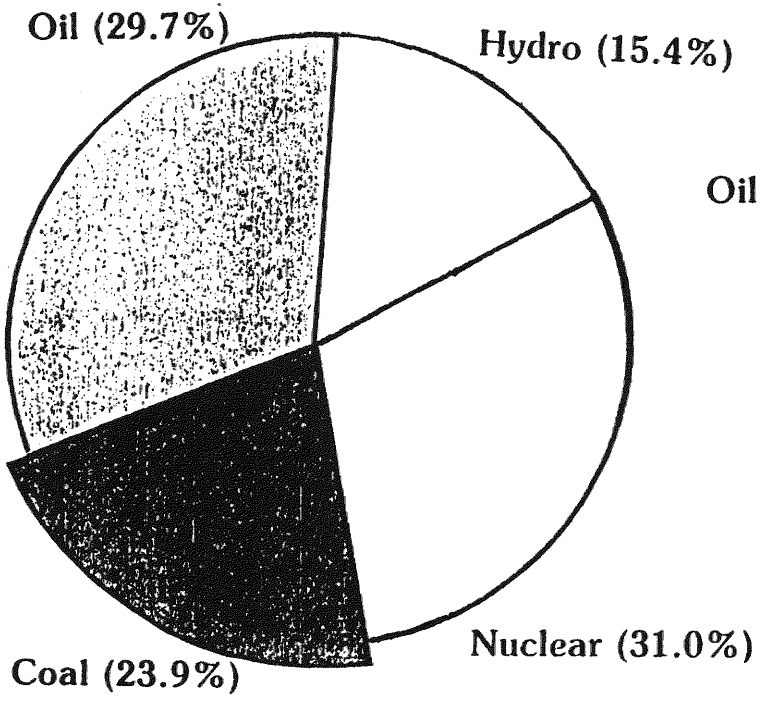
TABLE 2-2 LOAD FORECAST (with load management)

YEAR	GDP	Average load	Peak load	Generation**
	%	GW	GW	GWH
1988*	6.8	7.9	12.3	69,674
1989	6.5	8.5	13.4	74,478
1990	6.0	8.9	14.1	78,138
1991	5.8	9.3	14.7	81,754
1992	5.6	9.7	15.4	85,536
1993	5.7	10.3	16.1	90,088
1994	5.8	10.8	17.0	94,812
1995	5.9	11.4	17.9	99,787
1966	6.0	12.0	18.8	105,040
1997	6.2	12.6	19.8	110,627
1998	6.3	13.3	20.8	116,575
1999	6.4	14.0	22.0	122,901
2000	6.5	14.7	23.2	129,588
average increase rate(1989 -2000)	6.1	5.3	5.4	5.3

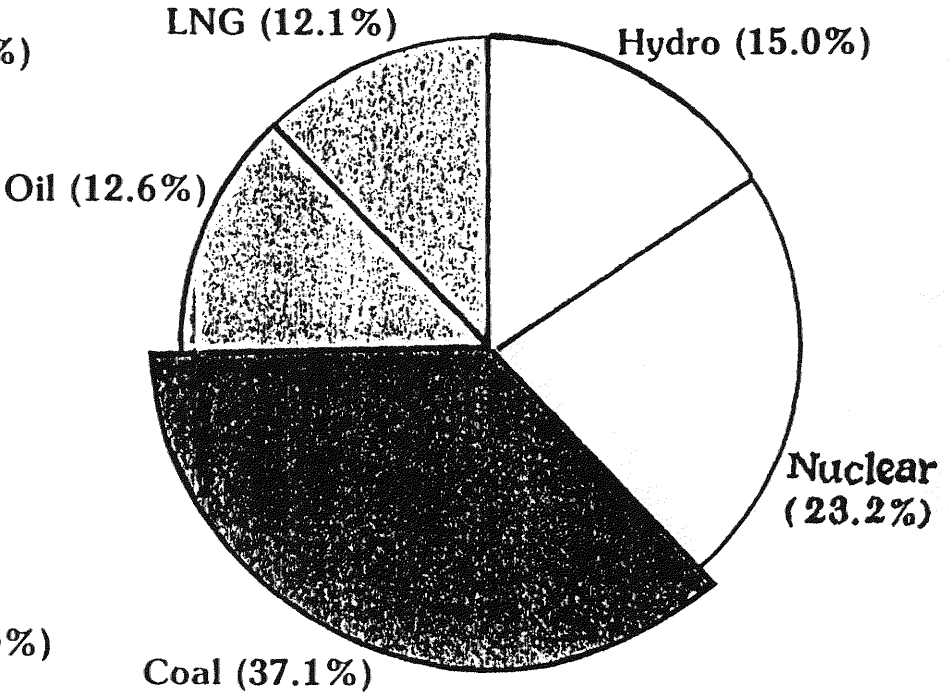
* Actual Figures.
** Exclude Pumping Energy.

Fig. 2-2

GENERATION EXPANSION PROGRAMME
(1) CONTRAST OF PROJECTED INSTALLATION

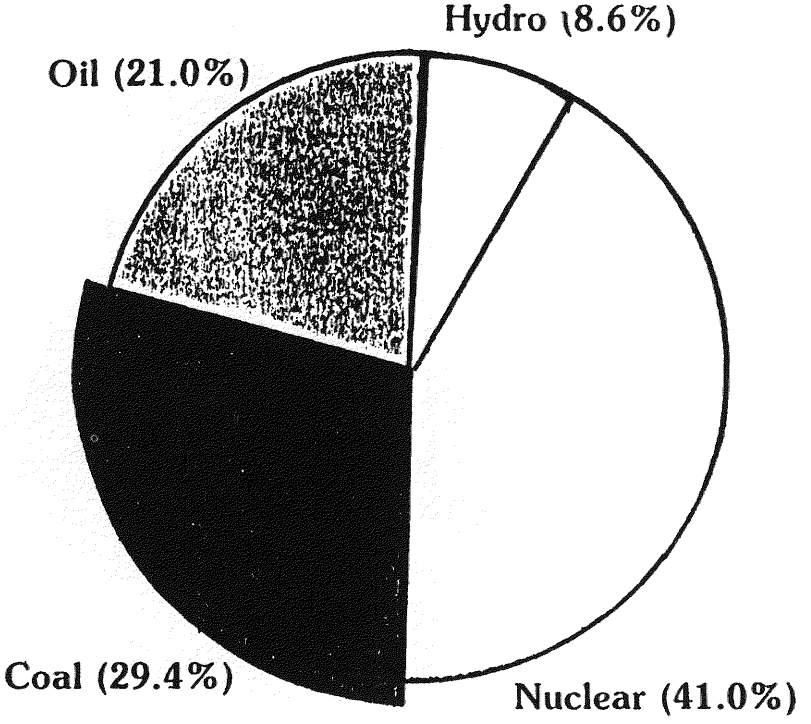


1989
TOTAL: 16,589 MW

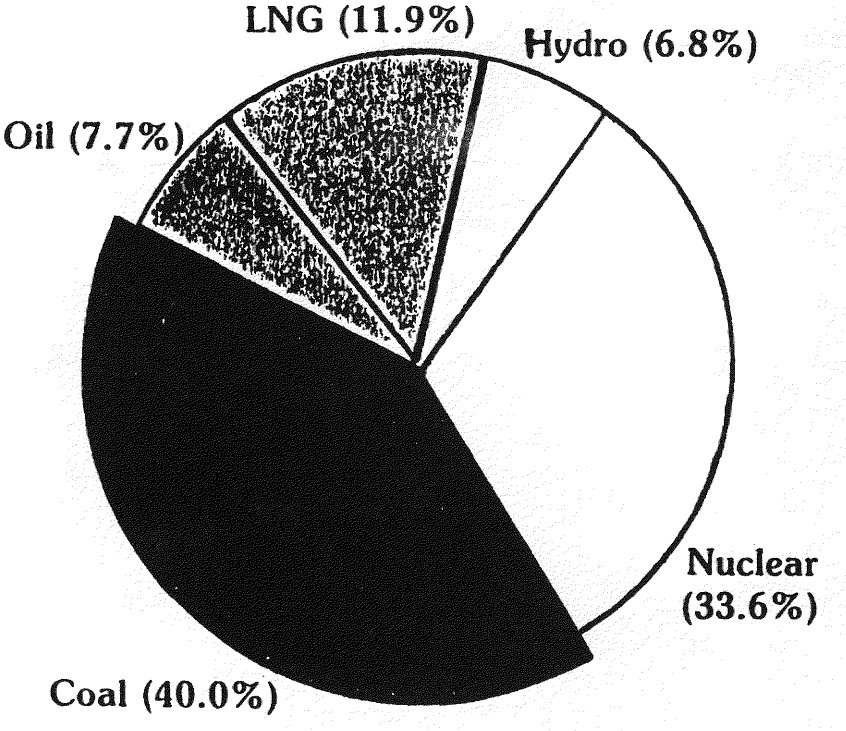


2000
TOTAL: 30,801 MW

GENERATION EXPANSION PROGRAMME
(2) CONTRAST OF PROJECTED GENERATION



1988
TOTAL: 71,641 GWH



2000
TOTAL: 133,021 GWH

TABLE 3-1 TAIPOWER'S EXISTING COAL-FIRED UNITS

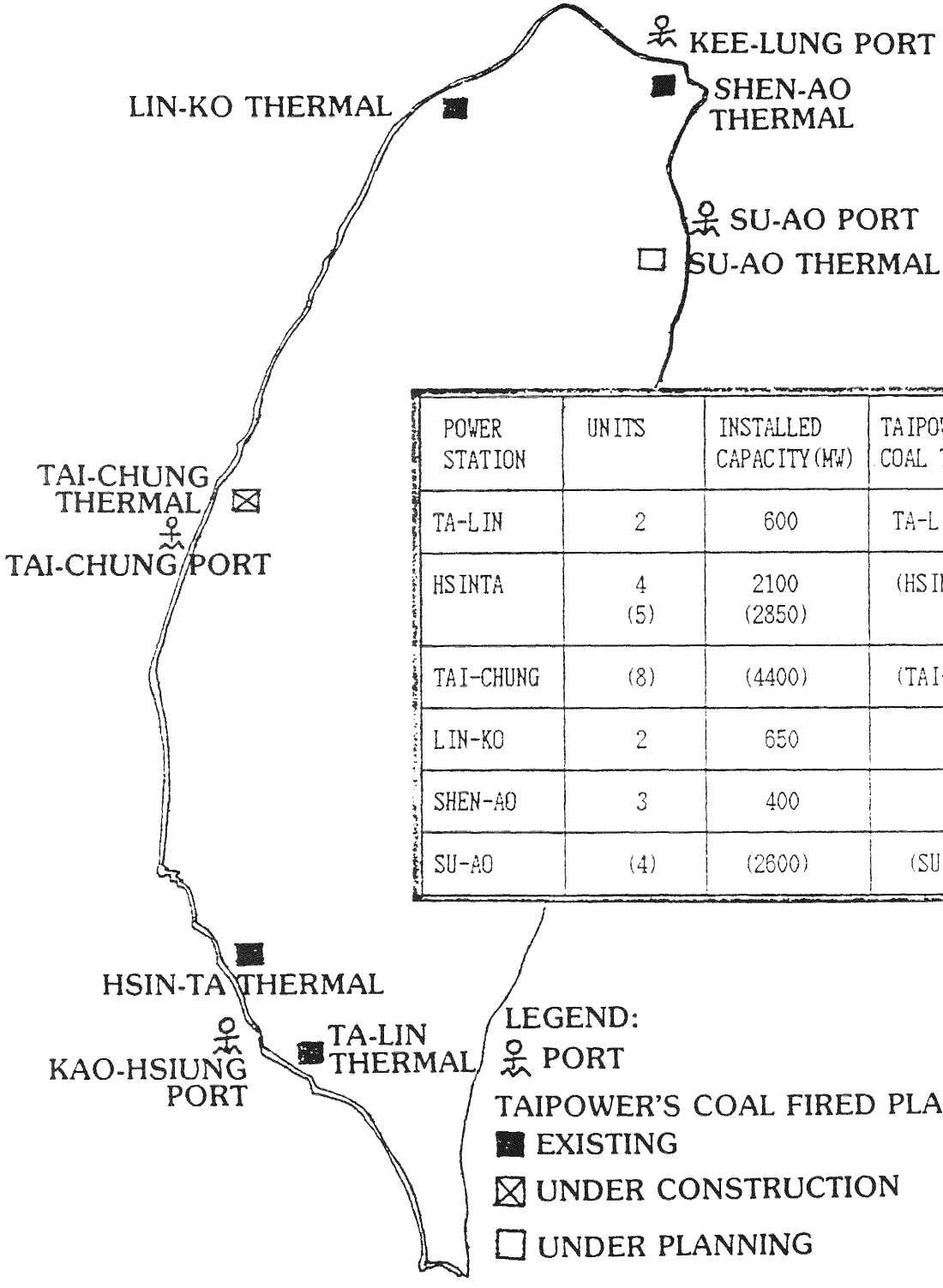
STATION	UNIT	DATE OF COMMERCIAL OPERATION	INSTALLED CAPACITY (M W)
TALIN	#1	07, 1969	300
	#2	05, 1970	300
	SUB-TOTAL		600
HSINTA	#1	05, 1982	500
	#2	05, 1983	500
	#3	03, 1985	550
	#4	02, 1986	550
	SUB-TOTAL		2,100
LINKO	#1	07, 1968	300
	#2	03, 1972	350
	SUB-TOTAL		650
SHENAO	#1	01, 1960	75
	#2	12, 1961	125
	#3	05, 1966	200
	SUB-TOTAL		400
TOTAL	11 UNITS		3,750

TABLE 3-2 TAIPOWER'S COAL-FIRED EXPANSION PROGRAM

STATIONS	UNITS	SCHEDULED COMMERCIAL OPERATION	INSTALLED CAPACITY (M W)	PRESENT STATUS
TAICHUNG	#1	06, 1991	550	UNDER CONSTRUCTION
	#2	12, 1991	550	UNDER CONSTRUCTION
	#3	06, 1992	550	UNDER CONSTRUCTION
	#4	06, 1993	550	UNDER CONSTRUCTION
	#5	04, 1995	550	PLANNING
	#6	10, 1995	550	PLANNING
	#7	06, 1996	550	PLANNING
	#8	03, 1997	550	PLANNING
	SUB-TOTAL		4,400	
SUAO	#1	05, 1995	550	PLANNING
	#2	05, 1996	550	PLANNING
	#3	05, 1998	750	PLANNING
	#4	05, 1999	750	PLANNING
	SUB-TOTAL		2,600	
HSINTA	#5	03, 2000	750	PLANNING
	SUB-TOTAL		750	
	TOTAL		7,750	

FIG. 3-1

LOCATIONS OF RECEIVING PORTS & COAL FIRED POWER PLANTS

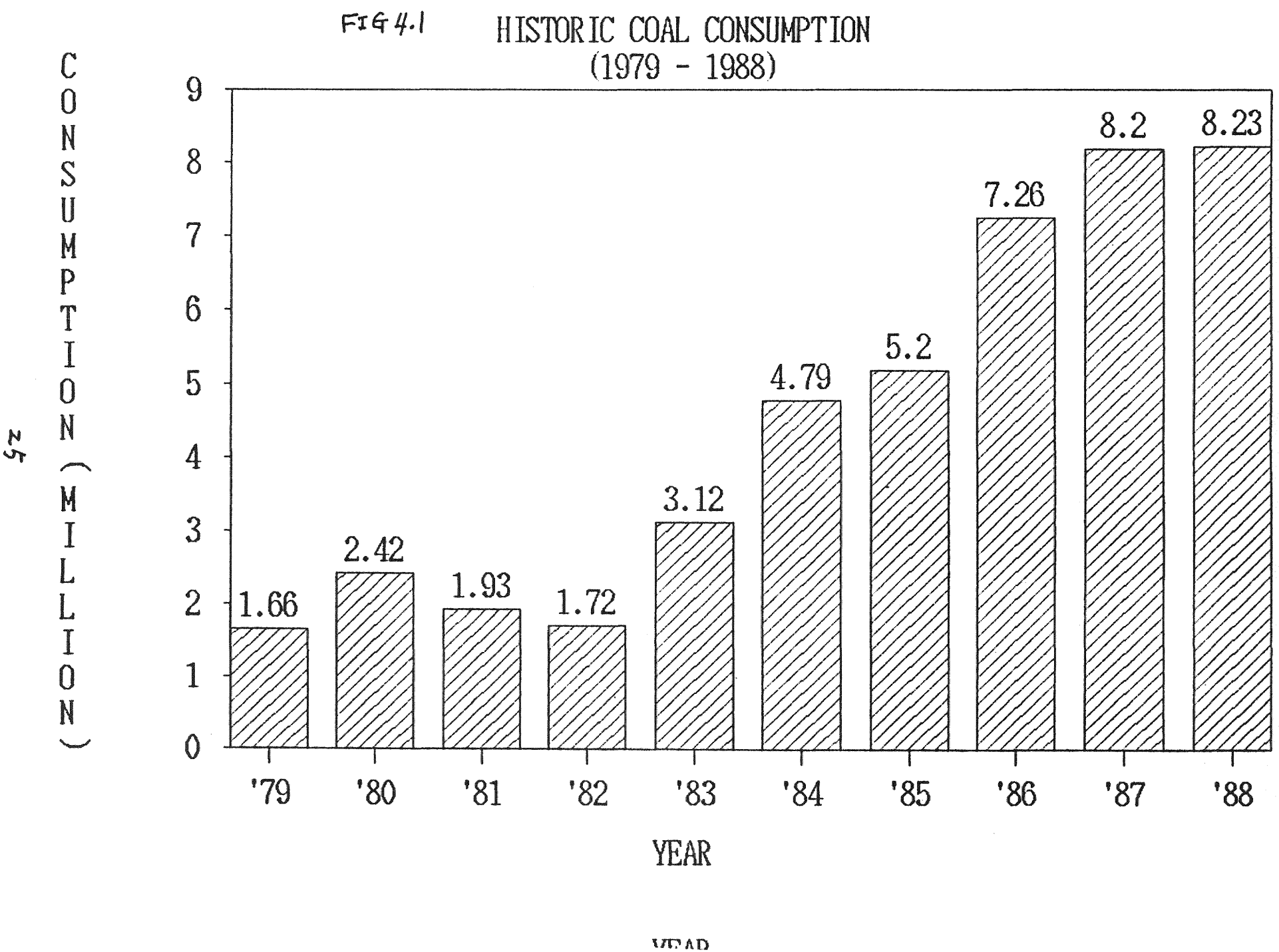


POWER STATION	UNITS	INSTALLED CAPACITY(MW)	TAIPOWER COAL TERMINAL
TA-LIN	2	600	TA-LIN
HSINTA	4 (5)	2100 (2850)	(HSIN-TA)
TAI-CHUNG	(8)	(4400)	(TAI-CHUNG)
LIN-KO	2	650	
SHEN-AO	3	400	
SU-AO	(4)	(2600)	(SU-AO)

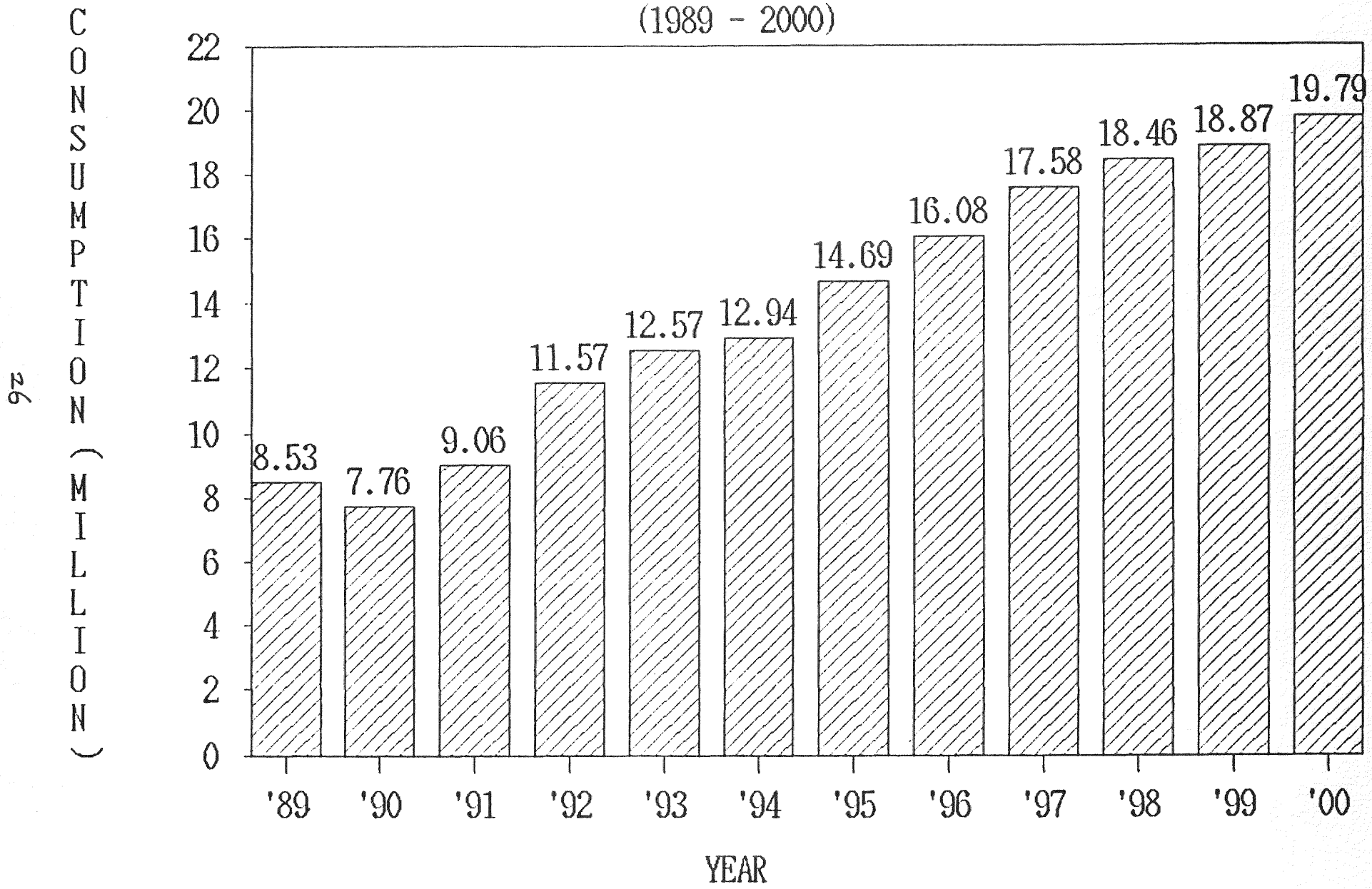
TABLE 3-3 ASSOCIATED FACILITIES OF NEW COAL-FIRED POWER PROJECT

Project Name	TAICHUNG	SU-AO	HSIN-TA	
			Existing	Projected
Terminal				
port name	TAICHUNG	SU-AO	TALINPU	HSIN-TA
berths	2-3	2	1	2
Max VSL(DWT)	60,000 125,000	60,000	120,000	125,000
Shipunloader	2-3	2	2	2-3
type	Grab bucket /continous	Grab bucket	Grab bucket	Grab bucket
capacity(each-tph)	2,000	2,000	2,000	2,000
Distance to coal yard	adjacent	9 km by conveyor	18 km by barge	3.7 km by conveyor
Coal yard				
area	100 ha	73.4 ha	27 ha	135 ha
capacity(mmt)	3.0	3.1 (including 7 days covered storage bin)	1.2	3.7 (including 7 days covered storage bin)
blending capability	YES	YES	NO	YES

FIG 4.1


HISTORIC COAL CONSUMPTION
(1979 - 1988)
CONSUMPTION (MILLION)
0
1
2
3
4
5
6
7
8
9
1.66
2.42
1.93
1.72
3.12
4.79
5.2
7.26
8.2
8.23
'79
'80
'81
'82
'83
'84
'85
'86
'87
'88
YEAR

Fig,4-2 FUTURE COAL REQUIREMENT
(1989 - 2000)



ERNESTO MONTNEGRO ABOITIZ
President
The Philippine National Power Corporation

Educational Attainment:	Bachelor of Science in Electrical Engineering University of Santa Clara
Professional/Government Examinations Passed:	Professional Electrical Engineer
Previous Positions Held:	
Government:	Acting Chairman - General Manager, Mindanao Development Authority, 1972 to July 1975 Presidential Regional Officer for Development (PROD) for Region XI, November 1972 to 1975
Private Sector:	President - Philipinas Kao, Inc., Davao Light & Power Co., Inc., Cotabato Light & Power Co., Inc. Director & Vice President for Mindanao-Aboitiz & Co., Inc. Director, Visayan Electric Co. President - Philippine Electric Plant Owners Association (PEPOA)
Civic:	Chairman & Trustee - Economic Development Foundation Member, Executive Committee - Bishops-Businessmens' Conference
Present Positions Held:	
Government:	President, National Power Corporation Board Member, National Electrification Administration Board Member, National Irrigation Administration
Civic:	Trustee Sariling Sikap Foundation Xaviar Science Foundation (Cagayan) Xavier University (Cagayan) Davao Developement Foundation Davao Research & Planning Foundation

FUTURE COAL-FIRED GENERATION AND CAPACITY REQUIREMENTS OF THE PHILIPPINES

ERNESTO M. ABOITIZ
President

NATIONAL POWER CORPORATION
Diliman, Quezon City
November 1989

FUTURE COAL-FIRED GENERATION AND CAPACITY REQUIREMENTS OF THE PHILIPPINES

Ernesto M. Aboitiz
President, National Power Corporation

1.0 INTRODUCTION

The Philippine power industry had been heavily dependent on oil-based generation in the Seventies and, as a result, was adversely affected by the rapid oil price fluctuations of the period. This forced the industry, particularly the National Power Corporation (NPC), to look towards other energy sources for power generation. The government took an active hand by encouraging and supporting the exploration and development of indigenous energy resources.

The country is blessed with a number of such resources: hydropower, geothermal steam, and coal. Hydropower had long been utilized by NPC in Luzon and Mindanao, the first geothermal plant was commissioned in 1979, and coal plant came into the picture as a major generation option in the early Eighties.

2.0 THE COAL INDUSTRY IN THE PHILIPPINES

Coal development in the Philippines is being administered and regulated by the government under the Coal Development Act of 1976 and Presidential Decree 1174 of 1977. These two laws, in effect, revamped the old concession system and introduced the service contract system. Under the service contract system, the state owns the coal, and the operator acquires only the right to explore, exploit and market the coal through an operating contract executed between the operator and the government.

Under the Coal Development Act, coal production rose from 120,810 MT in 1976 to 284,554 MT in 1977 (see Figure 2.1). Subsequent years saw a gradual decrease in production due to the resurgence of alternative energy sources; in 1972, the total production was only 39,000 MT. However, the price fluctuations in oil prices again caused production to perk up, and by 1985 the local coal produced amounted to 1.26 million metric tons (MMT). A slight dip occurred the following year with the reduction of local coal supply in Cebu.

The trend was soon corrected, and in 1988, the domestic coal production was about 1.29 MMT. The biggest share of about 583,000 MT came from the open pit mine in Semirara off Panay Island in the Visayas. The Philippine National Oil Company also produced about 293,000 MT from underground mines in Malangas, Mindanao and Uling mine in Cebu island. Another 240,000 MT was produced in Cebu from 18 small- to medium-scale underground coal mines. The remaining 178,000 MT production in 1988 came from similarly-sized mines in Batan and other islands.

Coal mining methods in the country are limited to those applicable to the geology of Philippine coal, which generally occurs in thin seams characterized by numerous faults and folds, as well as thinning and swelling characteristics. Small-scale underground mining characterizes around 80% of the companies engaged in coal mining. The open pit operations are generally small except that of Semirara Island which has a production capacity of 1.3 MT. The coal mine in Malangas, Zamboanga del Sur, operated by PNOC, is the most mechanized underground coal mine in the Philippines today.

As of 1988, a total of 14 major coal areas were being exploited in the Philippines (see Figure 2.2) by more than 30 mining firms. Aside from this, another 19 contractors have concessions to operate other mines in eight coal regions in the country. These coal regions have in-situ reserves estimated at 354 MMT with positive reserves of 273 MMT.

3.0 COAL UTILIZATION IN THE POWER INDUSTRY

Coal-based generation was first tapped by the Philippine power industry in 1982 with the commercial operation of a 50-MW dual-fired unit at Cebu in the Visayas region (see Figure 3.1). This was followed two years later by a 300-MW plant at Batangas in Luzon. By 1986, a 55-MW coal-fired unit was commissioned also in Cebu.

With these developments, the share of coal in the generation mix of NPC grew from 0.3 percent in 1982 to 2.3 percent in 1984,. finally reaching 10.2 percent in 1988 (see Figure 3.2). Percentage-wise, this translates to a growth rate of around 80 percent per annum, indicating that as far as energy sources for electricity are concerned, coal is being recognized more and more as one of the more convenient and easily implementable fuels for new power plants.

In 1988 the coal-based share amounted to 2,344 GWh and in the process the NPC plants consumed approximately 1.148 MMT of coal (estimated at a base of 10,000 Btu/lb). This reveals that the NPC coal thermal units were relatively well-utilized at an average plant factor of 66 percent and had

effective heat rates of around 10,800 Btu/kWh. The coal volume consumed corresponds to roughly 43 % of the country's coal consumption, making NPC the country's largest user of coal.

Specifically, the 300-MW Calaca Coal-Fired Plant, which is currently using a 50/50 blend of Semirara coal and imported coal, consumed some 944,000 MT of coal in 1988. Visayas' CTPP I is designed to burn local Cebu coal with a relatively high heating value of 9716 Btu/lb, while CTPP II can burn low grade coal of 8700 Btu/lb heating value. In 1988, the two units consumed a total of 206,000 MT of coal made up of 105,000 MT of Semirara coal, 73,000 MT of coal from Cebu and other islands in the Visayas, and 28,000 MT of imported coal.

Among other users of coal, the Atlas Consolidated Mining and Development Company (ACMDC) in Cebu is the third largest consumer in the country, consuming some 265,000 MT in 1988. ACMDC operates the world's sixth largest copper mine, and has an installed coal plant capacity of 96.25 MW.

4.0 NPC'S POWER DEVELOPMENT PROGRAM

The generation expansion program of NPC (Table 4.1) outlined in the June 1988 Power Development Program (PDP) envisions the addition of about 3,200 MW of coal-based capacity over the period 1989-2000. The bulk of these capacities will be put up in Luzon (around 3000 MW) while the remaining 200 MW is planned for Mindanao.

The first coal thermal addition for Luzon will be a 300-MW unit in 1992, followed by a similar unit the following year. The former is already in the implementation stage (Calaca II), while a feasibility study is being conducted for the second unit by the Japan International Cooperation Agency (JICA).

The NPC expansion program indicates that the subsequent years will see a number of geothermal capacity additions, most notable being the proposed utilization of geothermal reserves in Leyte Island. The power from these potentials (around 880 MW) will be transmitted to Luzon via a High Voltage Direct Current (HVDC) system.

The remaining 2400 MW of coal-based capacity will be added during the period 1997-2000 in 600-MW increments. For Mindanao, two 100-MW units will be added, one each in 1999 and 2000. The first 600-MW unit (Luzon Coal A) was the subject of a recent pre-feasibility study conducted by the Japanese Committee for Pacific Coal Flow (JAPAC).

The resulting capacity mix of NPC (Figure 4.1) indicates that power generation will become dependent more and more on geothermal and coal-based capacity. Specifically, the coal-based capacity will increase from 6.3 percent of the total in 1989 to almost 30 percent by year 2000. At the same time, the oil-based capacity share is expected to go down from almost half of the total capacity in 1989 to only 27 percent in the year 2000. The figures for year 2000 reflect a well-balanced capacity mix at the start of the next millennium.

In terms of generated energy, the coal-based share is expected to improve appreciably from around 10 percent in 1989 to the largest share of 39 percent by year 2000 (Figure 4.2). However, as shown in Figure 4.3, only two percent of the total generation can be supported from indigenous coal resources; the remainder has to be served by imported coal.

5.0 PROBLEMS AND ISSUES

A number of problems and issues specifically associated with the coal plant development program indicated by the PDP have to be addressed or resolved prior to implementation. Foremost among these are coal fuel supply problems, quality of coal, manpower support, and environmental issues.

5.1 Coal Supply

As indicated in Figure 4.3, the bulk of coal fuel to be used in the future will be foreign-sourced. This is primarily due to the quantity and quality of coal reserves in the Philippines.

The latest estimates by the Office of Energy Affairs (OEA) show that the Philippines has a total of approximately 460 million metric tons (MMT) of potential coal reserves (see Table 5.1 and Figure 5.1). Using standard estimation values for recovery, this figure represents around 367 MMT of minable reserves. However, the average heating value of these reserves is only 6,827 Btu per pound.

At the same time, the coal segment of the PDP will be consuming more than 10 million metric tons per annum (MMTPA) by year 2000 (see Table 5.2). Adding the coal consumption of other users such as the cement & fertilizer industries will raise the total requirement to almost 13 MMTPA. In contrast, the local coal industry may be able to supply only around 4 MMTPA by year 2000. This points to a shortfall of around 9 MMTPA to be secured from foreign sources (see Table 5.3 for the coal supply-&-demand outlook).

Bearing in mind the previous coal supply and demand picture which indicates the importation of substantial amounts of

coal fuel, the present government policy of penalizing coal importation to encourage the use of local coal will have to be reviewed. At the same time, the design of future coal plants may have to be studied whether the plant will be designed based on imported coal specifications or should it be capable of burning both local and imported coal.

5.2 COAL QUALITY

Another constraint, however, that now seriously impedes Philippine coal development and will continue to do so unless appropriate measures are taken is the quality imbalance between the various coal mine's production and the coal consumer design specification.

A classic case is that of Semirara coal which now produce 6.95 million MT per year of selectively-mined coal but the impurities (clay content which was never anticipated) would not allow full usage by NPC Calaca plant unless mixed with imported coal. This coal is not acceptable to most cement plants also. The other case is the various Cebu coal producers having difficulty meeting the requirements of NPC's Naga Plants as well as cement plants in Luzon and Mindanao.

For the immediate future, the only apparent solution to the problem is to import better quality coal for blending with local coal. This, however, requires the use of precious foreign currency which the country is trying to conserve as much as possible.

5.3 Manpower Requirements

Another concern is the lack of trained manpower not only for operating coal-fired plants but also for expanding the coal mining industry. Along this line, the OEA has proposed to NEDA a pair of projects:

a. Technical assistance for the Coal Mining Technology Development Project (CMTDP) whereby funding will be sourced from the Japanese government through the Project Type Technical Cooperation. This project has the objective of completely investigating and overhauling the existing technology of local coal mines. Foreign expertise will also be provided by Japanese consultants who have extensive experience in coal mining situations similar to the Philippines.

b. Establishment of a Coal Mining Technical Development Center for the CMTDP. This facility is intended to insure continuous technology development and transfer in the coal industry, with funding also by the Japanese government through grants-in-aid.

The NPC has ongoing technical training programs and has been sending qualified personnel abroad to imbibe the latest technologies in the field. At the same time, a technical training center is being proposed by NPC, complete with a power plant simulator, to provide operational training not only for the NPC staff but also for other utilities.

5.4 Environmental Issues

Fossil-fueled plants have recently been in the limelight due to their adverse environmental impact. Power generation using coal plants, with the attendant emission of gases and particles to the atmosphere, is being bruited about as leading towards global warming (the greenhouse effect) through depletion of the ozone layer. Another environmental concern is the increasing incidence of "acid rain" which has been wreaking havoc on temperate forests.

Although these problems are not too evident in the Philippines today, these have to be considered in the near future. Already, the Calaca Thermal Power Plant is the focus of criticism in the area due to the polluting effect of the effluents from the plant.

Particulates, sulfur dioxide, and nitrogen oxide are the major pollutants in coal combustion. Generally, the equipment necessary to reduce these pollutants dramatically increase the capital cost of the plant. Flue-gas desulfurization (FGD) equipment, in particular, will increase plant construction costs by about 20 to 40 percent.

Certainly, it has to be recognized that, alongside the expanded use of coal in power generation, corresponding means such as the installation of electrostatic precipitators and FGDs, boiler modification and other plant improvements like better emission monitoring, safer disposal of waste ash, and wider use of cooling towers, must be adopted in consideration of the long-term impact on the environment and agriculture.

6.0 CONCLUSION

Coal-fired power plant is one generation source that will be further utilized by the Philippines in the near future and NPC recognizes the pros and cons of this power source. NPC feels that there are a lot of things that should be done specifically in the areas of coal supply and quality, manpower training, and environmental concerns on coal production.

FIGURE 2.1

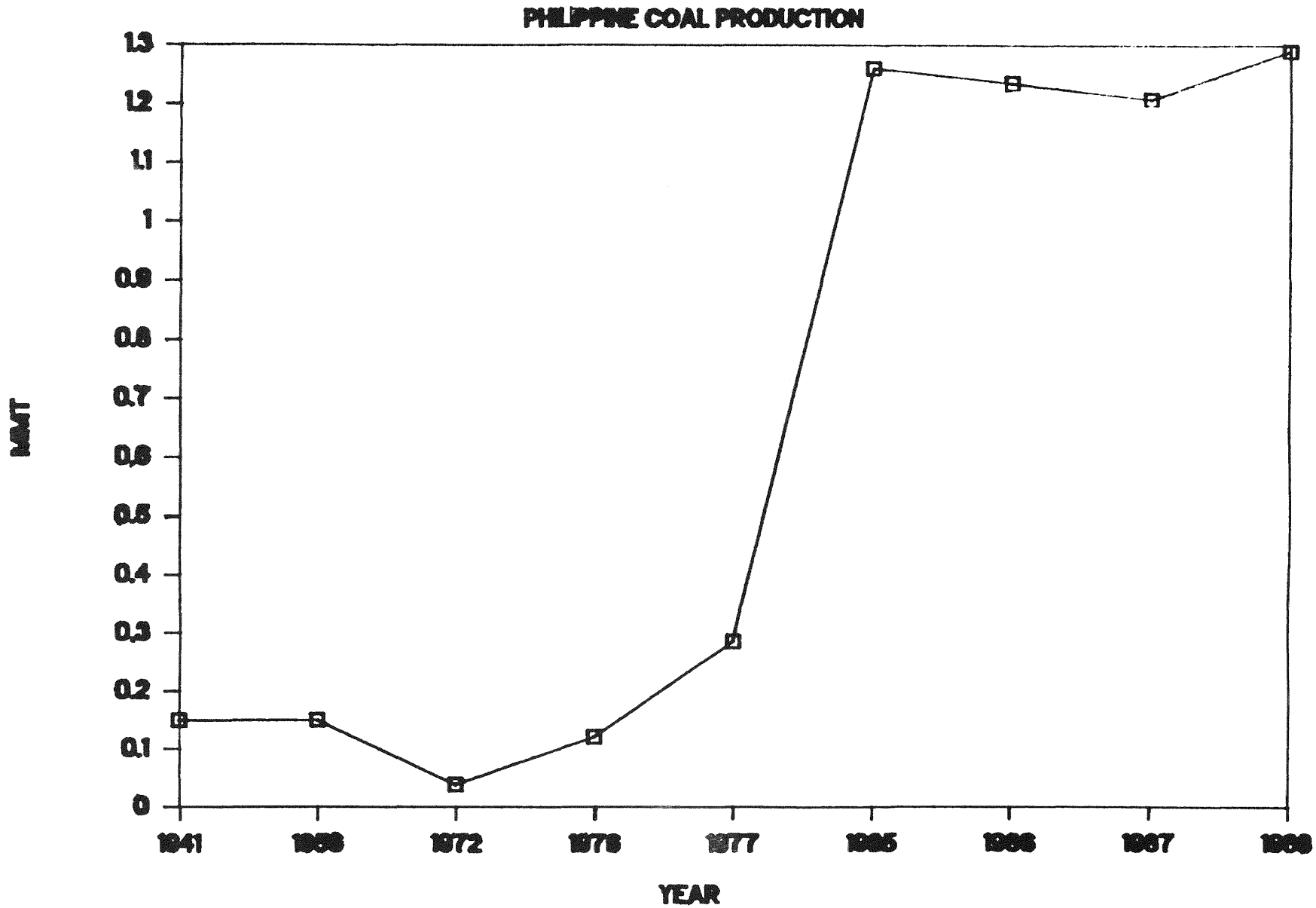

PHILIPPINE COAL PRODUCTION
MMT
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1941
1972
1978
1977
1985
1986
1987
1988
YEAR

FIGURE 2.2

MAIN COAL PRODUCERS IN THE PHILIPPINES

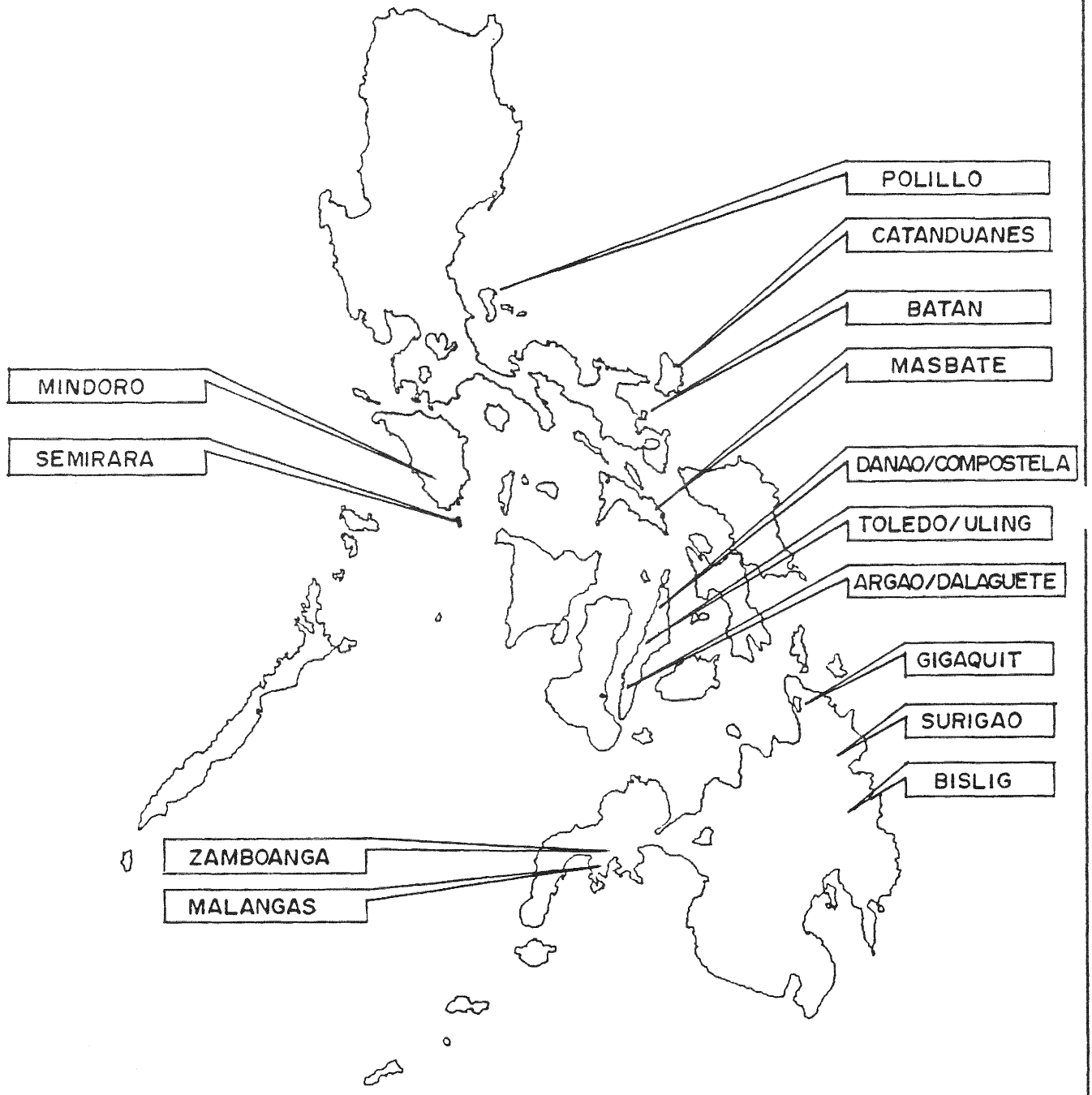


FIGURE 3.1

EXISTING COAL THERMAL PLANTS

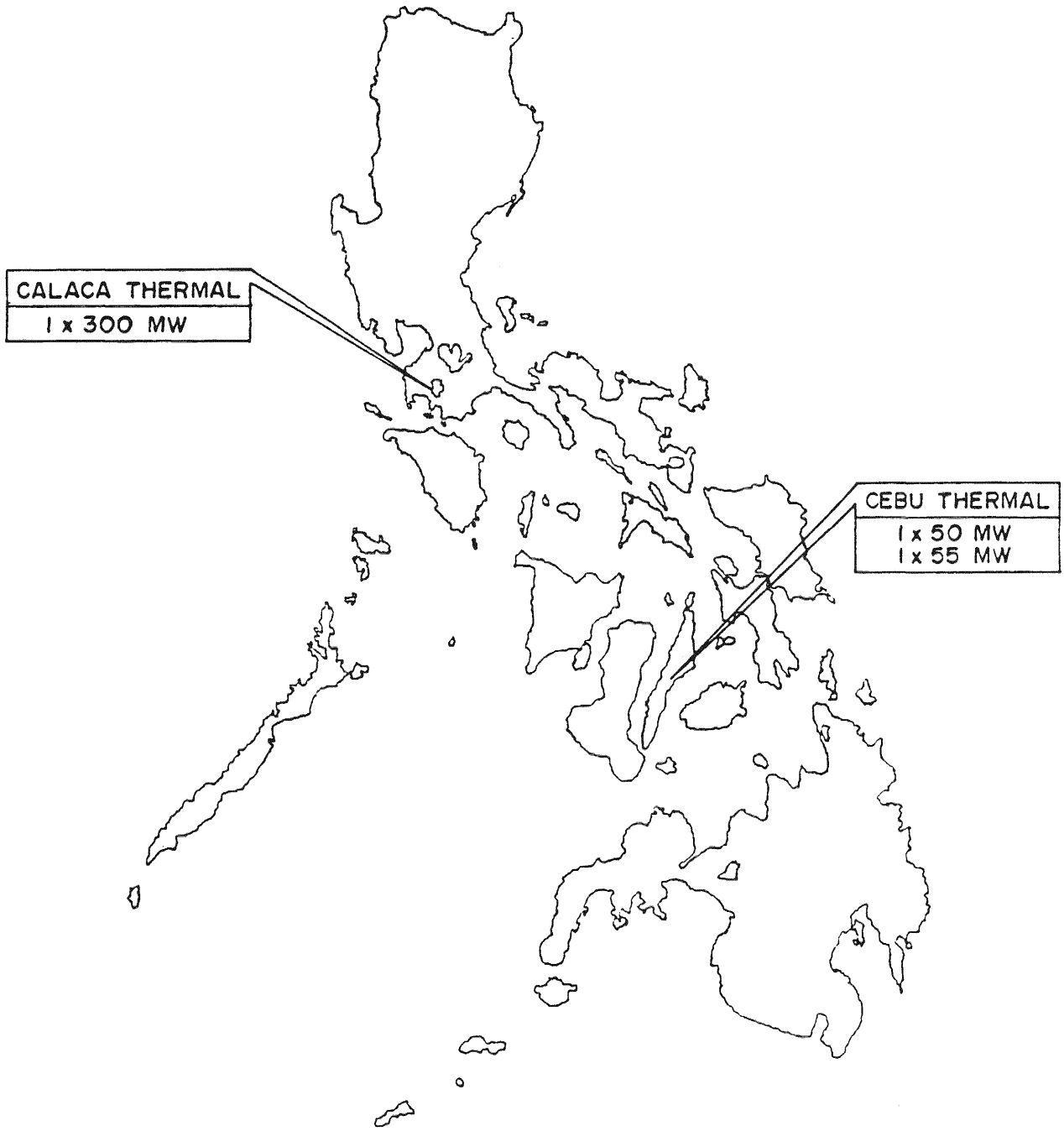


FIGURE 3.2

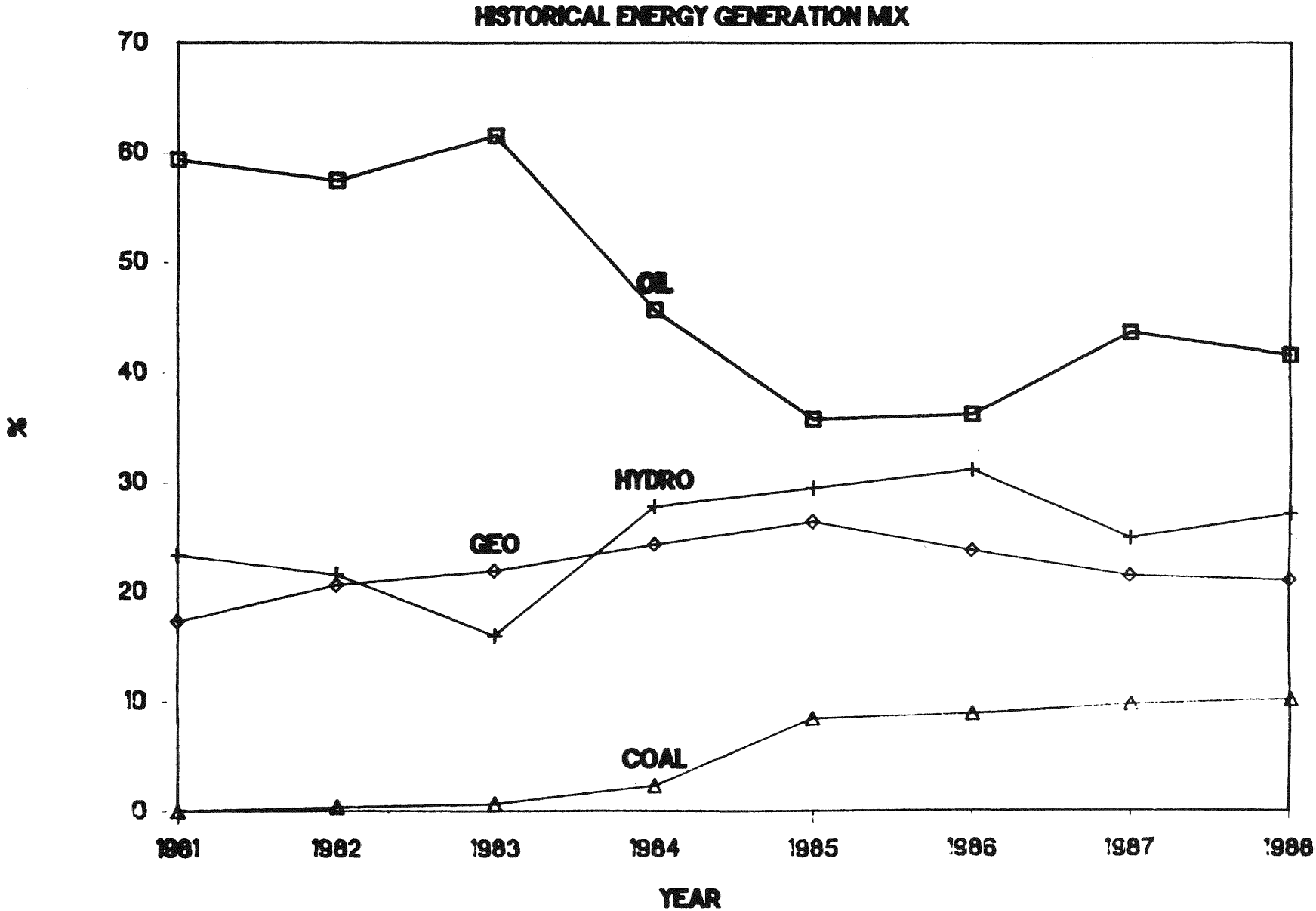

HISTORICAL ENERGY GENERATION MIX
70
60
50
40
30
20
10
0
%
OIL
HYDRO
GEO
COAL
1981
1982
1983
1984
1985
1986
1987
1988
YEAR

TABLE 4.1

JUNE 1988 GENERATION EXPANSION PROGRAM

YEAR	LUZON		VISAYAS		MINDANAO	
	PLANT ADDITIONS	MW	PLANT ADDITIONS	MW	PLANT ADDITIONS	MW
1988					DLPCO DSL	46
1989	GAS TURBINE REHAB SUCAT 1	500	LEYTE-SAMAR INTERCONNECTION 1/	-	AGUS I	80
1990	MAKBAN 7 GEO SMALL GEO REHAB SUCAT 4	55 40	JANOPOL HYDRO POWER BARGE 2 NEGROS-PANAY INTERCONNECTION	5 32 -	GAS TURBINE A (POWER BARGE 2)	150 (32)
1991	BAC-MAN I GEO GAS TURBINE	110 200		-	GAS TURBINE B	50
1992	CALACA II COAL BAC-MAN II GEO LUZON-MINDORO INTERCONNECTION	300 110	(POWER BARGE 2) PALIMPINON GEO 4 CEBU-NEGROS-PANAY INTERCONNECTION	(32) 37.5 -	POWER BARGE 2	32
1993	COAL III	300			MT. APO GEO. 1&2	110
1994	LUZON GEO	330	PALIMPINON GEO 5 2/	37.5	MT. APO GEO. 3	55
1995	TONGONAN GEO A HVDC-I + 350 KV	440		-	MT. APO GEO. 4	55
1996	TONGONAN GEO B HVDC-II + 350 KV	440	PALIMPINON GEO 6	37.5	AGUS III	225
1997	COAL A	600				
1998	COAL B	600	POWER BARGE 2 BOHOL DIESEL	32 5.5	(POWER BARGE 2)	(32)
1999	COAL C	600			COAL A	100
2000	COAL D	600	JALAUR HYDRO	24	COAL B	100

1/ National Electrification Administration Project
2/ Entry reset to 1992 due to uncertainties associated with non-NPC plants

NOTE: Parenthesis indicates pull out of Power Barge.

FIGURE 4.1

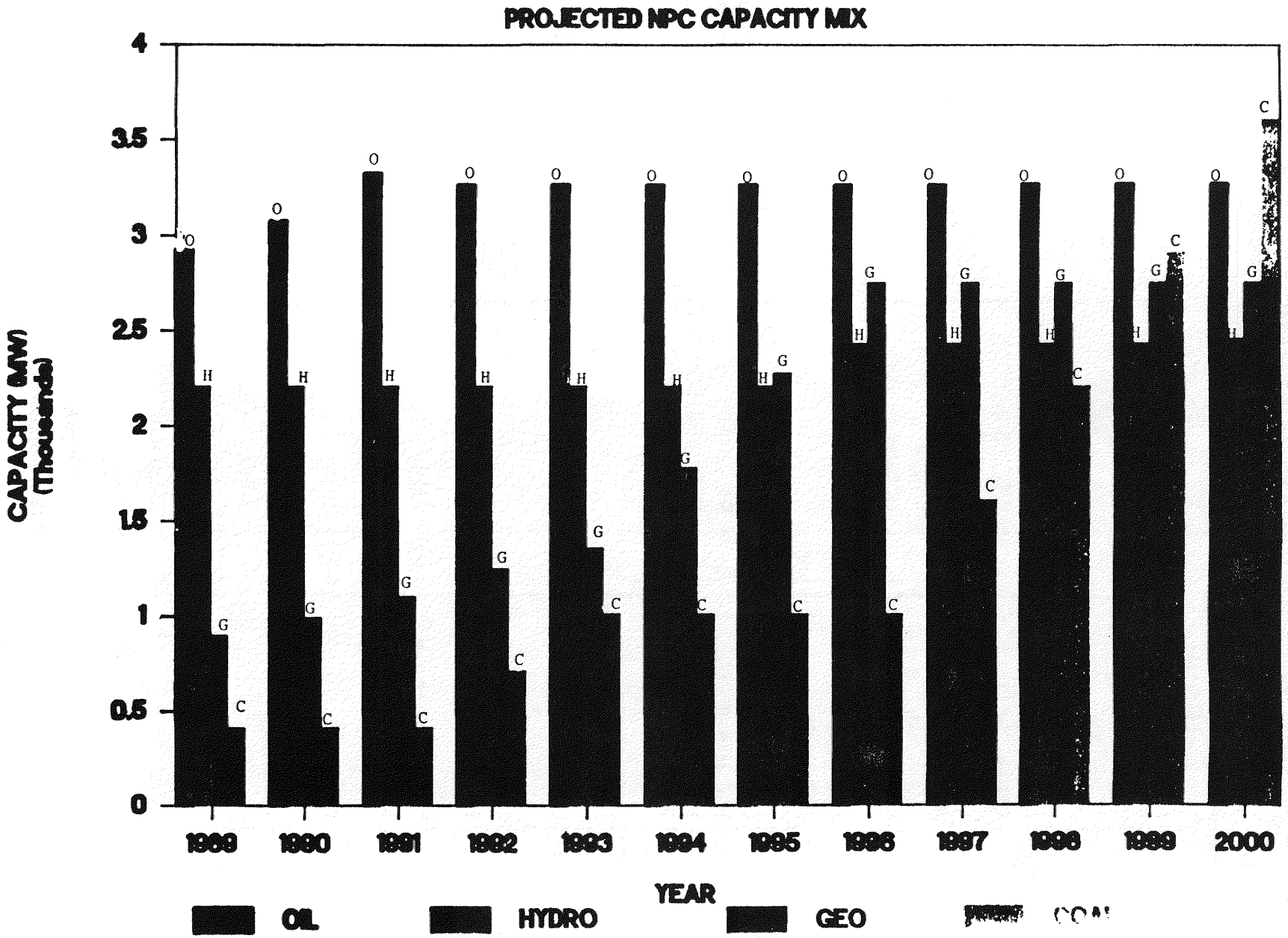

PROJECTED NPC CAPACITY MIX
CAPACITY (MW)
(Thousands)
4
3.5
3
2.5
2
1.5
1
0.5
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
YEAR
OIL
HYDRO
GEO
COAL

FIGURE 4.2

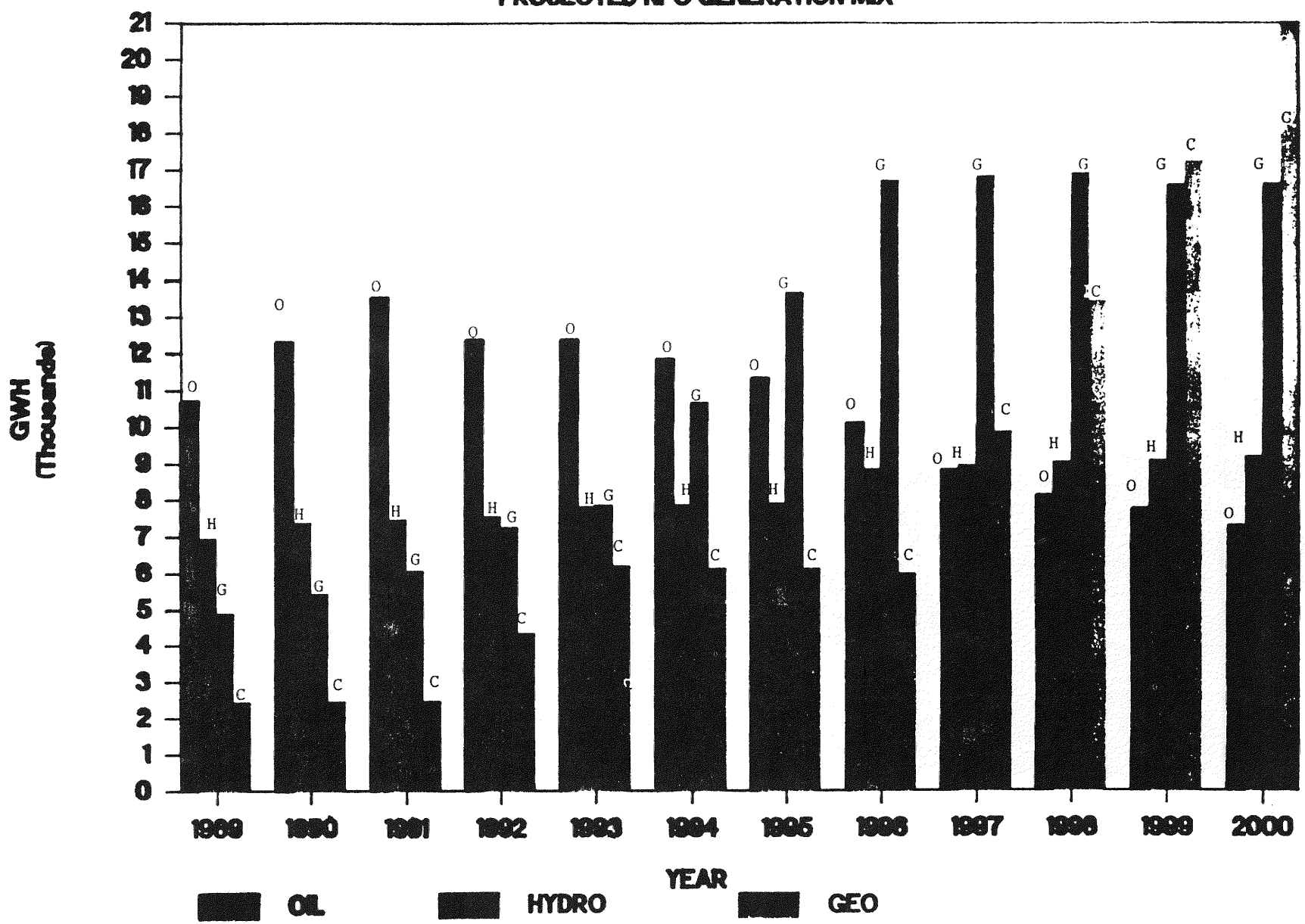
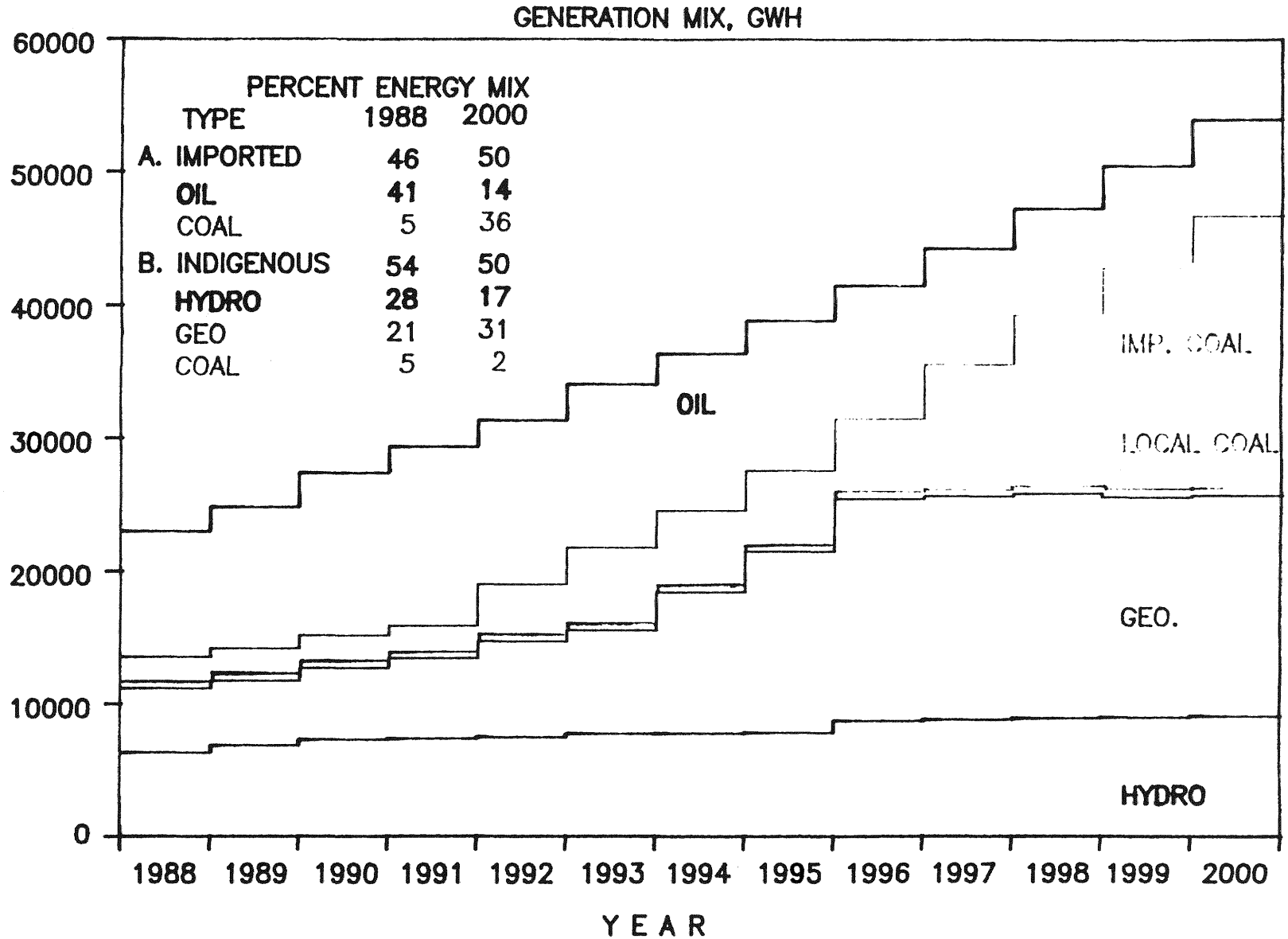

PROJECTED NPC GENERATION MIX
GWH (Thousands)
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
YEAR
OIL
HYDRO
GEO

FIGURE 4.3

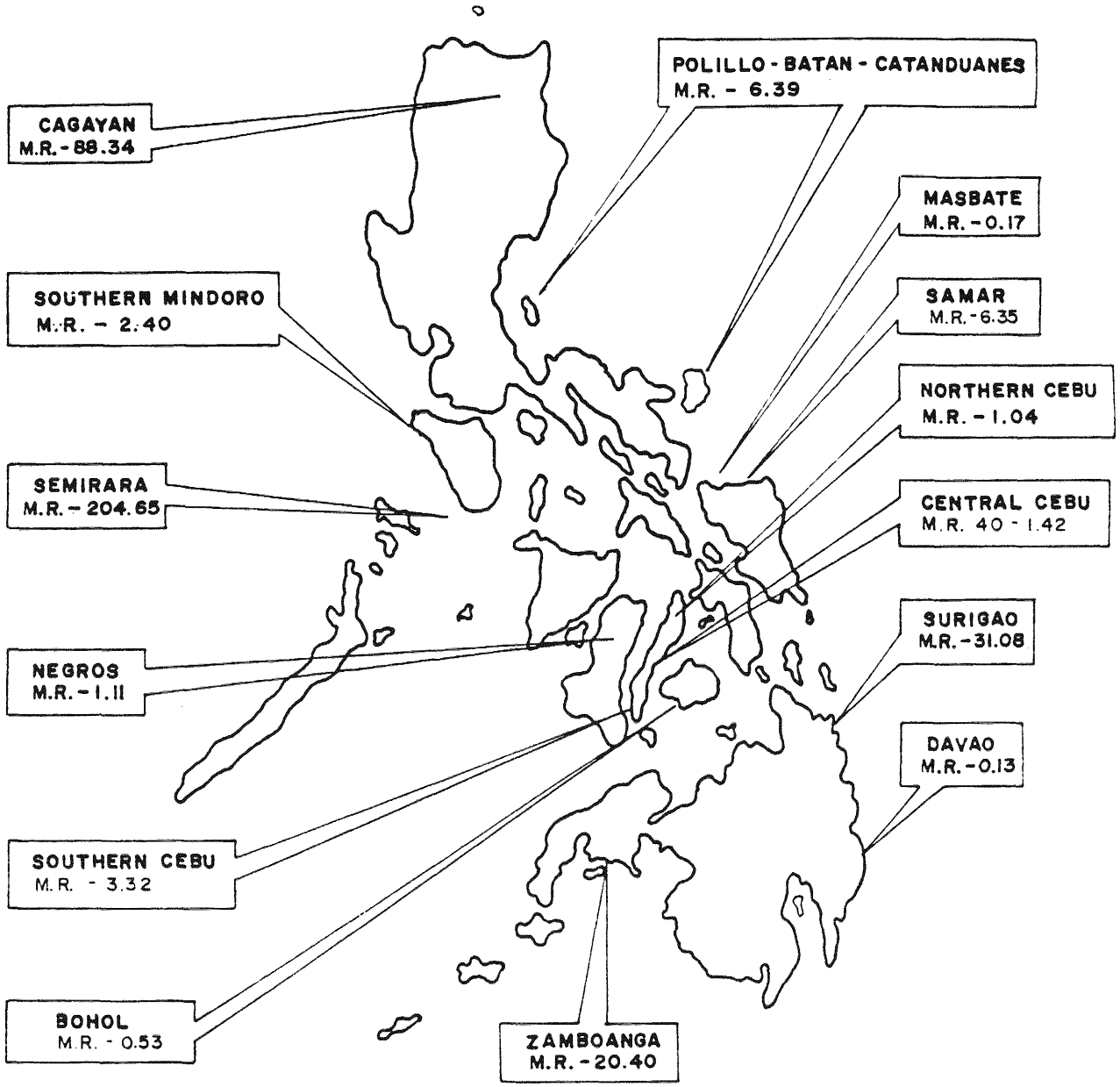
PHILIPPINES



PHILGPDP–8910

FIGURE 5.1

MAJOR COAL DEPOSITS IN THE COUNTRY
as of APRIL, 1989



M.R = MINABLE RESERVE
(in MILLION METRIC TONS)

MINABLE RESERVE (Million tons)	AVERAGE HEATING VALUE (BTU/LB)
367	6827

TABLE 5.1
SUMMARY OF PHILIPPINE COAL RESERVES BY REGION
(MMT, AS OF APRIL 1989)

REGION/LOCATION	IN-SITU RESERVE (MMT)	MINABLE RESERVE (MMT)	HEATING VALUE (BTU/LB)
LUZON			
Semirara	240.77	204.65	7000
Cagayan Valley	103.93	88.34	4600
Mindoro	4.00	2.40	8500
Polillo-Batan-Catanduanes	10.65	6.39	12000
Quezon	0.09	0.05	12000
Masbate	0.29	0.17	9800
Subtotal	359.73	302.00	6418
VISAYAS			
Negros	1.85	1.11	8100
Northern Cebu	1.73	1.04	9300
Central Cebu	2.37	1.42	9800
Southern Cebu	5.53	3.32	11500
Bohol	0.88	0.53	8700
Samar	7.47	6.35	7300
Subtotal	19.83	13.77	8840
MINDANAO			
Davao	0.21	0.13	7100
Surigao	46.04	31.08	7100
Zamboanga	33.99	20.40	11100
Subtotal	80.24	51.61	8681
TOTAL	459.80	367.38	6827

Source: OEA, NPC
Notes:
1. The minable reserves are computed by multiplying the in-situ reserves by a mining recovery factor of 85 % for open pit areas (Cagayan, Semirara, part of Samar and part of Surigao) and 60 % for underground areas (all other areas).
2. Heating values are quoted from NPC data and the subtotals/total figures are weighted average values.

TABLE 5.2
PROJECTED NPC COAL REQUIREMENTS
(000 MT @ 10,000 BTU/LB)

	1989	1995	2000
EXISTING			
CALACA I (300 MW)	918	905	880
CEBU THERMAL (105 MW)	281	320	337
PROPOSED			
CALACA II (300 MW)	---	905	880
LUZON III (300 MW)	---	905	880
LUZON A (600 MW)	---	---	1,761
LUZON B (600 MW)	---	---	1,761
LUZON C (600 MW)	---	---	1,761
LUZON D (600 MW)	---	---	1,761
MINDANAO A (100 MW)	---	---	226
MINDANAO B (100 MW)	---	---	226
TOTALS	1,199	3,035	10,473

Note: Average heat rates of plants assumed at 11,000 Btu/kWh.

TABLE 5.3
PHILIPPINE COAL SUPPLY-DEMAND OUTLOOK
(000 MT @ 10,000 BTU/LB)

SUPPLY	1988 1/	1989	1990	1991	1992	1993	2000
Semirara	583	609	609	609	1,257	1,473	1473
PNOC Areas	293	277	277	277	277	277	
Cebu	240	267	321	336	352	353	
Batan							
Other Areas	178	173	293	329	349	353	2518
TOTAL	1,294	1,326	1,500	1,551	2,235	2,456	3991
DEMAND							
NPC 2/	1,148	1,199	1,205	1,216	2,142	3,078	10473
Cement Plants	1,061	1,133	1,190	1,249	1,312	1,377	1392
Atlas	265	320	336	353	370	389	635
Philphos	15	14	14	14	14	14	40
Others	157	167	175	184	193	203	340
TOTAL	2,646	2,833	2,920	3,016	4,031	5,061	12880
SURPLUS/ (SHORTFALL)	(1,352)	(1,507)	(1,420)	(1,465)	(1,796)	(2,605)	(8,889)

1/ Historical values.
2/ Heat rate of coal plants at 11,000 Btu/kWh; based upon June 1988 PDP generation mix.

KUN JEONG
General Manager
Electricity Economics Department
Korea Electric Power Corporation

Present Position

Currently in charge of General Manager of Electricity Economics Dept., Korea Electric Power Corporation (KEPCO).

Working for Korea Electric Power Corporation (KEPCO) since 1961.

Past Positions:

Administration Manager of KORI Nuclear Division

Contracts Manager of New Project Office

Chief, Electricity Economics Dept., Research Center since Feb. 1987

Education:

Graduated from Seoul National University and has MBA and LL.M Degrees from the university.

STEAM COAL DEMAND FOR POWER GENERATION IN KOREA

The Asia-Pacific Coal Technology Conference 1989

November 15-16, 1989

Kun Jeong

Korea Electric Power Corporation

Contents

1. Introduction

   o Steam coal demand and domestic coal resources

2. Prospects of Electricity Demand

3. Summary of Power Development Program

4. Prospects of Steam Coal Demand

   o The level of past and future demand

   o Directions to meet the future demand

5. Environmental Constraint relevant to the Coal-fired Power Plants

6. Concluding Remarks

1. INTRODUCTION

o Steam coal demand and domestic coal resources :

Energy resources in Korea are very limited except for the domestic anthracite. Therefore, we have to largely depend on the imported energy. Since the sharp increase of petroleum prices in the 1970s, however, the diversification of energy resources has been strongly pursued. As a result, the share of oil-fired plants of total generating capacity has reduced substantially, and the composition of power generation has also steeply changed over the decade.

Meanwhile, 500 MW coal-fired plant has put into operation for the first time in 1982. Since then, the imports of steam coal for power generation have increased steadily to the present 6 million tons per year. During the next decade, coal imports for power generation will increase more than double-fold because of the steadily increasing power demand. The steam coal imports for steel making and other industrial use are also likely to be approximately doubled in a decade.

By the way, domestic coal, mainly low-grade anthracite, is mostly used for space heating in the residential sector, with the exception of power generation use of about one tenth of the total production.

Under the circumstances, rapidly increasing coal imports in Korea will bring renewed concern over the environmental effect of the emissions from the plants, and also bring increased interest to the development of advanced coal technology.

2. PROSPECTS OF ELECTRICITY DEMAND

Electricity sales of KEPCO are likely to reach around 82,000 GWH with approximate 10 percent growth in 1989. Summer peak load also increased to 15,058 MW in 1989.

The long term load forecast of 1988 shows that electricity sales will grow at 6.8 percent per year through 2001, and the peak load will also increase at 7.2 percent average annual growth rate for the period.

Electricity Sales and Peak Load
forecasted in 1988

	Actual	Forecast			Annual Growth
	1988	1991	1996	2001	1988-2001
(GWH)	74,300	92,071	124,234	158,808	6.8 (%)
(MW)	13,660	16,706	22,591	29,178	7.2 (%)

The forecast is based on the projection of real GNP growth in average 6.9 percent per year for the period, and also based on the assumption that annual peak load could be clipped by around 500 MW during the 90s in terms of the load management. According to the forecast, each share of the residential and tertiary demands in total will increase to around 20 percent in 2001 from the present level of 17 to 18 percent, and the industrial demand share will decrease from 65 percent to 60 percent in 2001. Accordingly, annual load factor is projected to decline from 71 percent to 69 percent during the period.

The forecast results in an electricity/GNP elasticity at 1.1 to 0.9 over the period. However, the conspicuous increase in non-industrial demand during 1988-1989 results in the electricity/GNP elasticity at an unexpected level of 1.3 to 1.5. It becomes a cause for someone to be concerned about whether the annual reserve margin of planned generating capacity would be low in the mid 90s.

3. SUMMARY OF POWER DEVELOPMENT PROGRAM

Based on the load forecast of 1988, power development program projects power supply options adding new capacity of 15,781 MW to the existing 19,944 MW generating capacity through 2001.

In projecting the program, KEPCO pursues continuously a balance between diversified energy resources and minimization of generation cost through optimized plant mix. 16 bituminous coal-fired units with 9,600 MW in total (i.e, 12 units of 500 MW coal-fired in the 90s, and 4 units of 900 MW coal-fired during the year 2000 and 2001), and 6 nuclear units of 5,650 MW will be installed during the planned period. One 200 MW anthracite-fired unit, 4 pumped-storage units of 1,100 MW and 4 LNG combined cycle units of 1,600 MW will be added.

In 2001, total installed capacity will account for 35,725 MW, of which coal-fired plants with 11,720 MW will share 32.8 percent, and 12,316 MW nuclear capacity will share 34.5 percent. The remainder will be shared by 10.2 percent with oil-fired (3,640 MW), 10.2 percent with LNG-fired (3,650 MW) and 10.1 percent with hydro power (3,599 MW).

The anthracite-fired plant is scheduled to be added to sustain the existing coal demand, but dual firing is expected to supplement the lower combustion efficiency of the coal.

Although both the nuclear and coal-fired units are alternative base load plants, the nuclear generation at an average capacity factor of over 70 percent, is so far more competitive. Therefore, the nuclear generation is scheduled to share steadily around 45 percent of the total generation through the planned period. For this purpose, two 1,000 MW PWR units and one 700 MW PHWR unit are scheduled to put into operation subsequent to Nuclear Unit 11 and 12 in the late 90s.

By the way, the share of coal-fired generation will increase double-fold to around 40 percent until 2001 in accordance with increased cycling duty and characteristics of the changed system load. But, part of the coal-fired generation is likely to turn away from its original program toward the more LNG-fired or combined heat and power on account of the tightened environmental regulations and the cost-effectiveness.

At present, 8 units among the 16 planned coal units are under construction with plant design standardization and equipments localization by 80 to 90 percent.

Planned Generation Capacity by Energy Sources

MW (%)

	Nu-clear	Bitu-minous	Anth-racite	Oil	LNG	Hydro	Total
1988 (Results)	6,666 (33.4)	2,680 (13.4)	1,020 (5.1)	4,792 (24)	2,550 (12.8)	2,236 (11.2)	19,944 (100)
1991	7,616 (36)	2,680 (12.7)	1,020 (4.8)	4,795 (22.6)	2,550 (12.1)	2,499 (11.8)	21,160 (100)
1996	9,616 (34.2)	7,180 (25.6)	925 (3.3)	4,186 (14.9)	3,100 (11)	3,099 (10.9)	28,106 (100)
2001	12,316 (34.5)	11,720 (32.8)	800 (2.2)	3,640 (10.2)	3,650 (10.2)	3,599 (10.1)	35,725 (100)

Planned Power Generation by Energy Sources

GWH (%)

	Nu-clear	Bitu-minous	Anth-racite	Oil	LNG	Hydro	Total
1988 (Results)	40,101 (46.9)	16,611 (19.4)	3,229 (3.8)	11,523 (13.5)	10,432 (12.2)	3,566 (4.2)	85,462 (100)
1991	52.450 (50.6)	18,426 (17.8)	3,286 (3.2)	18,557 (18.0)	7,113 (6.9)	3,598 (3.5)	103,430 (100)
1996	65,142 (47.0)	45,747 (33.0)	4,172 (3.0)	17,676 (12.8)	2,138 (1.5)	3,686 (2.7)	138,561 (100)
2001	83,894 (47.0)	69,962 (39.2)	3,674 (2.1)	13,112 (7.3)	4,072 (2.3)	3,686 (2.1)	178,400 (100)

4. PROSPECTS OF STEAM COAL DEMAND

o The level of past and future demand :

Since the operation of the first 500 MW coal-fired unit in 1982, 27,801 thousand tons of bituminous coal have been imported until 1988. KEPCO made up around 61 percent of its bituminous coal demand by coal mined in Australia, 21 percent by the Canadian coal, 8.8 percent by the United States and the remainder by the other areas.

For the time being, KEPCO imports all of its bituminous coal for power generation through a number of the existing long-term supply contracts, by which suppliers are scheduled to provide 6,550 thousand tons per year(mt/y) on the condition that the quantities be adjusted on an annual basis according to the level of plants operation.

Contracts made between 8 Australian suppliers are supposed to supply 3.35 million tons per year, around 51 percent of the total contract quantities. By the contracts with 3 Canadian suppliers, 1.6 million tons per year, occupying 25 percent of the total, will be supplied. The remaining 1.6 million tons per year will be supplied from the United States and other Asian countries.

In the future, the bituminous coal demand for power generation is expected to increase to 16 million tons in 1996, and to around 24 million tons in 2001 from the present level of 6 million tons per year, in accordance with the power development program which projects 16 additional coal units.

Estimated Coal Demand for Power Generation

(10^3 mt)

Actual	Estimated		
1988	1989	1991	1996
5,987	5,957	6,627	16,287

o Directions to meet the future demand ;

In providing future coal demand, KEPCO pursues to find out more cost-effective way through the various channels of coal supply as well as the diversification of the sources of supply.

It is scheduled to meet about one half of its bituminous coal demand by the long term supply contract as usual, about one third of the demand by resource imports developed through participation in overseas mine projects and the remaining demand by the purchase at the spot markets. Several proposals for joint development of coal mine are under review. In reviewing the diversification of

suppliers, we will also consider the bilateral balance of trade.

Existing coal specifications to the effect of the following will be applied the same as before to the subsequent 500 MW standardized plants so that KEPCO could meet the increased environmental requirements and take advantage of overall cost benefit.

Of the specifications, the higher heating value will be 6,400 Kcal/kg (air dry basis), moisture 10 percent maximum (air dry basis), fuel ratio 1.0 to 2.5, initial deformation temperature (IDT) 1,250°C and sulfur content 1.0 percent maximum.

5. ENVIRONMENTAL CONSTRAINT RELEVANT TO THE COAL-FIRED PLANTS

Subsequent to the environmental conservation law of 1977, a number of special laws and regulatory standards are enforced. And the emission limits for coal-fired plant have been strengthened up to now, but current standard can be met without recourse to additional control measures by the utility.

That is, the SO_2 emissions from the combustion of coal with a sulphur content of 0.7 percent, which is typical of imported coals, can be controlled at the level far below the emissions from low sulphur oil. Nitrogen oxide (NO_x) emissions can also be controlled properly through combustion modifications. Electro-static precipitators (ESPs) for dust separation and bag filters for small particles are effectively utilized. And waste water and solid waste treatment are under proper management.

However, as the concern over acid rain and other environmental problems grows in proportion to the increasing coal demand,, environmental regulations will become stricter through the 90s.

To cope with the possible strict emission limits, KEPCO is likely to install flue gas desulphurization system at the new coal-fired units to be operated after the mid 90s and also likely to retrofit appropriately the existing plants. But the capital and operating costs for wet lime/limestone FGD systems will account for more than 20 percent of the total cost of the plant. Fluidized-bed combustion systems are also utilized to the limited extent for relatively small units of industrial boilers up to 38 MW with combined heat and power plants. And three district heating projects near Seoul area are scheduled to install combined heat and

power(CHP) systems using liquefied natural gas to meet the increased environmental requirements.

Under these circumstances, KEPCO has much concern to the more effective way through future technological development, i.e., to find out the optimized flue gas treatment technology while avoiding the kind of legislative technology forcing that has proved so expensive in some countries.

Current and prospective emission limits for the bituminous coal-fired plant and actual emission level at present are as follows.

Pollutants	current limits	prospects '96	prospects 2001	actual emissions
SO_2 (max PPM)	700	500	250	240 - 570
NOx (")	350	250	150	330 - 340
Particulates (mg/sm^3)	250	100	50	190 - 220

6. CONCLUDING REMARKS

In accordance with the growing economy at an annual rate of around 7 percent in the 90s, electricity demand will increase steadily. Meanwhile, in the implementation of power development plan, KEPCO will continuously pursue

a balanced generation mix. The nuclear power generation will share an invariable portion of the total generation in the planned period. And the share of coal-fired generation will approximately double through 2001 to meet the increasing balance of the intermediate and base load. With this generation increase, steam coal imports for power generation are expected to nearly triple in a decade. But the planned share of the coal-fired generation is likely to be adjusted in part to maintain balanced target mix between energy sources and to meet the changing system characteristics with increased flexibility.

In coping with the increasing steam coal demand in the future, we expect the sources of supply to be fully diversified either under the long term supply contract or under the participation in overseas mine development. We also expect the contract terms will be equitable between the parties and the more cost-effective compared with other sources of energy. And while we are prepared to do our best to prevent environmental pollution relevant to the plant operation, we expect improved technology to be fully available in the near future to achieve better environmental protection.

HOWARD H. W. AU
Fuel Supply Engineer
China Light & Power Co., Ltd.

Professional Qualifications:

Fellowship of the Institute of Chartered Shipbrokers (F.I.C.S.)
Member of the Chartered Institute of Transport (M.C.I.T.)
Member of the Institute of Transport Administration (M. Inst. T.A.)

Employment History

1969 - 1972	China Motor Bus Co., Ltd., Hong Kong Position held--Assistant Executive Officer
1972 - 1982	World-wide Shipping Ltd., Hong Kong Position held--Manager, Ships Chartering and Operations
1982 to present	China Light & Power Co., Ltd., Hong Kong Position held--Fuel Supply Engineer Responsible for coal/oil procurement and all shipping activities

HONG KONG'S FUTURE COAL REQUIREMENTS

Paper to be presented by
Mr. Howard Au, FICS, MCIT, M Inst. T.A.
Fuel Supply Engineer
China Light and Power Company, Limited
Hong Kong

Asia-Pacific Coal Technology Conference
Honolulu, Hawaii
15-16, November 1989

Introduction

Hong Kong, situated adjacent to the south east corner of the People's Republic of China is one of the biggest and most important financial and manufacturing centres in South East Asia and one of the fastest growing regions in the world. It has a population of some 5.5 million and is principally engaged in light industry manufacturing, trading, commerce and tourism. It has hardly any natural resources and even such basic resources as land and fresh water are in short supply. The Territory's main resource is the enterprising spirit and hard working nature of its people. The growth of Hong Kong over the last two decades has surpassed all expectations. Hong Kong's phenomenal growth can be illustrated by reference to its Gross Domestic Product over the last ten years:

Growth Rates on GDP
1978 - 1988 (%)

Year	GDP Growth
78	9.5
79	11.7
80	10.9
81	9.4
82	3.0
83	6.5
84	9.5
85	-0.1
86	11.9
87	13.8
88	7.4
Average	8.5

Growth, however, cannot be achieved without a reliable supply of the most basic source of energy i.e. electricity.

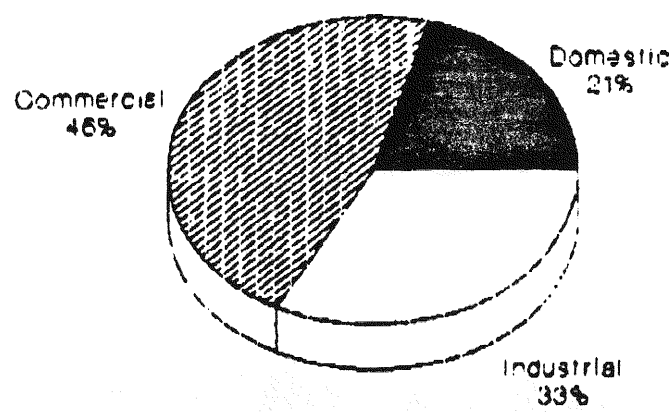
Electricity Demand Growth

The rapid growth of the Hong Kong economy has brought tremendous increases in demand for electricity. For the past 10 years, electricity consumption has been increasing at an average rate of 9%. Such increase is illustrated by the table below:

Electricity Consumption
(1978 to 1988)

Year	Million KWH	% Increase
78	9109	10.0
79	9879	8.4
80	10922	10.6
81	11561	5.9
82	12436	7.6
83	14035	12.9
84	15046	7.2
85	15928	5.9
86	17664	10.9
87	19618	11.1
88	21009	7.1
Average		8.9

The following chart shows the consumption of electricity by sectors in the year 1988:



Electricity Supply

The electricity in Hong Kong is supplied by two power companies, namely, Hong Kong Electric Company (HEC) and China Light & Power Company (CLP).

CLP supplies electricity to all the consumers in Kowloon peninsula, the New Territories including outlying islands and also exports to China whilst HEC supplies the Hong Kong island and Lamma island. CLP's system load accounts for about 70% of the total system demand.

The following table shows today's installed capacity and the power stations of CLP and HEC.

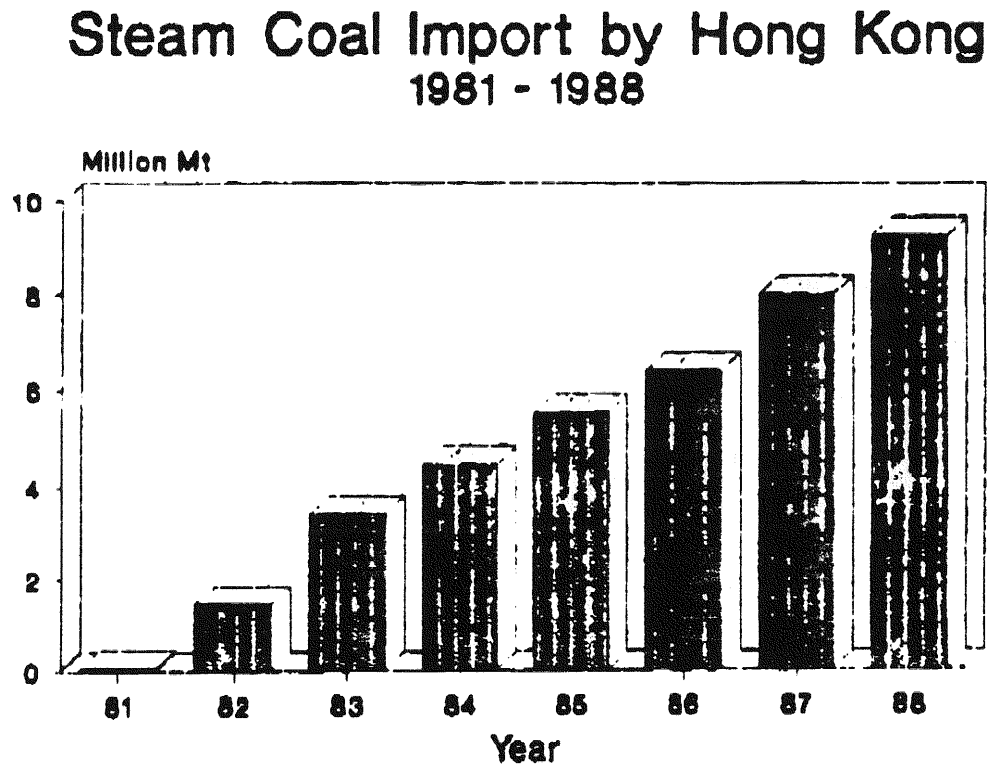
	CLP	HEC
Installed Capacity	6160 mw	2255 mw
Power Stations	Hok Un (292mw) 2 x 66 mw gas turbine 2 x 80 mw gas turbine	Ap Lei Chau (750mw) 6 x 125 mw oil
	Tsing Yi (1520 mw) 4 x 200 mw oil fired 6 x 120 mw oil fired	
	Castle Peak (4348 mw)	Lamma (1505 mw)
	'A' Station 4 x 350 mw coal	3 x 250 mw coal
	'B' Station 4 x 677 mw coal	2 x 350 mw coal
	4 x 60 mw gas turbine	1 x 55 mw gas turbine

Both CLP and HEC are privately owned and public listed on the stock exchange.

Fuel Requirements for Power Utilities

Hong Kong has no indigenous fuel of her own. All the fuels have to be imported. Prior to the year 1981 all the electricity generation was from oil firing. The commissioning of Castle Peak and Lamma power stations marked the start of coal import into Hong Kong.

The expansion of coal fired generation in Hong Kong will result in a steady increase in demand for coal to a level of 9-10 million tonnes in 1990. This growth is shown in the following chart.



It equates an average rising demand of 22% per annum for the past 5 years. Up-to-date a total of 46 million tonnes of coal has been shipped to Hong Kong two power companies, 70% of which were purchased by CLP.

Projection for Future Growth

In 1997, Hong Kong will become a Special Administrative Region of China. Hong Kong's future economic prosperity is considered to lie in three areas;

- as a regional base for high technology manufacturing, financial services and tourism

- as a main gateway for China

- as a regional service centre for lower technology manufacturing in China.

In this context, the Hong Kong Government has recently decided to provide expanded port facilities, new airport and all the associated infrastructure necessary to complement these development.

Power Generation

Both CLP and HEC are planning to commission more generation capacity to cope with the increasing demand through the 90's.

HEC

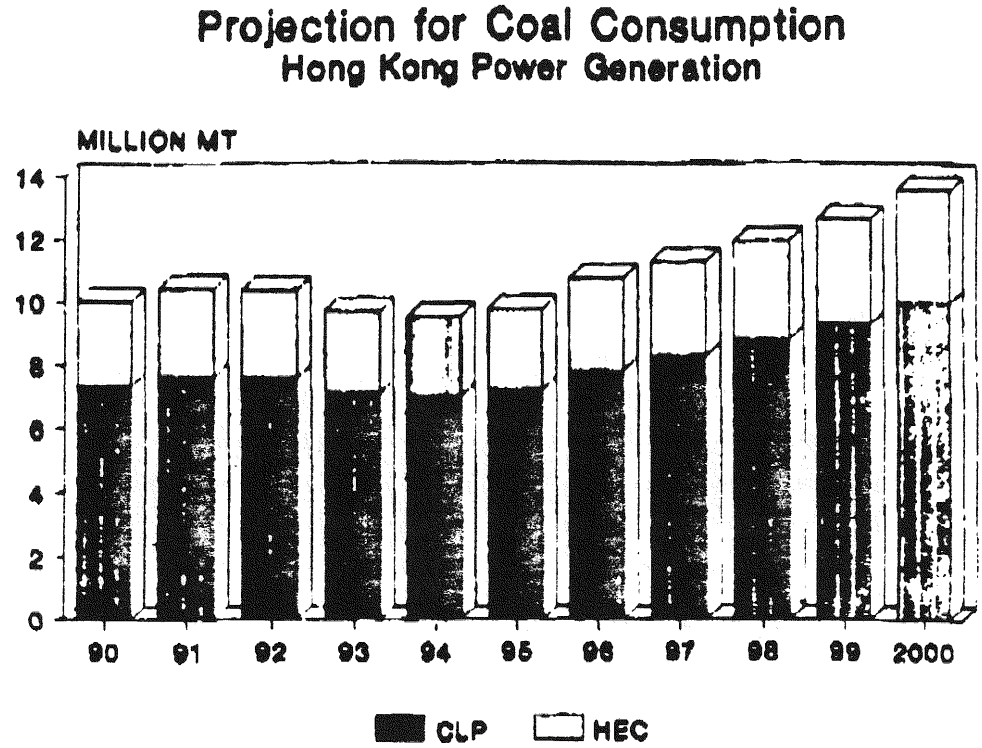
two more generators	1 x 350 mw plus 1 x 500 mw

CLP

New development of coal fired station capable of accomodating 5000 mw of capacity, comprising of 8 to 10 units, each of 680 mw is being planned for commission in mid-90's

On the assumption that additional coal fired power stations are built according to plan the Hong Kong's future coal requirement could reach 15 million level after the year 2000.

The projection for coal consumption is shown in the following chart.



China Light and Power Company, supplying electricity to the larger part of Hong Kong, is poised to benefit from the continuing growth of Hong Kong. More generating capacity is required to cope with the increasing demand. Larger quantity of coal has to be shipped to Hong Kong. I believe that the growth prospect of Hong Kong power utilities should offer exciting opportunities to coal producers who wish to have a share in a growing market.

TEXT OF VIDEO PRESENTATIONS

SENATOR FRANK MURKOWSKI (R-AK)

SENATOR MITCH MCCONNELL (R-KY)

REPRESENTATIVE RALPH REGULA (R-OH)

November 8, 1989

Script of presentation by Senator Frank Murkowski
on Alaska's Coal potential
For DOE's Asia-Pacific Coal Technology Conference

When you talk about the energy resources of the Great State of Alaska, the first thing that comes to mind for most people is oil.

They've heard about our vast petroleum reserves,

What they don't know, is that Alaska's COAL offers the greatest potential to fuel our Pacific allies for decades.

Alaska is a big state -- about one-fifth the size of the whole United States.

It contains the largest, high quality coal reserves in the world -- that are located conveniently for export to the Pacific Rim.

Our reserves are estimated to be over 5.5 Trillion tons-- approximately equal to the total estimated coal resources of the 48 contiguous states.

Alaska's coal, which underlies about 9 percent of the state's land area, is mainly bituminous and subbituminous, and has extremely low sulfur content.

It's been mined for more than 100 years.

For several reasons, however, production has always been very low in comparison with our potential.

That may be changing.

As a result of uncertain energy supplies, increasing desires to reduce demands for petroleum, and other economic and political factors, Alaska's coal resources are today receiving an increasing amount of attention.

In fact, the experts predict we'll see increased and expanded coal production in Alaska in the very near future.

We certainly know where the coal is. Major coal deposits are identified in several parts of the state.

The Nenana coal field, located on the north flank of the Alaska Range, is our only operational field at the present time.

Coal mining has been ongoing here since 1914.

Estimated reserves at Nenana are more than 14 billion tons.

The privately owned Usibelli Coal Mine produces approximately 1.6 million tons per year, and production is expanding in response to both increased demand for electricity in Alaska, and increased demand for coal in export markets.

Sulfur content of that coal is less than one-half of one percent.

The Usibelli Coal Mine is a modern and highly mechanized, year-round operation.

The company controls reserves in excess of 3 billion tons, of which approximately 250 million tons are recoverable.

One-half of the current production is sold to buyers in Interior Alaska for power generation and district heating.

The balance --approximately 640,000 tons -- is exported to South Korea.

Taiwan has also been a customer, purchasing 120,000 tons of coal for a major test program.

Coal exported to South Korea and Taiwan is moved by rail, 362 miles from the Usibelli Coal Mine's tipple at Healy Alaska, to the Suneel Seward Coal Terminal at Seward, Alaska.

The coal terminal is located at a deep water and ice-free port which is operated year-round. It is designed to handle a throughput of 3 million metric tons of coal per year.

The Seward coal terminal is owned and operated Suneel Alaska Corporation, a wholly-owned subsidiary of Sun Eel Shipping Company of Korea. It was built after Usibelli signed a long-term contract to provide coal to Korea Electric Power Corporation (KepCO).

One of Alaska's untapped coal fields that has the best potential for development in the near future, is the Beluga-Chuitna Field -- held by a consortium that includes Diamond Alaska Coal Company and Placer U.S. Incorporated.

It's one of Alaska's most accessible sources of very low sulfur steam coal, located within 6-to-25 miles of deep water port sites on the Cook Inlet.

The combined tonnage of surface-mineable low-sulfur coal, totals approximately 1 billion tons -- at less than 3 cubic yards of waste per ton of coal.

Engineering feasibility studies by the two companies show that up to 15 million tons of coal can be mined at Beluga annually.

This subbituminous coal contains less than two-tenths of one percent sulfur and a heating value of 7,800 to 8,200 Btu's per pound -- but a 23.6 percent moisture content.

Placer's Beluga coal reserves exceed 500 million tons.

Diamond Alaska controls leases in the Chuitna field -- a field with reserves estimated at 30 billion tons.

These subbituminous coals have an unusually low sulfur content, lower than any known coal reserve in the world. About one-tenth of one percent!

The company has overseen an intensified drilling program and the completion of many engineering and economic studies of the Chuitna field.

A majority of the permits necessary to begin mining have been obtained and the critical state mining permit has been issued to the project.

The favorable handling and the combustion characteristics of Alaska subbituminous coal have been demonstrated through the use of Usibelli coal in Korean power plants and through extensive testing of Beluga coals.

The extremely low sulfur content, large reserves, geographical location, buyer need for diversity and security of supply, as well as the desire to reduce the trade imbalance between the United States and our Asian allies -- are all good reasons why Beluga-Chuitna and Nenana coals should be attractive to Pacific Rim markets.

And that's not the extent of our possibilities for coal export either.

The Matanuska coal field is located in the Matanuska Valley of southcentral Alaska, about 50 miles northeast of Anchorage.

The Wishbone Hill district, one of four in the Matanuska field, has great coal development potential because of its excellent coal quality and the available transportation system.

Coal mining has taken place around Wishbone Hill since 1916, with 7 million tons of coal extracted for railroad, power plant and domestic use prior to 1968.

Idemitsu-Khosan, the holder of the Wishbone lease, has identified at least 17 million tons of surface-mineable bituminous coal.

Total mineable reserves here are estimated up to 60 million tons.

Export coal from this site can be transported by the Alaska Railroad from a location near the mine site to the Port of Seward, about 155 rail miles away.

Finally, let me mention the largest coal field in Alaska.

The bituminous coal resources of the Arctic are the largest in the state, and probably represent the largest in the United States, ranking with the top two or three coal provinces in the world!

Because the Northern Alaska province is remote, it has not been systematically divided into coal fields. Total hypothetical resources of the province are about 4 Trillion tons!

Sulfur content is under 3-tenths of one percent, heating value up to 13,500 Btu's.

Engineering and feasibility studies have been done on Western Arctic bituminous coal for domestic power and heating needs

But at this time, an export project utilizing this vast coal resource has not been planned.

Development of the Western Arctic coal region will provide the people of rural Alaska with a cheaper and more stable source of energy as an alternative to high cost fuel oil.

There is also a proposal before the Department of Energy for a clean coal technology grant to build a high-tech power plant in the Arctic.

Obviously, Alaska has the coal. Our challenge is to develop the export market for it -- and that's the Pacific Rim.

Over the next several decades, the Pacific region will exhibit one of the greatest per capita growths in the world .

This means they need additional electrical power, and new coal projects are now being planned and dedicated for completion in the next decade.

New developments in coal technology, such as fluidized bed combustion, will permit both greater variation in quality of coal feed and the use of a coarser coal size, -- factors which are beneficial to users of subbituminous coals.

Excellent combustion characteristics offset the extra grinding capacity which would be required for Alaska coal in coventional pulverized boilers.

The greatest attribute of Alaska coal, not presently recognized in the market place, is its extremely low sulfur content.

Without doubt, Alaska has within its borders the largest deposits of low sulfur coal in the world -- significant to address world environmental concerns.

New coal-processing technologies can produce upgraded Alaska coals with the attributes of a high heat value and extremely low sulfur which can be burned in existing power plants without the need for those plants to be modified with expensive pollution abatement equipment.

The greatest single market barrier for Alaska coal is the high moisture content, generally greater than 26 percent, of the subbituminous resources.

Understandably great emphasis is being placed upon the quest for cost effective technologies to remove much of the moisture and produce a much higher energy content fuel.

A dried or processed fuel with high heating value and excellent low pollution characteristics should command premium price in Pacific markets.

There is great promise that an upgraded fuel can be produced economically.

Usibelli Coal Company is currently evaluating appropriate coal processing technology in conjunction with a proposed coal-fired mine mouth power plant.

The power plant would produce electricity for the local area in addition to providing the primary heat source for the coal processing plant. This will be the cleanest burning power plant in the world!

Similarly, coal processing technologies could be successfully applied to the larger Beluga-Chuitna field projects to produce a high quality coal product.

The application of such technologies can remove market barriers which may be presented by high moisture of low heating values.

In other words, Alaska's has plenty of high quality coal available.

We also have an advantage in transportation.

The port of Seward is ice-free and routinely berths Panamax vessels (60,000-to-70,000 dead weight tons). And with increased tug capacity, the port could accept small Cape size bulk carriers (120,000 dead weight tons).

The capacity at Seward is currently underutilized. It could handle an additional 2 million metric tons per year.

And we're closer to the Pacific Rim markets than our competitors:

For instance, Alaska is about 4,300 nautical miles from Japan. While Australia is 4,500; South Africa 7,200 miles, and San Francisco more than 5,000 miles.

Alaska's existing port capacity, the availability of coal resources, a developed over-land transportation system (our Alaska Railroad), and proximity to the major export markets, are all key elements which Alaska's coal industry possesses.

Private interests are actively pursuing the development of these resources and are prepared to accept commitments from Pacific Rim buyers.

While run-of-mine Alaska coal is marketable, the application of new coal processing technologies, with the aid of U.S. grant programs, may produce the highest quality coal product available in the world.

Great opportunity awaits Alaska coal business ventures as export markets recognize the large environmentally sound resource which we have to offer.

Thank you.

SENATOR MITCH MCCONNELL

REMARKS BEFORE THE ASIA-PACIFIC COAL TECHNOLOGY CONFERENCE
NOVEMBER 15, 1989

LADIES AND GENTLEMEN, THANK YOU FOR THE OPPORTUNITY TO ADDRESS THIS GATHERING TODAY. IT IS ENCOURAGING TO SEE SUCH DISTINGUISHED GROUP OF ENERGY EXPERTS BROUGHT TOGETHER TO DISCUSS, STUDY AND ANALYZE A SUBJECT OF GREAT INTEREST TO ME AND I AM HONORED TO HAVE BEEN INVITED TO MAKE SOME BRIEF REMARKS.

WITHOUT HAVING SEEN THE WEATHER FORECAST FOR HONOLULU, I THINK IT IS SAFE TO ASSUME THE WEATHER YOU ARE ENJOYING IS BETTER THAN THE WEATHER HERE IN WASHINGTON. IF ANY OF YOU HAVE BEEN IN WASHINGTON IN NOVEMBER, YOU WILL UNDERSTAND WHY I MAKE THIS ASSUMPTION.

COAL IS TRULY ONE OF THE WORLD'S GREAT FUEL SOURCES. IT IS ABUNDANT, IT IS CHEAP, AND IT IS FOUND IN POLITICALLY AND ECONOMICALLY STABLE REGIONS OF THE WORLD. COAL CONTRIBUTES SIGNIFICANTLY TO MEETING THE ENERGY DEMANDS OF THE UNITED STATES AND THE INDUSTRIALIZED COUNTRIES. IT ALSO HAS THE POTENTIAL TO MEET THE GROWING ENERGY NEEDS OF DEVELOPING NATIONS.

IN MORE PAROCHIAL TERMS, COAL PLAYS AN IMPORTANT ROLE IN THE ECONOMY OF MY STATE OF KENTUCKY AND MANY OTHER COAL-PRODUCING STATES OF THIS NATION.

HOWEVER, IT IS BECOMING INCREASINGLY CLEAR THAT THE FUTURE OF COAL USE AROUND THE WORLD IS DIRECTLY LINKED TO THE DEVELOPMENT OF CLEAN COAL TECHNOLOGIES.

OVER THE LAST FEW YEARS, THERE HAVE BEEN CONCERNS RAISED ABOUT THE ENVIRONMENTAL IMPACT OF BURNING COAL. OBVIOUSLY, WE ARE ALL CONCERNED WITH PROTECTING AND PRESERVING OUR ENVIRONMENT. FORTUNATELY, CLEAN COAL TECHNOLOGIES WILL ALLOW US TO CONTINUE TO CONSUME COAL, AND DO SO IN AN ENVIRONMENTALLY PRUDENT MANNER.

BECAUSE THESE TECHNOLOGIES HOLD THE KEY TO MEETING THE WORLD'S GROWING ENERGY NEEDS AND MAINTAINING THE INTEGRITY OF OUR ENVIRONMENT, I HAVE LONG ADVOCATED THEIR DEVELOPMENT, DEMONSTRATION, AND EVENTUAL INTEGRATION INTO THE WORLD'S ELECTRICAL GENERATION SYSTEM. THE U.S. DEPARTMENT OF ENERGY'S CLEAN COAL TECHNOLOGY PROGRAM IS VITAL TO MAKING CONTINUED COAL USE -- AND ITS ASSOCIATED BENEFITS -- A REALITY AND I AM PERSONALLY COMMITTED TO PROVIDING WHATEVER CONGRESSIONAL SUPPORT IS NECESSARY TO MAKE THE PROGRAM WORK.

CLEARLY, PRESIDENT BUSH AND SECRETARY WATKINS ARE ALSO COMMITTED TO MAKING THE PROGRAM WORK. IN ADDITION TO SEEKING FULL FUNDING FOR THE CLEAN COAL PROGRAM, PRESIDENT BUSH HAS WISELY PROVIDED INCENTIVES FOR THE USE OF THESE TECHNOLOGIES IN HIS PROPOSED ACID RAIN CONTROL PROGRAM. SECRETARY WATKINS HAS TOLD CONGRESS IN NO UNCERTAIN TERMS THAT HE CONSIDERS THE DEVELOPMENT OF CLEAN COAL TECHNOLOGIES A VITAL **COMPONENT** OF OUR NATION'S OVERALL ENERGY STRATEGY.

AND THE PROGRAM IS WORKING. BY THE END OF THIS YEAR, THE FEDERAL GOVERNMENT WILL HAVE OBLIGATED TO COMMIT OVER $1.5 BILLION TO THE

PROGRAM. THIS WILL BE MATCHED BY AS MUCH AS $2.5 BILLION FROM THE PRIVATE SECTOR. TWENTY-NINE CLEAN COAL TECHNOLOGY PROJECTS ARE UNDERWAY AND MANY MORE ARE IN ADVANCED NEGOTIATIONS.

BUT SIMPLY DEVELOPING THE TECHNOLOGIES IS NOT ENOUGH. WE NEED TO GET THEM TO THE MARKETS WHERE THEY ARE NEEDED. THE DEPARTMENT OF ENERGY'S COAL AND COAL TECHNOLOGY EXPORT PROGRAM AND THE EXPORT PROMOTION PROGRAMS WITHIN OTHER FEDERAL AGENCIES ARE WORKING ON THIS.

ALSO, I KNOW HENSON MOORE, DEPUTY SECRETARY OF ENERGY, IS PERSONALLY COMMITTED TO EXPANDING THE EXPORT OF PRODUCTS FROM ALL U.S. ENERGY SECTORS. SECRETARY MOORE RECENTLY RETURNED FROM A TRIP TO EUROPE WHERE HE MET WITH SEVERAL ENERGY OFFICIALS ON BEHALF OF U.S. COAL AND CLEAN COAL TECHNOLOGIES. HIS REPORT WAS ENCOURAGING **AND IT APPEARS THERE MAY BE NEW OPPORTUNITIES FOR EXPORT TO THAT AREA OF THE WORLD.**

THE CLEAN COAL TECHNOLOGY PROGRAM ALSO ENJOYS STRONG SUPPORT IN CONGRESS, AS EVIDENCED BY THE NEARLY AUTOMATIC CONGRESSIONAL APPROVAL OF FUNDING FOR THE PROGRAM EACH YEAR.

CONGRESS ALSO CLEARLY SUPPORTS PROGRAMS TO PROMOTE THE EXPORT OF COAL AND CLEAN COAL TECHNOLOGIES. I RECENTLY OFFERED AN AMENDMENT WHICH WILL STREAMLINE AND BETTER COORDINATE THE VARIOUS FEDERAL EXPORT PROMOTION PROGRAMS RELATED TO CLEAN COAL

TECHNOLOGIES. THAT AMENDMENT WAS APPROVED UNANIMOUSLY BY THE SENATE.

ALSO, IN JULY, I ASKED MY COLLEAGUES TO JOIN ME ON A LETTER TO VARIOUS ADMINISTRATION OFFICIALS, ENCOURAGING THOSE OFFICIALS TO MORE ACTIVELY PROMOTE THE EXPORT OF COAL AND CLEAN COAL TECHNOLOGIES. OVER 25 PERCENT OF MY SENATE COLLEAGUES SIGNED THAT LETTER.

INDEED, IT IS CLEAR THE FEDERAL GOVERNMENT AND MANY MEMBERS OF CONGRESS ARE COMMITTED TO DEVELOPING AND DEPLOYING **ON A WORLDWIDE BASIS** CLEAN COAL TECHNOLOGIES AND THE COAL FOR THEM TO BURN. HOWEVER, MY STATE OF KENTUCKY IS ALSO COMMITTED TO PROVIDING COAL TO MEET THE WORLD'S ENERGY NEEDS AND I WOULD LIKE TO TAKE JUST A MOMENT TO DESCRIBE SOME OF THE THINGS BEING DONE THERE.

COAL IS CRITICAL TO THE ECONOMY OF KENTUCKY, AND THE STATE HAS HISTORICALLY LED THE NATION IN COAL PRODUCTION. LAST YEAR, KENTUCKY COAL OPERATORS PRODUCED 158 MILLION TONS, SECOND ONLY TO WYOMING. THE INDUSTRY EMPLOYS TENS OF THOUSANDS OF KENTUCKIANS AND PUMPS BILLIONS OF DOLLARS INTO THE ECONOMY.

BECAUSE OF THE IMPORTANCE OF COAL TO THE ECONOMY, KENTUCKY, IS COMMITTED TO DEVELOPING AND MAINTAINING A HEALTHY COAL INDUSTRY. A MAJOR PART OF THAT COMMITMENT INVOLVES ENCOURAGING AND PROMOTING THE EXPORT OF KENTUCKY COAL.

KENTUCKY IS A LEADING COAL-EXPORTING ~~NATION~~ STATE, WHICH COMES AS NO SURPRISE TO THOSE CLOSE TO THE INDUSTRY. KENTUCKY HAS LARGE DEPOSITS OF SOME OF THE FINEST QUALITY COAL IN THE WORLD. THOSE DEPOSITS ENJOY CLOSE PROXIMITY TO EAST COAST AND GULF PORT FACILITIES AND ARE SERVED BY A WELL-DEVELOPED RAILROAD, TRUCK, AND RIVER TRANSPORTATION SYSTEM.

KENTUCKY'S COAL PRODUCERS OPERATE WITH A GLOBAL PERSPECTIVE. THEY UNDERSTAND THAT SALES GROWTH IN THEIR INDUSTRY IS DEPENDENT NOT JUST ON EXPANDING DOMESTIC MARKETS, BUT ON FINDING AND DEVELOPING OVERSEAS MARKETS FOR THEIR PRODUCT. YEARS OF EXPORTING HAVE GIVEN THESE OPERATORS A WORKING KNOWLEDGE OF FOREIGN MARKETS AND FOREIGN BUYERS, AND THEY UNDERSTAND HOW TO DO BUSINESS OVERSEAS.

KENTUCKY SUPPORTS THE EXPORT EFFORTS OF IT COAL OPERATORS. THE STATE HAS HOSTED SEVERAL INTERNATIONAL COAL SEMINARS IN CONJUNCTION WITH THE U.S. DEPARTMENT OF COMMERCE WHICH HAVE BROUGHT TOGETHER U.S. COAL OPERATORS AND OVERSEAS BUYERS. ALSO, THE STATE RECENTLY REORGANIZED AND RESTRUCTURED THE ENERGY CABINET TO ENABLE IT TO MORE EFFECTIVELY PROMOTE THE EXPORT OF COAL. THIS OFFICE PRODUCES SEVERAL KENTUCKY-SPECIFIC COAL BUYING GUIDES AND PROVIDES MANY SERVICES TO OVERSEAS COAL BUYERS TO ASSIST THEM IN LOCATING AND SELECTING **KENTUCKY** SUPPLIERS.

IT SHOULD BE CLEAR BY NOW THAT THE FEDERAL GOVERNMENT AND THE STATE OF KENTUCKY ARE COMMITTED TO EXPANDING THE EXPORT OF COAL

OVERSEAS COAL AND COAL TECHNOLOGY BUYERS.

SINCE THE U.S. IS A LEADER IN COAL PRODUCTION AND HOLDS 35 PERCENT OF THE WORLD'S KNOWN COAL RESERVES, IT IS LOGICAL THAT WE LOOK TO COAL TO MEET BOTH OUR DOMESTIC ENERGY NEEDS AND TO ASSIST OTHER COUNTRIES IN MEETING THEIR ENERGY NEEDS. SINCE THE U.S. HAS ALSO BEEN A HISTORIC LEADER IN COAL TECHNOLOGY, IT IS LOGICAL THAT WE TAKE A LEAD IN HELPING OTHER NATION'S DEVELOP THEIR COAL COMBUSTION TECHNOLOGY BASE.

FEDERAL AND STATE OFFICIALS RECOGNIZE THAT THE REALITY OF THE 1980'S IS THAT WE LIVE IN A GLOBAL ECONOMY AND A GLOBAL ENVIRONMENT. WE ARE ACUTELY AWARE OF THE IMPORTANCE OF PROTECTING AND PRESERVING THE EARTH'S ENVIRONMENT. AT THE SAME TIME, WE KNOW THAT COAL CAN, SHOULD, AND WILL PLAY A VITAL ROLE IN MEETING THE WORLD'S CURRENT AND FUTURE ENERGY NEEDS.

WE REALIZE THAT AS DEVELOPING COUNTRIES BEGIN TO MODERNIZE AND INDUSTRIALIZE, AMERICA CAN -- AND SHOULD -- PLAY AN IMPORTANT ROLE IN ASSISTING THESE COUNTRIES TO BUILD AN ENVIRONMENTALLY SOUND AND STRATEGICALLY SECURE ENERGY POLICY BASED ON COAL.

WE REALIZE THAT THIS CAN BE ACCOMPLISHED BY PROMOTING THE EXPORT OF U.S. COAL AND U.S. CLEAN COAL TECHNOLOGIES WITH WHICH TO BURN IT. THIS WILL HELP DEVELOPING COUNTRIES INDUSTRIALIZE AND OBTAIN

A LONG-TERM, SECURE ENERGY FUEL SUPPLY WHILE AT THE SAME TIME HELPING TO PRESERVE AND PROTECT THE GLOBAL ENVIRONMENT.

WITH THE COMMITMENT OF THE U.S. GOVERNMENT AND INDUSTRY TO DEVELOPING CLEAN COAL TECHNOLOGIES AND TO THE EXPANDING THE EXPORT OF THESE TECHNOLOGIES AND THE COAL TO BURN WITH THEM, THE U.S. CAN CONTRIBUTE TO THE MEETING THE ENERGY AND ENVIRONMENTAL NEEDS OF THE WORLD FOR DECADES TO COME.

THANK YOU AND BEST OF LUCK IN YOUR EFFORTS.

REPRESENTATIVE RALPH REGULA (R-OH)

First let me thank you all for inviting me to participate in your conference. I only wish I could be there in person.

You are meeting at an opportune time and to discuss a critical issue, coal and the technologies we are developing to burn this abundant resource cleanly and efficiently.

In the 1970s the United States pursued a goal of energy independence. I do not believe that goal is any longer a realistic one. Rather, energy interdependence is a reality. For that reason, conferences such as this one are even more vital.

It is critical both to our energy and national security futures that we find ways to burn coal cleanly. The United States is unequivocally the Saudi Arabia of coal. Coal is by far our most abundant domestic energy resource. Our country is home to the world's largest recoverable coal reserves, or 28.7 percent of estimated world reserves.

Moreover, the known world reserves of coal in BTU equivalent far outweigh those of oil and gas combined.

Despite ominous warning signs here of a future energy crisis -- oil imports in excess of 50 percent for the first time in 12 years, imports exceeding domestic production for the first time in nine years -- coal represents one bright spot in our domestic energy picture when we look at the supply side of the energy equation.

The acceptance of coal as a fuel of choice holds the key to our hopes for energy security and the key to that is technology -- clean coal technologies.

By using more coal since the early 1970s, the United States has reduced its dependence on oil without sacrificing economic development. In the future, coal can continue to contribute to our economic growth and energy security. By burning more coal we reduce our dependence on oil. By selling U.S. coal and coal technologies abroad, we can also reduce our Allies' dependence on oil.

Despite vast reserves of coal and our relatively limited supply of oil, the Unites States still gets less than half as much energy from coal as it does from oil.

Coal currently furnishes about one-fifth of all the primary energy sued int eh free world. Given its abundant supply, however, it should provide an even greater percentage of world energy use. However, as the President's 1987 Energy Security Report noted: "Unless prospective coal users have positive incentives to choose coal, it may frequently be more convenient and less risky to turn to oil and gas. The challenge is to maximize coals use and thereby curb demand for oil imports in the United States and the free world without overlooking economic efficiency."

However, if acid rain legislation, currently being considered in Congress is enacted, it would have precisely the opposite effect, creating a substantial disincentive for increased coal consumption.

The United States is the number one consumer of energy in the world. As an energy dependent society we have an obligation to play a dominant role ins supplying the world's energy as well as consuming it. Yet each energy resource exacts a price for is production and/or consumption. In the case of coal that price has been environmental performance.

For nearly a decade now, Congress has been grappling with the question of reauthorizing the Clean Air Act, including provisions to deal with the issue of acid rain. Coal burning power plants have long been labeled the culprit in the on-going acid rain debate.

In June President Bush announced the broad outlines for sweeping revisions to the Clean Air Act, the first such revisions proposed by the Administration in over a decade.

At the time, I was optimistic about the acid rain portion of the Administration's package. The President promised a plan which would allow utilities maximum flexibility in achieving emissions reductions. He called for a market based approach which would promote least-cost compliance. And most importantly, he pledged to maintain and enhance the viability of the clean coal program.

Somewhere between the Rose Garden ceremony and the legislative drafting board, however, those principles were compromised.

The proposed acid rain bill would have a chilling effect on economic growth and jobs. The proposal is not balanced. It is not a program that fosters economic growth or energy security.

We do have in place, however, a fair and balanced acid rain program, and that is the Clean Coal Technology program.

As the President's Energy Security report recognized, "For coal to fulfill its potential as a prime domestic energy resource, technological and regulatory barriers limiting its ability to compete with oil and gas must be removed."

Since 1985, Congress has committed $2.7 billion in federal funds to this program to demonstrate innovative technologies to burn coal more cleanly and efficiently. The program requires industry to provide at least 50 percent of the total cost of a demonstration project, but the average industry share has been far greater.

The Clean Coal program is addressing those technological barriers. I can think of no comparable federal program. The private sector has sent a strong signal that they are willing to spend their own money in support of a technological solution to pollution control which will also address the very real needs for future generating capacity.

The viability of the Clean Coal program and this substantial federal and private investment must be protected. Any acid rain legislation must not jeopardize this significant investment. Industry has demonstrated their strong commitment with a significant dollar contribution. We must

demonstrate that Congress is equally committed to the commercialization of these technologies.

Caution must be exercised so that arbitrary deadlines do not prevent clean coal technologies from being a part of the solution.

The substantial federal and private investment could be largely wasted if adequate time is not provided for clean coal technologies to be demonstrated, commercially available and deployed in sufficient numbers. A premature, arbitrary deadline would effectively eliminate the clean coal option and insure that yet another generation of power plants would be equipped with outdated 1970s technology.

It is a fact that is often ignored, but United States commitment to cleaner coal began long before the 1985 program. Since passage of the Clean Air Act in 1970, American industry has spent over $225 billion to control air emissions.

DOE's 1987 report, "America's Clean Coal Commitment," revealed that U.S. industry, states and the federal government will likely spend more than $6 billion between 1986 and 1992 to develop and deploy advanced clean coal technologies.

There is another dimension to that and that is the question of the global environment. Coal is not only abundant and cheap in the United States, but is increasingly becoming a fuel of choice around the world. We have a responsibility to encourage other nations to pursue clean burning technologies.

Other than the environmental benefits there is no economic incentive to install a scrubber. There could, however, be an economic incentive to install a clean coal technology which not only would achieve improved environmental performance, but improved overall productivity. We could enhance the export market for these technologies as well as contribute to an improved global environment.

Clean coal technologies are the key not only to a cleaner environmental, but also to a more secure energy and national security future. These technologies offer a promise to energy intensive industries for reductions in energy costs through improved efficiencies. They offer a promise that we could insure energy security, but finding ways to burn an abundant energy resource leanly. They offer a promise of a cleaner environment.

The successful demonstration of a wide range of clean coal technologies could make these promises realities. Enactment of acid rain legislation which does not provide sufficient time for development nor appropriate incentives, may result in the promise of those new technologies never being realized.

WENCELSAO R. DE LA PAZ

Executive Director
Office of Energy Affairs
Office of the President of the Republic of the Philippines

Education: Masters of Laws, New York University, 1972
Bachelor of Laws (Valedictorian-Magna Cum Laude), Iloilo
Rotary Club Awardee as Most Outstanding Graduate, University of San Agustin, Iloilo City, 1963

Government Examination: 1963 Philippine Bar - Third Place

Past Positions:

Nov 1977 - Oct 28, 1987	Acting Director, Bureau of Energy Development, Office of Energy Affairs (OEA)/Office of the President
Nov. 1977 - Oct, 28, 1987	Acting Chief, Adminstrative Services, OEA
Nov. 1975 - Nov. 1977	Deputy Executive Director/Adminstrative Services Director, Petroleum Board/Energy Development Board

Articles Written:

a) Negotiating Energy-Related Contracts in the Philippines
b) Petroleum Exploration: A New Departure
c) Oil and Energy Productoin
d) Philippine Offshore Oil Exploraton and Exploitation: Its Impact on National Development
e) Tax Incentives for Oil Exploration
f) Update on the Philippine Coal Development Program
g) Economics of Coal Use
h) Plans and Policies of Government on the Coal Industry

Energy-Related Work

1) Participated in Philippine Government Missions in an effort to enhance cooperative interactions with various countries in the field of energy.
2) Organizing Chairman of the Legal Committee of the ASEAN Cooperation on Petroleum.
3) Chairman of the BED Negotiation Panel for Energy Service Contracts.
4) Alternate Representative for Energy to the Cabinet Assistant Systems, a Sub-Cabinet Committee providing staff assistance to the President and the Cabinet.
5) Member of various government Interagency Committees representing the Office of Energy Affairs.
6) Assisted in the preparation of various energy legislations such Legislation on Coal Development, Legislation on Geothermal Development, Legislation on Non-Conventional Energy Development, providing preferential tax treatment for Petroleum sub-Contractors and Non-Filipino employees of Petroleum Service Contractors and Foreign Petroleum Subcontractors, amending the National Internal Revenue Code by providing additional expenses and other deductible items from Gross Petroleum Income of Petroleum Service Contractors and amending P.D. 87 by providing additional incentives to Service Contractors with Deepwater Contracts.

ALOYSIUS ANDOYO
Director
Electric Power Planning and Development
Directorate General of Electricity and New Energy

Education:	Gajah Mada University, Yogyakarta Civil Engineering Faculty graduated 1960	
Training:	1963 - 1964	Hydropower Engineering and Construction U.S.B.R., Denver, Colorado
Experience:	1960 - 1963	Project Engineer, Hydro Electric Power Plant Projects in West Java
	1965 - 1974	Project Manager of Hydro Electric Power Projects in North Sulawesi and South Kalimentan
	1974 - 1981	Project Manager of Steam Power Plants and Transmission Networks of East Java
	1981 - 1984	Deputy Director of Construction Administration of PLN Head Office, Jakarta
	1984 - present	Director of Electric Power Planning and Development, Directorate General of Electricity and New Energy, Jakarta

THE FUTURE OF COAL FOR POWER GENERATION IN INDONESIA

A. Andoyo
Director of Electric Power Planning and Development
Directorate General of Electric Power and New Energy
Ministry of Mines and Energy
The Republic of Indonesia

Asia-Pacific Coal Technology Conference
East-West Center
Honolulu, Hawaii

November 1989

THE FUTURE OF COAL FOR POWER GENERATION IN INDONESIA*)

by

A. ANDOYO

Director of Electric Power Planning and Development
Directorate General of Electric Power and New Energy
Ministry of Mines and Energy
The Republic of Indonesia

1. It gives me a great pleasure to be here this afternoon to make a presentation concerning a subject which is very close to my responsibility and also to my heart.

In this short paper I will try to describe the past, current and future development of electric power in Indonesia. I will describe in more detail about the role of coal in such a development to be in accordance with the theme of this important conference, that is about coal technology.

2. Electric power development has been an important segment of the economic development in Indonesia to meet huge demand from industrial, commercial and residential sectors. During the last twenty years (1968-1988) electricity consumption from the public utility has been growing at an annual rate of 15.1 percent from 1.2 TWh to 20.0 TWh. The largest growth was experienced during the last ten years of 16.6 percent per year from 4.3 TWh to 20.0 TWh. The fastest growing consumption was made possible by the

*) *Presented at Asia-Pacific Coal Technology Conference, Honolulu, Hawaii, November 15-16, 1989.*

increasing amount of installed capacity from only 527 MW in 1968/69 to 8529 MW in 1988/89 or growing at an annual rate of 14.9 percent as shown on Table 1. Of that increasing capacity, most are supplied by oil-fired power plants either diesel, steam or gas turbine plants. Hydropower, as the cheapest energy source, is also continously developed, while geothermal and natural gas contribute relatively in small percentage. The latter two are considered potential and prospective to meet the government policy on energy diversification. Another energy source which gives increasing share is coal which has been on stream since 1984 with the first coal power plant of 400 MW which contribute about 10 percent of total installed capacity. The role of coal is getting more important with additional coal power plants on stream of 930 MW during the last five years totalling to 1330 MW nowadays. Such amount is equal to about 16 percent of total installed capacity.

Table 1

Electric Power Development
in Indonesia
Past Trend Experience, Public Supply

	1968/69	1973/74	1978/79	1983/84	1988/89
Consumption (TWh)	1.2	2.1	4.3	10.0	20.0
Average Growth Rate (%)		12.9	14.1	18.5	14.5
Installed Capacity (MW)	527	776	2288	3935	8529
Coal-fired SPP Capacity (MW)	-	-	-	-	1330

3. The last 20 years of fast growing electricity demand is caused by many reasons. First of all it is because the strong economy of Indonesia supported by high revenue from oil export. Secondly, better infrastructure created by a strong economy takes more energy consumption by all consuming sectors. Thirdly, there were suppressed demand of electricity that were satisfied mainly from rural electrification. Currently about 18 thousand villages out of 63 thousand villages (or about 28%) have been electrified by the utility. That growing demand has increased the electricity consumption per capita to 235 kWh and electrification ratio to 24.7 percent.

4. The strong electricity demand is expected to continue in the next five years (Fifth Five-Year Plan). Shown in Table 2, the total electricity demand will grow to 38.8 TWh in 1993/94 or growing at annual rate of 14.6 percent. If the demand is broken down into Java and outside Java, the demand in Java and outside Java in 1993/94 will be 30.1 TWh and 8.8 TWh respectively or growing at annual rate of 14.4 percent for Java and 15.2 percent for outside Java. Those growing demand will be met by adding more capacity to the available capacity so that the total installed capacity will grow from 8529 MW in 1988/89 to 12225 MW in 1993/94. This means that during the next five years there will be an additional capacity of 3696 MW of which the share of coal power plant will be 1365 MW or about 37 percent. The total installed capacity of coal power plant will then increase from

1330 MW in 1988/89 to 2695 MW in 1993/94.

Table 2

Electric Power Development
in Indonesia
for the Fifth Five-Year Development Plan
(1989/90 - 1993/94)

	89/90	90/91	91/92	92/93	93/94
Energy Supply (TWh)					
Java	17.6	20.2	23.2	26.2	30.1
Outside Java	5.1	5.9	6.7	7.7	8.8
Indonesia	22.7	26.1	29.9	34.2	38.8
Average Growth Rate (%)					
Java	----------		14.4	----------	
Outside Java	----------		15.2	----------	
Indonesia	----------		14.6	----------	
Additional Capacity (MW)	669	393	345	909	138(
Total Installed Capacity (MW)	9198	9591	9936	10845	12225
Additional Coal-Fired Steam Power Plant (MW)	400	-	-	165	800
Total Coal-Fired SPP Capacity (MW)	1730	1730	1730	1895	2695

5. Based on projections of energy demand using different models made for Indonesia, a moderate demand for electricity from public utility in the long term beyond the next five years can be expected. Table 3 shows electricity demand projection for Java that will grow to 101.2 TWh in 2010 or about five fold increase in 20 years. The average growth rate from 1995 to 2010 will be

around 5.5 percent per year which is lower than that between 1990 and 2000 which is around 12.5 percent. The main reason for such a low growth rate is that almost all suppressed demand will be disappeared as almost all areas in Java will have been electrified in 2010. The installed capacity will grow to 25500 MW in 2010 of which the share of coal power plant will be 13200 MW or more than one half of total installed capacity. This larger share of coal power plant will increase the coal requirement to 33 million tons in 2010.

Table 3

Electric Power Development
in Indonesia
Long Term Projections of Public Supply (PLN)
for Java System

	1990	1995	2000	2005	2010
Electricity Supply	20.2	37.9	55.7	76.6	101.2
Average Growth Rate (%)	15.0	10.5	6.0	5.5	5.0
Installed Capacity (MW)	6133	9896	16536	18621	25467
Coal Fired SPP (MW)	1600	4200	10200	11400	13200
Coal Supply (million tons)	4.0	10.5	25.5	28.5	33.0

6. The long term demand for outside Java will still grow at almost the same growth rate as the next five years. Until 2005 the average growth rate of electricity demand will be around 12

Table 4

Electric Power Development
in Indonesia
Long Term Projections of Public Supply (PLN)
for Outside Java

	1990	1995	2000	2005
Electricity Supply	5.9	11.1	19.5	56.8
Average Growth Rate (%)	15.2	12.1	11.9	11.0
Installed Capacity (MW)	3065	4210	5850	9704
Coal Fired SPP (MW)	130	675	765	830
Coal Supply (million tons)	0.2	1.0	1.2	1.3

percent of which the growth will be decreasing as the years go by. This growth is higher than Java's that can be explained by the fact that there will still be suppressed demand outside Java that will be satisfied by rural electrification and industry as well. The electricity demand for outside Java will grow to 56.8 TWh in 2005 or almost ten fold increase than the demand in 1990. Such high demand will be served by adding more capacity from 3065 MW in 1990 to 9700 MW in 2005 of which coal power plant share will grow from just 130 MW in 1990 to 830 MW in 2005 and the coal requirement will grow to 1.3 million tons in 2005. The installed capacity of coal-fired power plant outside Java will be around 9 percent of the total installed capacity which is not as high as

that for Java. The reason is that because the distribution of consumers outside Java is more dispersed in many islands than that in Java which make low capacity power plants such as diesel is more technically viable although in some cases economically not feasible. On the other hand there are sufficient hydropower potentials in the islands outside Java suitable to be developed for hydropower plants. However, the higher growth rate of outside Java than in Java is expected to continue beyond the year 2005 because more potential consumers will be expecting to get electricity.

7. The supply of coal for power generation in Java will be originated from Sumatera and Kalimantan. Therefore suitable mode of coal transportation shall be thoroughly studied since a considerable tonnage a year is required for each power plant. For outside Java, most of the coal-fired power plants are to be constructed nearby coal mines to minimize transportation cost. In addition environmental issues can be also soundly managed. Table 5 shows the estimated construction schedule of coal-fired power plants in Indonesia until the year 2000.

8. As above described the huge requirements of electricity in the future would be mainly met by the use of coal for power generation. Therefore, it can be expected substantial development in coal-mining industry as well in the construction of coal-fired generating plants. The development of coal-mining industry and

Table 5

Coal Fired Thermal Power Plant
Construction Scedule

	Java		Outside Java	
Year	Site	Capacity (MW)	Site	Capacity (MW)
1986	Suralaya #1-2	800		
1987			Bukit Asam #1 (S. Sumatera)	65
1988	Suralaya #3	400	Bukit Asam #2 (S. Sumatera)	65
1989	Suralaya #4	400		
1992			Bukit Asam #3 (S. Sumatera)	65
			Ombilin #1-2 (W. Sumatera)	100
1993	Paiton #1-2	800	Balikpapan #1-2 (E. Kalimantan)	100
1994	Suralaya #5	600	Banjarmasin #1-2 (S. Kalimantan)	50
1995	Suralaya #6-7	1200	Tarahan #1-2 (S. Sumatera)	130
			Ujung Pandang #1-2 (S. Sulawesi)	100
1996	Paiton #3	600		
1997	Paiton #4	600		
	C. Java #1-2	1200		
1998	W. Java #1-2	1200	Bukit Asam #4 (S. Sumatera)	65
1999	C. Java #1-2	1200		
2000	W. Java #3-4	1200	Banjarmasin #3 (S. Kalimantan)	25
Total		10200		765

the supply of coal for power generation at the required time can be made possible through suitable coal technology since abundant coal reserves are available. Tables 6 and 7 show Indonesian coal reserves by types and by catagory of availability. The total coal reserves in Indonesia is more than 26 billion tons, most of them are available in Sumatera and Kalimantan. However, more than 63 % is catagorized as low-grade coal or lignite, or about 17 billion tons in total.

Table 6

Indonesian Coal Reserves
by Types
(million tons)

Region	Anthracite	Bituminous	Sub-Bituminous	Lignite	Total
Sumatera	14.0	158.9	4583.9	16924.5	21681.3
Kalimantan	-	1632.3	3076.6	-	4708.9
Java	-	14.6	-	11.7	26.3
Sulawesi	-	-	89.8	-	89.8
Irian Jaya	-	0.5	-	3.5	4.0
Total Indonesia	14.0	1806.3	7750.3	16939.7	26510.3

Table 7

Indonesian Coal Reserves
by Categories
(million tons)

Region	Measured	Indicated & Inferred	Hypothetic	Total
Sumatera	1196.2	4152.6	16435.4	21681.2
Kalimantan	883.8	3825.1		4708.9
Java		26.3		26.3
Sulawesi		89.8		89.8
Irian Jaya		4.0		4.0
Total Indonesia	2080.0	7994.9	16435.4	26510.3

Conclusion

10. Based on presentation above it can be concluded that:

a. Electric power development in Indonesia will grow considerably fast until the year 2000 to meet increasing demand from each consuming sectors and suppressed demand and slightly moderate afterwards.

b. Coal will contribute larger share for electric power generation in the long term as it is the commitment of the

government to develop non-oil resources to save oil for export. It is fortunate that Indonesia has large reserves of coal that can be tapped as much as possible for electric power generation primarily.

c. The pace of coal development, however, will depend on how those large reserves are developed and how its price is set to compete with other alternative energy resources such as natural gas, geothermal and the introduction of nuclear power plants in the future.

CHARMON SUTHIPHONGCHAI
Deputy General Manager
Thermal Power and Mine Development
Electricity Generating Authority of Thailand

Qualifications: Graduate with Honor in Electrical Engineering from Faraday House College, London, in 1958

Post Graduate Studies:

1. Advance Power System Engineering Course at Westinghouse Education Center
2. Selective graduate-level courses from Pennsylvania State University

Social & Professional Activities:

1. Fellow Member--Institute of Engineering of Thailand
2. Senior Member of the Institute of Electrical and Electronics Engineer (IEEE)
3. Honorary Fellow of the Association of the Electricity Supply Industry of East Asia and the Western Pacific (AESIEAP)
4. Member of Thai National Committee of CIGRE
5. Member of CIGRE Study Committee SC.39 (Power System Operation and Control)
6. Chairman of the Institute of Electrical and Electronics Engineers, Inc., Thailand Section (IEEE Thailand Section)

Professional Experiences:

1953 - 1955	Customer engineer with IBM Thailand Co., Ltd.
1958 - 1959	Information engineer with AEG (All gemeine Elektrictitats Gesollschaft) in West Germany
1959	Employed by Yanhee Electricity Authority and in 1969 they merged with Lignite Authority and North-East Electricity Authority as the Electricity Generating Authority of Thailand (EGAT)
1965 - 1969	Superintendent of System Protection and Communication Division
1968	Assistant Director of Construction Department and working on the design and construction of Central Dispatching and Control Center
1969 - 1980	Director of Electrical Maintenance Department
1980 - 1985	Assistant General Manager - Maintenance
1985 - 1987	Deputy General Manager - Transmission System Operation
1987 - present	Deputy General Manager - Thermal Power and Mine Development

ELECTRIC POWER SYSTEM IN THAILAND

Mr. Charmon Suthiphongchai
Deputy General Manager
Electricity Generating Authority of Thailand

The Asia-Pacific Coal Technology Conference 1989
on Coal Investment and Technology in the Asia-Pacific

November 1989

TABLE OF CONTENTS

		Page
1.	GEOGRAPHY OF THAILAND	1
2.	PRESENT ELECTRIC POWER SECTORS AND THE ROLE OF EGAT	1
3.	POWER DEVELOPMENT IN THAILAND FOR THE PAST	1
	3.1 Power Development Fundamental	1
	3.2 Power Development During the Period of Rapid Economic Growth	2
	3.3 Power Development After World Oil Crises up to the Present	3
4.	PRESENT FACILITIES	4
5.	POWER DEVELOPMENT PLAN	4
	5.1 Development Options	4
	- Hydroelectric	5
	- Natural Gas	5
	- Crude Oil and Condensate	5
	- Lignite (Domestic Coal)	5
	- Imported Coal	8
	5.2 Power Exchange with Neighbouring Countries	9
	5.3 The EGAT Power Development Plan	9
6.	CONCLUSION	11

APPENDIXES

Appendix 1 :	Percentage Distribution of EGAT Generating Capacity	18
Appendix 2 :	Summary of EGAT's Fuel Requirement and Energy Generation Classified by Types of Fuel	19
Appendix 3 :	EGAT Recorded Daily Load Curves on Peak Day	21

1. GEOGRAPHY OF THAILAND

The Kingdom of Thailand is an independent constitutional monarchy with a unique history for it has never been a colony. Bordered by Myanma (Burma), Lao PDR, Kampuchea and Malaysia, Thailand is located in the heart of mainland of Southeast Asia and covers a total area of 514,000 square km. (319,399 square mi). Thailand extends approximately 1,660 km (1,031 mi) from north to south, and its widest is over 800 km (499 mi) east to west. Its 2,100 km (1,304 Mi) coastline encloses most of the Gulf of Thailand on the South China Sea and borders the Andaman Sea and straits of Malacca on the western side of southern peninsula.

2. PRESENT ELECTRIC POWER SECTORS AND THE ROLE OF EGAT

There are at present three electric power sectors in Thailand. They are the Electricity Generating Authority of Thailand (EGAT), the Metropolitan Electricity Authority (MEA), and the Provincial Electricity Authority (PEA). EGAT is responsible for the generation and transmission; MEA for the distribution in Greater Bangkok and two nearby provinces, Samut Prakarn and Nonthaburi; and PEA for the distribution throughout the remainder of the Kingdom.

Among the three power utilities, only EGAT is responsible for the generation and transmission of electric power throughout the country. It could, therefore, be mentioned that EGAT plays the very important role in the power development of Thailand.

3. POWER DEVELOPMENT IN THAILAND FOR THE PAST

3.1 Power Development Fundamental

The extensive power development of Thailand was started in late 1950's, when the power utilities had been set-up. The main tasks of the power utilities at that time were to overcome the power shortage problems after the Second World War and to stabilize the supply-and-demand situation throughout the country. The power development then aimed at looking for the energy sources to be developed for large scale of power generation. In 1957

the plan for constructing the Yanhee Project was started. The Project included the Bhumibol Dam, the 2 sets of generating unit each rated at 70 MW at the first stage, and the transmission lines between Bhumibol Dam and Bangkok.

While the first stage of the Yanhee Project was under construction, a thermal power plant at North Bangkok was concurrently built in order to maintain sufficient power supply to the people in Bangkok. The first unit of North Bangkok power plant rated at 75 MW completed for commercial operation in 1961, and it was the first large and modern power plant in the country.

3.2 Power Development During the Period of Rapid Economic Growth

The following stage of power development in Thailand was considered in the period during the First and Second National Economic and Social Development Plans (1961-1966 and 1967-1971), the years before oil crisis.

The power development emphasized on speeding up the expansion program and improvement of supply. A large size of power generating unit including the transmission and distribution systems was constructed and expanded to the areas where power supplies were from small diesel generators which were consequently closed down. Together with the expansion of supply there was also a marked improvement in its reliability of supply through the revamping and strengthening of the distribution systems.

Due to rapid growth of electricity demand, the expansion of power supplies had been tackled with crash programs. As a result, it was unavoidable to develop with more effort on the large capacity thermal power plants fueled by heavy oil which was also quite cheap at that time. The development of domestic energy resources for power generation required a long lead time and could not catch the demand. The total electricity generation from oil-fired power plant rose sharply from 20 % in 1961 to 56 % in 1971, and up to 80 % in 1980.

It was also in 1967 that the work program on developing nuclear power in Thailand was proposed. However, the nuclear power project had to be shelved due to public opposition and the hopeful discovery of domestic natural gas.

3.3 Power Development After World Oil Crises up to the Present

The two oil crises in 1973 and 1979 caused the changing conditions to the power development policy. There was as a drive to develop alternative energy sources to compete with oil particularly for the exploration and development of domestic water resources, lignite deposits, including natural gas and other non-conventional energy.

At the present EGAT operates two lignite mines at Mae Moh in the North and Krabi in the South. Mae Moh mine has the largest lignite deposit. Eight units of steam power plant, a total capacity of 1,125 MW, are presently in operation. The mine is being expanded to increase the production of lignite for firing another three generating units, a total capacity of 900 MW, which are under construction.

In response to the discoveries of onshore and offshore petroleum, the most important of which was the natural gas, the construction of two 386 MW blocks of combined cycle units were undertaken for the first time in Thailand followed by two 550 MW conventional gas-fired thermal units, both at the Bang Pakong Power Plant. Additionally, the existing five units with a total capacity of 1,300 MW, had been converted from oil-fired to oil/gas-fired. At present, the natural gas production from the Gulf of Thailand is supplied through a gas pipe line to the Bang Pakong and South Bangkok power plants, whose power generation reach 3,172 MW in capacity, about half of the total installed capacity in the system.

The total domestic hydro potential is estimated to be over 10,000 MW, whose development cannot be easily expedited due to political, environmental and social obstacles. At present the hydro of 2,250 MW is in operation and that of 180 MW is under construction.

Resulting from speeding up the exploitation of domestic energy resources, the portion of energy generation from oil has decreased to about 11 % at the present. Part of oil used for power generation today is from Phet Crude, the domestic oil from Sirikit field in Kamphaeng Phet Province.

Apart from the aim to diversify the power sources from conventional energy to arrive at the best mix, EGAT has also conducted the studies of non-conventional energy sources for electricity generation, such as solar energy, wind power, and geothermal energy.

4. PRESENT FACILITIES

Resulting from the past power development up to the present, EGAT has a total installed generating capacity of 7,194 MW which comprises 2,250 MW hydroelectric plants(31.3 %), 3,907 MW thermal power plants (54.3 %), 772 MW combined cycle power plants (10.7 %), and 265 MW gas turbine units (3.7 %).

For the transmission system, EGAT operates some 16,535 circuit-kilometers of transmission lines using voltages of 69 kV,115 kV, 230 kV and 500 kV. The electricity demand of the country is now served by EGAT from 152 substations with a total transformer capacity of 15,712 MVA.

In fiscal year 1989, total electricity sold to MEA, PEA and ten direct customers together with Lao PDR and Malaysia, reached 33,548 GWh. The share of electric energy sale was : 16,144 GWh (48.1 %) sale to MEA, 16,130 GWh (48.1 %) sale to PEA and the balance of 1,274 GWh (3.8 %) was sold to direct customers including the export to Lao PDR and the energy exchange with Malaysia.

Total electricity generation within the same fiscal year was 36,436 GWh, which was made up of 5,226 GWh (14.3 %) from hydroelectric power, 7,360 GWh (20.2 %) from lignite, 19,301 GWh (53.0 %) from natural gas, 4,033 GWh (11.1 %) from fuel oil, 7 GWh (0.0 %) from diesel oil, and the balance of 509 GWh (1.4 %) was the energy purchased from Lao PDR and Malyasia.

5. POWER DEVELOPMENT PLAN

5.1 Development Options

The five-fuel policy has been adopted for the planning, four of them are domestic energy resources, i.e., hydro, gas, oil, lignite to be considered for short and medium-term planning and the other one is imported energy such as coal to be considered for long-term profile which can be discussed as follows :

Hydroelectric

The hydroelectric potential in Thailand is estimated at about 10,626 MW up to 1989, only 2,430 MW of hydro power capacity or 23 percent of total potential have been exploited. Of this amount, 2,250 MW has been in operation, and 180 MW is under construction. The remaining potential of about 8,200 MW (77 percent of the total potential) is suitable only for medium and small scaled development and not easy to be developed through environmental and forestry problems. However, hydro projects of the multipurpose type are still useful for future development.

Natural Gas

The known natural gas reserve in Thailand is estimated at about 19.25 TCF, comprising 23 fields off-shore and 1 field on-shore which are expected to have a recoverable reserve of 12.9 TCF. Of this amount, 3.9 TCF is a proven reserve which has been discovered and ready to be developed.

In the EGAT power development plan, additional 6 blocks of 300 MW combined cycle power plants have been included. The gas/oil dual-firing power plants for the capacity of 2x600 MW are also included in the power development plan.

Crude Oil and Condensate

The crude oil reserves in Thailand are of small quantity. The known reserves of crude oil and condensate in Thailand are estimated at about 1,150 million barrels.

Under the present plan, the demand of natural gas for power generation will increase at high level in the real term. The natural gas resources cannot be developed to meet the requirements. The heavy oil will, therefore, have to be used at the existing dual-firing power plants and will share some significant fraction of generation during the next 3-5 years.

Lignite (Domestic Coal)

Thailand's indigenous coal resources are all relatively low grade of the variety generally categorized as lignite. Detailed discussion on lignite resources are as follows :

a) Development of Lignite Resources

Lignite was first surveyed in 1917 and was found at Mae Moh, Lampang province in the northern part of Thailand and at Khlong Bang Pu Dam, Krabi province in the South. In the year 1954, the government formed a state enterprise, called Lignite Electric Energy Authority (later on it was changed to Lignite Authority) to be responsible for producing lignite for utilization in the country. At first, a mine was operated at Mae Moh, Lampang province. Since then, the lingite was supplied to various utilizers such as State Railway Authority of Thailand, Tobacco curing mill, and various industries, etc., including Mae Moh lignite power plant which began operating in 1960 with the rating capacity of 12.5 MW.

In 1964, the Lignite Authority continually opened a mine at Khlong Bang Pu Dam, Krabi province to supply lignite for Krabi lignite power plant, rated 60 MW for the replacement of fuel oil.

In 1969, the government consolidated functions and responsibilities of the three independent state enterprises; i.e. the Yanhee Electricity Authority, the Northest Electricity Authority, including the Lignite Authority, and then formed the Electricity Generating Authority of Thailand (EGAT) so that the effectiveness of better performance and higher efficiency in lignite production as well as electricity generation could be achieved.

b) Lignite Reserves

There are so many lignite resources scattered around in every regions of Thailand. The total geological reserve of lignite in Thailand is estimated at about 2,069.2 million tons. The significant resources located in the North are about 1,598.3 million tons or equivalent to 77.2% of the total reserves of the country and the other 470.9 million tons (22.8%) is located in the South.

The estimated minable reserve of the whole country is expected to be about 1,017 million tons of which 812 million tons is located in Mae Moh,Lampang province; 20 million tons at Krabi, Krabi province; 137 million tons at Saba Yoi, Songkhla province; 23 million tons at Sin Pun, Krabi province and 25 million tons at Wiang Haeng, Chiang Mai province.

Table 1 and Figure 1 show the lignite reserves.

c) Development of Lignite-Fired Power Plant

1) Mae Moh Power Plant

The quantity of lignite at Mae Moh is sufficient for power generation of about 4,400 MW. At present, there are 8 units of Mae Moh power plant with the total rating of 1,125 MW. The first three units (Units No.1-3) have the rating capacity of 75 MW each (the commissioning of the first unit was in March 1978), and the other four units (Units No.4-7) have the rating capacity of 150 MW each (the commissioning of the fourth unit was in March 1984) and the last unit (Unit No.8), rated 300 MW is recently in operation and is considered as the largest unit size and high technology for lignite-fired power plant.

The power plants under construction are Units No.9-11 with the rating capacity of 300 MW each and proposed for commissioning in early 1991, 1992 and 1993 respectively.

As for the future development of lignite-fired power generation at Mae Moh, there will be another 8 units of power plant for Units No.12-19 with the rating capacity of 300 MW each which probably increases the capacity of the system by another 2,400 MW by 1998. The commissioning date of the Units No.12-19 is expected to be during 1994-1998. However, the power plant site at Mae Moh for Units 12-19 will be transferred to a new site, called Mae Wang, for Mae Wang power plant Units 1-8 at the same sizes. The Mae Wang site is located on the National Highway No.1 in the vicinity of Mae Wang Weir which provides water supply to irrigate areas on both sides of Mae Wang River, upstream of Lampang city.

2) Krabi Power Plant

The present lignite minable reserve at Krabi is sufficient to provide lignite for power generation at Krabi power plant Units 1-3, rating 20 MW each, totalling 60 MW which has been put into operation since 1964-1968.

Based upon the average economic life time of thermal power plant of 25 years, and the conditions of the plant, these units are considered possible for retirement in 1993 (excluding Unit No. 2 which was already retired) and will be replaced by a new 75 MW unit (Krabi Unit 4) which will utilize the remaining lignite from the old Krabi lignite mine for base-load

energy generation. However, the new Krabi unit 4 may be delayed for construction owing to some reasons, i.e. possibility to extend the service life of the plant for some years and the unexpected increment of the rating capacity of new combined cycle power projects after bidding (about 93 MW).

3) Saba Yoi Power Plant

The proven lignite reserve at Saba Yoi mine, Songkhla province in the southern part of Thailand has been initially estimated at approximately 137 million tons. This will be sufficient for power production of at least 900 MW for life time of the power plant.

The power plant project at Saba Yoi has been proposed to increase the generating capacity for the system with the additional capacity of either 2x150 MW and 2x300 MW or 3x300 MW. The commissioning of the units is expected during 1996 and 1999.

d) Share of the Generating Capability

In 1989, the share of the generating capacity depending upon lignite as fuel is 12.5 % of the total system capability while the electric energy generated by lignite is 19.5 %.

In 2001, the share of lignite-fired power plant capacity will be 29.3% while the electric energy generated by lignite will be 36.8%.

Appendix 1 shows percentage distribution of EGAT generating capacity.

Appendix 2 shows the summary of EGAT's fuel requirement and energy generation classified by types of fuel.

Imported Coal

Besides the mentioned domestic energy resources, EGAT has also considered imported coal in its long-term generation development program. The decision to utilize imported coal will have to be carefully reviewed in conjunction with the lignite exploration and development.

As for the first unit of imported coal-fired plant, rated 600 MW, it is expected for commissioning in 1998. Up to 2001, there will be 5 units of 600 MW coal-fired plant included in the PDP with the commissioning of the last unit in 2001.

The share of generating capacity of the coal-fired plant will be 3.9 % in 1998 and 16.3 % in 2001. (Detailed in Appendix 1)

The share of energy generation by the coal-fired plant will be 5 % in 1998 and 19.5 % in 2001. (Detailed in Appendix 2)

Nevertheless, the main energy sources for EGAT power generation will be lignite, natural gas, hydro power, and imported coal. Oil-fired generation will be a small fraction if the gas price is reasonable and sufficient quantity is available to EGAT.

5.2 Power Exchange with Neighbouring Countries

At present, EGAT purchases surplus energy from Nam Ngum Dam in Lao PDR. Power system interconnection with Malaysia enables the exchange of power in the order of 30-80 MW.

The plan for upgrading the interconnection between Thailand and Malaysia is now under joint study by EGAT and LLN with the use of a Consultant to get benefits of interconnected system such as peak power saving and sharing of spinning reserves.

The international hydroelectric projects such as the potential on Mekong and Salween Rivers have not been seriously considered at this time. However, there is a possibility to include those projects in the EGAT's long-term PDP provided that the political problems have been solved.

5.3 The EGAT Power Development Plan (PDP)

The EGAT PDP is the result of an optimization in term of the least-cost sequence of development following an extensive studies of the alternative generation and transmission projects. EGAT has formulated a comprehensive development program up to the year 2001. The studies have included a review and a comparison of power plant alternatives such as

lignite, gas and coal-fired power plant in different locations, including domestic hydroelectric sources. The recommended PDP is usually prepared based on the base case load forecast and the sensitivity studies related to deviation in load growth was also simulated for contingency plan.

Projects in the Sixth NESDP (1987-1991)

Referring to the latest recommended PDP, there are 46 projects that require capital expenditures in the period of 1987-1991 of the Sixth National Economic and Social Development Plan (NESDP) which was approved by the Government on March 14, 1989 of Baht 100 billion. Out of 46 projects, 11 projects were already approved and included in the Fifth Plan and currently under construction or in operation in 1987-1989 and the rest 35 projects,which were approved and included in the Sixth NESDP, consisted of 19 power plant constructions (1,800 MW combined cycle, 1,575 MW lignite-fired, 1,200 MW gas-fired, and 574 MW hydro power plants), 6 mining projects and 10 transmission projects. Table 2 shows list of the 35 projects.

Long-Term Power Development Plan

The long-term profile of EGAT PDP beyond the Sixth Plan period has been prepared based on the policy to utilize the indigenous resources to the greatest extent. The plan includes the additional 5x300 MW lignite-fired power plants Units 15-19 at Mae Moh, as well as new 4 units : 2x150 MW and 2x300 MW lignite-fired at the new Saba Yoi lignite mine in the South.

According to the information on the potential and economic feasible reserves of natural gas and lignite at the present time, up to year 2001, there will be 5 units of 600 MW coal-fired power plant included in the PDP.

The PDP also includes the development of some hydroelectric projects as the peaking units to maintain the best mix of hydro-thermal system.

In association with power plant construction, transmission lines are required to link those power plants to the main grid systems. The transmission system expansion program are also planned to keep abreast of the load growth and to expand the service area, the transmission system development in the future will cover the expansion of 500, 230 and 115 kV transmission lines and substations to all provinces of Thailand. The 500 kV

Extra High Voltage (EHV) transmission system is being developed for long distance bulk power transmission and to superimpose the 230 kV system. The long-term plan for power development in Thailand up to the year 2001 will be concentrated in five areas, namely : Eastern area (Bang Pakong/Ao Phai), Western area (Quae Yai and Quae Noi Rivers); Northern area (Mae Moh), Northeastern area (Nam Phong), and Southern area (Rajjaprabha, Khanom, and Saba Yoi). Transmission voltages of 230 kV and 500 kV have been considered for most of the future projects.

The recent EGAT's PDP up to year 2001 is tabulated in Table 3 and illustrated by a chart in Figure 2.

6. CONCLUSION

Economic Development requires expansion of infrastructure facilities, including the supply of electric power.

So far, EGAT has allocated increased reliance on domestic energy resources for power generation in a short and medium-term planning followed by imported energy phase in a long-term profile.

Within the range of foreseeable prices and costs, both natural gas and lignite score over imported coal although imported coal seems to play a major role in EGAT's PDP for years after 1997 when presently indentified reserves of gas and lignite could be fully committed.

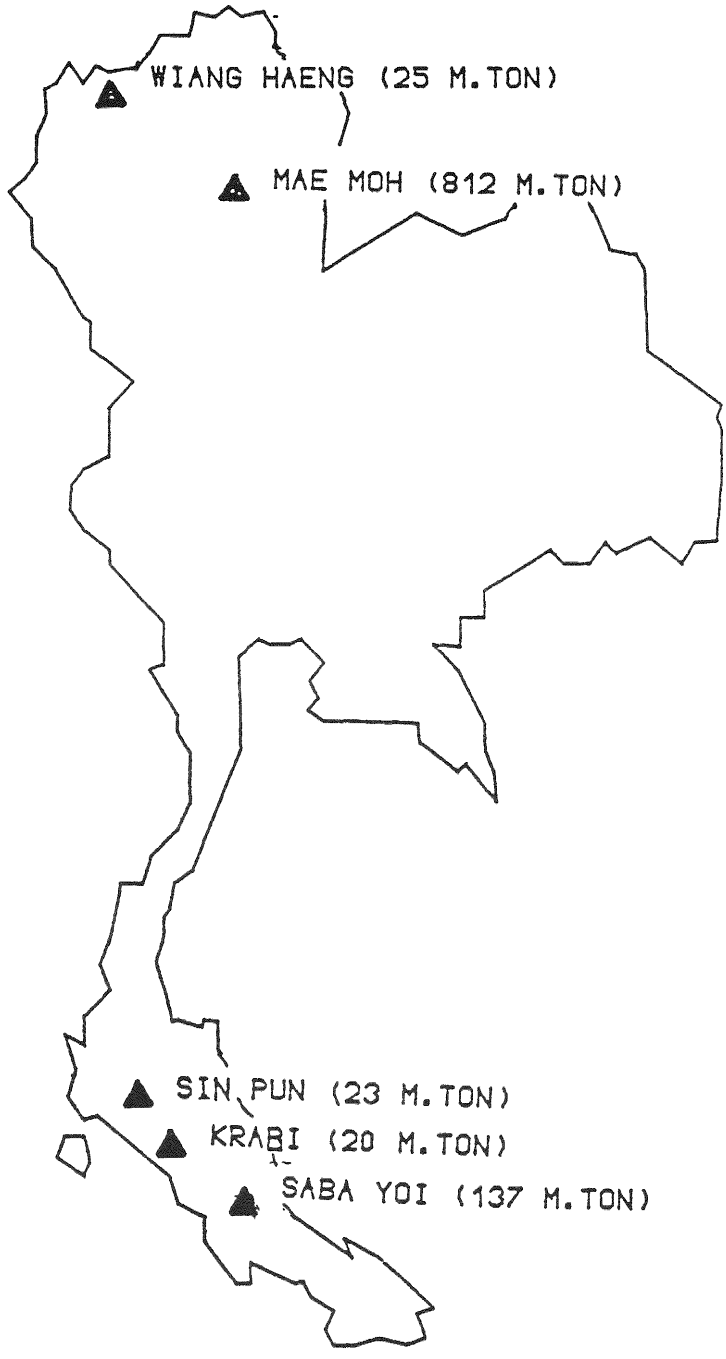
TABLE 1

EGAT'S LIGNITE RESERVES

Location	Reserve (Million Tons)		Status
	Minable	Total	
1. Mae Moh Lampang Province	812.0	1,491.5	In Operation
2. Krabi Krabi Province	20.0	120.7	In Operation
3. Saba Yoi Songkhla Province	137.0	285.0	Feasibility Exploration
4. Sin Pun Krabi Province	23.0	65.2	Feasibility Study
5. Wiang Haeng Chiang Mai Province	25.0	106.8	Detailed Exploration
Total	1,017.0	2,069.2	-

FIGURE 1

LIGNITE MINES FOR EGAT POWER PLANTS



ECONOMIC PROVEN RESERVE 1,017 MILLION TONS

TABLE 2

LIST OF PROJECTS IN THE SIXTH PLAN PERIOD

(1987-1991)

Name of Project	Capacity (MW)	Proposed Commissioning Date	Status (As of July 1989)
Hydroelectric Projects			
1. Srinagarind Unit 5	1x180	April 1991	Under Construction
2. Bhumibol Renovation	(2x70)	March 1992	Procurement
3. Pak Mun Units 1-4	4x34	November 1993	Government Consideration
4. Kaeng Krung Units 1-2	2x40	December 1994	Government Consideration
5. Bhumibol Unit 8	1x178	January 1996	Feasibility Study
Thermal Power Plant Projects			
1. Bang Pakong Combined Cycle Block 3	1x300	Jun 90 - Jun 91	Under Construction
2. Bang Pakong Combined Cycle Block 4	1x300	Aug 90 - Aug 91	Under Construction
3. Rayong Combined Cycle Block 1	1x300	Sep 90 - Sep 91	Under Construction
4. Rayong Combined Cycle Block 2	1x300	Oct 90 - Oct 91	Under Construction
5. Nam Phong Combined Cycle	1x300	Nov 90 - Dec 91	Under Construction
6. Rayong Combined Cycle Block 3	1x300	Jan 91 - Jan 92	Under Construction
7. Mae Moh Lignite Unit 10	1x300	February 1992	Under Construction
8. Bang Pakong Thermal Unit 3	1x600	May 1992	Under Construction
9. Krabi Lignite Unit 4	1x75	November 1992	Postponement
10. Mae Moh Lignite Unit 11	1x300	February 1993	Under Construction
11. Bang Pakong Thermal Unit 4	1x600	May 1993	Procurement
12. Mae Moh Lignite Unit 12	1x300	October 1993	Feasibility Study
13. Mae Moh Lignite Unit 13	1x300	April 1994	Feasibility Study
14. Mae Moh Lignite Unit 14	1x300	October 1994	Feasibility Study
Mining Projects			
1. Mae Moh MIne Expansion (Stage 1) for Mae Moh Units 8, 9	-	October 1991	Under Construction
2. Mae Moh Mine Expansion for Mae Moh Units 10,11	-	February 1993	Feasibility Study
3. Krabi Mine Expansion for Krabi Unit 4	-	October 1993	Postponement
4. Mae Moh Mine Expansion (Stage 2) for Mae Moh Units 8-9	-	October 1993	Procurement
5. Mae Moh Mine Expansion for Mae Moh Unit 12	-	October 1993	Feasibility Study
6. Saba Yoi Mine Development for Saba Yoi Units 1-2	-	October 1995	Feasibility Study
Transmission Projects			
1. 230 kV 2nd Central-Southern Tie Line	-	February 1990	Under Construction
2. Transmission System Expansion No.7	-	April 1990	Under Construction
3. 230 kV Khon Kaen 3-Roi Et	-	January 1991	Under Construction
4. 230 kV Tha Tako-Khon Kaen 3	-	January 1992	Procurement
5. EHV Transmission System for Mae Moh Unit 10	-	February 1992	Procurement
6. Accelerated Transmission Project (ATP)	-	April 1992	Procurement
7. EHV Transmission System for Mae Moh Unit 11	-	February 1993	Procurement Procurement
8. Transmission System Expansion No.8	-	April 1993	Feasibility Study
9. EHV Transmission System for Mae Moh Unit 12	-	October 1993	Feasibility Study
Miscellaneous Transmission System Expansions and Construction Work	-	1987-1991	Under Construction

TABLE 3 LIST OF PROJECTS FOR RECOMMENDED PDP (1989-2001)
(LONG TERM PROFILE)

	Power Plant	Fuel Type	Unit Number	Rating (MW)	Total (MW)	Commissioning Date
Under Construction	Khanom 2nd PPB	Oil/Gas	2	75	75	October 1989
	Mae Moh	Lignite	8	300	300	November 1989
	2nd CSTL	-	-	(270)	(270)	February 1990
	Mae Moh	Lignite	9	300	300	August 1990
	Srinagarind	Hydro	5	180	180	April 1991
	Bang Pakong CC	Gas	3	300	300	May 90 - Jun 91
	Bang Pakong CC	Gas	4	300	300	Jul 90 - Aug 91
	Mae Moh	Lignite	10	300	300	February 1992
	Bang Pakong Thermal	Oil/Gas	3	600	600	May 1992
	Rayong Combined Cycle	Gas	1	300	300	Sep 90 - Sep 91
	Rayong Combined Cycle	Gas	2	300	300	Oct 90 - Oct 91
	Nam Phong Combined Cycle	Gas	1	300	300	Nov 90 - Dec 91
	Rayong Combined Cycle	Gas	3	300	300	Jan 91 - Jan 92
	230 kV Tha Tako-Khon Kaen 3	-	-	(300)	(300)	January 1992
	Mae Moh	Lignite	11	300	300	February 1993
	Bang Pakong Thermal	Oil/Gas	4	600	600	May 1993
	Bhumibol Renovation	Hydro	1-2	(70)	(140)	March 1992
	North Bangkok Renovation	Oil	1-3	(2x75+87.5)	(237.5)	August 1993
	Mae Moh	Lignite	12	300	300	October 1993
	Pak Mun	Hydro	1-4	34	136	November 1993
	Mae Moh	Lignite	13	300	300	April 1994
	Mae Moh	Lignite	14	300	300	October 1994
	Kaeng Krung	Hydro	1-2	40	80	December 1994
	Mae Moh	Lignite	15	300	300	April 1995
	Mae Taeng	Hydro	1-2	18+8	26	June 1995
	Saba Yoi	Lignite	1	150	150	October 1995
	Mae Moh	Lignite	16	300	300	November 1995
	South Bangkok Renovation	Oil/Gas	1-5	(2x200+3x300)	(1,300)	December 1995
	Bhumibol	Hydro	8	178	178	January 1996
	Sirikit	Hydro	4	125	125	February 1996
	Lower Sirikit	Hydro	1	15	15	February 1996
	Saba Yoi	Lignite	2	150	150	April 1996
	Saba Yoi	Lignite	3	300	300	October 1996
	Mae Moh	Lignite	17	300	300	November 1996
	Mae Moh	Lignite	18	300	300	April 1997
	New Thermal	Coal	1	600	600	October 1997
	Saba Yoi	Lignite	4	300	300	November 1997
	Lower Mae Ping	Hydro	1-2	20	40	July 1998
	New Thermal	Coal	2	600	600	October 1998
	Mae Moh	Lignite	19	300	300	November 1998
	Nam Khek (1)	Hydro	1-2	25	50	January 1999
	Nam Khek (2)	Hydro	1-2	35	70	February 1999
	New Thermal	Coal	3	600	600	October 1999
	Nam Chern	Hydro	1-4	100	400	November 1999
	New Thermal	Coal	4	600	600	October 2000
	New Thermal	Coal	5	600	600	January 2001

Existing Capacity by 1988	=	6,894.2	MW
Total Added Capacity (Up to 2001)	=	11,875.0	MW
Plant Retirement	=	-435.0	MW
Total Capacity by Year 2001	=	18,334.2	MW

APPENDIXES

Appendix 1 : Percentage Distribution of EGAT Generating Capacity

Appendix 2 : Summary of EGAT's Fuel Requirement and Energy Generation Classified by Types of Fuel

Appendix 3 : EGAT Recorded Daily Load Curves on Peak Day

PERCENTAGE DISTRIBUTION OF EGAT GENERATING CAPACITY

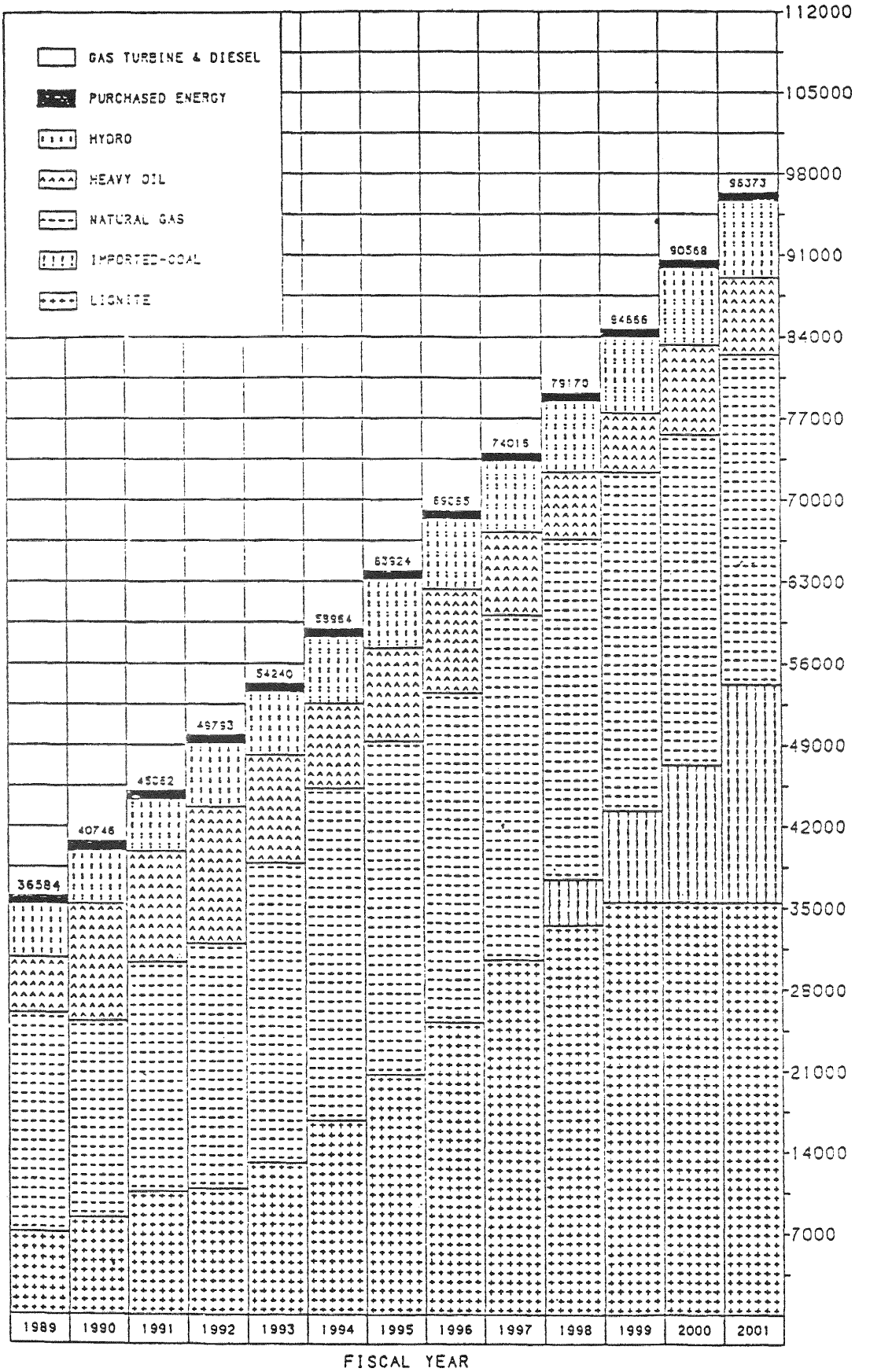
Types of Power Plant	Units	Fiscal Year												
		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Hydroelectric	MW	2,250.1	2,250.1	2,430.1	2,430.1	2,430.1	2,566.1	2,672.1	2,990.1	2,990.1	3,030.1	3,150.1	3,550.1	3,550.1
	%	32.6	28.6	27.2	23.3	21.3	21.2	20.9	21.9	20.6	19.7	19.1	20.4	19.3
Oil-Fired	MW	742.5	817.5	1,717.5	1,717.5	1,717.5	1,717.5	1,717.5	1,717.5	1,717.5	1,687.5	1,687.5	1,687.5	1,487.5
	%	10.8	10.4	19.2	16.4	15.1	14.2	13.4	12.6	11.8	10.9	10.3	9.7	8.1
Gas-Fired	MW	2,000.0	2,000.0	1,100.0	1,700.0	2,300.0	2,300.0	2,300.0	2,300.0	2,300.0	2,300.0	2,300.0	2,300.0	2,300.0
	%	29.0	25.4	12.3	16.3	20.2	19.0	18.0	16.9	15.8	14.9	14.0	13.2	12.5
Lignite-Fired	MW	865.0	1,165.0	1,165.0	1,765.0	2,100.0	2,700.0	3,300.0	3,900.0	4,800.0	5,100.0	5,400.0	5,400.0	5,400.0
	%	12.5	14.8	13.0	16.9	18.4	22.4	25.8	28.6	33.0	33.0	32.8	31.0	29.3
Coal-Fired	MW	–	–	–	–	–	–	–	–	–	600.0	1,200.0	1,800.0	3,000.0
	%	–	–	–	–	–	–	–	–	–	3.9	7.3	10.3	16.3
Combined Cycle	MW	771.6	1,371.6	2,271.6	2,571.6	2,571.6	2,571.6	2,571.6	2,571.6	2,571.6	2,571.6	2,571.6	2,571.6	2,571.6
	%	11.3	17.4	25.4	24.6	22.6	21.3	20.1	18.9	17.8	16.7	15.6	14.8	14.0
Peaking Gas Turbine	MW	265.0	265.0	265.0	265.0	265.0	235.0	235.0	145.0	145.0	145.0	145.0	100.0	100.0
	%	3.8	3.4	2.9	2.5	2.3	1.9	1.8	1.1	1.0	0.9	0.9	0.6	0.5
Total	GWh	6,894.2	7,869.2	8,949.2	10,449.2	11,384.2	12,090.2	12,796.2	13,624.2	14,524.2	15,434.2	16,454.2	17,409.2	18,409.2
	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

SUMMARY OF EGAT'S FUEL REQUIREMENT AND ENERGY GENERATION CLASSIFIED BY TYPES OF FUEL

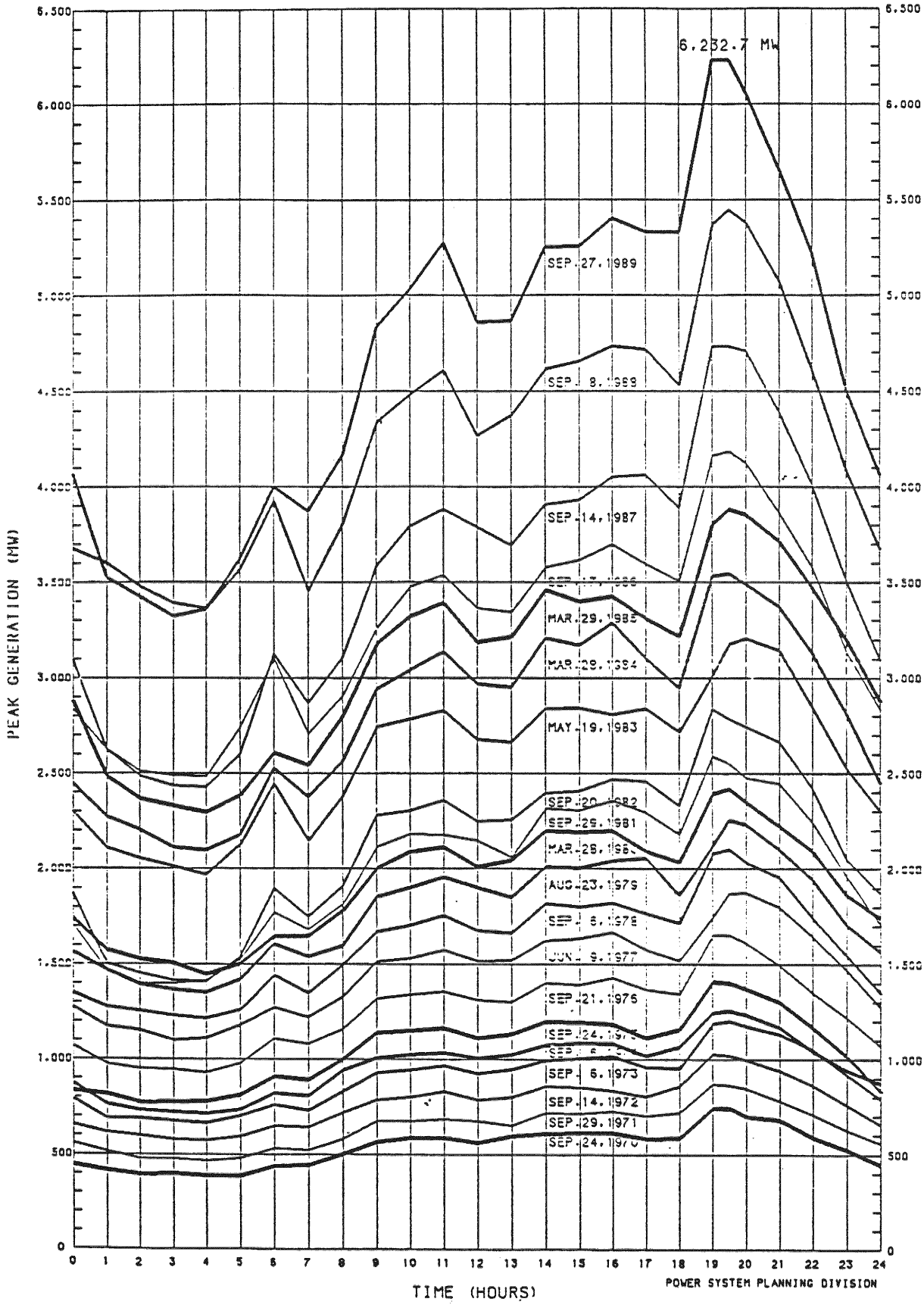
Type of Power Plant	Units	Fiscal Year												
		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1. Hydro	GWh	4,531	4,567	4,502	5,410	5,410	5,727	5,942	6,060	6,082	6,132	6,506	6,599	6,599
	%	12.4	11.2	10.0	10.9	10.0	9.7	9.3	8.8	8.2	7.7	7.7	7.3	6.8
2. Natural Gas	GWh	18,491	15,708	19,120	21,011	26,270	29,862	31,241	32,611	32,610	32,553	32,431	31,923	31,887
	%	50.5	38.6	42.4	42.2	48.4	50.6	48.9	47.2	44.1	41.1	38.3	35.2	33.1
	MMSCFD	466	420	524	527	657	808	848	888	888	888	888	870	870
3. Heavy Oil	GWh	5,741	11,319	10,082	11,796	8,745	5,935	5,361	4,499	4,094	2,350	1,674	4,041	2,970
	%	15.7	27.7	22.4	23.7	16.1	10.1	8.4	6.5	5.5	3.0	2.0	4.5	3.1
	10^6 Litres	1,479	2,926	2,614	2,926	2,199	1,506	1,365	1,151	1,050	609	436	1,025	759
4. Diesel Oil	GWh	119	166	46	-	-	-	-	-	-	-	-	-	-
	%	0.3	0.4	0.1	-	-	-	-	-	-	-	-	-	-
	10^6 Litres 1/	67.0	95.0	28.0	9.1	10.2	11.0	12.8	14.2	15.9	16.7	17.8	18.3	19.1
5. Lignite	GWh	7,118	8,296	10,622	10,866	13,110	16,735	20,675	25,190	30,525	33,480	35,450	35,450	35,450
	%	19.5	20.4	23.6	21.8	24.2	28.4	32.3	36.5	41.2	42.3	41.9	39.1	36.8
	10^6 Tons	6.180	7.386	9.014	10.806	12.870	16.356	20.144	24.531	29.672	32.514	34.408	34.408	34.408
6. Imported Coal	GWh	-	-	-	-	-	-	-	-	-	3,950	7,900	11,850	18,762
	%	-	-	-	-	-	-	-	-	-	5.0	9.3	13.1	19.5
	10^6 Tons	-	-	-	-	-	-	-	-	-	1.517	3.035	4.552	7.207
7. Purchase	GWh	584	690	690	710	705	705	705	705	705	705	705	705	705
	%	1.6	1.7	1.5	1.4	1.3	1.2	1.1	1.0	1.0	0.9	0.8	0.8	0.7
Total	GWh	36,584	40,746	45,062	49,793	54,240	58,964	63,924	69,065	74,016	79,170	84,666	90,568	96,373
	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note : 1/ Including diesel used for plant start up.

FORECAST OF ENERGY GENERATION AND PURCHASES
(FISCAL YEARS 1989-2001)



EGAT RECORDED DAILY LOAD CURVES ON PEAK DAY
(FISCAL YEARS 1970-1989)



MOHD. ARIFFIN BIN ABDUL RAHMAN
Deputy General Manager (Corporate Planning)
National Electricity Board

Tertiary Education: Diploma in Electricial Engineering, Brighton College of Technology, Brighton, United Kingdom

Professional Career:

Sept. 1962 - Aug. 1964	Pupil Engineer, NEB. Attachment for training with: (1) GEC, United Kingdom (2) North Eastern Electricity Board Norwich, United Kingdom (3) Planning and Construction Dept. NEB, Kuala Lumpur
Sept. 1964 - Sept. 1965	Assistant Contract Engineer - North (Based in NEB Ipoh)
Oct. 1965 - Aug. 1967	Assistant Engineer (Mains) NEB District, Butterworth
Sept. 1967 - June 1968	District Engineer NEB District, Butterworth
July 1968 - April 1972	District Manager NEB District, Taiping
May 1972 - Jan. 1973	Purchasing and Contract Engineer NEB Head Office, Kuala Lumpur
Feb. 1973 - Aug. 1980	Senior Purchasing and Contract Officer NEB Head Office, Kuala Lumpur
Sept. 1980 - July 1981	Chief Engineer (Materials Management) NEB Head Office, Kuala Lumpur
Aug. 1981 - Jan. 1984	Chief Engineer (Rural Electrification) NEB Head Office, Kuala Lumpur
Feb. 1984 - present	Deputy General Manager (Corporate Planning) NEB Head Office, Kuala Lumpur

COAL IN MALAYSIA - A POSITION PAPER

Mohd Ariffin Abdul Rahman
Deputy General Manager (Corporate Planning)
National Electricity Board, Malaysia

Presented at the 1989 Asia-Pacific Coal Technology Conference
November 15-16, 1989

NATIONAL ELECTRICITY BOARD OF THE STATES OF MALAYA
NO. 129, JALAN BANGSAR, P.O.BOX 11003,
50732 KUALA LUMPUR, MALAYSIA.

COAL IN MALAYSIA - A POSITION PAPER

Mohd Ariffin Abdul Rahman
Deputy General Manager (Corporate Planning)
National Electricity Board, Malaysia

Presented at the 1989 Asia-Pacific Coal Technology Conference

1. BACKGROUND

Malaysia consists of two land masses, Peninsular Malaysia and the states of Sabah and Sarawak which lies to the north of Borneo Island. With a total land area of 330,434 sq. km., the country supports a total population of approximately 17 million, representing a population density of about 51 persons per sq. km.

The country's GDP in 1988 was approximately US$ 31 billion with a per capita income of US$1,830. Future GDP growth prospects of the country are estimated to be in the order of 6.5%.

Per capita energy consumption is about 4.36 barrels of oil equivalent (0.91 tonne coal equivalent,tce) which is substantially below that of developed countries. The total final energy demand in 1988 was 15.48 million tce of which, petroleum products contributed about 73% and natural gas 11%. Coal contribution was less than 5%. Energy consumption continued to increase at a rate of about 8%.

It was after the second oil crisis in 1978 that coal was considered seriously as a source of energy in Malaysia. This was in line with the worldwide move towards fuel diversification away from oil dependence .

In the early 1980's the Malaysian Government also formulated its four-fuel energy policy based on hydro, gas, coal and oil, aimed at diversifying the country's energy base and ensuring adequate and secure energy supplies by reducing dependence on oil.

Up to 1979, the only coal imported was anthracite used in tin smelting plants (22,000 tonnes in 1979). With the emergence of coal-fired cement plants in 1980, steam coal began to be imported. By 1990, the estimated coal consumption will amount to 2.15 million tonnes. To date, all coal consumed is imported.

2. ENERGY RESOURCES

Malaysia is well endowed in energy resources which includes oil, hydro, natural gas and coal. Figure 1.0 shows the location of the various energy resources in Malaysia. Its oil reserves stand at around 2.9 billion barrels and the country is currently a net exporter, with production rates of the order of 540,000 barrels per day. At this rate of extraction, the reserve is expected to last only 17 years. Oil resources are located exclusively in offshore areas. Malaysian crudes are light and are mainly exported, at the rate of about 300,000 barrels per day. Exploration activities continue, and the prospects for adding to the oil resource base can be considered to be favourable. There is however, general awareness that the current reserves are finite and can be exhausted within a matter of decades.

Natural gas reserves currently at around 53 trillion cubic feet (TCF) is about 3 times larger than the oil reserves. It is again located exclusively offshore, and in the same general areas as oil. There are also quantities of associated gas encountered with oil production. Several large projects have materialised in the recent past to utilise this resource such as the Bintulu LNG plant, the ASEAN Bintulu Fertiliser Plant, the methonol/Hot Briquetted Iron plant and 79MW Combined Cycle plant in Labuan. Future plans include an MTBE plant and poly propylene plants.

In the electric power sector, the 900 MW Paka combined cycle power station was completed in 1985. Other major power stations in Peninsular Malaysia currently burning oil will also be converted to gas/oil firing upon completion of the second phase of the Peninsular Gas Utilisation (PGU) project in 1991/92. This pipeline project will reticulate natural gas from offshore fields to urban and industrial centres in the west and south of the Peninsular and this will also pave the way for natural gas exports to Singapore.

Malaysia also have large hydro resources, the bulk of which is located in Sarawak, where recent studies have confirmed a potential of some 25 GW and energy output of 123 TWh per year from a number of extremely promising large sites. This can be compared with the electricity demand of 17.4TWh in 1987. Within the Peninsula, some 4.7 TWh annually will be available from existing or ongoing hydro projects, and a further 5 TWh can be considered for future development. The assessed hydro resources in Malaysia can in theory supply all of the country's needs now and for some time into the future. However, the distribution of

this resource is not favourable. The bulk of electricity demand is in the Peninsula with only 13% of the hydro potential while 71% is located in Sarawak and 16% in Sabah. Furthermore, most of the promising sites in Peninsular Malaysia have already been developed.

In contrast, coal is less dominant in terms of resources. A resource base of around 800 million tonnes is believed to exist, with qualities varying from lignitic to sub-bituminous. However, measured reserves to date total only approximately 80 million tonnes (57 MTce).

TABLE 1.0 : ENERGY RESERVES	
CRUDE OIL	544 MTce
NATURAL GAS LIQUIDS	67 MTce
RAW NATURAL GAS	1764 MTce
COAL	57 MTce
HYDRO	39 MTce/Year
MTce : Million Tonne Coal Equivalent = 29.3 X 10^6 GJ	

3. COAL RESOURCES

Most of the known coal resources of Malaysia are found in Sarawak and Sabah. The deposits in Peninsular Malaysia is small. Coal exploration and evaluation are being carried out both by the private sector and the Government's Geological Survey Department. Figure 2.0 shows the location of coal deposits. Sarawak has by far the best potential for coal where some of the largest coal deposits in the country are found. Coal is known in the Merit Pila, Silantek, Sadong, Bintulu, Mukah-Balingian, Hose Mountains and Usun Apau areas. In Sabah, coal deposits are located in Silimpopon and Labuan.

The Merit Pila coal basin, the largest known coal area in Malaysia, lies about 100 km south of the port of Bintulu on the upper reaches of the River Rajang. Merit Pila was the first area selected for extensive investigation due to its large potential reserves. Work in the Merit and Tebulan blocks within the Merit Pila area have been completed and a total geological reserve of 157 million tonnes of coal have been delineated. It is planned that the coal resource of the entire Merit Pila Coal Field which has a potential for 370 million tonnes of coal will be assessed progressively. Several economic coal seams of up to 4 meter thick have been identified.

The coal in the Merit Pila area is quite uniform in quality and can be described as sub-bituminous B coal. The ash content is generally low, less than 5%. Sulphur content is very low (less about 0.1%), calorific value is 5500-7100 kcal/kg, and total moisture less than 20%.

Silantek coking and anthracite coal deposit is situated about 130 km from Kuching. Reserves of 7.2 million tonnes as measured and 50 million tonnes as indicated and inferred has been identified.

The Bintulu coal deposit lies within 50 km radius of Bintulu. It has an estimated coal resource of about 20 million tonnes, which mainly comprises of bituminous coal with coking coal properties. The ash content is low, but the sulphur is high (up to 7%, averaging 2%). Most of the deposit have to be mined using underground mining method. The deposit is also situated in areas of structural complexities severely limiting the mineable coal reserves. Buroi Mining holds a mining certificate over part of the Bintulu coal deposit.

The Mukah-Balingian deposits has a total indicated reserves of about 270 million tonnes. Two local companies, Buroi Mining and Sebangun were issued with General Prospecting Licences and are actively carrying out coal exploration over the Mukah Balingian area.

Buroi Mining is conducting grid drilling to block out reserve for possible exploitation, and Sebangun is carrying out general prospecting to the west of Buroi's area. However, the coal from the Mukah-Balingian field is of lower quality, hydrous lignite type, and potential use would be for mine-mouth power generation.

Initial exploration has also been carried out in the Labuan and Silimpopon deposits in Sabah. Labuan deposit is located on the island of Labuan and covers an area of about 6 square km. There are about 9 million tonnes inferred coal reserves and of the sub-bituminous type with ash content of about 4.5% (ar) and heat value 6200 kcal/kg (as received).

The Silimpopon coal field, which covers an area of about 30 square km, is located in western Sabah, approximately 40 km west of Tawau. The coal is of high ranking sub-bituminous, with coking characteristics with heating value of 7450 kcal/kg (as received). Indications are these deposits have difficult mining conditions making the deposits incompetitive for exploitation.

BHP (Australia) holds a prospecting permit over this area covering 7,000 square km and has commenced exploration since 1986. At least 4 good quality coal seams of more than 1.5 m thick are known. The reserve potential is in the order of several hundred million tonnes. A 3 m thick seam had also been identified. Although the coal quality is variable, it is generally of good quality; very low ash (<3%), low moisture (<4%), and high heating values (8,300 kcal/kg) with some coking properties. It is classified as high volatile, bituminous A coal.

Coal development in Sarawak and Sabah is still in the stage of resource identification and quantifications. Specific potential areas would then have to be identified for detail exploration to determine the feasibility of exploitation. Detail exploration works are normally done by the private sector with mining licence.

TABLE 2.0 : POTENTIAL COAL RESOURCES IN MALAYSIA

LOCATION	MEASURED	INDICATED	INFERRED	COAL TYPES
SARAWAK 1.Silantek	7.2	-	50.0	Coking coal,semi anthracite,anthracite
2.Merit Pila	68.1	63.3	118.6	Hard brown coal, sub-bituminous B
3.Bintulu	2.0	-	18.0	Bituminous coal (part coking)
4.Mukah Balingian	-	30.0	240.0	Hydrous Lignite
SABAH 1.Silimpopon	4.8	1.5	6.9	Sub-bituminous, Coking
2.Labuan	-	-	8.9	Sub-bituminous
PENINSULA 1.Batu Arang	-	-	17.0	Lignite, sub-bituminous
TOTAL	82.1	81.8	594.4	

Source: Guide for Mineral Exploration Strategy, Geological Survey Department, Malaysia.

4. COAL EXPLOITATION

Historically Malaysia has been a small scale coal producer and mining was carried out in Peninsular Malaysia, Sarawak and Sabah in the late 1800's and early 1900's. Coal mining activities can be traced back to 1851 when the first mine was in operation in Labuan. Coal mining became important with the opening up of the Batu Arang coal mine in 1915 and maximum production of 660,000 tonnes per year was reached in 1937. Between 1951 and 1960 when the last coal mine was closed, a total of 18.2 million tonnes of coal were produced from two coal mines in Peninsular Malaysia, two mines in Sabah and one mine in Sarawak.

TABLE 3.0 : Historical Coal Production			
	Year in Operation	Name of Mine	Production (10^6 tonnes)
Peninsular Malaysia	1915 - 1960 1925 - 1928	Batu Arang Engor	13.35 0.03
Sarawak	1874 - 1931	Sadong	0.88
Sabah	1851 - 1911 1909 - 1929	Labuan Silimpopon	0.59 1.35
TOTAL			18.20

Most of the coal produced were used for the railway and steamships.

Coal experienced a long period of decline when it was displaced as a fuel by oil in the 1960's. Renewed interest on coal was shown from 1974 as a result of the oil crisis. After a long period of exploration and development, 1988 witnessed the re-emergence of coal mining in Malaysia with the coming-on-stream of the modest scale open cast coal mine at Beredai in Merit Pila area by the Global Minerals, a local and American joint venture company. Exploitation is initially by the conventional contour (strip) mining with the shovel and truck option. Initial mining is targetted at the 4 m thick seam where the coal overburden ratio is at the minimal at 1:3.

Actual mining commenced in 1988 and the first shipment was made in August of that year. By the end of the year, 3 shipments totalling 20,450 tonnes were exported to Taiwan and Japan. Production for the initial years is projected at about 350,000 tonnes. The mine site is located about 44 km from the coal preparation and loading site. Thirty-five tonne haulage trucks are used to transport raw coal to the processing site where the coal is crushed, screened, and washed before loading onto 1000-2000 tonnes barges to be carried 220 km down the Rejang River. Final loading is at Tanjung Mani where 10,000 tonnes vessels are used to transport the coal to market destination in Taiwan and Japan. Global Mineral in addition to operating the Beredai mine also holds a General Prospecting License covering 5,000 square kilometer of the Merit Pila Coal Field and surrounding areas.

Lucky Hill Mining, a local-Korean joint venture company started mining operation in the Silantek area in late 1988. The underground mine has an initial production capacity of 60,000 tonne per annum increasing to 120,000 tonnes. The seam being mined using long wall mining method is of 1.2m thick. The coal is not suitable for use in power station. The producer plans to export the coal to Taiwan, Korea and industrial user in Penisular Malaysia. BHP (Australia) also holds a General Prospecting Licence over part of the Silantek area covering 2,613 sq. km.

In the short and medium terms, it is envisaged that coal production will be modest, probably below one million tonnes per annum. The major obstacles for large scale development of the coal are the long transportation distance and complicated handling, which also increase the FOB cost price of the Sarawak coal.

5. COAL UTILISATION IN THE POWER SECTOR

Malaysia has three public owned electric utilities coordinated through the Ministry of Energy, Telecoms and Posts. The National Electricity Board (NEB), which is by far the largest, operates in Peninsular Malaysia, while Sabah Electricity Board (SEB) and Sarawak Electricity Supply Corporation (SESCO) operates in Sabah and Sarawak respectively.

The current installed capacity of NEB is 4940 MW with peak demand at around 3000 MW and annual generation at 18TWh. The installed capacity for SEB and SESCO are 331 MW and 336 MW respectively.

The percentage composition of NEB's generation capacity is approximately 39% oil-fired thermal, 6% Gas Turbine,25%hydro, 12% coal-fired thermal, and 18% gas combined cycle. The expected generation fuel mix for 1989/90 is 40% oil, 21% Gas, 21% Hydro, and 18% coal.

The decision was made in 1981 to construct NEB's first coal-fired power plant of 2x300 MW units using imported coal. The coal units have been designed to burn coal of certain quality range (as shown in Figure 3.0). This range was determined after an extensive study in 1982 on the possible sources of coal that were known at that time. The boiler design was chosen based on this study. Unfortunately, very little quality information data was available on domestic coal.

The two units are now operating to system demand and are expected to consume about 1.4 million tonnes of coal per annum. The contribution of these units to LLN's generation mix is shown in Figure 4.0.

These units have been designed with triple-fuel firing capability of coal, gas and oil. Whilst coal has been designated as the main fuel in order to realise fuel diversification strategy, fuel switching to cheaper fuel sources can be done on short notice.

Apart from these two coal units, LLN currently has no plans in the immediate future to build more coal plants. LLN's immediate power generation expansion plans are likely to be dominated by gas fired plants.

The electricity demand to the year 2000 is forecasted to grow at a rate of 8% per annum. At this rate, the system peak demand in year 2000 is forecasted to increase to 7500 MW from the current peak of 3000 MW. Total generation is forecasted to increase to 45 TWh. To cater for the growth in demand as well as replacement of plants being retired, about

5000 MW of new capacity would be needed. About 1000 MW of this capacity is likely to be met through development of future hydro sites in Peninsular Malaysia. The bulk of the thermal capacity is likely to be based on gas generation.

However in the longer term, future gas-fired generation would depend on the gas availability to the power sector. Future development of value added gas utilisation projects, export potential of LNG and availability from the fields would be limiting factors in gas-fired generation development. LLN would also need to look into fuel diversification in its generation mix for reasons of security and cost competitiveness of fuel supply. Coal plants are the most viable alternative to gas for thermal generation.

Further development of coal generation in Peninsular Malaysia could be boosted with availability of Sarawak coal at competitive price.

SEB and SESCO have yet to announce any coal generation plan.

6. CEMENT INDUSTRY

The current total installed cement manufacturing capacity is 6,700 million tonne of cement per annum. There are five companies with manufacturing facilities in six locations, all of which is located in Peninsular Malaysia. This capacity has doubled since 1981. Table 4.0 shows current installed capacity of cement manufacturing plants in Malaysia.

TABLE 4.0: CEMENT MANUFACTURERS IN MALAYSIA

COMPANY	Clinker Capacity '000 Tonnes	Coal Consumption at full capacity '000 Tonnes
APMC - Rawang	1500	100
APMC - Khantan	600	100
CIMA	1000	150
Perak Hanjong	1200	160
Kedah (Langkawi)	1200	160
Tasek	1200	150
TOTAL	6700	820

The cement manufacturers commenced converting their oil based plants to coal in 1979. By 1988, all cement plants were using coal either totally or as a mix with oil.

Gas is an alternative fuel for cement manufacture. Only one cement plant however, located in Rawang would be within the range of the natural gas pipeline supply when it becomes available in 1991/92. Switching to gas would not involve high capital expenditure compared to coal conversions. Gas availability and pricing to these industries would be the determining factor. Gas is not likely to be made available to other existing cement plants until after the mid-1990's. Gas utilisation in future new plants would depend on the location of these plants which is also dictated by availability of raw materials such as limestone.

Cement manufacturers have been purchasing coal mainly on spot or short term contract basis through traders by issue of tenders. The preferred coal quality specifications is:

Total Moisture (ar)	: 12 Max
Ash (adb)	: 15 Max
Sulphur (adb)	: 1.0 Max
Volatile Matter (adb)	: 30-38 (25 Min)
HGI	: More than 50
Size (adb)	: 0-50 mm
C.V. (adb)	: 6700kcal/kg (Min)

The coal are sourced from Indonesia, China and Australia. Supplies from Indonesia are delivered in barges or vessels of up to 15,000 DWT. Supplies from China and Australia are delivered in handy sized vessels of about 35,000 DWT.

Kedah Cement plant is located on the island of Langkawi and has a berthing facility for 10,000 DWT vessels. Coal has also been delivered in 30,000 DWT vessels with transshipment in barges. Coal from Indonesia (Ombilin) arrives in 10,000 DWT vessels.

Cima plant is located in the State of Perlis, in the North West of Peninsular Malaysia. Coal is normally received in vessels up to 35,000 DWT discharged in mid-stream and railed to the plant for a distance of about 150 km.Recently as a trial, a 10,000 DWT vessel was discharged alongside the Prai Bulk Cargo Terminal.

APMC Khantan, Perak Hanjong and Tasek are located in the Ipoh area. The usual method of coal delivery is by mid-ocean discharge from 10,000 - 35,000 DWT vessels on to barges to Lumut jetty. The coal is then trucked to Ipoh area for a distance of 85 - 120km km.

APMC Rawang is located in the town of Rawang some 40 km north of Kuala Lumpur and about 70 km from NEB's coal-fired power station. The Rawang works has received coal by following means:

- Trucked from Lumut.
- At one time,railed from Telok Intan where barges of up to 8000 DWT can berth. Coal deliveries through Telok.Intan are usually shared between Rawang & Kantang works where both are served with rail line from Telok.Intan. For economic reasons, APMC has since ceased from using Telok Intan.
- Rawang works has also used Port Klang Bulk terminal using vessels of 35,000. Unloading facilities are however inadequate to handle coal deliveries and coal has to be shuttled from vessel to temporary storage yard using trucks. Nevertheless it has been reported that discharge rate achieved was satisfactory.

7. COAL USE IN OTHER INDUSTRIES

There is no known existing use of steam coal by industrial users apart from the cement manufacturers. In 1983/84, Malaysia Mining Corporation (MMC) is reported to have carried out a study on industrial boilers installed in the country with the aim of analysing the potential of converting existing oil fired boilers to coal. Out of more than 2000 boilers installed a standardised coal conversion method could be developed for 600 boilers of over 20,000 lb/hr capacity. Most of these boilers are located in the Port Klang or Prai areas.

Coal utilisation could come about as a result of conversion of existing oil fired boilers, installation of new coal fired boilers with existing oil fired boilers acting as standby sets, or installations in new industrial projects. However, a number of factors would influence the choice of coal as fuel source to these industries; the industries would need to be convinced of coal's long term availability at their site at competitive rates to oil or gas. It would be far easier for these boilers to be converted to gas firing when piped natural gas becomes available from 1991/92. Coal use in locations where gas will be available would depend on gas pricing and distribution to these industries. Gas however is not likely to be available to areas north of Kuala Lumpur until after mid-1990s. Coal fired boilers generally cost significantly more than oil fired boilers.

8. COAL HANDLING FACILITIES

The berth at NEB's coal-fired power station is capable of handling vessels of up to 80,000 DWT. Coal is unloaded by two 1400 tonne per hour grab unloaders and transported by single conveyor to the stockpiles. Three stacker-reclaimers service the storage yard which has design capacity to accommodate 750,000 tonne of coal. The coal handling facility is shown in Figure 5.0.

The coal handling facilities have been designed for coal throughput of 2.5 mtpa. This is to cater for NEB's requirement of about 1.5 mtpa and possible other users requirement of another 1.0 mtpa.

A number of parties both locally and from overseas have shown keen interest to privatise the operation and management of the coal terminal. There is a possibility that the coal terminal could be privatised to enable the installed facilities be optimally used. With a privately run coal terminal, prospects of developing coal utilisation in smaller industries would be enhanced. Truck loadout facility can be installed at minimal cost. The nearest rail line however is some 20 km away. The jetty and berth has been designed to also accommodate barge loading facilities if installation of such facilities can be justified. With barge loader, the coal terminal could possibly service other neighbouring countries and act as one of a network of regional coal centres.

The equipment has also been designed to enable coal blending to be carried out.

9. CONCLUSIONS

Coal utilisation projects which were initiated in the late 1970's and early 1980's have all now been completed. This has resulted in coal demand increasing from 81,000 tonnes in 1980 to 2.15 million tonnes in 1990. This growth in consumption is shown in Table 5.0.

TABLE 5.0 : COAL IMPORT IN MALAYSIA ('000 TONNE)

YEAR	1980	1985	1986	1987	1988	1989	1990	1995
POWER	-	-	-	-	416*	860	300	1400
CEMENT	50	478	358	440	500	800	800	1200
OTHERS	31	30	30	30	30	50	50	300
TOTAL	81	508	388	470	946	1710	2150	2900

Note: (*) Includes stockpile building

Currently, no decision has been made on other coal utilisation projects.
Future development would depend on such factors as:

- availability of gas as substitute fuel to various industrial locations at competitive price.
- successful experience of coal utilisation at the coal-fired power station.
- coal price competiveness against oil and gas
- development of domestic coal resources
- development of effective distribution centres.

ENERGY RESOURCES AND GENERATION PLANTS

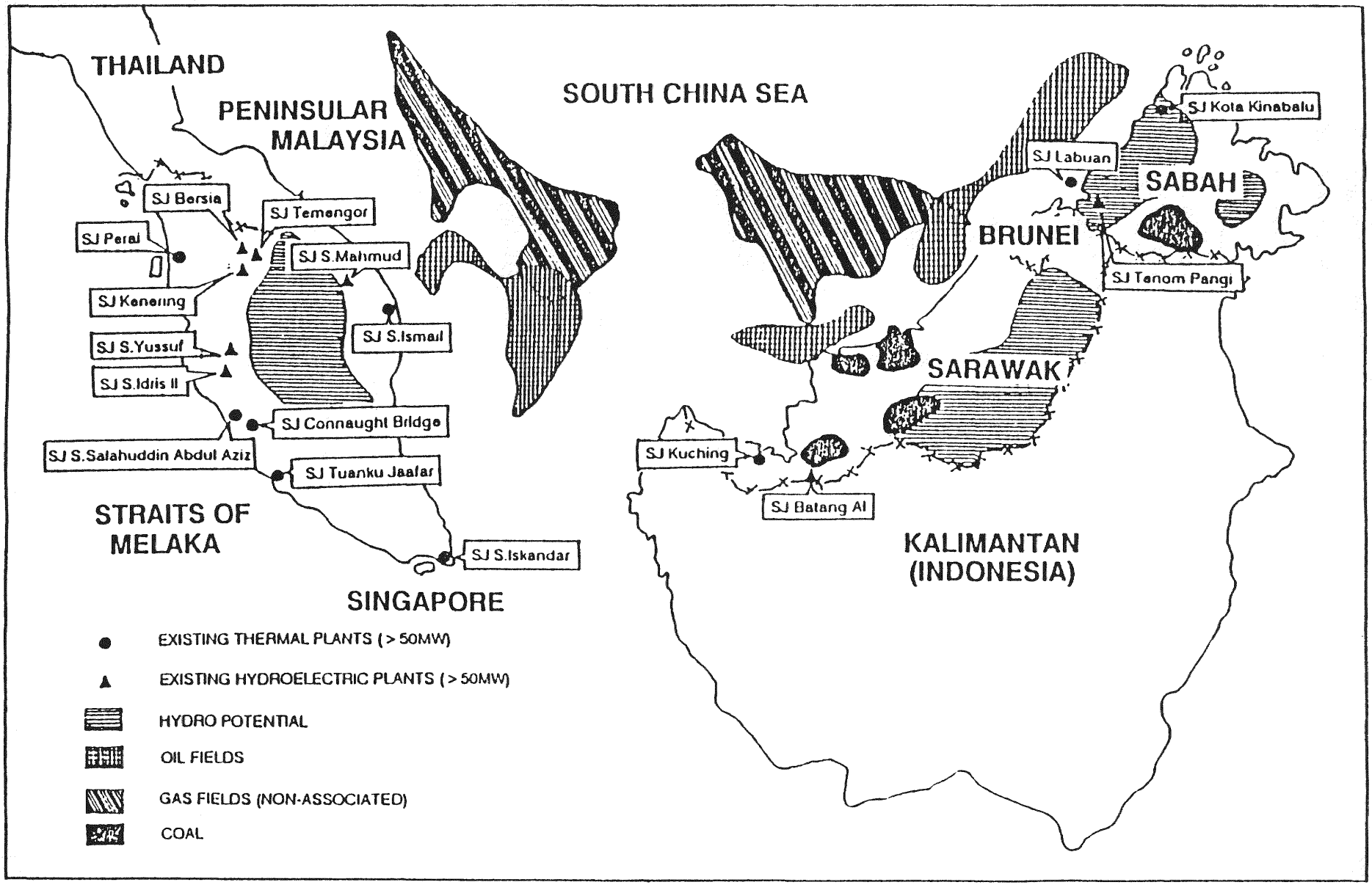


FIG. 1

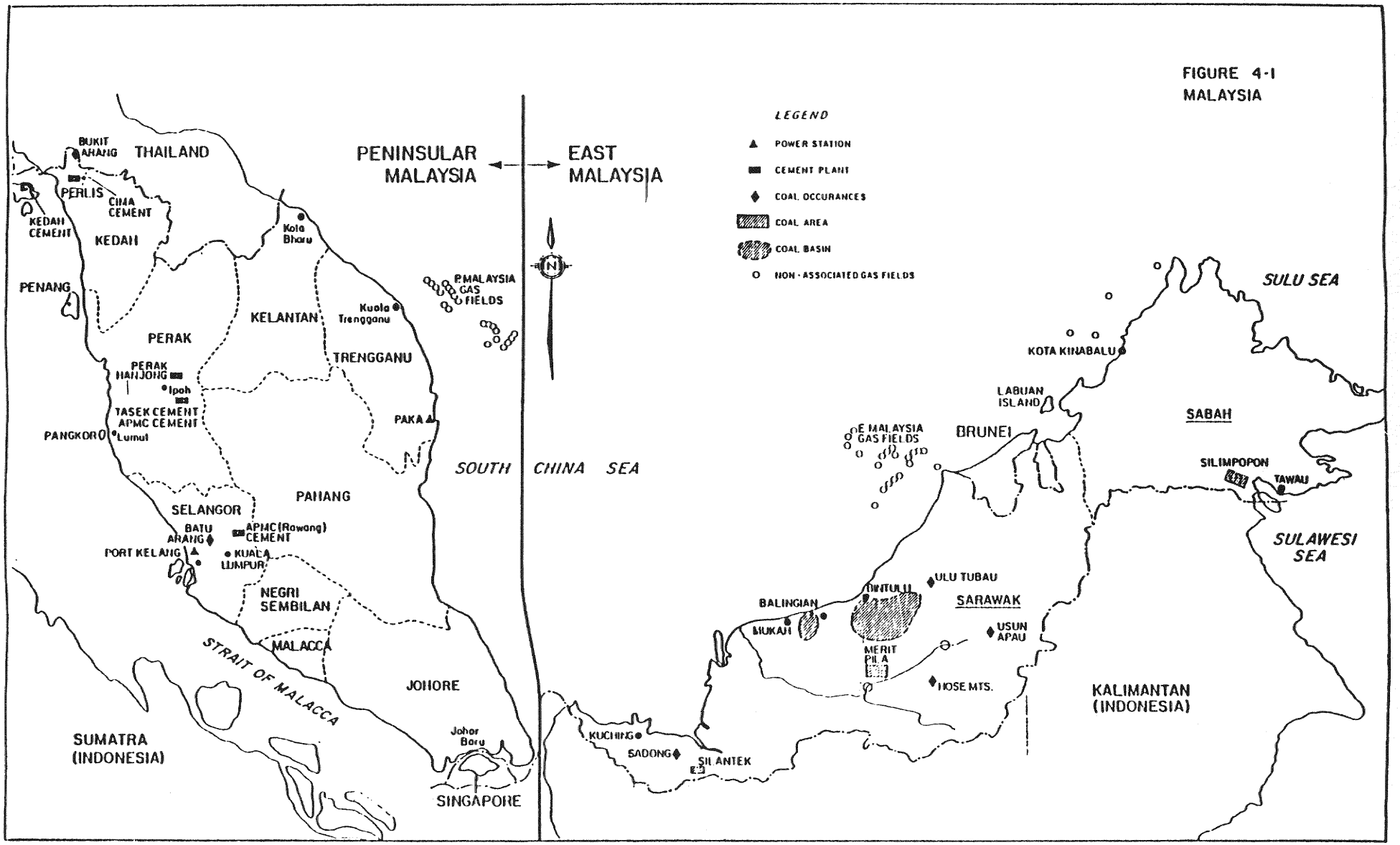

FIGURE 4-1
MALAYSIA
LEGEND
POWER STATION
CEMENT PLANT
COAL OCCURANCES
COAL AREA
COAL BASIN
NON-ASSOCIATED GAS FIELDS
PENINSULAR MALAYSIA
EAST MALAYSIA
THAILAND
BUKIT AHANG
PERLIS
CIMA CEMENT
KEDAH CEMENT
KEDAH
Kota Bharu
PENANG
P.MALAYSIA GAS FIELDS
KELANTAN
Kuala Trengganu
PERAK
TRENGGANU
PERAK HANJONG
Ipoh
TASEK CEMENT
APMC CEMENT
PAKA
PANGKOR
Lumut
SOUTH CHINA SEA
PAHANG
SELANGOR
BATU ARANG
APMC(Rawang) CEMENT
PORT KELANG
KUALA LUMPUR
NEGRI SEMBILAN
MALACCA
STRAIT OF MALACCA
JOHORE
Johor Baru
SUMATRA (INDONESIA)
SINGAPORE
SULU SEA
KOTA KINABALU
LABUAN ISLAND
SABAH
E MALAYSIA GAS FIELDS
BRUNEI
SILIMPOPON
TAWAU
SULAWESI SEA
ULU TUBAU
BINTULU
SARAWAK
BALINGIAN
MUKAH
USUN APAU
MERIT PILA
HOSE MTS.
KALIMANTAN (INDONESIA)
KUCHING
SADONG
SILANTEK

FIG 2

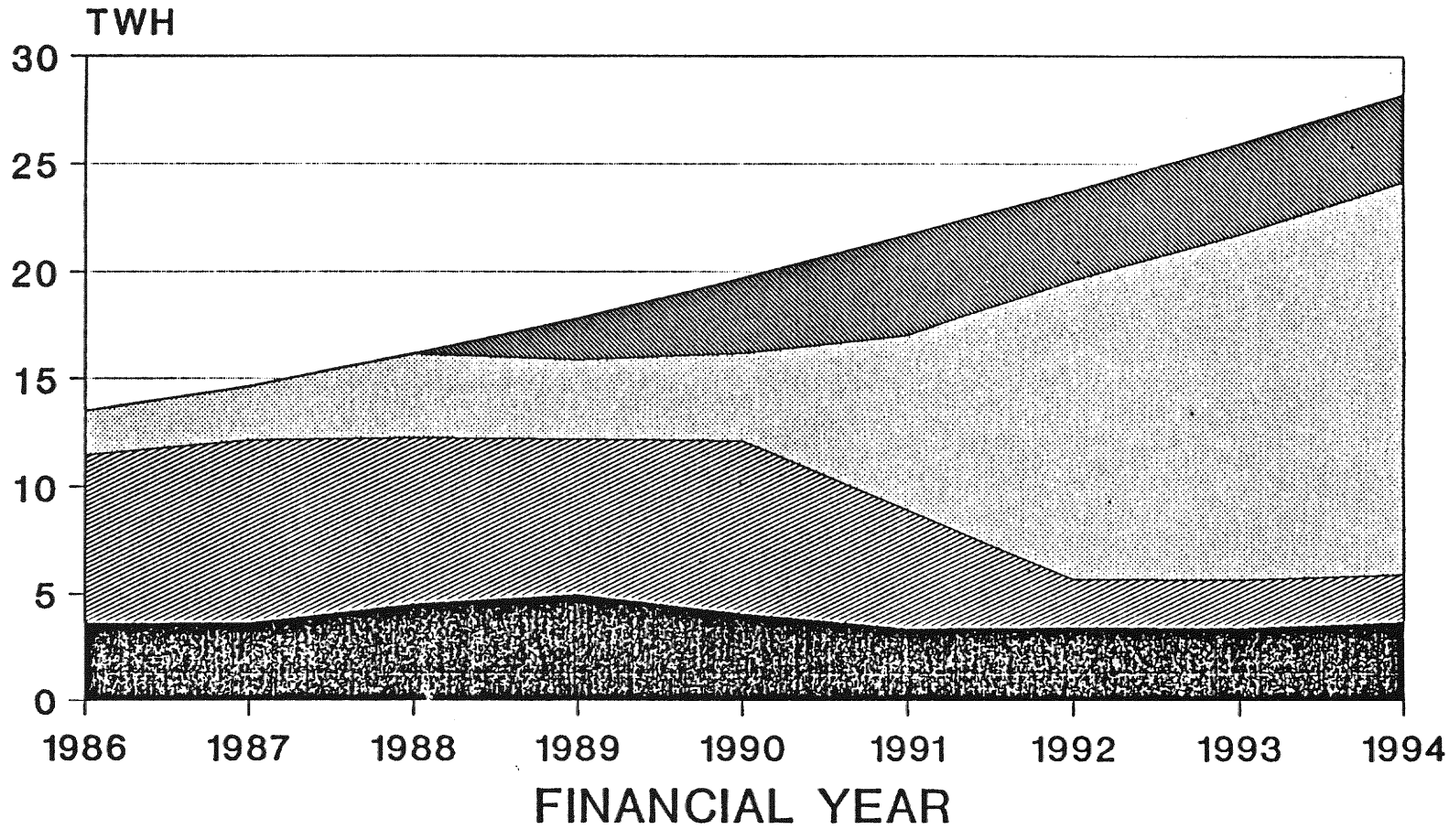
FIG. 3

INDICATIVE COAL SPECIFICATION RANGE
FOR SULTAN SALAHUDDIN ABDUL AZIZ POWER STATION PHASE II

GENERAL	Gross Calorific Value kcal/kg	a.d.b.	6,350 min
	(Specific Energy) KJ/kg		26,586
	Total Sulphur	% a.d.b.	0.3 - 1.0
	Hardgrove Index		45.0 - 78.0
	Size - maximum	mm	32.0 - 64.0
	- % passing 2 m/m	(max)	30.0
	Fuel Ratio (FC:VM)		1.3 - 2.4
ASH FUSION TEMPERATURE (REDUCING)	Initial deformation	°C	>1200
	Hemisphere	°C	>1320
	Flow	°C	>1350
PROXIMATE ANALYSIS	Total Moisture (as received)	%	8.0 - 16.0
	Inherent Moisture	%	1.5 - 7.5
	Ash	% a.d.b.	8.0 - 18.0
	Volatile Matter	% a.d.b.	>24.0
	Fixed Carbon	% a.d.b.	45.0 - 58.0
ULTIMATE ANALYSIS (D.A.F)	Carbon	%	77.9 - 86.5
	Hydrogen	%	4.4 - 6.0
	Nitrogen	%	0.8 - 2.1
	Oxygen	%	7.5 - 15.0
	Sulphur	%	0.3 - 0.83
	Phosphorus	%	0.008 - 0.4
	Chlorine	%	0.03 - 0.13
ASH ANALYSIS (D.M.M.F.)	SiO_2	%	47.5 - 76.9
	Al_2O_3	%	17.0 - 37.5
	Fe_2O_3	%	0.52 - 10.34
	CaO	%	0.12 - 5.57
	MgO	%	0.15 - 2.23
	TiO_2	%	0.50 - 2.18
	Na_2O	%	0.14 - 2.43
	K_2O	%	0.24 - 1.59
	Mn_3O_4	%	0.01 - 0.10
	P_2O_5	%	0.15 - 1.30
	SO_3	%	0.02 - 4.17

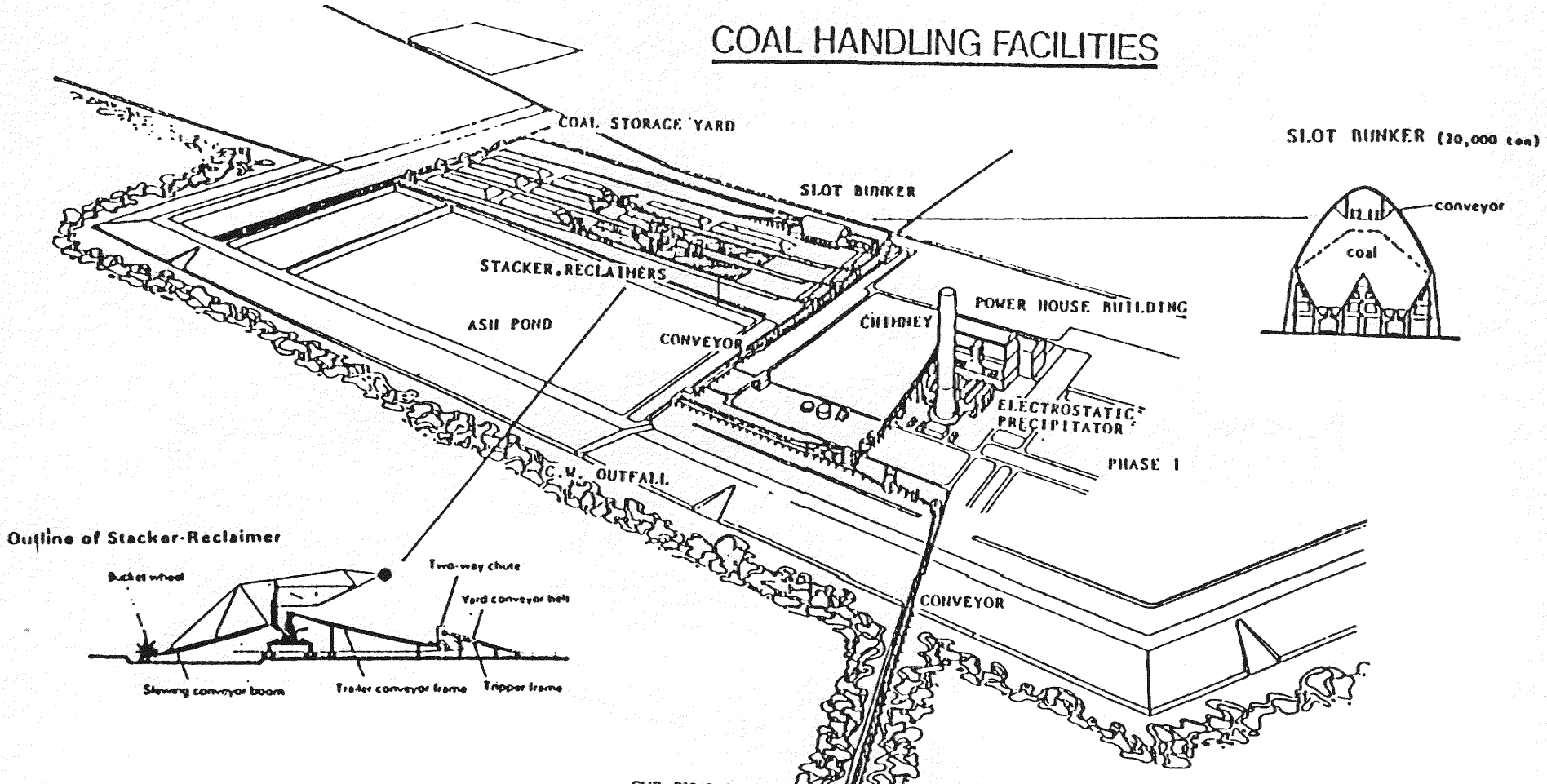
NOTE: 1 kcal = 4.1868 KJ
BTU/lb = kcal/kg x 1.8

NEB GENERATION MIX(TWH)



FIG,4

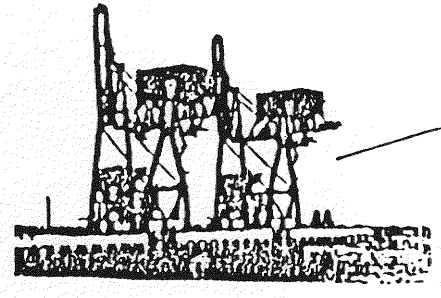
COAL HANDLING FACILITIES



SLOT BUNKER (20,000 ton)

Outline of Stacker-Reclaimer

Gantry Type Unloader



MAJOR EQUIPMENT AND FACILITIES		
EQUIPMENT AND FACILITIES	CAPACITY	NO. OF SET
SHIP UNLOADERS	1400 t/h	2
STACKER/RECLAIMERS	3400/1800 t/h	3
BELT CONVEYORS		10400 m (32 LINES)
RECEIVING LINES	3400 t/h × 250 m/min	5500 m (8 LINES)
DISCHARGING LINES		
- FROM STOCKYARD TO THE SLOT BUNKER	1600 t/h × 220 m/min	2400 m (6 LINES)
- FROM SLOT BUNKER	800 t/h × 220 m/min	400 m (3 LINES)
- FROM SLOT BUNKER TO THE STATION BUNKER	400 t/h × 220 m/min	2100 m (15 LINES)

FIG. 5

THE UNITED STATES AND ASIA: PACIFIC PARTNERS IN COAL AND COAL TECHNOLOGY

Thad Grundy, Jr.
Deputy Assistant Secretary for
International Affairs
Department of Energy

Asia-Pacific Coal Technology Conference
East-West Center
Honolulu, Hawaii

November 15, 1989

IT IS A GREAT HONOR TO ADDRESS THIS DISTINGUISHED GROUP AND A PLEASURE TO BE PARTICIPATING IN THIS VERY IMPORTANT CONFERENCE ON ASIA-PACIFIC COAL TECHNOLOGY. I WOULD LIKE TO THANK DENISE SWINK FROM DOE'S OFFICE OF FOSSIL ENERGY AND DR. FEREIDUN FESHARAKI FROM THE EAST-WEST CENTER FOR THE OUTSTANDING JOB THEY HAVE DONE IN PUTTING THIS CONFERENCE TOGETHER. I'M SURE YOU ALL AGREE THAT WE HAVE AN EXCITING AGENDA AND JUDGING FROM WHAT WE HAVE JUST HEARD, SOME IMPORTANT THINGS TO TALK ABOUT IN THE COAL TECHNOLOGY ARENA.

HAVING ONLY BEEN SWORN IN LAST WEEK AS THE NEW DEPUTY ASSISTANT SECRETARY FOR INTERNATIONAL AFFAIRS AT THE DEPARTMENT OF ENERGY, I CAN ASSURE YOU THAT DURING THIS CONFERENCE I PLAN TO TAKE THE OPPORTUNITY TO FORM NEW FRIENDSHIPS AND ASSOCIATIONS SO THAT WE ALL MIGHT WORK MORE CLOSELY TOGETHER PREPARING FOR THE ENERGY NEEDS OF THE NEXT DECADE, IF NOT THE NEXT CENTURY. I THINK YOU WILL AGREE WITH ME THAT ONE OF THE PRINCIPAL VALUES OF THIS CONFERENCE WHICH HAS BROUGHT SO MANY EXPERTS TOGETHER IN ONE PLACE IS THE WAY IT IS STRUCTURED -- WITH A PLENARY SESSION SUCH AS THIS TO BE FOLLOWED UP BY GATHERINGS OF SMALLER GROUPS WHERE THERE CAN BE INCREASED INTERACTION AMONG THE PARTICIPANTS. IT IS OUT OF THESE WORKING GROUPS THAT I HOPE WILL BE GENERATED SOME NEW INITIATIVES AND PROPOSALS SO THAT WHEN WE HAVE ALL RETURNED BACK HOME WE CAN LOOK BACK AND SAY THAT WE ACCOMPLISHED SOMETHING HERE IN HAWAII AND THAT WE DEVELOPED SOME CONCRETE ACTIVITIES TO FOLLOW UP ON.

WHAT I PROPOSE TO DO HERE TODAY AS THE TRANSITION SPEAKER BETWEEN OUR REPRESENTATIVES FROM ASIA AND OUR PRESENTERS FROM THE UNITED STATES

IS TO STRESS THE TREMENDOUS POTENTIAL THIS CONFERENCE HAS IN HELPING US ALL ADDRESS THE MANY COMMON CHALLENGES WE FACE IN OUR RESPECTIVE ENERGY SECTORS WITH A PARTICULAR EMPHASIS UPON THE FUTURE ROLE OF COAL AND COAL TECHNOLOGY IN SATISFYING THE GROWING DEMAND FOR ELECTRICITY WHICH ALL OF US ARE FACING.

NONE OF US HERE CAN AFFORD TO PURSUE ENERGY POLICIES IN ISOLATION FROM THE GLOBAL COMMUNITY AND I PROPOSE THAT WE WORK TOGETHER AS PACIFIC PARTNERS. A VERY RELEVANT EXAMPLE OF THIS IS THE CHALLENGE WHICH THE PROSPECTS OF GLOBAL WARMING AND CLIMATE CHANGE POSE TO THE WORLD AT LARGE AND, OF COURSE, TO THE ASIA-PACIFIC REGION IN WHICH WE LIVE. NOT ONLY MUST MANY OF THE SOLUTIONS BE INTERNATIONAL ONES REFLECTING THE INTERDEPENDENCE OF NATIONS IN THIS MODERN TECHNOLOGICAL ERA, BUT THESE SOLUTIONS MUST BE SENSITIVE TO THE DIVERSITY OF OUR ECONOMIC AND ENERGY PROFILES.

THE MESSAGE I WISH TO CONVEY TO YOU TODAY IS SIMPLE AND STRAIGHT FORWARD: COAL IS HERE TO STAY - IT IS A MAJOR RESOURCE OF THE ASIA-PACIFIC REGION AND WILL DEFINITELY PLAY A SIGNIFICANT ROLE IN OUR ENERGY FUTURES - ESPECIALLY IN THE POWER SECTOR. MORE COAL IS PRODUCED IN THE ASIA-PACIFIC REGION THAN IN ANY OTHER REGION OF THE WORLD AND GIVEN THE UNCERTAINTY OF NUCLEAR POWER, I BELIEVE COAL WILL LIKELY BE THE FOSSIL FUEL OF CHOICE IN THE GENERATION OF ELECTRICITY WELL INTO THE NEXT CENTURY.

THE U.S. ENERGY INFORMATION ADMINISTRATION (EIA) ESTIMATES THAT THE U.S. ALONE ACCOUNTS FOR 29% OF THE WORLD'S RECOVERABLE COAL RESOURCE BASE, WITH 291 BILLION SHORT TONS OUT OF A GLOBAL TOTAL OF APPROXIMATELY ONE TRILLION TONS. THIS IS EQUIVALENT TO SEVERAL HUNDRED YEARS OF SUPPLY AT CURRENT CONSUMPTION LEVELS. IN TERMS OF RECOVERABLE COAL RESERVES, THE U.S. IS FOLLOWED BY THE SOVIET UNION, CHINA, AND AUSTRALIA IN THAT ORDER SO THAT NOT ONLY DO ASIA-PACIFIC NATIONS HOLD THE TOP 4 PLACES IN TERMS OF COAL RESERVES BUT THESE 4 NATIONS AS A GROUP COMPRISE 73% OF THE GLOBAL TOTAL. AND, OF COURSE, INDONESIA, KOREA, MALAYSIA, THE PHILIPPINES, TAIWAN, AND THAILAND ALSO HAVE COAL DEPOSITS OF THEIR OWN WITH INDONESIA PROJECTED TO BE A SIGNIFICANT EXPORTER, PERHAPS AS EARLY AS THE END OF THIS CENTURY.

BECAUSE COAL IS SUCH AN IMPORTANT ENERGY RESOURCE FOR THE U.S., WE INTEND TO PROMOTE ITS USE DOMESTICALLY AND TO ENCOURAGE ITS USE INTERNATIONALLY BY PROMOTING U.S. COAL AND COAL TECHNOLOGY EXPORTS. IN THIS ERA OF INCREASING ENVIRONMENTAL CONCERNS WORLDWIDE, COAL'S FUTURE DEMAND AND ACCEPTABILITY WILL BE CONTINGENT UPON TECHNOLOGY AS WELL AS RESOURCE ABUNDANCE. TO ATTAIN THIS GOAL, THE DEPARTMENT OF ENERGY IS UNDERTAKING A VARIETY OF COAL EXPORT INITIATIVES, SUCH AS THIS CONFERENCE FOR EXAMPLE, TO INCREASE THE ACCESS OF U.S. COAL EXPORTERS TO FOREIGN MARKETS AND TO STIMULATE TRADE IN COAL AND COAL-RELATED TECHNOLOGY.

AT THIS JUNCTURE I WOULD LIKE TO TAKE A STEP BACK TO VIEW THE IMPORTANCE OF CLEAN COAL TECHNOLOGY FROM A BROADER PERSPECTIVE. IN ORDER TO FULLY APPRECIATE HOW AND WHY COAL'S FUTURE IS

"RESOURCE-DRIVEN AND TECHNOLOGICALLY-LED", I THINK IT IS USEFUL TO REVIEW HOW THE WORLD COAL MARKET HAS EVOLVED OVER THE YEARS AND HOW THE U.S., WHICH HAS ALWAYS BEEN A MAJOR PLAYER AS A COAL PRODUCER, IS NOW PLAYING AN EVEN MORE IMPORTANT ROLE AS A WORLD LEADER IN THE SCIENCE AND ECONOMICS OF COAL COMBUSTION. BY VIRTUE OF THE SIZE OF AMERICA'S DOMESTIC MARKET AND ITS ECONOMIES OF SCALE, FOREIGN COUNTRIES NOW HAVE A TREMENDOUS OPPORTUNITY TO TAKE ADVANTAGE OF OUR PROGRESS THUS FAR IN THE MULTI-BILLION DOLLAR CLEAN COAL TECHNOLOGY DEMONSTRATION PROGRAM, WHICH YOU WILL HEAR MUCH MORE ABOUT LATER.

U.S. ROLE IN WORLD COAL TRADE

THE UNITED STATES GREW UP ON COAL; IT HAS BEEN MINED COMMERCIALLY IN OUR COUNTRY FOR OVER 240 YEARS. COAL FUELED THE INDUSTRIAL REVOLUTION. COAL WAS THE PREDOMINANT FOSSIL FUEL UNTIL EARLY IN THIS CENTURY WHEN OIL AND GAS BECAME INCREASINGLY POPULAR. BUT THE OIL PRICE SHOCKS OF THE 1970'S AND ENSUING CONCERNS OVER SECURITY OF SUPPLY GAVE COAL NEW OPPORTUNITIES AS AN ALTERNATIVE FUEL AND HELPED SPUR THE EVOLUTION OF A WORLD MARKET FOR COAL THAT DID NOT EXIST BEFORE.

AS YOU KNOW, BEFORE 1960, INTERNATIONAL COAL COMMERCE WAS PRIMARILY LAND BASED BETWEEN NEIGHBORING COUNTRIES AND VOLUMES TRADED WERE NOT THAT LARGE. INTERNATIONAL TRADE IN COKING COAL BEGAN TO INCREASE AS NEWLY INDUSTRIALIZED COUNTRIES DEVELOPED THEIR STEEL INDUSTRIES. THE BOOM IN STEAM COAL TRADE CAME AFTER THE 1970'S OIL PRICE SHOCKS WHEN IT WAS ECONOMICAL FOR MANY COUNTRIES TO BUILD NEW ELECTRIC POWER

PLANTS THAT WOULD BURN RELATIVELY CHEAP IMPORTED COAL. AS A RESULT, BETWEEN 1973 AND 1986 WORLD HARD COAL TRADE ALMOST DOUBLED. IN PARTICULAR,THE UNITED STATES, SOUTH AFRICA AND AUSTRALIA RAPIDLY EXPANDED THEIR CAPACITY FOR PRODUCTION AND EXPORT TO FOREIGN MARKETS RESULTING IN A TRIPLING OF SEABORNE TRADE IN COAL. HOWEVER, THE WORLD COAL MARKET IN VERY COMPETITIVE AND BY 1984 AUSTRALIA OVERTOOK THE UNITED STATES AS THE WORLD'S LARGEST EXPORTER OF COAL.

FROM THE PERSPECTIVE OF U.S. COAL PRODUCERS AND TRANSPORTERS, COAL IS A DEMAND CONSTRAINED COMMODITY FOR WHICH EXPORTS PROVIDE AN IMPORTANT OUTLET. GIVEN THE FACT THAT SURPLUS CAPACITY IN THE WORLD COAL MARKET HAS BEEN ESTIMATED AT 40 MILLION TONS, WITH ANOTHER 100 MILLION TONS OVERCAPACITY IN THE U.S., POTENTIAL SUPPLIES SHOULD WELL EXCEED ANTICIPATED FUTURE DEMAND. THIS, IN TURN, SHOULD CONTRIBUTE TO CONTINUED PRICE STABILITY IN WORLD COAL MARKETS. THIS PRICE STABILITY WILL ADD TO THE ATTRACTIVENESS OF COAL, ESPECIALLY WHEN COMPARED TO OIL.

THE DOE'S ENERGY INFORMATION AGENCY PROJECTS A MAJOR EXPANSION IN WORLD COAL TRADE FROM 383 MILLION TONS IN 1987 TO 532 MILLION TONS IN THE BASE CASE FOR THE YEAR 2000 FOR AN OVERALL INCREASE OF ALMOST 40%. ALTHOUGH THE UNITED STATES IS NOT PRICE COMPETITIVE IN SEVERAL MARKETS, CONCERNS OF IMPORTING COUNTRIES REGARDING RELIABILITY OF SUPPLY, DESIRE FOR SUPPLY DIVERSIFICATION, AND ISSUES RELATED TO BALANCE OF TRADE CONSIDERATIONS ARE EXPECTED TO MAKE THE U.S. A CONTINUED MAJOR PARTICIPANT IN WORLD COAL TRADE, WITH A SHARE OF BETWEEN 20 AND 25 OF THE GLOBAL MARKET. INDEED, AMERICA'S DEMONSTRATED

ABILITY TO RESPOND TO UNEXPECTED SURGES IN DEMAND AS THE WORLD'S "SWING SUPPLIER" IS EXPECTED TO ENHANCE OUR LONG TERM PROSPECTS AS AN EXPORTER. AN IMPORTANT POINT TO REMEMBER HERE IS THAT NATIONS OTHER THAN THE U.S., SUCH AS AUSTRALIA, WILL ALSO INCREASE THEIR COAL EXPORTS AS WELL WHICH, IN TURN, WILL SERVE TO CREATE EVEN GREATER REQUIREMENTS FOR COAL-RELATED EQUIPMENT AND ADVANCED COMBUSTION TECHNOLOGIES DEVELOPED AND MANUFACTURED IN THE UNITED STATES.

IN GENERAL, STEAM COAL IS EXPECTED TO BECOME THE PRIMARY TYPE OF COAL TRADED DURING THE LATE 1990'S AND WILL PROVIDE VIRTUALLY ALL THE GROWTH IN THE WORLD COAL MARKET - AT AN ANNUAL AVERAGE RATE OF ABOUT 5 PERCENT. THIS EXPANSION WILL OCCUR FOR THE MOST PART IN RESPONSE TO RISING COAL DEMAND BY ELECTRIC UTILITIES AND INDUSTRIAL USERS IN WESTERN EUROPE AND ASIA. MEANWHILE, TRADE IN METALLURGICAL OR COKING COAL IN THE YEAR 2000 IS PROJECTED TO BE SLIGHTLY LOWER THAN 1987 LEVELS FOR THE WORLD AS A WHOLE ALTHOUGH SOME GROWTH IS EXPECTED IN ASIA, SOUTHERN EUROPE AND BRAZIL AS A RESULT OF EXPANSION IN STEEL PRODUCTION. ASIA IS EXPECTED TO REMAIN THE LARGEST MARKET FOR COKING COAL IMPORTS, WITH A 45% SHARE OF WORLD COKING COAL TRADE, THROUGH THE YEAR 2000.

THE PROJECTED RISE IN ASIAN COAL DEMAND IS ATTRBUTED LARGELY TO GROWTH IN COAL CONSUMPTION BY ELECTRIC UTILITIES. SINCE MOST OF THE MAJOR IMPORTING COUNTRIES IN THE REGION HAVE LITTLE IF ANY DOMESTIC PRODUCTION, MOST GROWTH IN DEMAND MUST BE MET BY INCREASED IMPORTS. AND NO MATTER WHETHER THE COAL BURNED IS OF DOMESTIC OR FOREIGN ORIGIN, THE PROCESS BY WHICH IT IS COMBUSTED WILL HAVE A MAJOR

INFLUENCE UPON ITS ECONOMIC EFFICIENCY AND ENVIRONMENTAL IMPACT. THUS, THE MORE WE KNOW ABOUT THE NEEDS OF OUR PACIFIC PARTNERS IN TERMS OF COAL AND COAL TECHNOLOGY, THE MORE WE CAN DO TO HELP IDENTIFY THE TECHNOLOGIES MOST APPROPRIATE TO YOUR INDIVIDUAL SITUATIONS.

THE U.S. CLEARLY HAS THE ABILITY TO SUPPLY THE WORLD WITH MORE COAL. WE HAVE COMPETITIVE COALS, EXCESS PRODUCTION CAPACITY, A REPUTATION OF SUPPLY RELIABILITY, AND SUPERIOR TECHNOLOGY. OUR INLAND TRANSPORTATION SYSTEM IS READY TO HANDLE SURGES IN DEMAND AND COAL TERMINAL CAPACITY HAS BEEN EXPANDED. INCREASING COAL EXPORTS WILL PROVIDE A STABLE, SECURE SOURCE OF ENERGY FOR OUR TRADING PARTNERS. EVERYONE WILL BENEFIT FROM ITS SUCCESS. THE UNITED STATES HAS ALWAYS PLAYED A MAJOR ROLE IN WORLD COAL AND AT THE PRESENT TIME OVER 60 COUNTRIES USE AMERICAN COAL, AMERICAN COAL EQUIPMENT, AND AMERICAN COAL TECHNOLOGIES.

EXPORTING U.S. COAL AND COAL TECHNOLOGY

IN ADDITION TO THE DEPARTMENT OF ENERGY, THE PROMOTION OF COAL EXPORTS BY THE FEDERAL GOVERNMENT INVOLVES AGENCIES SUCH AS THE DEPARTMENT OF COMMERCE, THE DEPARTMENT OF STATE, AND THE OFFICE OF THE U.S. TRADE REPRESENTATIVE. THIS COMBINATION OF INTERNATIONAL ENERGY AND COMMERCIAL EXPERTISE, IN ADDITION TO THE TECHNICAL CAPABILITY, ASSURES A COMPREHENSIVE, COORDINATED FEDERAL EFFORT IN SUPPORT OF THE EXPORT MARKETING EFFORTS BY THE PRIVATE SECTOR.

ONE OF THE PRIORITIES OF THIS FEDERAL EFFORT IS TO ENSURE THAT AMERICAN COMPANIES ARE ABLE TO COMPETE ON AN EQUITABLE BASIS ANYWHERE IN THE WORLD. THIS GOAL IS ACCOMPLISHED IN PART, THRU BILATERAL AND MULTILATER FORUMS. THRU THIS MECHANISM, WE CONSTANTLY ADVOCATE THE ELIMINATION OF DOMESTIC COAL SUBSIDIES AND COAL IMPORT RESTRICTIONS.

IN ADDITION, WE ARE COMMITTED TO ACTIVELY SUPPORTING INTERNATIONAL ACTIVITIES THAT WILL LEAD TO INCREASED COAL USE WORLDWIDE.

THESE ACTIVITIES INCLUDE REDUCING IMPEDIMENTS AND BARRIERS TO AMERICAN COAL EXPORTS, IMPROVED CONSUMER UNDERSTANDING OF HOW EFFICIENTLY AMERICAN COAL CAN BE USED, PROMOTING CLEAN COAL TECHNOLOGY TO PROTECT THE ENVIRONMENT, AND INCREASING THE LEVEL OF RESEARCH AN DEVELOPMENT WHICH WILL LEAD TO THE DEVELOPMENT OF NEW, MORE EFFICIENT COAL TECHNOLOGIES.

SINCE THE U.S. HAS SO MUCH EXPERIENCE HANDLING AND BURNING THE WIDE VARIETY OF COALS THAT IT HAS AVAILABLE DOMESTICALLY, THE DOE CLEAN COAL TECHNOLOGY PROGRAM IS A FUNDAMENTAL COMPONENT OF OUR NATIONAL ENERGY STRATEGY. IT IS AN AS YET UNEXPLOITED POTENTIAL THAT SHOULD BE VIEWED FROM THE BUYER'S PERSPECTIVE AS A DISTINCT ADVANTAGE IN CHOOSING AMERICAN COAL. BY LINKING TECHNOLOGY EXPORTS TO COAL EXPORTS WE IN DOE PLAN TO EXPLORE NEW GOVERNMENT-TO-GOVERNMENT TECHNICAL AGREEMENTS AND TO STIMULATE EX-IM BANK FINANCIAL SUPPORT FOR EXPORT-RELATED PROJECTS. FOR EXAMPLE, WE ALREADY HAVE IN PLACE A CLEAN COAL TECHNOLOGY ARRANGEMENT WITH COSTA RICA THAT PROVIDES FOR INFORMATION EXCHANGES ON VARIOUS ASPECTS OF DOE'S COAL PROGRAMS AND WE

STAND READY TO DISCUSS SIMILAR FORMS OF COOPERATION WITH OTHER INTERESTED NATIONS.

AS YOU CAN TELL, THIS IS A VERY AMBITIOUS EFFORT BUT PROMOTING COAL TECHNOLOGY EXPORTS IS ONLY ONE ASPECT OF THE ENERGY RELATIONSHIP DOE MAINTAINS WITH OTHER NATIONS. HOWEVER, IT IS AN IMPORTANT DIMENSION BECAUSE OF THE POTENTIAL FOR EXPANDED EXPORTS BY MAKING COAL MORE ATTRACTIVE TO KEY CONSUMERS WHO WILL BENEFIT FROM ITS USE.

CONCLUSION

IN CONCLUSION, OUR APPROACH TO COAL AND COAL TECHNOLOGIES IS CONSISTENT WITH U.S. INTERNATIONAL ENERGY POLICY TOWARD ASIA, WHICH REVOLVES AROUND THE TWIN THEMES OF POLICY COORDINATION FOR REGIONAL ENERGY SECURITY AND ENVIRONMENTAL PROTECTION, AND EXPORT PROMOTION BASED UPON PRINCIPLES OF FREE TRADE AND MUTUAL ECONOMIC GROWTH.

ON AN OFFICIAL LEVEL, INFORMAL EXCHANGES AMONG KEY PARTICIPANTS IN THE PACIFIC ENERGY SCENE WILL BE A PARTICULARLY IMPORTANT MECHANISM FOR IMPROVING MUTUAL UNDERSTANDING OF ENERGY ISSUES, AND FOR SHARING INFORMATION WHICH MIGHT LEAD TO A COMMON UNDERSTANDING OF HOW TO MEET THE CHALLENGES OF THE FUTURE. THROUGH THIS KIND OF DIALOGUE IT IS ALSO POSSIBLE TO IMPROVE THE TRANSPARENCY OF ENERGY MARKETS AND TO FACILITATE THE ROLE OF THE PRIVATE SECTOR IN DEVELOPING THESE MARKETS. THE UNITED STATES HAS ESTABLISHED REGULAR BILATERAL CONSULTATIONS, OCCURING AT AN EXPERT LEVEL, WITH SUCH PACIFIC PARTNERS AS JAPAN

AND SOUTH KOREA. IN THESE MEETINGS WE DISCUSS TRADE AND POLICY ISSUES OF MUTUAL INTEREST AND SHARE PERSPECTIVES ON GLOBAL ENERGY DEVELOPMENTS. WE ARE INTERESTED IN EXPANDING OUR ENERGY RELATIONSHIPS WITH OTHER PACIFIC NATIONS THROUGH THESE MECHANISMS AND THROUGH A PATTERN OF MORE FREQUENT BILATERAL VISITS BY SENIOR AND WORKING LEVEL OFFICIALS TO DISCUSS THE IMPORTANT ISSUES WHICH CONFRONT ALL OF US.

THE UNITED STATES PLANS TO PLAY AN ACTIVE AND POSITIVE ROLE COMMENSURATE WITH ITS TRMENDOUS INTEREST IN THE PACIFIC REGION. IN TODAY'S RAPIDLY CHANGING INTERNATIONAL ENERGY ENVIRONMENT, WE AND OUR PACIFIC PARTNERS FACE MANY HURDLES IN PURSUING OUR COMMON OBJECTIVES OF ADEQUATE, STABLE AND SECURE ENERGY SUPPLIES AT REASONABLE PRICES. GIVEN THE SUCCESS OF THE ASIA PACIFIC REGION THUS FAR IN MEETING THE BROADER OBJECTIVES OF SUSTAINED AND RAPID ECONOMIC GROWTH, I BELIEVE THAT THERE IS A SOUND BASIS FOR OPTIMISM THAT OUR ENERGY CHALLENGES CAN BE SUCCESSFULLY MET AS WELL.

ANTHONY A. CHURCHILL
Director
Industry and Energy Department
World Bank

Anthony A. Churchill, a Canadian citizen, is currently Director of the Industry and Energy Department of the World Bank. He has a B.A. degree from the University of British Columbia and a Ph.D. from the University of Washington (Seattle). Prior to joining the Bank's Public Finance Division in 1965, he taught at the University of Western Ontario. He has held a number of positions in the Bank: Chief of the Transportation and Public Utilities Division of the Economics Department, Chief of the Transportation Research Division, then Economic Advisor in the Transportation Department and, prior to his present assignment, Director of the Water Supply and Urban Development Department. A list of his publications includes: *Road User Charges in Central America* (World Bank Staff Occasional Paper No. 15); with S. Basta, *Iron Deficiency, Anemia and the Productivity of Adult Males in Indonesia* (Staff Working Paper No. 172); co-author of *The Task Ahead for the Cities of the Developing Countries* (Staff Working Paper No. 209) and *Rural Water Supply and Sanitation - Time for a Change* (World Bank Discussion Paper No. 18).

THAD GRUNDY JR.
Deputy Assistant Secretary for International Affairs
U.S. Department of Energy

Thad Grundy Jr. is Deputy Assistant Secretary for International Affairs, U.S. Department of Energy (DOE). In this position, he is responsible for developing and implementing international energy and energy trade policy, nuclear nonproliferation policy, and international research and development policy.

Prior to joining DOE on August 7, 1989, Mr. Grundy was a partner with the Houston law firm of Hutcheson and Grundy. Mr. Grundy's background while in private practice includes broad experience in oil and gas law, primarily on exploration, production and regulatory matters. He also has extensive experience in the savings and loan industry, and represented the Federal Savings and Loan Insurance Corporation in connection with the liquidation of insolvent savings and loan associations. Mr. Grundy has been a frequent speaker before legal and industry groups on the savings and loan industry and related topics.

A native of Houston, Texas, Mr. Grundy received his B.A. from Washington and Lee University in 1975, and his J.D. from the University of Houston in 1980. He is married and has two children.

THE UNITED STATES AND ASIA: PACIFIC PARTNERS IN COAL AND COAL TECHNOLOGY

Thad Grundy, Jr.
Deputy Assistant Secretary for
International Affairs
Department of Energy

Asia-Pacific Coal Technology Conference
East-West Center
Honolulu, Hawaii

November 15, 1989

IT IS A GREAT HONOR TO ADDRESS THIS DISTINGUISHED GROUP AND A PLEASURE TO BE PARTICIPATING IN THIS VERY IMPORTANT CONFERENCE ON ASIA-PACIFIC COAL TECHNOLOGY. I WOULD LIKE TO THANK DENISE SWINK FROM DOE'S OFFICE OF FOSSIL ENERGY AND DR. FEREIDUN FESHARAKI FROM THE EAST-WEST CENTER FOR THE OUTSTANDING JOB THEY HAVE DONE IN PUTTING THIS CONFERENCE TOGETHER. I'M SURE YOU ALL AGREE THAT WE HAVE AN EXCITING AGENDA AND JUDGING FROM WHAT WE HAVE JUST HEARD, SOME IMPORTANT THINGS TO TALK ABOUT IN THE COAL TECHNOLOGY ARENA.

HAVING ONLY BEEN SWORN IN LAST WEEK AS THE NEW DEPUTY ASSISTANT SECRETARY FOR INTERNATIONAL AFFAIRS AT THE DEPARTMENT OF ENERGY, I CAN ASSURE YOU THAT DURING THIS CONFERENCE I PLAN TO TAKE THE OPPORTUNITY TO FORM NEW FRIENDSHIPS AND ASSOCIATIONS SO THAT WE ALL MIGHT WORK MORE CLOSELY TOGETHER PREPARING FOR THE ENERGY NEEDS OF THE NEXT DECADE, IF NOT THE NEXT CENTURY. I THINK YOU WILL AGREE WITH ME THAT ONE OF THE PRINCIPAL VALUES OF THIS CONFERENCE WHICH HAS BROUGHT SO MANY EXPERTS TOGETHER IN ONE PLACE IS THE WAY IT IS STRUCTURED -- WITH A PLENARY SESSION SUCH AS THIS TO BE FOLLOWED UP BY GATHERINGS OF SMALLER GROUPS WHERE THERE CAN BE INCREASED INTERACTION AMONG THE PARTICIPANTS. IT IS OUT OF THESE WORKING GROUPS THAT I HOPE WILL BE GENERATED SOME NEW INITIATIVES AND PROPOSALS SO THAT WHEN WE HAVE ALL RETURNED BACK HOME WE CAN LOOK BACK AND SAY THAT WE ACCOMPLISHED SOMETHING HERE IN HAWAII AND THAT WE DEVELOPED SOME CONCRETE ACTIVITIES TO FOLLOW UP ON.

WHAT I PROPOSE TO DO HERE TODAY AS THE TRANSITION SPEAKER BETWEEN OUR REPRESENTATIVES FROM ASIA AND OUR PRESENTERS FROM THE UNITED STATES

IS TO STRESS THE TREMENDOUS POTENTIAL THIS CONFERENCE HAS IN HELPING US ALL ADDRESS THE MANY COMMON CHALLENGES WE FACE IN OUR RESPECTIVE ENERGY SECTORS WITH A PARTICULAR EMPHASIS UPON THE FUTURE ROLE OF COAL AND COAL TECHNOLOGY IN SATISFYING THE GROWING DEMAND FOR ELECTRICITY WHICH ALL OF US ARE FACING.

NONE OF US HERE CAN AFFORD TO PURSUE ENERGY POLICIES IN ISOLATION FROM THE GLOBAL COMMUNITY AND I PROPOSE THAT WE WORK TOGETHER AS PACIFIC PARTNERS. A VERY RELEVANT EXAMPLE OF THIS IS THE CHALLENGE WHICH THE PROSPECTS OF GLOBAL WARMING AND CLIMATE CHANGE POSE TO THE WORLD AT LARGE AND, OF COURSE, TO THE ASIA-PACIFIC REGION IN WHICH WE LIVE. NOT ONLY MUST MANY OF THE SOLUTIONS BE INTERNATIONAL ONES REFLECTING THE INTERDEPENDENCE OF NATIONS IN THIS MODERN TECHNOLOGICAL ERA, BUT THESE SOLUTIONS MUST BE SENSITIVE TO THE DIVERSITY OF OUR ECONOMIC AND ENERGY PROFILES.

THE MESSAGE I WISH TO CONVEY TO YOU TODAY IS SIMPLE AND STRAIGHT FORWARD: COAL IS HERE TO STAY - IT IS A MAJOR RESOURCE OF THE ASIA-PACIFIC REGION AND WILL DEFINITELY PLAY A SIGNIFICANT ROLE IN OUR ENERGY FUTURES - ESPECIALLY IN THE POWER SECTOR. MORE COAL IS PRODUCED IN THE ASIA-PACIFIC REGION THAN IN ANY OTHER REGION OF THE WORLD AND GIVEN THE UNCERTAINTY OF NUCLEAR POWER, I BELIEVE COAL WILL LIKELY BE THE FOSSIL FUEL OF CHOICE IN THE GENERATION OF ELECTRICITY WELL INTO THE NEXT CENTURY.

THE U.S. ENERGY INFORMATION ADMINISTRATION (EIA) ESTIMATES THAT THE U.S. ALONE ACCOUNTS FOR 29% OF THE WORLD'S RECOVERABLE COAL RESOURCE BASE, WITH 291 BILLION SHORT TONS OUT OF A GLOBAL TOTAL OF APPROXIMATELY ONE TRILLION TONS. THIS IS EQUIVALENT TO SEVERAL HUNDRED YEARS OF SUPPLY AT CURRENT CONSUMPTION LEVELS. IN TERMS OF RECOVERABLE COAL RESERVES, THE U.S. IS FOLLOWED BY THE SOVIET UNION, CHINA, AND AUSTRALIA IN THAT ORDER SO THAT NOT ONLY DO ASIA-PACIFIC NATIONS HOLD THE TOP 4 PLACES IN TERMS OF COAL RESERVES BUT THESE 4 NATIONS AS A GROUP COMPRISE 73% OF THE GLOBAL TOTAL. AND, OF COURSE, INDONESIA, KOREA, MALAYSIA, THE PHILIPPINES, TAIWAN, AND THAILAND ALSO HAVE COAL DEPOSITS OF THEIR OWN WITH INDONESIA PROJECTED TO BE A SIGNIFICANT EXPORTER, PERHAPS AS EARLY AS THE END OF THIS CENTURY.

BECAUSE COAL IS SUCH AN IMPORTANT ENERGY RESOURCE FOR THE U.S., WE INTEND TO PROMOTE ITS USE DOMESTICALLY AND TO ENCOURAGE ITS USE INTERNATIONALLY BY PROMOTING U.S. COAL AND COAL TECHNOLOGY EXPORTS. IN THIS ERA OF INCREASING ENVIRONMENTAL CONCERNS WORLDWIDE, COAL'S FUTURE DEMAND AND ACCEPTABILITY WILL BE CONTINGENT UPON TECHNOLOGY AS WELL AS RESOURCE ABUNDANCE. TO ATTAIN THIS GOAL, THE DEPARTMENT OF ENERGY IS UNDERTAKING A VARIETY OF COAL EXPORT INITIATIVES, SUCH AS THIS CONFERENCE FOR EXAMPLE, TO INCREASE THE ACCESS OF U.S. COAL EXPORTERS TO FOREIGN MARKETS AND TO STIMULATE TRADE IN COAL AND COAL-RELATED TECHNOLOGY.

AT THIS JUNCTURE I WOULD LIKE TO TAKE A STEP BACK TO VIEW THE IMPORTANCE OF CLEAN COAL TECHNOLOGY FROM A BROADER PERSPECTIVE. IN ORDER TO FULLY APPRECIATE HOW AND WHY COAL'S FUTURE IS

"RESOURCE-DRIVEN AND TECHNOLOGICALLY-LED", I THINK IT IS USEFUL TO REVIEW HOW THE WORLD COAL MARKET HAS EVOLVED OVER THE YEARS AND HOW THE U.S., WHICH HAS ALWAYS BEEN A MAJOR PLAYER AS A COAL PRODUCER, IS NOW PLAYING AN EVEN MORE IMPORTANT ROLE AS A WORLD LEADER IN THE SCIENCE AND ECONOMICS OF COAL COMBUSTION. BY VIRTUE OF THE SIZE OF AMERICA'S DOMESTIC MARKET AND ITS ECONOMIES OF SCALE, FOREIGN COUNTRIES NOW HAVE A TREMENDOUS OPPORTUNITY TO TAKE ADVANTAGE OF OUR PROGRESS THUS FAR IN THE MULTI-BILLION DOLLAR CLEAN COAL TECHNOLOGY DEMONSTRATION PROGRAM, WHICH YOU WILL HEAR MUCH MORE ABOUT LATER.

U.S. ROLE IN WORLD COAL TRADE

THE UNITED STATES GREW UP ON COAL; IT HAS BEEN MINED COMMERCIALLY IN OUR COUNTRY FOR OVER 240 YEARS. COAL FUELED THE INDUSTRIAL REVOLUTION. COAL WAS THE PREDOMINANT FOSSIL FUEL UNTIL EARLY IN THIS CENTURY WHEN OIL AND GAS BECAME INCREASINGLY POPULAR. BUT THE OIL PRICE SHOCKS OF THE 1970'S AND ENSUING CONCERNS OVER SECURITY OF SUPPLY GAVE COAL NEW OPPORTUNITIES AS AN ALTERNATIVE FUEL AND HELPED SPUR THE EVOLUTION OF A WORLD MARKET FOR COAL THAT DID NOT EXIST BEFORE.

AS YOU KNOW, BEFORE 1960, INTERNATIONAL COAL COMMERCE WAS PRIMARILY LAND BASED BETWEEN NEIGHBORING COUNTRIES AND VOLUMES TRADED WERE NOT THAT LARGE. INTERNATIONAL TRADE IN COKING COAL BEGAN TO INCREASE AS NEWLY INDUSTRIALIZED COUNTRIES DEVELOPED THEIR STEEL INDUSTRIES. THE BOOM IN STEAM COAL TRADE CAME AFTER THE 1970'S OIL PRICE SHOCKS WHEN IT WAS ECONOMICAL FOR MANY COUNTRIES TO BUILD NEW ELECTRIC POWER

PLANTS THAT WOULD BURN RELATIVELY CHEAP IMPORTED COAL. AS A RESULT, BETWEEN 1973 AND 1986 WORLD HARD COAL TRADE ALMOST DOUBLED. IN PARTICULAR,THE UNITED STATES, SOUTH AFRICA AND AUSTRALIA RAPIDLY EXPANDED THEIR CAPACITY FOR PRODUCTION AND EXPORT TO FOREIGN MARKETS RESULTING IN A TRIPLING OF SEABORNE TRADE IN COAL. HOWEVER, THE WORLD COAL MARKET IN VERY COMPETITIVE AND BY 1984 AUSTRALIA OVERTOOK THE UNITED STATES AS THE WORLD'S LARGEST EXPORTER OF COAL.

FROM THE PERSPECTIVE OF U.S. COAL PRODUCERS AND TRANSPORTERS, COAL IS A DEMAND CONSTRAINED COMMODITY FOR WHICH EXPORTS PROVIDE AN IMPORTANT OUTLET. GIVEN THE FACT THAT SURPLUS CAPACITY IN THE WORLD COAL MARKET HAS BEEN ESTIMATED AT 40 MILLION TONS, WITH ANOTHER 100 MILLION TONS OVERCAPACITY IN THE U.S., POTENTIAL SUPPLIES SHOULD WELL EXCEED ANTICIPATED FUTURE DEMAND. THIS, IN TURN, SHOULD CONTRIBUTE TO CONTINUED PRICE STABILITY IN WORLD COAL MARKETS. THIS PRICE STABILITY WILL ADD TO THE ATTRACTIVENESS OF COAL, ESPECIALLY WHEN COMPARED TO OIL.

THE DOE'S ENERGY INFORMATION AGENCY PROJECTS A MAJOR EXPANSION IN WORLD COAL TRADE FROM 383 MILLION TONS IN 1987 TO 532 MILLION TONS IN THE BASE CASE FOR THE YEAR 2000 FOR AN OVERALL INCREASE OF ALMOST 40%. ALTHOUGH THE UNITED STATES IS NOT PRICE COMPETITIVE IN SEVERAL MARKETS, CONCERNS OF IMPORTING COUNTRIES REGARDING RELIABILITY OF SUPPLY, DESIRE FOR SUPPLY DIVERSIFICATION, AND ISSUES RELATED TO BALANCE OF TRADE CONSIDERATIONS ARE EXPECTED TO MAKE THE U.S. A CONTINUED MAJOR PARTICIPANT IN WORLD COAL TRADE, WITH A SHARE OF BETWEEN 20 AND 25 OF THE GLOBAL MARKET. INDEED, AMERICA'S DEMONSTRATED

ABILITY TO RESPOND TO UNEXPECTED SURGES IN DEMAND AS THE WORLD'S "SWING SUPPLIER" IS EXPECTED TO ENHANCE OUR LONG TERM PROSPECTS AS AN EXPORTER. AN IMPORTANT POINT TO REMEMBER HERE IS THAT NATIONS OTHER THAN THE U.S., SUCH AS AUSTRALIA, WILL ALSO INCREASE THEIR COAL EXPORTS AS WELL WHICH, IN TURN, WILL SERVE TO CREATE EVEN GREATER REQUIREMENTS FOR COAL-RELATED EQUIPMENT AND ADVANCED COMBUSTION TECHNOLOGIES DEVELOPED AND MANUFACTURED IN THE UNITED STATES.

IN GENERAL, STEAM COAL IS EXPECTED TO BECOME THE PRIMARY TYPE OF COAL TRADED DURING THE LATE 1990'S AND WILL PROVIDE VIRTUALLY ALL THE GROWTH IN THE WORLD COAL MARKET - AT AN ANNUAL AVERAGE RATE OF ABOUT 5 PERCENT. THIS EXPANSION WILL OCCUR FOR THE MOST PART IN RESPONSE TO RISING COAL DEMAND BY ELECTRIC UTILITIES AND INDUSTRIAL USERS IN WESTERN EUROPE AND ASIA. MEANWHILE, TRADE IN METALLURGICAL OR COKING COAL IN THE YEAR 2000 IS PROJECTED TO BE SLIGHTLY LOWER THAN 1987 LEVELS FOR THE WORLD AS A WHOLE ALTHOUGH SOME GROWTH IS EXPECTED IN ASIA, SOUTHERN EUROPE AND BRAZIL AS A RESULT OF EXPANSION IN STEEL PRODUCTION. ASIA IS EXPECTED TO REMAIN THE LARGEST MARKET FOR COKING COAL IMPORTS, WITH A 45% SHARE OF WORLD COKING COAL TRADE, THROUGH THE YEAR 2000.

THE PROJECTED RISE IN ASIAN COAL DEMAND IS ATTRBUTED LARGELY TO GROWTH IN COAL CONSUMPTION BY ELECTRIC UTILITIES. SINCE MOST OF THE MAJOR IMPORTING COUNTRIES IN THE REGION HAVE LITTLE IF ANY DOMESTIC PRODUCTION, MOST GROWTH IN DEMAND MUST BE MET BY INCREASED IMPORTS. AND NO MATTER WHETHER THE COAL BURNED IS OF DOMESTIC OR FOREIGN ORIGIN, THE PROCESS BY WHICH IT IS COMBUSTED WILL HAVE A MAJOR

INFLUENCE UPON ITS ECONOMIC EFFICIENCY AND ENVIRONMENTAL IMPACT. THUS, THE MORE WE KNOW ABOUT THE NEEDS OF OUR PACIFIC PARTNERS IN TERMS OF COAL AND COAL TECHNOLOGY, THE MORE WE CAN DO TO HELP IDENTIFY THE TECHNOLOGIES MOST APPROPRIATE TO YOUR INDIVIDUAL SITUATIONS.

THE U.S. CLEARLY HAS THE ABILITY TO SUPPLY THE WORLD WITH MORE COAL. WE HAVE COMPETITIVE COALS, EXCESS PRODUCTION CAPACITY, A REPUTATION OF SUPPLY RELIABILITY, AND SUPERIOR TECHNOLOGY. OUR INLAND TRANSPORTATION SYSTEM IS READY TO HANDLE SURGES IN DEMAND AND COAL TERMINAL CAPACITY HAS BEEN EXPANDED. INCREASING COAL EXPORTS WILL PROVIDE A STABLE, SECURE SOURCE OF ENERGY FOR OUR TRADING PARTNERS. EVERYONE WILL BENEFIT FROM ITS SUCCESS. THE UNITED STATES HAS ALWAYS PLAYED A MAJOR ROLE IN WORLD COAL AND AT THE PRESENT TIME OVER 60 COUNTRIES USE AMERICAN COAL, AMERICAN COAL EQUIPMENT, AND AMERICAN COAL TECHNOLOGIES.

EXPORTING U.S. COAL AND COAL TECHNOLOGY

IN ADDITION TO THE DEPARTMENT OF ENERGY, THE PROMOTION OF COAL EXPORTS BY THE FEDERAL GOVERNMENT INVOLVES AGENCIES SUCH AS THE DEPARTMENT OF COMMERCE, THE DEPARTMENT OF STATE, AND THE OFFICE OF THE U.S. TRADE REPRESENTATIVE. THIS COMBINATION OF INTERNATIONAL ENERGY AND COMMERCIAL EXPERTISE, IN ADDITION TO THE TECHNICAL CAPABILITY, ASSURES A COMPREHENSIVE, COORDINATED FEDERAL EFFORT IN SUPPORT OF THE EXPORT MARKETING EFFORTS BY THE PRIVATE SECTOR.

ONE OF THE PRIORITIES OF THIS FEDERAL EFFORT IS TO ENSURE THAT AMERICAN COMPANIES ARE ABLE TO COMPETE ON AN EQUITABLE BASIS ANYWHERE IN THE WORLD. THIS GOAL IS ACCOMPLISHED IN PART, THRU BILATERAL AND MULTILATER FORUMS. THRU THIS MECHANISM, WE CONSTANTLY ADVOCATE THE ELIMINATION OF DOMESTIC COAL SUBSIDIES AND COAL IMPORT RESTRICTIONS.

IN ADDITION, WE ARE COMMITTED TO ACTIVELY SUPPORTING INTERNATIONAL ACTIVITIES THAT WILL LEAD TO INCREASED COAL USE WORLDWIDE.

- THESE ACTIVITIES INCLUDE REDUCING IMPEDIMENTS AND BARRIERS TO AMERICAN COAL EXPORTS, IMPROVED CONSUMER UNDERSTANDING OF HOW EFFICIENTLY AMERICAN COAL CAN BE USED, PROMOTING CLEAN COAL TECHNOLOGY TO PROTECT THE ENVIRONMENT, AND INCREASING THE LEVEL OF RESEARCH AN DEVELOPMENT WHICH WILL LEAD TO THE DEVELOPMENT OF NEW, MORE EFFICIENT COAL TECHNOLOGIES.

SINCE THE U.S. HAS SO MUCH EXPERIENCE HANDLING AND BURNING THE WIDE VARIETY OF COALS THAT IT HAS AVAILABLE DOMESTICALLY, THE DOE CLEAN COAL TECHNOLOGY PROGRAM IS A FUNDAMENTAL COMPONENT OF OUR NATIONAL ENERGY STRATEGY. IT IS AN AS YET UNEXPLOITED POTENTIAL THAT SHOULD BE VIEWED FROM THE BUYER'S PERSPECTIVE AS A DISTINCT ADVANTAGE IN CHOOSING AMERICAN COAL. BY LINKING TECHNOLOGY EXPORTS TO COAL EXPORTS WE IN DOE PLAN TO EXPLORE NEW GOVERNMENT-TO-GOVERNMENT TECHNICAL AGREEMENTS AND TO STIMULATE EX-IM BANK FINANCIAL SUPPORT FOR EXPORT-RELATED PROJECTS. FOR EXAMPLE, WE ALREADY HAVE IN PLACE A CLEAN COAL TECHNOLOGY ARRANGEMENT WITH COSTA RICA THAT PROVIDES FOR INFORMATION EXCHANGES ON VARIOUS ASPECTS OF DOE'S COAL PROGRAMS AND WE

STAND READY TO DISCUSS SIMILAR FORMS OF COOPERATION WITH OTHER INTERESTED NATIONS.

AS YOU CAN TELL, THIS IS A VERY AMBITIOUS EFFORT BUT PROMOTING COAL TECHNOLOGY EXPORTS IS ONLY ONE ASPECT OF THE ENERGY RELATIONSHIP DOE MAINTAINS WITH OTHER NATIONS. HOWEVER, IT IS AN IMPORTANT DIMENSION BECAUSE OF THE POTENTIAL FOR EXPANDED EXPORTS BY MAKING COAL MORE ATTRACTIVE TO KEY CONSUMERS WHO WILL BENEFIT FROM ITS USE.

CONCLUSION

IN CONCLUSION, OUR APPROACH TO COAL AND COAL TECHNOLOGIES IS CONSISTENT WITH U.S. INTERNATIONAL ENERGY POLICY TOWARD ASIA, WHICH REVOLVES AROUND THE TWIN THEMES OF POLICY COORDINATION FOR REGIONAL ENERGY SECURITY AND ENVIRONMENTAL PROTECTION, AND EXPORT PROMOTION BASED UPON PRINCIPLES OF FREE TRADE AND MUTUAL ECONOMIC GROWTH.

ON AN OFFICIAL LEVEL, INFORMAL EXCHANGES AMONG KEY PARTICIPANTS IN THE PACIFIC ENERGY SCENE WILL BE A PARTICULARLY IMPORTANT MECHANISM FOR IMPROVING MUTUAL UNDERSTANDING OF ENERGY ISSUES, AND FOR SHARING INFORMATION WHICH MIGHT LEAD TO A COMMON UNDERSTANDING OF HOW TO MEET THE CHALLENGES OF THE FUTURE. THROUGH THIS KIND OF DIALOGUE IT IS ALSO POSSIBLE TO IMPROVE THE TRANSPARENCY OF ENERGY MARKETS AND TO FACILITATE THE ROLE OF THE PRIVATE SECTOR IN DEVELOPING THESE MARKETS. THE UNITED STATES HAS ESTABLISHED REGULAR BILATERAL CONSULTATIONS, OCCURING AT AN EXPERT LEVEL, WITH SUCH PACIFIC PARTNERS AS JAPAN

AND SOUTH KOREA. IN THESE MEETINGS WE DISCUSS TRADE AND POLICY ISSUES OF MUTUAL INTEREST AND SHARE PERSPECTIVES ON GLOBAL ENERGY DEVELOPMENTS. WE ARE INTERESTED IN EXPANDING OUR ENERGY RELATIONSHIPS WITH OTHER PACIFIC NATIONS THROUGH THESE MECHANISMS AND THROUGH A PATTERN OF MORE FREQUENT BILATERAL VISITS BY SENIOR AND WORKING LEVEL OFFICIALS TO DISCUSS THE IMPORTANT ISSUES WHICH CONFRONT ALL OF US.

THE UNITED STATES PLANS TO PLAY AN ACTIVE AND POSITIVE ROLE COMMENSURATE WITH ITS TRMENDOUS INTEREST IN THE PACIFIC REGION. IN TODAY'S RAPIDLY CHANGING INTERNATIONAL ENERGY ENVIRONMENT, WE AND OUR PACIFIC PARTNERS FACE MANY HURDLES IN PURSUING OUR COMMON OBJECTIVES OF ADEQUATE, STABLE AND SECURE ENERGY SUPPLIES AT REASONABLE PRICES. GIVEN THE SUCCESS OF THE ASIA PACIFIC REGION THUS FAR IN MEETING THE BROADER OBJECTIVES OF SUSTAINED AND RAPID ECONOMIC GROWTH, I BELIEVE THAT THERE IS A SOUND BASIS FOR OPTIMISM THAT OUR ENERGY CHALLENGES CAN BE SUCCESSFULLY MET AS WELL.

ALAN M. DUNN
Deputy Assistant Secretary for Basic Industries
International Trade Administration
U.S. Department of Commerce

Mr. Dunn assumed his responsibilities as the Deputy Assistant Secretary for Basic Industries in Trade Development, International Trade Administration, effective May 26, 1989. He came from the law firm of O'Connor & Hannan where he practiced maritime and shipping law. Mr. Dunn served in the Foreign Service for almost five years before leaving in 1980 to practice law in the areas of international trade and environmental law with Collier, Shannon, Rill & Scott. He also held a political appointment as the Executive Assistant to the Chairman of the Consumer Product Safety Commission during 1984 and 1985.

Mr. Dunn earned his law degree from the University of Virginia and was a scholarship student at the Academie de Doit Internationale in The Hague for postgraduate study in private international law. Mr. Dunn also attended Washington & Lee University and George Mason University as an undergraduate.

U.S. COAL PRODUCTION AND EXPORT

REMARKS TO
ASIA-PACIFIC COAL TECHNOLOGY CONFERENCE
NOVEMBER 15-16, 1989

ALAN DUNN
Deputy Assistant Secretary
for Basic Industries
International Trade Administration

It is a pleasure for me to address the Asia Pacific Coal Technology Conference. I congratulate the East West Center and the Department of Energy for hosting this conference to promote more efficient and environmentally sound technologies for the use of coal among our Pacific Rim trading partners. In addition to talking about the export capabilities of the U.S. coal industry, I would like to address relevant coal trade issues, including technology developments.

I believe it would be helpful to know a little bit about what my office does in order for you to better understand my remarks. As the Deputy Assistant Secretary for the Basic Industries Sector of the International Trade Administration, I am responsible for promoting trade in chemicals, forest products, minerals, metals and commodities, and energy fuels.

The industry experts on my staff understand the competitive factors and forces in both domestic and international markets. They monitor and analyze a variety of economic, technical and political factors that directly and indirectly influence the abilities of U.S. companies to compete in international markets. For example, some of the key factors are current and emerging worldwide production and use technologies, availability of raw materials and cost of production, effects of government policies, regulations and subsidies, import/export policies and purchasing practices of foreign customers.

In the energy fuels area, the Office of Energy works closely with U.S. coal exporters and foreign coal buyers to promote the export and use of U.S. coal. Our objective is to facilitate the removal of obstacles that hinder foreign coal users from importing U.S. coal. There are many domestic and international aspects of our activities to promote U.S. coal exports and what we do specifically to assist the U.S. coal industry. I will mention some of them later, as they are very relevant to the message that I came here to give.

The basic message I bring is that the U.S coal industry has more than 300 years of reserves of quality coals, the world's largest production and export capabilities, and the desire to supply the

growing international market, and in particular the expanded coal use forecasted for the Pacific Rim countries. The U.S. coal industry has a solid reputation for reliability and quality control. Another important factor to a foreign customer is that exports of U.S. coal are not subject to government regulation or intervention. Complementing and supporting the strengths and capabilities of the U.S. coal industry are the interests of the U.S. government in promoting the use of U.S. coal, as an alternative to less secure oil and gas supplies in order to enhance the energy security of our trading partners.

What I have in mind today is to give you a perspective on our coal industry in an effort to let you mentally compare the U.S. industry with other major coal exporting countries. I am sure your comparisons will highlight the substantive reasons why U.S. coal has an important role in international trade.

The U.S. coal industry supplies both domestic and international markets and these markets complement each other. In 1988, the U.S. coal industry produced approximately 863 million metric tons, of which U.S. electric utilities consumed over 660 million tons, accounting for 77 percent of total shipments. Coal exports were sent to 55 countries and totaled more than 86 million metric tons. Unlike any other major coal exporting country, the United States has a very large and stable domestic market and, as a consequence, a large and stable base of production capacity. This base gives the foreign buyer an assured source of supply, not only in normal market times, but also during unexpected disruptions in world coal supplies or other emergency situations.

Just a few more important facts: Coal production is geographically dispersed among 27 states. All coal is mined by private companies. All ranks of coal -- anthracite, bituminous, subbituminous and lignite -- are produced and exported, with the exception of lignite. There are over 4,000 surface and underground mines, many of which have the highest productivity among comparable mines anywhere in the world.

The U.S. coal industry has repeatedly proven its ability to meet surges in demand in international coal trade. In 1980, 1981, and 1988 and again this year, U.S. exporters are supplying coal to meet higher than expected increases in steel production and electric power demand, and to cover production shortfalls in other exporting countries. U.S. coal exports are up 14 percent for the first 7 months of 1989 as compared to 1988. And this happened despite the much publicized, but relatively minor, labor disruptions experienced this year. This performance shows that the U.S. coal industry is a very reliable supplier of a broad range of quality coals, a capability not matched by any other major coal exporting country.

I also want to stress that the U.S. coal industry is making great strides in improving its international competitiveness. The work force has been reduced by over 80 thousand workers, or roughly 35 percent, since 1980, and worker productivity increased over 70 percent during the same period. Our railroads have also vastly improved their operations, and together the railroads and coal producers have aggressively sought new markets and additional market share in existing markets.

Currently, about two thirds of our exports are high quality metallurgical coal for steelmaking, with the remainder being steam coal used primarily for power generation. About 60 percent of the met coal sales are under long term contract, while only 10 to 20 percent of the steam coal tonnage is shipped under long term contract. So approximately 40 million metric tons of our metallurgical and steam coal exports are short term or spot sales. The U.S. supplies more short term and spot export sales than any other coal exporting country, which demonstrates that our industry has the flexibility to meet the demands of even the largest coal consumers in major coal importing countries.

A very important factor in the ability of U.S. coal exporters to increase coal exports on a sustained basis or to meet surges in demand is the fact that the coal terminals at our major ports have an estimated excess capacity of over 100 million metric tons. In sharp contrast is the fact that no other coal exporting country has any appreciable excess coal terminal capacity.

However, I do feel compelled to add a cautionary note. While we are proud of the U.S. coal industry's ability to meet flexible demand, at the same time foreign buyers should not take for granted that this excess exporting capacity will remain available. Economic facts are that world coal prices on average are less than full cost recovery making it unlikely that a large idle exporting capacity will stay in place indefinitely. The assurance needed to keep U.S. export surge capacity in place is for foreign buyers to commit a part of their current coal requirements to long-term contracts with U.S. coal suppliers, or make investments in the U.S. industry.

Now, let me turn more specifically to the policy of the U.S. government regarding the exports of coal. This policy has its genesis in 1981 when the former Secretary of Commerce Malcolm Baldrige announced a National Coal Export Policy. The policy was designed to expand the worldwide use of coal by assuring secure and reliable supplies of U.S. coals for the world markets.[1] In 1988 the Secretary of Commerce, C. William Verity, reaffirmed the

---

[1] Administration's Coal Export Policy Statement, U.S. Department of Commerce, July 17, 1981.

1981 National Coal Export Policy in his report on the conclusions and findings of the Federal Coal Export Commission.[2]

If I may digress for a few minutes, I believe it would be of interest to you to note the basic conclusion and recommendation that the Federal Coal Export Commission made to the President and Congress of the United States. First, the Commission, chaired by the Secretary of Commerce, was composed of 30 members, ten members from various U.S. government agencies, and twenty members from the private sector representing coal producers, organized labor, transporters, and financial institutions. Obviously, the Commission represented very diverse interests.

Despite the wide differences in views that the Commission held regarding most issues affecting U.S. coal in international coal markets, it did unanimously conclude the following which I quote from the Commission's report:

> "The Commission has been especially aware of the important role coal exports play in our trade relationships with many countries, not only in helping [balance] trade accounts, but also in improving worldwide energy security. To increase the contribution U.S. coal can make in both these areas, the Commission recommends that the private sector and the federal and state governments explore every opportunity to expand the use of coal worldwide and to enhance the capability of the U.S. coal industry to compete in international trade."

I think that the Commission's report is more than just a reaffirmation of the 1981 National Coal Export Policy. It concludes that this policy is soundly based on economic and geopolitical principles that can lead to achieving the objective of increasing the role of U.S. coal in world trade.

This now brings me back to my earlier promise that I would outline some of the specific activities and initiatives that the International Trade Administration undertakes as the lead agency to implement the National Coal Export Policy.

Without too much detail, our main activities are:

1) We participate in bilateral energy consultations to encourage foreign governments, particularly those vulnerable to oil supply disruptions, to increase their coal use and to promote long-term commitments to U.S. coal suppliers in order to assure a reliable and economic supply.

---

[2] Report of the Federal Coal Export Commission, United States Department of Commerce, Washington, DC, May 1988.

2) We participate in the efforts of multilateral organizations, mainly the General Agreement on Tariffs and Trade known as GATT, the Organization for Economic Cooperation and Development or OECD, and the International Energy Agency or IEA. We press in these organizations for countries with uneconomic coal industries to eliminate protectionist measures that restrict imports of coal.

3) We provide advice, counsel and assistance to U.S companies seeking export sales of steam and metallurgical coals. We constantly monitor coal export opportunities and market developments through our Foreign Commercial Service officers located in more than 60 foreign embassies and consulates.

4) We plan and organize educational and promotional activities, such as coal seminars and visits by foreign officials to coal mines and other industry infrastructure facilities.

5) We conduct studies to analyze the costs of mining coal in the United States compared to other major exporting countries and to provide a rational basis for development of policy options and legislation to improve the competitiveness of U.S. coal in international trade. For example, we have completed three country studies on Colombia, Canada, and Australia, and a study on South Africa is underway. We are also conducting a study of the costs of mining coal in countries which subsidize their coal industries.

6) We conduct policy analysis of legislative and regulatory proposals that would affect the competitiveness of the coal industry and develop appropriate policy options.

I would be remiss at this point if I failed to mention that we are also assisting the Department of Energy in promoting the international use of clean coal technologies. We are convinced that the key to expanding coal use worldwide is through technologies that convert coal to useful energy forms while producing the lowest feasible emissions of sulfur and nitrogen oxides, the so-called acid rain gases, and carbon dioxide, a greenhouse gas. Clean coal technologies can provide us with the necessary energy to support growth in the world's economy without degrading the environment.

In closing, I would like to underscore our willingness to assist foreign coal users in exploring the full potential of U.S. coal to meet their current and future demands. To our friends from the Pacific Rim countries and to the U.S. coal industry, let me say that we welcome the challenge -- indeed the obligation -- to increase the use of U.S. coal and strengthen our economic and energy security ties around the world.

E. ALLEN WOMACK, JR.
Vice President
Research and Developmem

Dr. E. Allen Womack, Jr., is a vice president of the Babcock & Wilcox company, responsible for the company's Research and Development and Contract Research Divisions.

Dr. Womack joined B&W in 1975 and has served the company in engineering, project, and business segment management responsibilities. He was named vice president of utility sales and marketing for the Power Generation Group in 1983 and moved to his present responsibility in 1985. Prior to joining B&W, Womack served with the U.S. Atomic Energy Commission and the U.S. Energy Research and Development Administration.

Dr. Womack holds bachelor's, master's, and PhD. degrees in physics from the Massachusetts Institute of Technology. Womack is author of technical papers and patents. He serves with a number of technical organizations including the Industrial Research Institute, the American Society of Mechanical Engineers' Industrial Advisory Board, Materials Properties Council's Board of Directors, and the American Management Association's R&D Advisory Council.

Babcock & Wilcox is a subsidiary of McDermott International, Inc., a leading worldwide energy services company. The company and its subsidiaries manufacture steam-generating equipment, defense products, tubular products, and process control systems. They also provide engineering and construction services for industrial and utility facilities onshore, and to the oil and gas industry offshore.

Technical Paper

United States Clean-Coal Technologies

E. Allen Womack, Jr., Vice President
The Babcock & Wilcox Company
Research and Development Division
Alliance, Ohio

Presented at the
Asia-Pacific Coal Technology Conference
Honolulu, Hawaii

November 15, 1989

Babcock & Wilcox
a McDermott company

RDTPA 89-50

United States Clean-Coal Technologies

E. Allen Womack, Jr., Vice President, The Babcock & Wilcox Company
Research and Development Division, Alliance, Ohio 44601

Presented to Asia-Pacific Coal Technology Conference
Honolulu, Hawaii, November 15, 1989

RDTPA 89-50

ABSTRACT

Babcock & Wilcox (B&W) is a member of the United States Clean-Coal Technology Coalition — a group of 87 U.S. companies and organizations dedicated to the increased production and utilization of U.S. coal in the most economical and environmentally acceptable manner. The coalition members include producers of coal, electric utilities, manufacturers, architect engineers, state governments, industrial and nonprofit associations, universities and colleges. This paper provides an overview of clean-coal technologies and examples of state-of-the-art environmental control systems now in development.

INTRODUCTION

History has shown that the use of energy in all its forms has gone hand in hand with economic growth. As we work to improve our living standards worldwide, we can anticipate the continuing growth in demand for energy to power our factories and light our homes (Figure 1, Reference 1).

In the United States, coal is our most plentiful fossil fuel. We rely on it to generate more than 50% of the electrical power we use and to produce industrial steam as well. Worldwide, coal plays a similar role. The available reserves are large (Figure 2; Reference 2), and use of coal is expected to grow with increased energy demand.

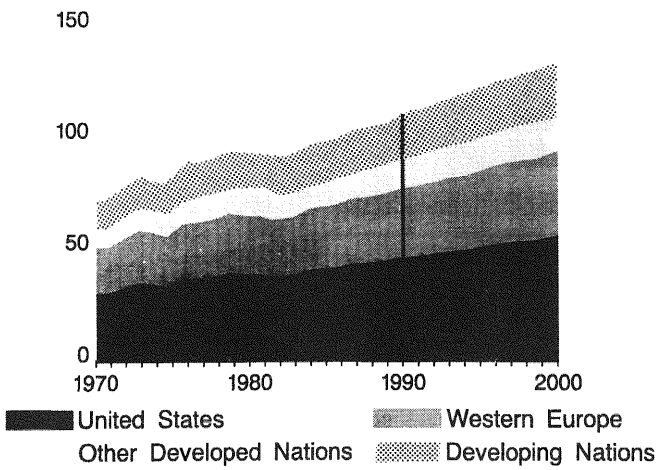


Figure 1. World energy demand, equivalent to millions of barrels of oil per day. (Source: Conoco World Energy Outlook 1989.)

Country/Region	Millions Of Tons
China	730,700
USSR	241,000
North America	222,207
Other CPE's*	92,281
Australasia	91,059
Western Europe	74,073
Other Asia	67,949
Africa	62,910
Latin America	15,608
Middle East	193
Worldwide Total	1,597,980

*Centrally planned economies

Figure 2. Worldwide proven recoverable coal resources, 1987. (Source: World Energy Conf. 1989; Survey of Energy Resources.)

Clearly, it is important to all of us to be able to increase our use of this excellent energy resource in a manner both economical and environmentally safe.

In recent years, concern has grown about the effects on the environment of certain of the gases formed when coal is burned to produce energy. In particular, attention in the United States has focussed on the effects of the oxides of sulfur, or SO_x, and the oxides of nitrogen, called NO_x. A typical 500-MW_e boiler burning a bituminous coal mined in the eastern U.S.

will release some 80,000 tons per year of SO_x to the atmosphere and some 15,000 tons per year of NO_x as NO_2 (Figure 3). These SO_x and NO_x emissions are thought to play a role in forming acid rain.

The coal reserves of many of the major producing countries contain substantial quantities of sulfur (Figure 4, References 2 - 4). It is important to have technology that will allow this coal to be used in an environmentally safe way.

CLEAN-COAL OVERVIEW

Technologies have been developed to reduce the quantities of SO_x and NO_x released to the atmosphere. These technologies fall into four broad categories:

- Precombustion
- Advanced combustion
- Advanced postcombustion
- Conversion

A general overview of each of these technologies follows, along with some examples of new developments [5].

Precombustion Technologies

Precombustion technologies (Figure 5) are often called "coal cleaning." A third of the coal burned today in U.S. power plants is cleaned. Conventional cleaning extracts the heavier forms of mineral matter and reduces sulfur by 10% to 30%.

Advanced physical cleaning technologies include several processes with the potential of removing up to 65% of the total sulfur in certain coals. In many

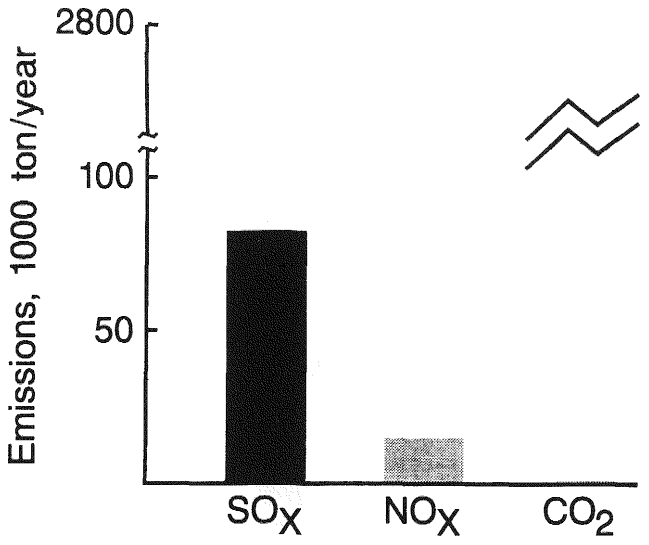


Figure 3. Selected coal-fired boiler emissions (1 - 500 MW eastern bituminous coal boiler).

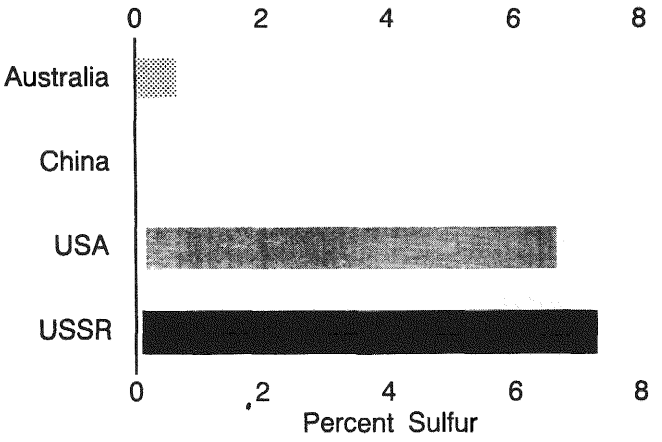


Figure 4. Coal sulfur content from selected producing countries.

cases, these new technologies rely on finely grinding the coal. Chemical coal cleaning, another advanced cleaning concept, has the potential to remove more than 90% of the sulfur and 98% of the coal ash. These processes are effective but so far too expensive for commercial use.

A relatively new concept in coal cleaning involves the use of micro-organisms that remove the sulfur. This technology ultimately may provide a low-cost process that produces an unaltered, highly cleaned coal.

Combustion Technologies

Several new advanced combustion processes (Figure 6) are now coming into demonstration or early use. Perhaps the best known of these is fluidized-bed combustion. These systems burn coal particles while they are "floating" in a "bed" of inert material suspended by upward-blowing air jets (rather than being swept rapidly through the combustion zone as in a conventional pulverized-coal boiler).

When limestone is used as the bed material, it absorbs 90% to 95% of the sulfur dioxide (SO_2) released from the burning coal. The reaction produces a dry solid waste that can be removed with the ash. Because these systems burn cooler than conventional combustors, they inhibit the formation of thermal NO_x. They can be designed to operate at atmospheric pressure or under pressurized conditions.

Several types of advanced and modified combustors are being tested. These include modifications to conventional coal burners that can reduce NO_x substantially at a modest cost. Other modified burners, such as a slagging combustor, seek to reduce SO_x.

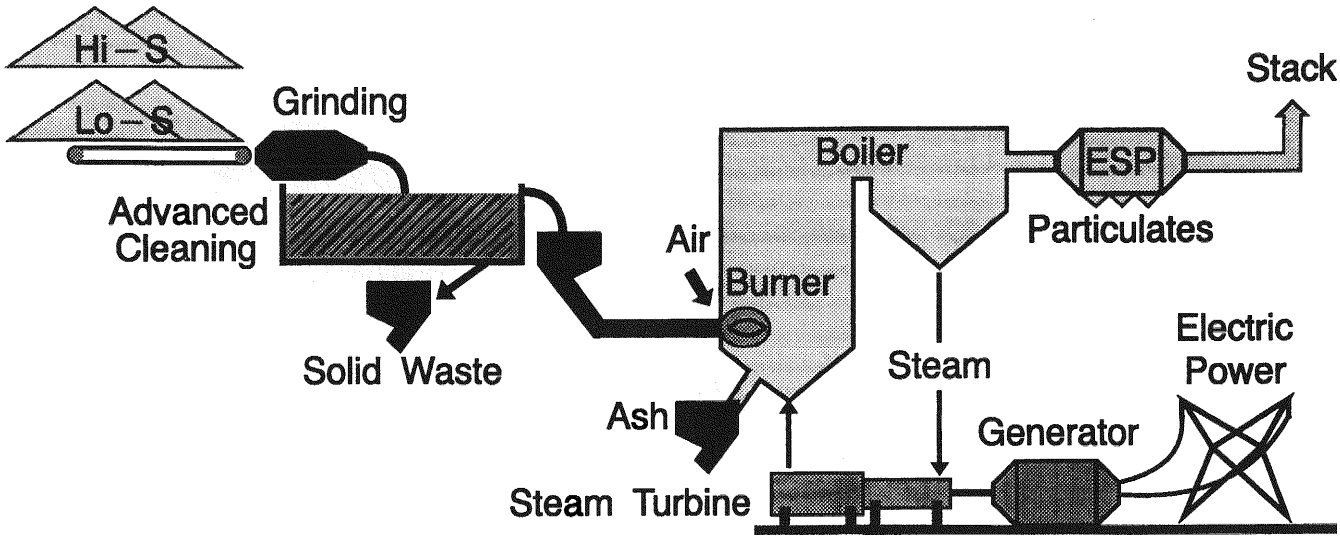


Figure 5. Advanced (precombustion) coal cleaning.

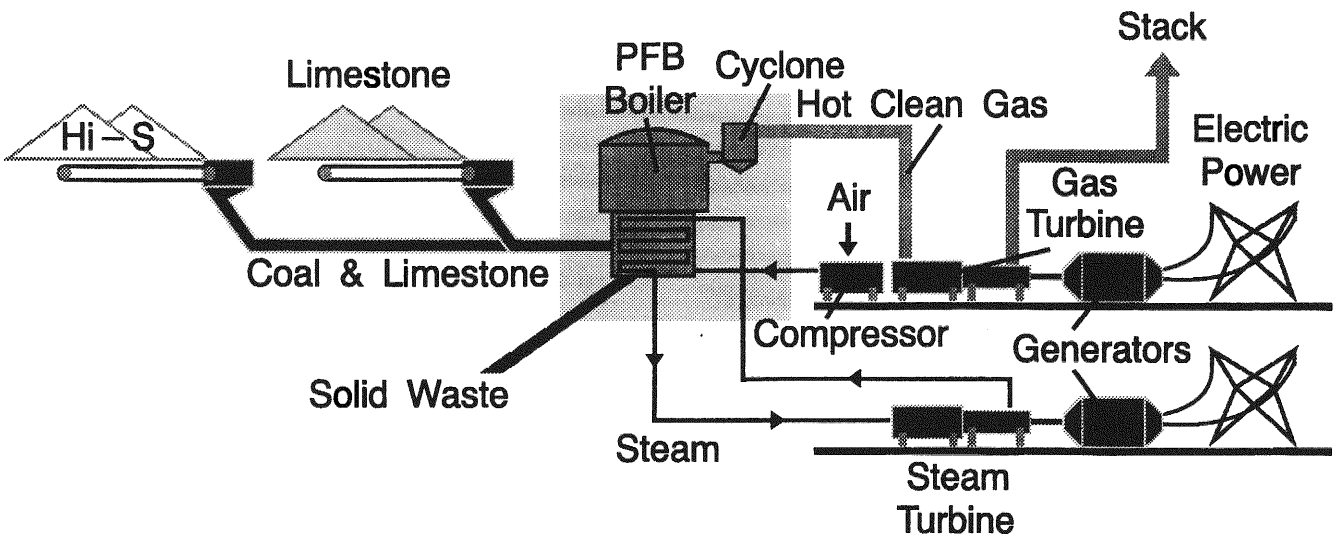


Figure 6. Advanced combustion process.

A special modification of the boiler where lime is injected directly into the furnace is called LIMB (limestone injection multistage burner). The lime reacts directly with the gaseous SO_2 to produce solid calcium sulfate, which is collected with fly ash downstream in existing particulate-collecting equipment. SO_2 emissions can be reduced by 50% to 60%, and when combined with low-NO_x burners, NO_x emissions can also be cut by 50%.

Reburning, a new NO_x-control option, injects some fuel (15% to 30%) above the normal combustion zone to form an oxygen-deficient condition. Here, NO_x produced in the lower regions of the furnace is "reburned" and converted to molecular nitrogen. Additional air is then introduced to complete the combustion process.

Postcombustion Technologies

Postcombustion technologies (Figure 7) have received great interest in recent development. A variety of special retrofit technologies are being developed to make partial use of existing hardware to remove SO_x and NO_x where possible to minimize capital costs. In addition, new generations of wet scrubber systems are

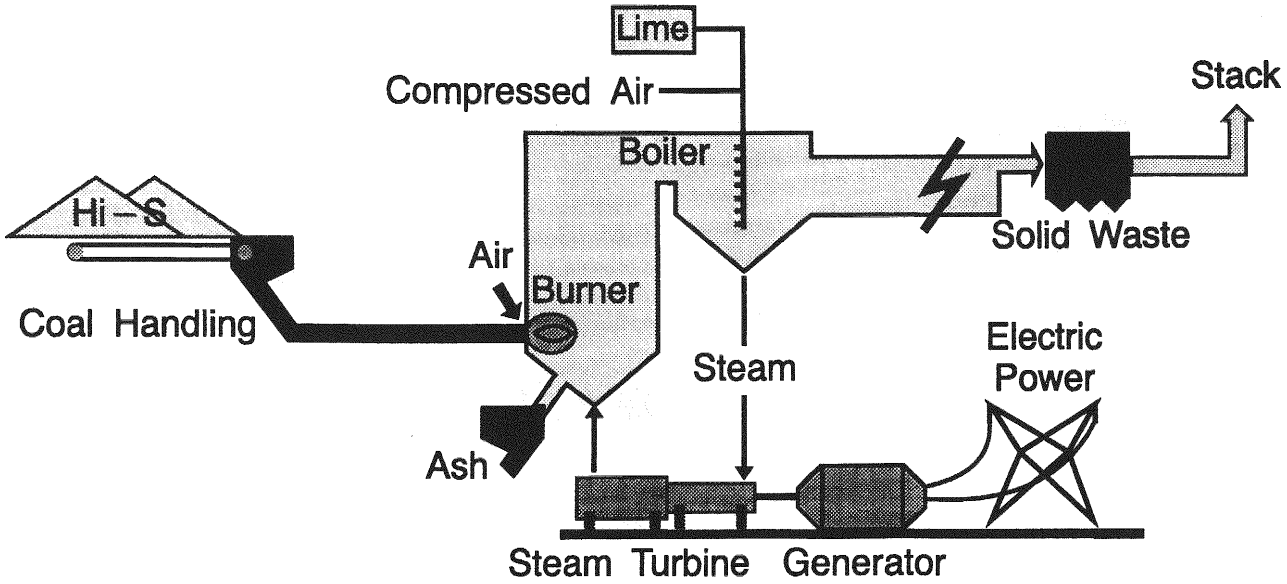


Figure 7. Advanced postcombustion process.

being developed that also combine SO_x and NO_x removal and produce more benign and easily managed waste.

A number of systems are being developed for application in existing and new units. For example, the technique of in-duct sorbent injection is receiving considerable attention. In this extension of dry-scrubber technology, sorbents are sprayed into the ducts carrying flue gas out of the coal boiler. By carefully controlling the humidity of the flue gas and the spray pattern of the sorbent, 50% to 70% of the SO_2 can be removed. The reaction produces dry particles that can be captured in downstream particulate-collecting devices. Since a plant's existing ductwork is used (eliminating the need for extensive new construction), in-duct injection could be very attractive for older power plants. The technique can also be used in new facilities, either alone or in combination with other cleaning techniques. It is also particularly suited for application with coals containing lower amounts of sulfur.

Conversion Technologies

Conversion technologies (Figure 8) bypass or eliminate the direct coal combustion process altogether. Instead, coal is converted into a gas or liquid form that is then cleaned before use.

Integrated gasification combined cycle links gasifiers to a combined-cycle arrangement of gas and steam turbines. This configuration can potentially achieve thermal efficiencies in the range of 40% to 45%. In the gasification process, the sulfur in the coal is converted almost entirely to hydrogen sulfide, which is then recovered. Techniques are being developed to remove 99% of the sulfur released from the coal. Several other conversion technologies are under development or study. Among these are manufacturing of coal liquids as slurries with oil or water.

TODAY'S STATE OF THE ART

There are a number of so-called state-of-the-art technologies — those that are in fairly wide use today and readily available for coal-fired units of virtually all sizes. These technologies consist of physical coal cleaning, flue gas scrubbing, atmospheric fluidized-bed combustion, and NO_x reduction using a catalyst in the flue gas stream.

Physical Cleaning

The physical coal-cleaning process extracts the heavier forms of mineral matter such as ash and pyritic sulfur. Since the coal is lighter than the ash and pyrite, it can be essentially "floated" and thereby separated, as shown in this diagram of a froth flotation system (Figure 9). Since none of the organic sulfur can be removed by this method, total sulfur reduction by state-of-the-art systems ranges from 10% to 30%.

Wet scrubbing

Wet scrubbing of flue gas is in widespread use; B&W has installed approximately 10,000 MW_e of these systems. They are effective and reliable, regularly providing sulfur removal of more than 90%.

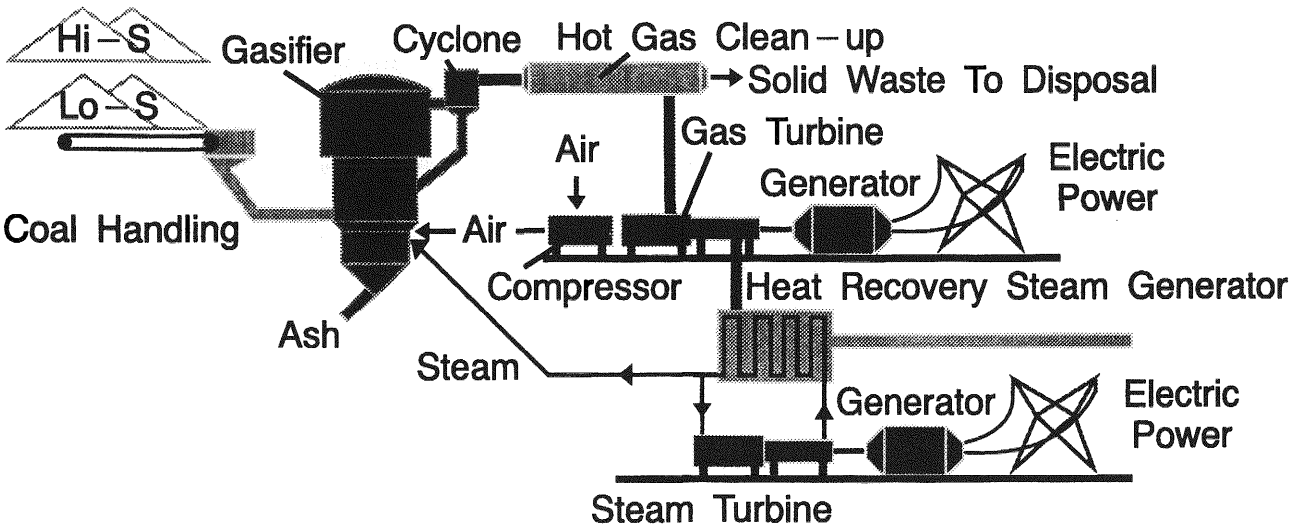


Figure 8. Conversion process.

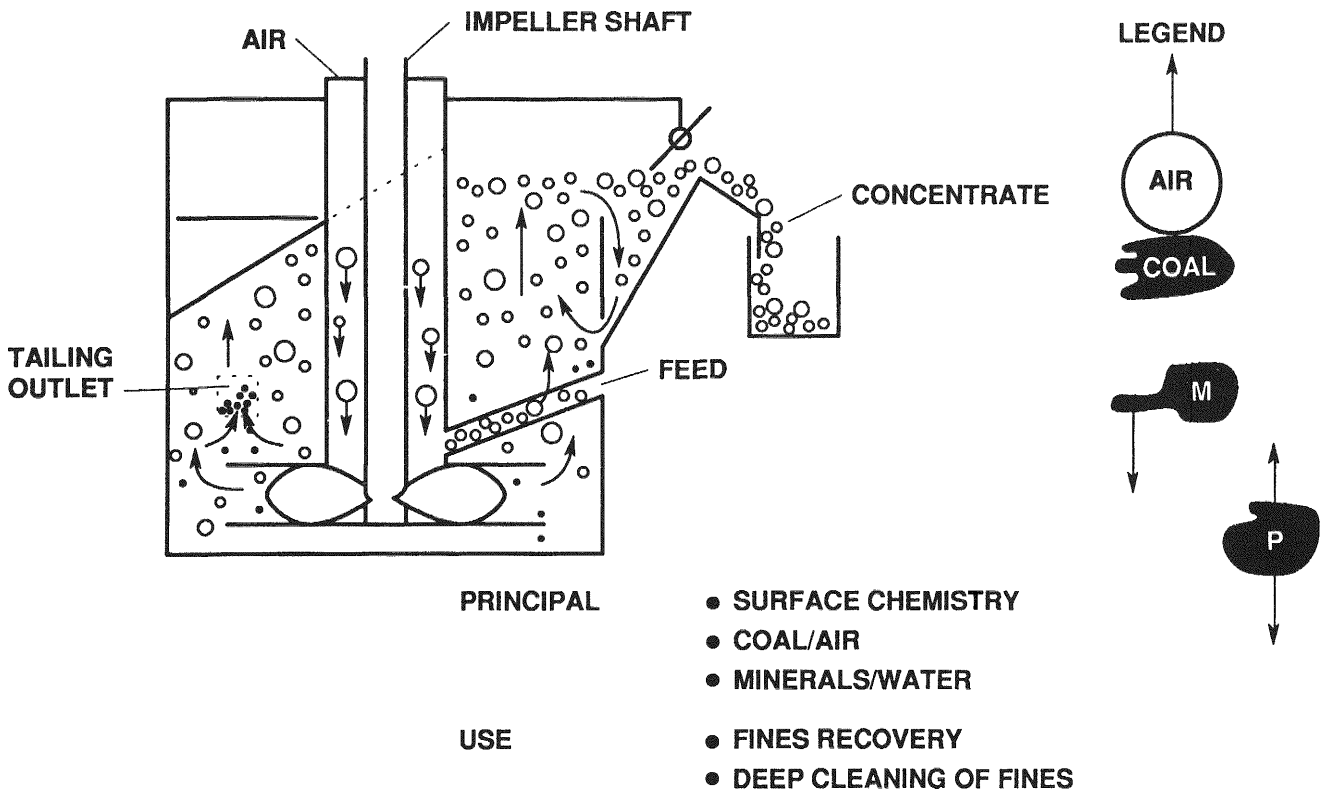


Figure 9. Froth flotation process.

They work by spraying a mixture of sorbent and water through the flue gas stream in a large chamber. Contact between the flue gas and the sorbent atoms in the slurry leads to capture of the SO_x from the flue gas. The resulting product is a slurry that is often subject to further processing.

Wet scrubbers are proven, and they are effective. Their principal drawbacks are their relatively high capital cost and the necessity to handle their liquid waste.

Dry Scrubbing

Such drawbacks have led to the development of the dry scrubber, a system that uses essentially the same chemistry but is arranged so that the droplets of slurry dry in the flue gas, and the residue is captured in dry form.

A number of dry-scrubbing systems are installed worldwide. The effectiveness of these systems is not as great as the wet systems, but they have the advantage of eliminating the need to handle liquid waste. Many of the advanced systems under development are based on the principles of the dry scrubber and are aimed at achieving low capital and operating costs with good SO_x capture.

Fluidized-bed combustion

Fluidized-bed combustion (FBC) has been under development for many years and now is coming into regular use. (Principles of FBC were discussed previously.) The state of the art for these systems today suggests their use as the combustor of choice for smaller systems, particularly where the coal is of lower quality. For these systems, FBC can offer advantages over the combination of a pulverized-coal combustor with a scrubber. Advanced development aims at increasing the power level at which fluidized-bed combustion is effective and increasing the efficiency. The pressurized, fluidized-bed-combustion (PFBC) system is one such approach; it is described later.

Selective Catalytic NO_x Reduction

The final example of current state-of-the-art systems is the selective catalytic reduction converter for NO_x. The chemical principle of these systems is illustrated in Figure 10. Ammonia is injected into the flue gas, and the resulting mixture is passed over a catalyst. The ammonia reacts with the NO_x in the presence of the catalyst to produce molecular nitrogen and water vapor. A number of these systems are installed worldwide. They are quite effective in reducing NO_x (70% to 90%) but are relatively expensive. The development of advanced systems focuses on improved cost effectiveness for NO_x reduction.

INNOVATION FOR TOMORROW

America is making a major investment in developing and demonstrating new, more effective systems for environmentally safe use of coal under the clean-coal program of the U.S. Department of Energy (DOE). Together, U.S. industry and government plan to spend

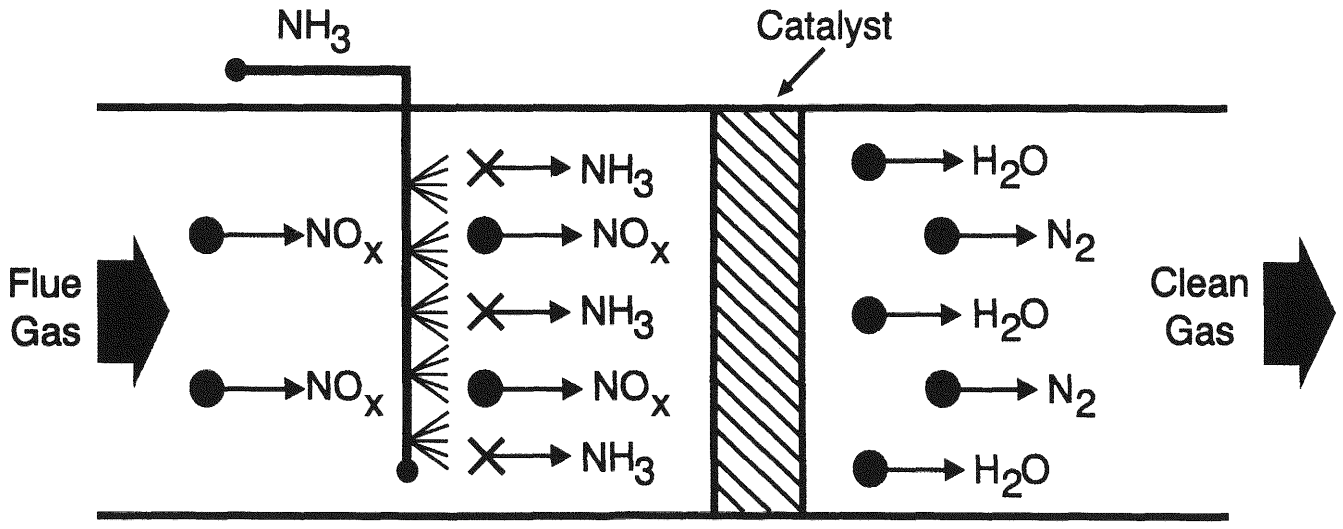


Figure 10. Principle behind process of removing NO_x.

more than $5 billion demonstrating the effectiveness of these technologies.

The first three phases of this program have already been announced, and more than 150 demonstration projects have been proposed. The nine phase-one projects chosen are already into implementation, and the 16 picked for phase two are in contract negotiations. The DOE intends to announce its choices for the third round of projects later this year. When this is done, projects costing more than $3 billion are expected to have been selected for demonstration.

This major program offers increased confidence to the entire world that coal can be used cleanly and economically. Here are a few examples of advanced-system demonstration projects that are part of the program [6 - 9].

Furnace sorbent Injection

One of the first of the innovative clean-coal concepts to be demonstrated is called limestone injection multistage burner (LIMB). This concept is designed especially for use on existing boilers, though it can be applied effectively on new systems, too (Figure 11).

SO_x capture is achieved by injecting a dry sorbent into the upper furnace where it mixes with the flue gas and reacts with the SO_2. Some moisture may be added by a humidification system in the flue gas duct to condition the fly ash and spent sorbent for more effective collection in the existing electrostatic precipitator. NO_x reduction can also be obtained by replacing the burners with units redesigned to produce a lower peak flame temperature using staged combustion to lower NO_x. The result is a reduction of greater than 50% in both SO_x and NO_x, with only a modest amount of new capital equipment added to the plant.

The LIMB demonstration project, located at Ohio Edison's Edgewater Station, was chosen in round one of the DOE clean-coal program and has already demonstrated NO_x reduction effectiveness and SO_x reduction of more than 50% with the injection of hydrated lime sorbent.

LIMB is destined to become one of the first of the innovative clean-coal technologies to move from the laboratory to an actual working system. Saskatchewan Power Corporation has chosen to use LIMB for SO_x reduction in its new 300-MW_e boilers for Shand Station, due to enter service in 1992.

E-SO_x

A second example of innovative clean-coal technology being developed today in the U.S. is based on dry-scrubber technology and is called E- SO_x (Figure 12). In this concept, a portion of an existing precipitator is used as the spray chamber. This is possible be-

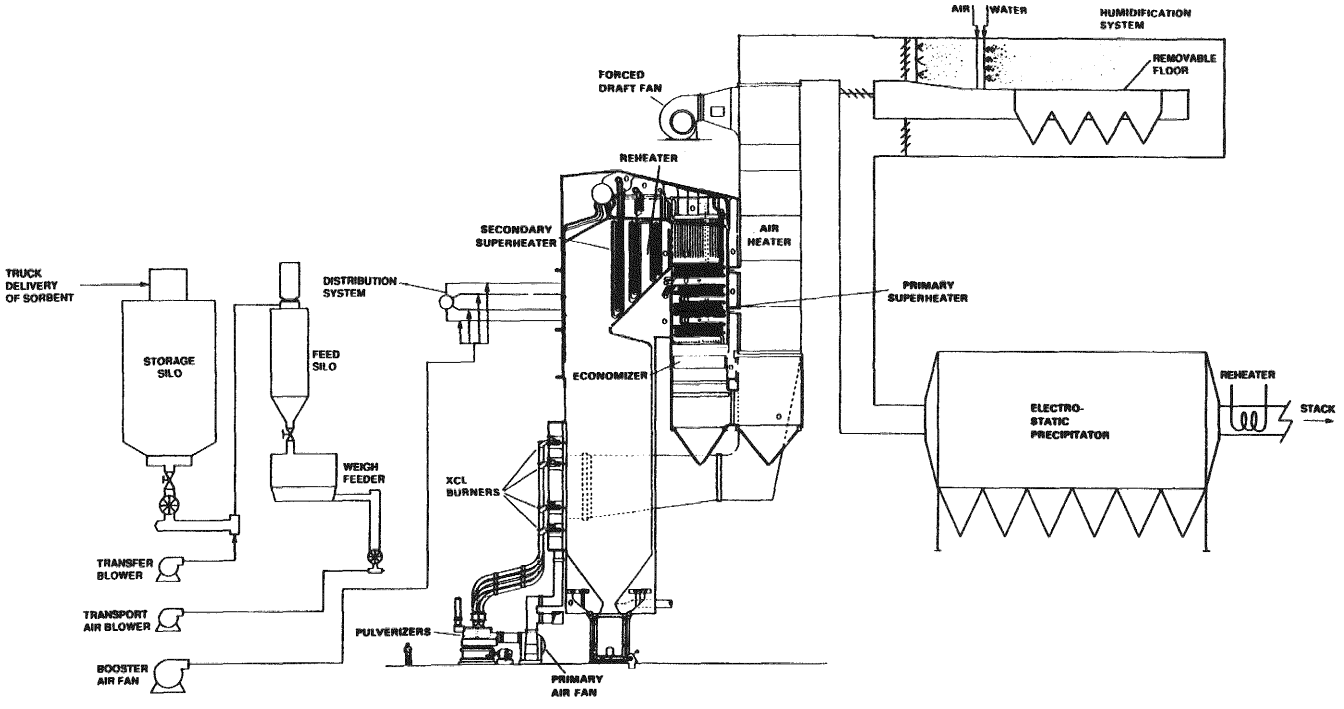


Figure 11. Schematic of limestone injection multistage burner (LIMB) demonstration.

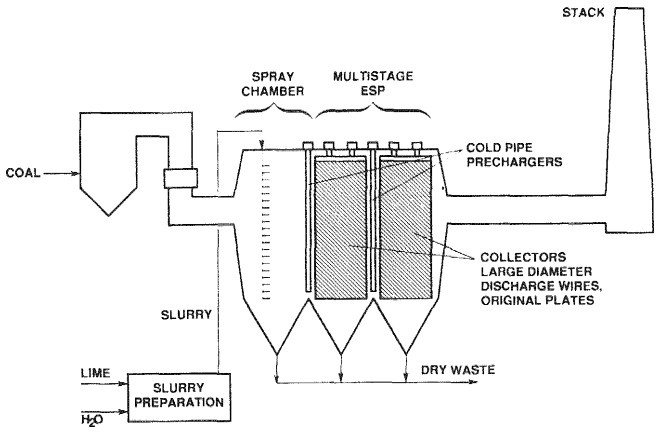


Figure 12. E-SO_x process.

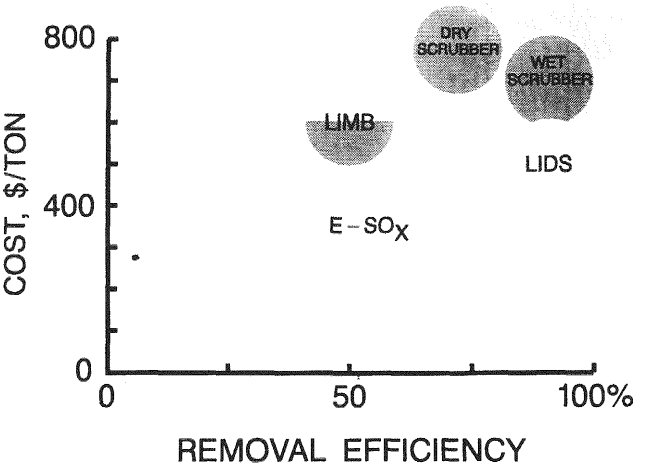


Figure 13. SO_2 control, removal efficiency versus cost per ton.

cause many precipitators have extra capacity, enabling some of the plates to be removed. The effectiveness of the remaining precipitator plates can be enhanced by special modifications.

The volume created by removing the first set of precipitator plates is used as a spray chamber for injecting a lime slurry. SO_x is captured by the lime in the slurry droplets, which then dry and are captured as dry particles in the back portion of the precipitator.

A pilot demonstration of the E-SO_x process is being carried out at Ohio Edison's R.E. Burger Plant. The pilot has met its objectives of better than 50% sulfur capture and, when tests are complete, it will be ready for full-scale demonstration.

ECONOMICS

LIMB and E-SO_x are examples of innovative retrofit systems under development. They offer effective capture of SO_x at a cost substantially lower than current state-of-the-art systems as measured by the cost per ton of sulfur removed (Figure 13).

Similar cost improvements are being forecast for innovative NO_x-control systems under development (Figure 14). In addition to lower cost per ton of sulfur removed, these systems also have a reduced capital cost, which can be very important for many applications (Figure 15). B&W believes that no single concept is going to be best overall for every boiler and every requirement worldwide. We intend to demonstrate a range of technologies for SO_x control; these can be applied alone or in conjunction with other measures to achieve effective control at the lowest possible cost.

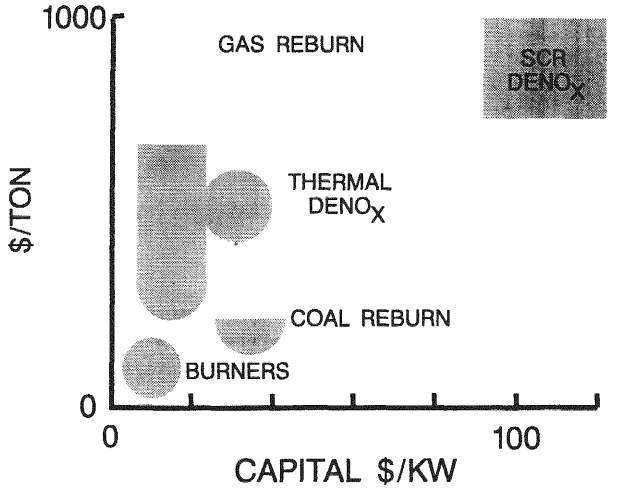


Figure 14. NO_x control, capital cost per KW versus cost per ton.

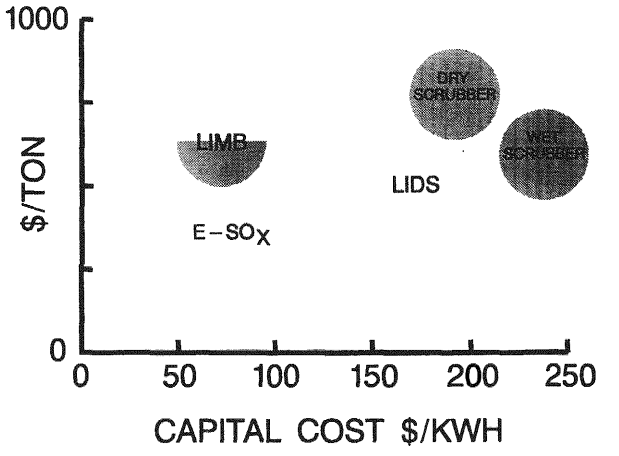


Figure 15. SO_2 control,capital cost per KWH versus cost per ton.

COMBINED SO_x/NO_x CONTROL

SOx NOx ROx BOx

Some of the innovative systems under development seek to achieve SO_x and NO_x control through a single system. One is called the SOx NOx ROx BOx. It derives its name from the fact that it operates within a single enclosure (a box) to capture particulate matter ("rocks" or ROx), sulfur dioxide (SO_x), and oxides of nitrogen (NO_x). The principle is shown in Figure 16.

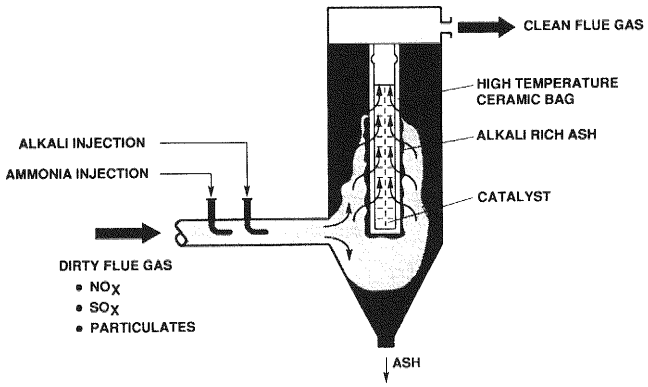


Figure 16. SOx ROx NOx BOx seeks to control SO_x and NO_x in one system.

The system operates at high temperature near the exit of the boiler's economizer. Alkali sorbent is injected into the flue gas where it absorbs SO_x in the manner previously described. The dry residue from this injection is captured along with the fly ash on the surface of high-temperature filter bags.

NO_x removal begins with the injection of ammonia. The conversion of NO_x is catalyzed by material placed after the bags in the stream. It is particularly effective here, because the SO_x and particulate matter, which sometimes act to reduce the life of catalyst, have already been removed.

Because the cleaning system operates at high temperature, it is placed before the boiler's air heater. This means that the hot flue gas stream entering the air heater has already been cleaned of SO_x, NO_x, and particulate matter. This will allow the air heater to be designed to remove more heat, since the minimum flue gas exit temperature will no longer be restricted to avoid acid condensation. As a result, overall efficiency of the boiler system can potentially be improved, in contrast to other cleaning systems, which normally reduce available power generation. And since the stream is cleaned of particulate, air heater design can be more efficient, with less concern for particle fouling.

Laboratory pilot work for this system has been done. The objectives of capturing 90% of SO_x and 90% of NO_x have been shown to be reasonable.

The concept has been chosen for pilot-scale demonstration as part of the second round of the DOE clean-coal program. The demonstration will be carried out on a 5-MW_e-equivalent flue gas slipstream at Ohio Edison's R.E. Burger plant. Since the technology is highly modular, this demonstration should provide enough data for scale up to much larger applications.

Pressurized fluidized bed

The demonstrations underway for the pressurized, fluidized-bed-combustion system, or PFBC, represent the the last example of new clean-coal technology discussed here. This system combines the environmental advantages of atmospheric FBC with the efficiencies of a combined-cycle turbine-boiler plant. (See Figure 17, which represents the repowering of American Electric Power's Tidd Station.)

Combustion of the coal takes place in a fluidized-bed combustor operated within a pressure vessel at an elevated pressure, typically 10 bar. The pressurized system is a more efficient combustor, allowing components to be much smaller than for an equivalent atmospheric system.

The hot exhaust gas from the combustor is cleaned of particulate and used to drive a gas turbine. Its mechanical energy is used to generate electricity and to compress air for the combustor.

The remaining energy from the exhaust gas is extracted by a conventional steam cycle, which also extracts energy directly from the combustor through heat

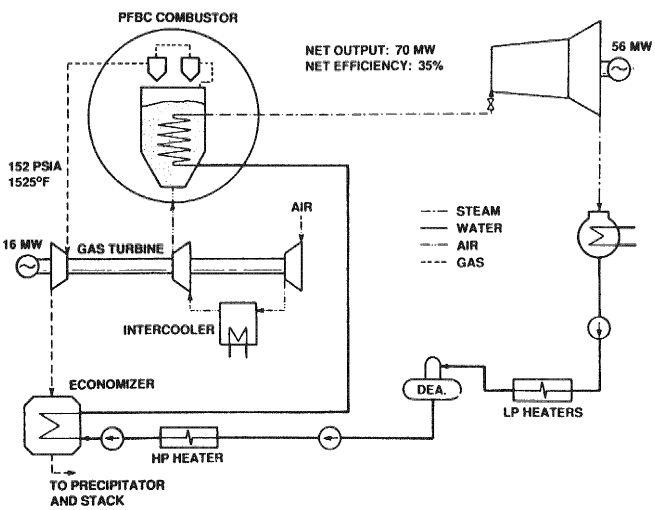


Figure 17. Schematic of pressurized fluidized-bed combustion system.

transfer surface in the bed and walls. The steam turbine in this cycle produces more electricity, for a total energy conversion efficiency expected to exceed 38% in advanced systems.

First units of this concept are being built today in the U.S. and in Sweden. The initial demonstration site in the U.S. is American Electric Power's Tidd Station. This is an older station in Ohio; its boiler system will be replaced with the PFBC system. It is a 70-MW_e demonstration and is expected to achieve a thermal efficiency of 35%, with very low emissions of SO_x and NO_x. The unit will begin operation next year.

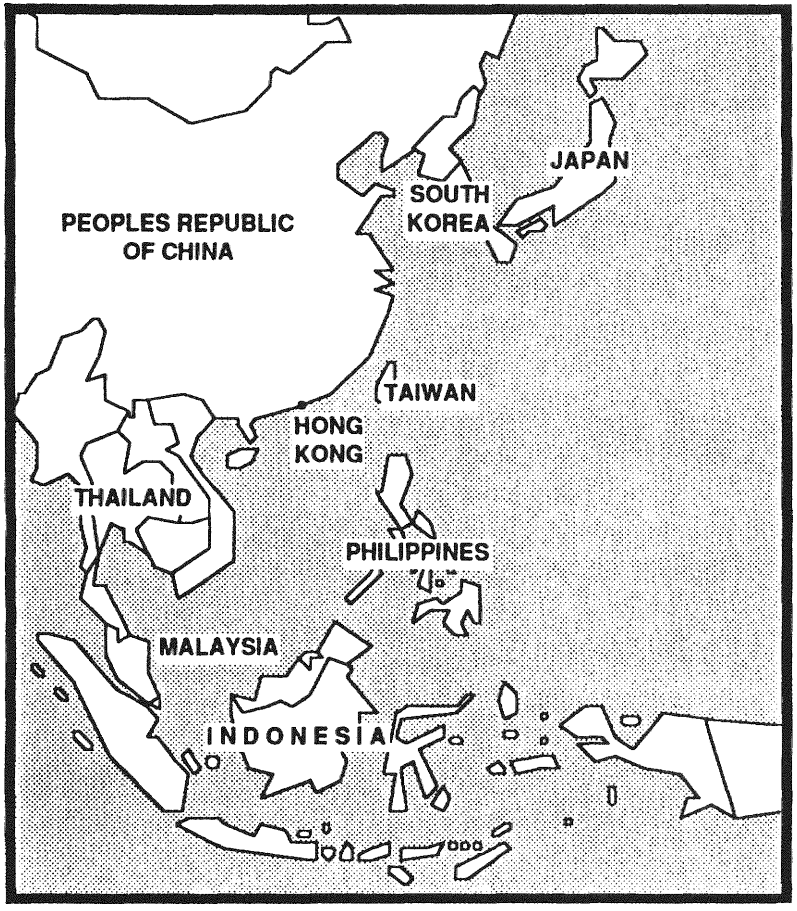
Even as construction is being completed on the Tidd PFBC demonstration project, a larger PFBC repowering project is being proposed. The project is being considered for American Electric Power's Sporn Plant and would have a total generating capacity of 325 MW and a thermal efficiency in excess of 38%. AEP and its industrial partners, along with the DOE and the Ohio Coal Development Office, would plan to invest nearly $580 million in this repowering project alone.

THESE EXAMPLES show that we are very serious about providing improved options for the environmentally safe use of coal. We are optimistic and enthusiastic about our future ability to continue to enjoy the economic benefits of coal-fired power generation while protecting our environment.

REFERENCES

1. *World Energy Outlook Through 2000,* Conoco Inc., a DuPont subsidiary, Houston, Texas, 1989.
2. *1989 Survey of Energy Resources,* World Energy Conference, London, U.K.
3. *Combustion Fossil Power Systems,* J.G. Singer, Ed., Combustion Engineering, Windsor, Conn., 1981.
4. *Steam: Its Generation and Use,* 39th Edition, Babcock & Wilcox Co., Barberton, Ohio, 1978.
5. Clean-Coal Technology Coalition Briefing Materials, Washington, D.C., 1989.
6. J.B. Doyle, J.M. Rackley, and J.S. Kulig, "Babcock & Wilcox Clean-Coal Program," *Proceedings of the 1989 American Power Conference,* Vol. 51, to be published.
7. J.B. Kitto, A.D. LaRue, and J.S. Kulig, "Coal-Fired NO_x Emission Control Technologies," *Proceedings of the Sixth Pittsburgh Coal Conference,* University of Pittsburgh, 1989, pp. 405-414.
8. "LIMB Demo Advanced Retrofit Technology for SOx/NOx Removal," *Power,* Vol. 133, No. 4, April 1989, pp. 57-59.
9. J.B. Kitto, The SOx NOx ROx BOx Uses Hot Catalytic Scrubbers," *Modern Power Systems,* January 1989, pp. 24-25.

PACIFIC BASIN COAL TRADE ISSUES



Innovative/Alternative Transport Modes for Movement of U.S. Coal Exports to the Asian Pacific Basin

ASIAN PACIFIC BASIN UTILITY COAL SUPPLIES BY SOURCE

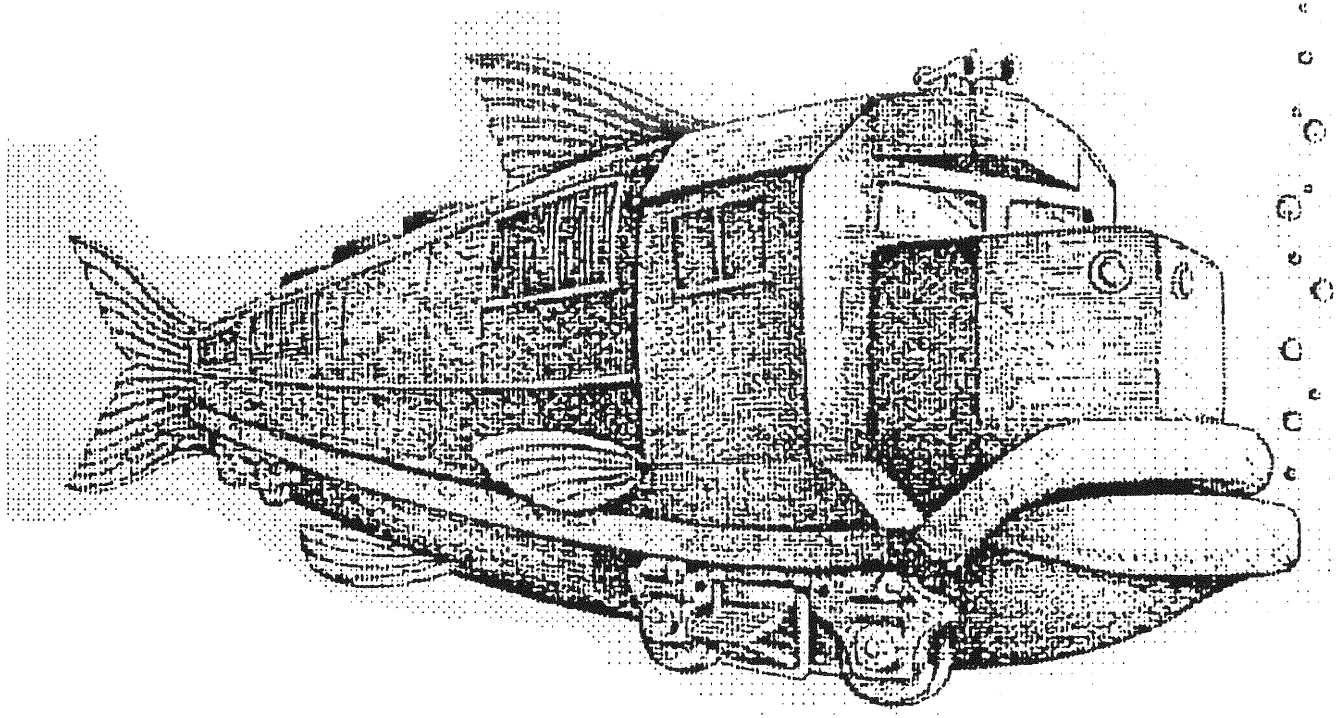
	Delivered Price (U.S. $/MBtu)	
	1987-1988	1988-1989
Australia	1.55-1.73	1.82-2.05
South Africa	1.50-1.55	1.66-1.88
Canada	1.48-1.79	1.86
China	1.09-1.43	1.44-1.61
Indonesia		1.59
U.S.S.R.		
- Chernogorsky		1.75
U.S.		
- Cyprus	1.92	
- Utah		1.88

COAL PRICE DELIVERED TO THE ASIAN PACIFIC BASIN (Currently and Hypothetically)

Current Coal Suppliers	Delivered Price ($/MBtu)
Australia	1.82-2.05
South Africa	1.66-1.88
Canada	1.86
China	1.44-1.61
Indonesia	1.59
U.S.S.R.	1.75
U.S. (Utah)	1.88

Transportation Study Scenarios	Estimated Delivered Price ($/MBtu)
Powder River Basin	
- Coal	1.78-2.04
- CWF	2.54-3.04
Utah	
- Coal	1.84-2.20
- CWS	2.05-2.13
- CWF	2.62-2.82
Four Corners	
- CWS	1.90-1.99
- CWF	2.41-2.73
Alaska	
- Coal	2.12-2.41
- CWF	4.41-4.48

INNOVATIVE TRANSPORT MAY MAKE THE DIFFERENCE FOR U.S. COAL EXPORTS TO THE ASIAN PACIFIC BASIN



HENRY J. BROLICK
Vice President
Williams Technologies, Inc.

Summary

More than twenty years experience in corporate management and operations, project administration; slurry engineering; and pipeline feasibility, design, construction and operations.

Abbreviated Professional Experience:

Present	Executive Vice President, Williams Technologies, Inc. Executive management of Black Mesa Pipeline, Inc.; and supervision of technical and economic evaluations of WTI and client sponsored projects.
1983-1984	Vice President, Operations, Tamny Corporation Technical and administrative supervision of projects involving an automated, advanced oil in water emulsion recovery system of crude and refined oils from storage tanks, barges and disposal pits.
1981-1983	Vice President, Operations, Spectral Enterprises, Inc. Management of a major truck transportation company in Michigan specializing in contract hauling.
1974-1981	Engineering Manager, Australia/Houston, Texas, Williams Brothers Engineering Company; Activities included project design and management of Caltex, Sydney to Newcastle products pipeline, Australian Gas Light natural gas pipeline, Moomba to Sydney, Gladstone Limestone Slurry pipeline, Petroperu N. Peruvian Crude Oil Pipeline.
1968-1981	Pipeline Engineer and Transportation Planning, Shell Oil Company Activities include all aspects of products pipeline design, construction management and operations, and planning and implementing and marketing activities.

Education:
B.S. Civil Engineering, Michigan State University
MBA Marketing, Michigan State University

Associations:
Vice Chairman of Coal & Slurry Technology Association
Board of Directors, Tulsa Cerebral Palsy Men's Auxiliary

PACIFIC RIM COAL TRADE ISSUES

INNOVATIVE TRANSPORT MODES

"Coal Slurry Pipelines"

Presented at

Asia-Pacific Coal Technology Conference
East-West Center
Honolulu, Hawaii
November 15-16, 1989

Presented by

H. J. Brolick
Executive Vice President
Williams Technologies, Inc.
320 South Boston Avenue, Suite 831
Tulsa, Oklahoma, U.S.A. 74103
(918) 582-5811

ASIA-PACIFIC COAL TECHNOLOGY CONFERENCE

Pacific Rim Coal Trade Issues
Innovative Transport Modes

"Coal Slurry Pipelines"

November 16, 1989

It is a privilege to present a scenario whereby an existing technology may offer opportunities for western U.S. coal exports. Coal Pipelines!

Obviously, innovations are necessary in the U.S.-Asia Pacific Basin (APB) coal chain for the U.S. to compete as a major coal supplier. Innovation often implies new and untested, untried, or unproven. Transportation of coal by pipeline is neither new nor untested. In fact, there is an impressive track record. Reliability has been unsurpassed and long term cost savings have been confirmed.

(Slide 1)

Before moving into my discussion of slurry pipelines and U.S. coal export opportunities, we need to review the coal pipeline technologies available; in other words, what is in our bag of tricks. Also, we need to review the terminology necessary to understanding the different slurry technologies.

Conventional Slurry Pipelines ship coal in a liquid medium. The coal and liquid medium are separated at the pipeline terminus. After further grinding, the coal is then burned as a typical coal product. Coal water slurry (CWS) pipelines ship coal at a ratio of roughly 50/50 coal and water by weight. The slurry moves along the pipeline at 5-6 feet per second in turbulent flow. The pipeline can be shut down safely in slurry for short durations. Under normal circumstances, a water flush is used to displace the slurry for any planned shutdowns.

Other liquid media that fall into the "conventional slurry" category, could be liquid carbon dioxide and methanol. During the period 1984 to 1986, our company, Williams Technologies, Inc., worked on a liquid CO_2 coal slurry pipeline from the Powder River Basin (PRB) to Los Angeles. This slurry concept provides a set of economics in which both the coal and the liquid

medium are salable commodities. After separation from the coal, the carbon dioxide could be used for enhanced oil recovery; and in the project I mentioned, it was to be used in the Los Angeles Basin. Unfortunately, the drop in oil prices in the spring of 1986 caused us to shelve this project for the time being. I will discuss coal methanol slurries later on in this presentation.

The second type of slurry is Coal Water Fuels (CWF). Let's first define coal water fuels as a mixture of coal and water which can be direct-fired. The coal and water, with about 1% surfactants and dispersants, form a stable slurry. The weight percent of dry coal will vary from 60% to 75% depending on the coal type. The Btu content of a coal water fuel will range from 6,000 to 8,000 Btu per pound, depending on the coal quality. Viscosities of coal water fuels will range from 500 to 1500 centipoise. This compares to a CWS at less than 30 centipoise. For pipeline transportation to be efficient, a maximum of 500-700 centipoise is essential. This is possible according to a number of CWF suppliers.

Coal water fuels are thixotropic, which means that their viscosity will decrease as the flow rate increases. Accordingly, special design considerations for pipeline start-ups is essential. CWF will move in a laminar flow regime, at 2-4 feet per second. It is important to note that the stability of the slurry will allow pipeline shutdown and therefore greater flexibility of operation than for a coal water slurry pipeline.

Coal Oil Fuels: These slurries contain coal mixed with a hydrocarbon and stabilizing additives. While there was a substantial amount of burn test work carried out by two Florida utilities, until the price of oil dropped in 1986, we do not envision that the coal oil mixtures would be a potential export project from the U.S., except for one special case. That would be the possibility of coal methanol fuel (CMF), which will be discussed later.

Coarse Coal: Coarse coal shipped in pipelines is by brute force at high velocity, causing high wear rates within the pipeline. We do not envision this as feasible for long distance coal transport. Both the power requirements and pipe wear are too great. There have been advancements in the study of shipping lump coal in a fine coal slurry, using the fine coal slurry as a

carrier. However, that work is still in the proof-of-concept phase and is not a part of this report.

(Slide 2)

Let me briefly review the success story of coal slurry pipelines within the U.S. In March of 1957, the Consolidation Coal Pipeline began delivering coal from Cadiz, to Cleveland, Ohio, supplying Cleveland Electric Illuminating's Eastlake Station. This was a 108-mile pipeline which operated successfully for six years, transporting seven million tons of coal. In fact, it is generally well-accepted that the Consolidation Coal Pipeline provided the impetus for the unit-train concept.

Building on the success of the Consolidated Coal Pipeline, the Black Mesa Pipeline began operation in 1970. Black Mesa is 273 miles of 18-inch pipeline, transporting nearly five million tons of coal per year. It connects the Black Mesa Mine in northeastern Arizona to the Mohave Generating Station at Laughlin, Nevada. It is the only coal fuel supply for the power plant, and its operating reliability has been greater than 99%. The Black Mesa Pipeline currently transports coal for less than 1.4 cents per ton mile.

Therefore, over 70 million tons of coal have already been reliably transported by long distance pipeline. I suggest that this is a formidable demonstration to substantiate reliability, availability, security, and economics.

The history of commercialization is not as formidable for coal water fuels, but significant demonstrations have taken place. To date there have been about 20 coal water fuel production plants erected, with only a few now in operation. In Italy, two 100,000 metric ton per year demonstration plants were put into operation in 1983 and 1985. You may be aware of the Siberian project, which involves a five million metric ton per year coal water fuel pipeline between Belovo and Novosibirsk, a distance of 260 kilometers. This will be the first long distance coal water fuel pipeline in the world and is now in the commissioning phase.

Tokyo Electric together with Tohoku and Joban, joint venture power companies, have successfully conducted burn tests of CWF on a 75 megawatt unit.

My company, Williams Technologies, Inc., manages the Black Mesa Pipeline operation. Our principals were responsible for building the Consolidation Coal Pipeline; and have for many years managed the testing, planning and implementation of slurry pipeline projects throughout the world. Our database of design and operational data on coal slurry pipelines was the basis for quickly evaluating slurry projects covered in this report.

(Slide 3)

Let's take a look at the major components of a slurry pipeline system. The first step in coal preparation will consist of grinding, usually dry grinding, followed by wet grinding to a particle size distribution that will maximize pumpability and slurry stability. It seems ideal to integrate coal cleaning or deep coal cleaning as part of the slurry preparation process and without excessive cost. The coal prep facility is followed by a small amount of storage and then a pump station to provide the energy to move the slurry down the pipeline. Most long distance slurry pipelines will have booster pump stations at intervals along the pipeline.

At the pipeline terminus, a conventional coal water slurry line would typically have slurry storage followed by dewatering and dry storage. Tests have shown that coal can now be dewatered mechanically to 10% to 12% surface moisture, which will make the fine coal safely transportable with conventional equipment. A coal water fuel pipeline system schematic would be similar to this illustration except the preparation facilities would have additional grinding equipment. The pipeline, while looking similar, would be flowing at a lower velocity; and finally, the terminal and port facilities would only have tankage from which tankers would be loaded at the port facility.

(Slide 4)

Now that we have covered slurry technologies available and technical readiness, it is important that we all agree on components in the decision tree as viewed by project developers or coal consumers associated with potential projects. We are going to categorize these considerations as technical, economic, and institutional.

(Slide 5)

I have already discussed the level of commercialization of conventional coal water slurries. There can be no question about their technical readiness. Coal water fuels have been demonstrated in sizable projects, and except for further work on pipeline transport with specific coals, there is a high degree of confidence in the preparation, burning, and demonstration of the fuels such that commercial size units are feasible.

The specifications of each slurry will be dependent on coal quality. We have looked at both subbituminous and bituminous coals. Lower Btu subbituminous coals may not provide economically feasible CWS because the solids loading will be too low, although drying at the origin may provide a solution.

Pipelines will have less volume flexibility than a typical railroad. Coal water slurry pipelines are single purpose facilities, sensitive to economies of scale; however, once the design is complete and the pipeline installed, there is only about a 10% variation in capacity without cost penalties. Coal water fuel pipelines will have more flexibility because of the stability of the slurry, eliminating water flushes at pipeline shutdowns.

One of the trade-offs for this reduced flexibility is reliability. Black Mesa has proven to have reliability of 99% over its 18-year history, which speaks for itself.

Coal pipelines, as other pipelines, offer one of the most environmentally secure forms of transportation available. In Black Mesa, the slurry has been determined to be non-hazardous and nontoxic. Blowout from rail cars can vary from .5% to 3% of coal loss along the tracks. Pipelines are not subject to these losses.

Opponents of coal slurry pipelines raise the issue of effluent water quality when dewatering the coal at the pipeline terminus. A battery of tests have been run showing that water cleanup with conventional technology will meet U.S. federal and state standards.

Water availability will be a continuing concern in the western U.S. Water availability for slurry pipelines is often more an emotional issue than factual, since many other industries use far greater quantities of water. For instance, a power plant burning 5 million tons of coal would consume six times the amount of water that a pipeline delivering that same coal would consume. Regardless, techniques to conserve water are essential. Coal water fuels can reduce water consumption by 25% to 50%. Recycle water pipelines are possible in some instances. The hot water drying process to prepare coal water fuels from subbituminous coals can also greatly reduce the required water.

Water cost is not as much of a factor as water availability. If it cost $150 per acre foot for water, which is roughly the industrial rate in the U.S., this would add 13 cents per ton to the cost of the coal. Water availability will be an issue, but water sources can usually be found that will not adversely deplete this valuable resource. Often, these are at greater depth than can be afforded for agricultural or industrial uses.

(Slide 6)

Coal quality is always a consideration when evaluating transportation costs. Quite simply, the lower the Btu coal, the higher the Btu transportation cost. However, mine-mouth costs are also critical when looking at coal quality. Compare the figure used in this study for mine mouth costs.

	$/Ton	Btu/lb. ROM	$/MBtu
Four Corners	15.50	11,200	0.69
Central Utah	21.00	12,200	0.86
Powder River Basin	4.00	8,500	0.24
Alaskan - Beluga	16.00	8,300	0.96

Obviously, increased transportation costs of PRB coals are greatly offset by low mine mouth cost. Beneficiation of coal to reduce inherent moisture, such as with the hot water drying process, can improve the thermal value of the subbituminous coals to the 11,000 Btu/lb. range.

There are threshold volumes for pipelines to be competitive. The minimum volume necessary will be dependent on the distance from mine to port. Some slurry projects may be competitive with as low as three to five million tons per year. Greater economies are available at ten million tons per year. PRB, for instance, could support, twenty, thirty, or even forty million tons per year for long term projects.

Both distance and the terrain will affect pipeline costs. There are some grade limitations on slurry pipelines, but in most cases, routes can be found which add little excess distance over that of a straight line.

Ideally, a dual commodity pipeline, such as coal and liquid CO_2 or coal and methanol will reduce the transportation cost of both commodities. However, there are few applications which can source both commodities at the pipeline origin and have a demand for both commodities at the pipeline destination. In addition, the long term supplies and demands must somewhat coincide to achieve the full benefits of cost savings and insure the longevity of the project.

Another major trade-off to reduced flexibility is cost stability. Roughly 70% of pipeline costs are fixed, therefore, only 30% is subject to inflationary pressures. Inflationary cost increases for pipeline transportation have traditionally been lower than those of other forms of transportation.

(Slide 7)

Regardless of the technical readiness of slurry pipelines or the obvious economies, there are other matters to consider. The customer must be willing to commit for a dedicated fuel supply. There is reluctance of APB coal consumers to do so, but not necessarily reluctance with regard to other fuels, such as LNG supplies to power generation facilities. Long term contracts are necessary to support the new infrastructure and justify facility conversion. In the case of coal water slurries, facility conversion should be minimal (only that necessary to accommodate handling a finer coal). Coal water fuels will require a new infrastructure, including retrofitting of oil or gas facilities or completely new facilities. As I will show later, the economics seem to justify these modifications.

One other issue that should be brought to your attention is the right of federal eminent domain for slurry pipelines in the U.S. Federal eminent domain would give slurry pipelines the right of condemnation to access private lands. This is not essential to many projects, but it will provide a comfort factor to those making commitments to projects that the pipeline right-of-way can realistically be obtained without excessive cost or time delay. This U.S. federal legislation has been proposed many times over the last 20 years and is currently in the Energy & Natural Resources Committee of the U.S. Senate.

(Slide 8)

The four U.S. coal regions reviewed in this study were Four Corners, Utah, Powder River Basin and Alaska. With many variations possible, there was no intent to discriminate against any coal producing areas, but the study obviously did not have the scope to analyze all possible applications. This slide shows two potential pipeline routes considered from the Four Corners area. We picked the Black Mesa reserves in northeastern Arizona primarily because more information was available from our management of the Black Mesa Pipeline system. We looked at both coal water slurry systems and coal water fuel systems to both Stockton and Los Angeles. Four Corners offers high quality, low sulfur coals with good reserves for large scale projects.

(Slide 9)

Central Utah reserves were also reviewed for coal water slurry and coal water fuel pipelines, to the ports of both Stockton and Los Angeles. These are high quality, low sulfur coals, but at higher mining costs than those of Black Mesa. Gathering costs at the source could be more expensive in the Utah area for larger pipeline systems.

(Slide 10)

Powder River Basin has vast reserves of subbituminous coal. We considered only pipeline delivery to Puget Sound. Other possibilities of existing ports, of course, would include Los Angeles, adding only 100 miles to the pipeline distance. Powder River being a high moisture content, subbituminous coal would only be suitable for export in the form of a coal water fuel, using a hot

water drying process to remove inherent moisture. With large reserves and mine sizes of over 10 million tons per year, PRB would easily support coal pipeline projects as high as 40 million tons per year.

(Slide 11)

Since pipeline financing requires long term commitments, the coal reserves must be adequate to maintain these commitments. As a result, our evaluation in Alaska, was limited to the inland Nenana reserves and the near coastal Beluga reserves, both subbituminous coals; one being a pipeline of 250 miles in length and the other 21 miles in length. The route to Cook Inlet from Nenana would be 100 miles less than extending a pipeline to the Seward area. Only coal water fuels, pre-dried with the hot water drying process were considered for Alaskan coals.

(Slide 12)

It might be appropriate at this point to provide the criteria for our determination of unit transportation costs. Since this study was limited in scope, a model was set up in which we input the variables of volume, distance, unit costs, and many other factors for different pipeline alternatives. Terrain for individual projects was not considered in detail. This was offset by the fact that no credit was taken for the savings in power for inland to coastal shipments having the advantage of being downhill. The unit transportation costs for pipelines are based on 15% return with 100% equity which should provide adequate incentive for private investment in projects, especially when leveraged. The estimates are based on 1989 costs with 20% contingency added to all capital and operating costs. Regardless of thoroughness and the contingencies added, these, as all preliminary estimates, cannot be relied upon for an accuracy more precise than plus or minus 30%.

Now let's look at the numbers. First, the conventional coal water slurry. As a reminder, the coal and water will be separated at the port and a fine coal material will be shipped to the customer. Our targets for coal delivered by CWS pipeline was a maximum of $2.05 per million Btu's to compete in today's market. Note the pipeline transportation costs and the delivered cost at the Pacific Rim port. Four Corners to Los Angeles is within the targeted rates to

be competitive in today's market. Utah to Los Angeles is close, and considering that this is only a preliminary study, may prove to be competitive after more detailed evaluation. Considering the accuracy of our estimates, there would be a range of $1.89 to $2.49 per million Btu's. Also note that for the Utah case, we looked at the water conservation measure, of recycling all the water captured from the dewatering process at the pipeline terminus. This adds 25% to the pipeline transportation costs, but adds less than 10% to the total delivered price, since pipeline transportation is only a segment of the total coal delivery chain.

(Slide 13)

CWF will compete with oil and LNG in the APB power generation market. According to Platt's Oilgram, current delivered fuel oil prices are at $17 to $19 per barrel ($2.90 to $3.25 per million Btu's). Transportation costs for pipeline includes the coal preparation costs. For Powder River and the Alaskan coals preparation cost includes a hot water drying process which has been demonstrated at the University of North Dakota Energy and Mineral Research Center. This process not only dries the coal to 10% inherent moisture, but allows the recapture of 85% of the inherent moisture driven off and reuse of this water in the coal water fuel.

In available reports, costs of CWF preparation vary greatly, but a consensus among a number of companies who have CWF technology is that $1.00 per million Btu's is a fair cost estimate to use in this report. This includes the preparation and additives. This is for a CWF with a grind similar to the typical power plant grind. You may have heard higher prices for CWF, but many of these are for micro fine grind CWF's aimed at the turbine markets. These micro-grind CWF's have higher viscosities and will not be transportable by long distance pipelines.

The cost of the hot water drying process to produce a CWF was estimated at $1.50 per million Btu's, based on available reports.

As you can see, the Alaskan costs are significantly higher. A 1.9 factor was applied to all operating and capital costs for Alaskan projects compared to those

of the lower forty-eight states. Cost of coal water fuels in Alaska are seemingly not competitive.

(Slide 14)

The economies of scale for pipeline transportation of coal are outstanding. This is a typical unit cost representation for a coal water fuel pipeline. Notice that the 10 million tons displayed in the previous example, for PRB, was in the range of $22 per ton. For 30 million tons per year, the cost is $11.80, about half. These types of economies of scale are not achievable with other transport modes. This graph also portrays why there must be a threshold volume for each particular project with costs increasing rapidly for low volumes.

(Slide 15)

Coal Methanol slurries have been discussed in some detail in the past but have not been demonstrated in pipelines primarily because the demand for methanol has never been sufficient to support the large volume necessary for movements of coal. Since President Bush is now proposing methanol as one of the alternative transportation fuels, we felt there was merit in again reviewing the potential for methanol as a means of coal transport.

The cost of methanol from natural gas, according to Bechtel and Battelle Memorial Institute 1988 studies, is approximately 39 cents per gallon or $5.80 per million Btu's when produced on a large scale. This is based on a natural gas price of $1.75 per million Btu. The cost to produce methanol in large quantities from coal, as reported by Battelle, is not less than 83 cents per gallon, that's $12.30 per million Btu's, this is even considering the coal at zero cost. Recent work sponsored by the Department of Energy does show promise in reducing these costs by 20% when an advanced technology methanol plant is operated in conjunction with an electric power plant. These numbers indicate that the cost of methanol from natural gas will be less than from coal until natural gas reaches at least $6.00 per million Btu's. Another point to keep in mind is, while there are natural gas supplies in the general vicinity of many coal fields, obtaining long term guaranteed pricing would be difficult and unusual.

One justification for considering methanol for coal slurry pipelines is the elimination for the need of water as the transport medium. This may be somewhat misleading since our preliminary investigations show that production of methanol from natural gas and coal requires in the range of two to nine tons of water per one ton of methanol produced; thus likely to be several times the consumption of water for conventional coal water slurry pipelines.

Nevertheless, there appears to be some promise for greatly expanded methanol markets in the U.S. Although the decision is in no way final, President Bush's June 12, 1989 package of clean air proposals recommended the automobile industry be required to build cars capable of running on methanol or other alternative fuels. Sales of these cars would be required in nine designated cities in the U.S.

Let's assume that methanol is going to be produced as a transportation fuel and large markets will materialize. Shipments of methanol with coal can be accomplished with a pumping energy increase of only 32% for an energy payload increase of 222% compared to coal water slurry.

However, let's look at the technical problems in shipping methanol and coal with the intent to separate them at the pipeline terminus.

If only mechanical separation was implemented at the pipeline terminus, the fine coal would remain saturated with methanol and would require special handling techniques. If thermal drying were used to remove this remnant methanol in the coal, a dry fine coal explosive product would result.

Methanol is a drying agent and will absorb the coal's inherent moisture and that moisture will remain with the methanol after mechanical separation. Plus, methanol may extract up to 2.5 weight percent of the coal during the shipment. Therefore, methanol separated from coal mechanically would be contaminated with water and possibly coal extracts. Distillation of the methanol would certainly be required to obtain the purity necessary for a transport fuel. Given all these cost considerations, we decided not to proceed further with a coal methanol slurry concept.

We did consider a coal methanol fuel which would not be separated at the pipeline terminus but would be delivered as a fuel to be burned directly as an offset for oil and natural gas.

(Slide 16)

The results of this analysis for a Powder River Basin to Puget Sound project show delivered costs for CMF higher than that of coal water fuels. The Btu content of this fuel, subbituminous coal mixed with methanol, is in the range of 9,000 Btu per pound, which is only slightly more attractive.

(Slide 17)

Another reason that we are optimistic that slurry pipelines offer competitive opportunities is that there are other credits related to their use. In both coal water slurries and coal water fuels, grinding work for the power plant is done at the mine in the coal preparation process. This grinding can be accomplished at much lower cost per kilowatt hour in the western U.S. than in the Asian Pacific Basin with costs of 3-6 cents per kilowatt hour versus as high as 14 cents per kilowatt hour in the APB. This converts to power cost savings for grinding of $1.50 per ton for coal water fuels and $.60 per ton for conventional coal water slurries. These are credits directly attributable to slurry pipelines.

Handling of coal water fuels will be similar to heavy oils and will be almost half the cost of dry bulk handling.

The potential to integrate coal cleaning with the coal slurry preparation process could result in use of coal with reduced sulfur and particulate emissions. As you know, sulfur reductions from 2% down to .5% can provide savings in emissions equipment costs of $15.00 to $25.00 per ton of coal at the power plant.

(Slide 18)

In summary, coal slurry pipelines offer an economical technology that is ready for further commercial application. There is need for a new openness by APB coal consumers to consider long term commitments with a trade-off of price

stability and security of supply. Specific opportunities outlined in this evaluation show the Powder River Basin has potential for coal water fuels and especially in large volume projects. Four Corners and Utah, being closer to existing ports, provide opportunities in both conventional coal water slurries and coal water fuels. The coals have low sulfur and low ash contents. Reserves are abundant and adequate to support long term commitments.

(Slide 19)

These results are not conclusive, but they do highlight obvious opportunities. Each project must be evaluated on its own merits, considering the needs of the customer and site specifics. With cooperation, we can increase U.S. trade on a competitive basis. This new trade link is badly needed to offset the trade imbalances that now exist between the Pacific Rim and the U.S.

COAL PIPELINE TECHNOLOGIES

- Conventional slurries
- Coal water fuels
- Coal oil fuels
- Coarse coal

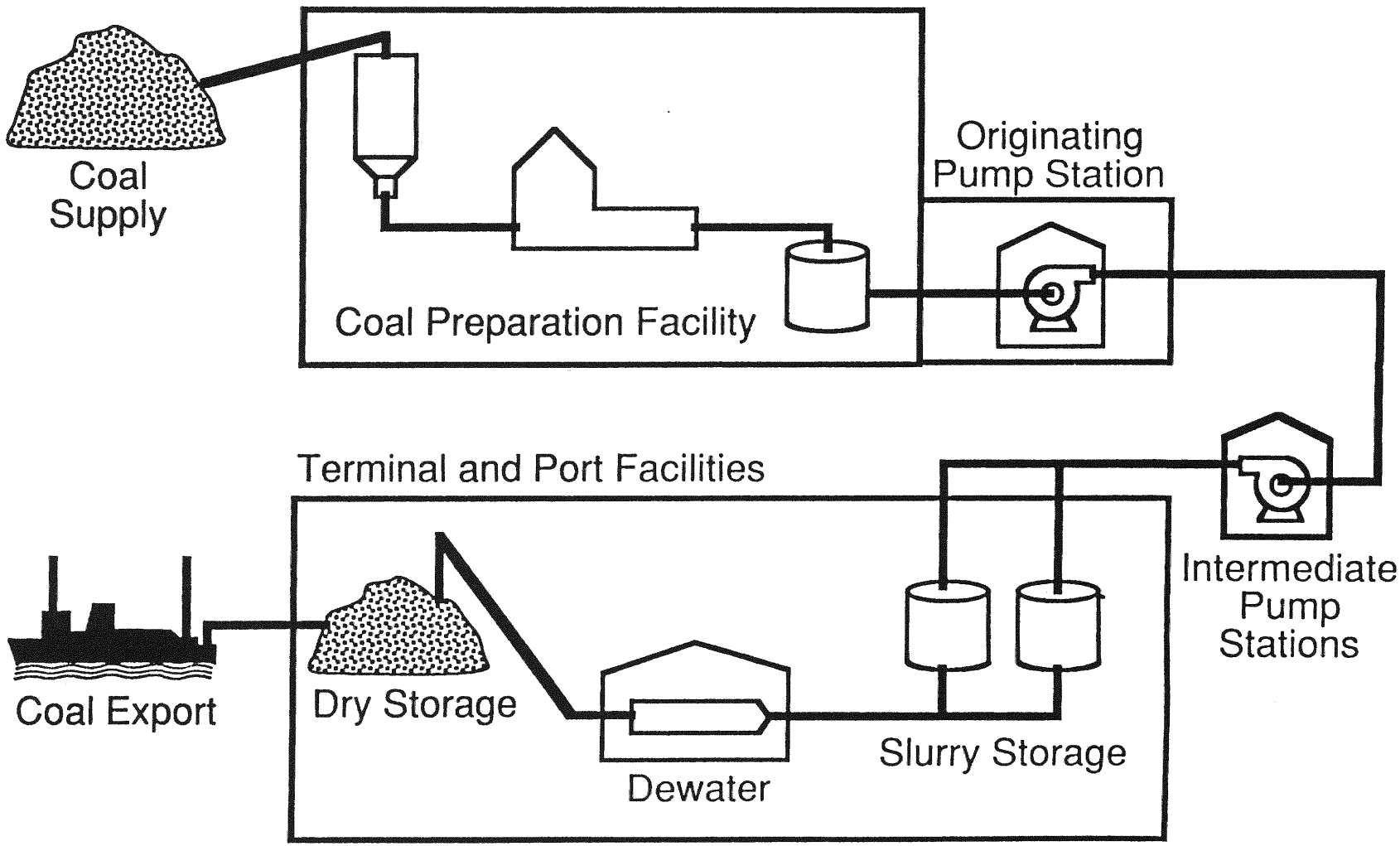
COMMERCIAL COAL PIPELINES

- Consolidation Coal Pipeline
  1957 - 1963

- Black Mesa Pipeline
  1970 -

- Kuzbass to Novosibirsk
  1989 -

TYPICAL COAL SLURRY PIPELINE



U.S. DOE/Office of Fossil Energy

CONSIDERATIONS

Technical

Institutional

Economic

CONSIDERATIONS - TECHNICAL

State-of-the-Art

Coal Quality

Volume Flexibility

Environmental

Reliability

CONSIDERATIONS - ECONOMIC

Coal Quality	Volume
Distance	Terrain
Dual Commodity	Tariff Stability

CONSIDERATIONS - INSTITUTIONAL

Market Acceptance
- Dedicated fuel supply
- Facility conversion

Federal Eminent Domain

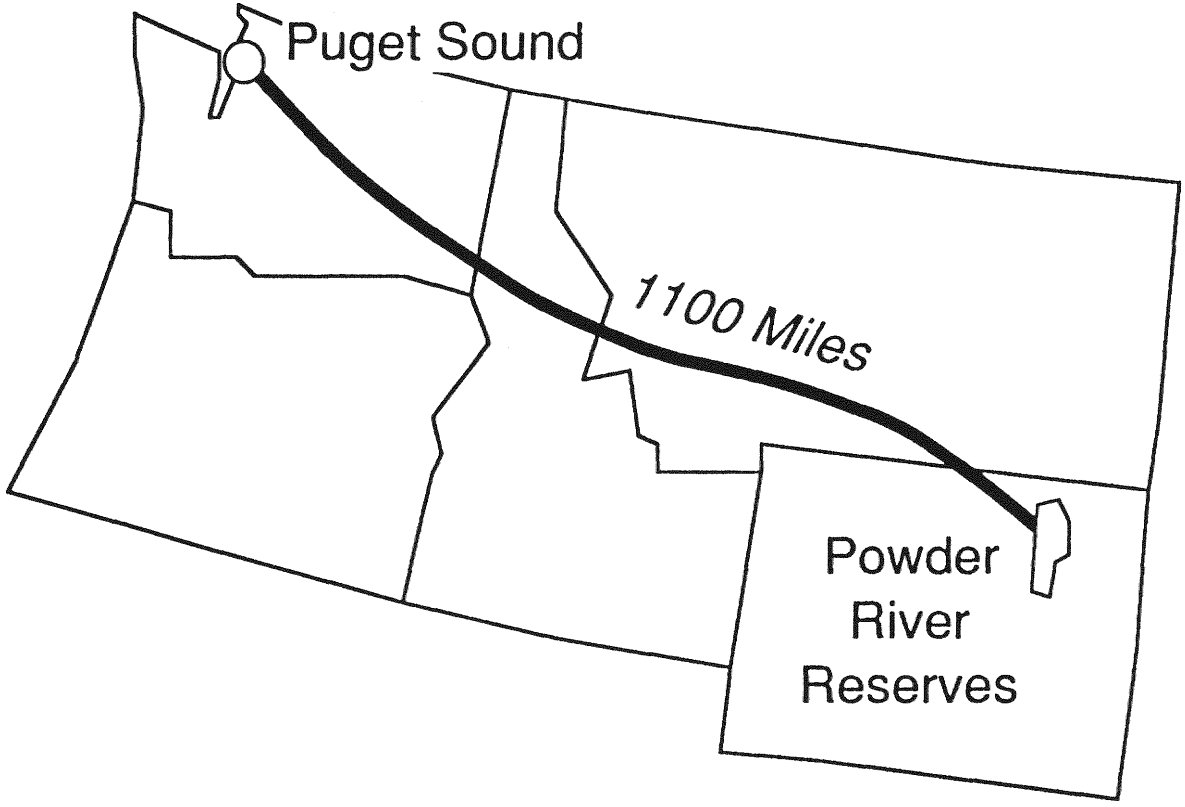
FOUR CORNERS TO CALIFORNIA PORTS



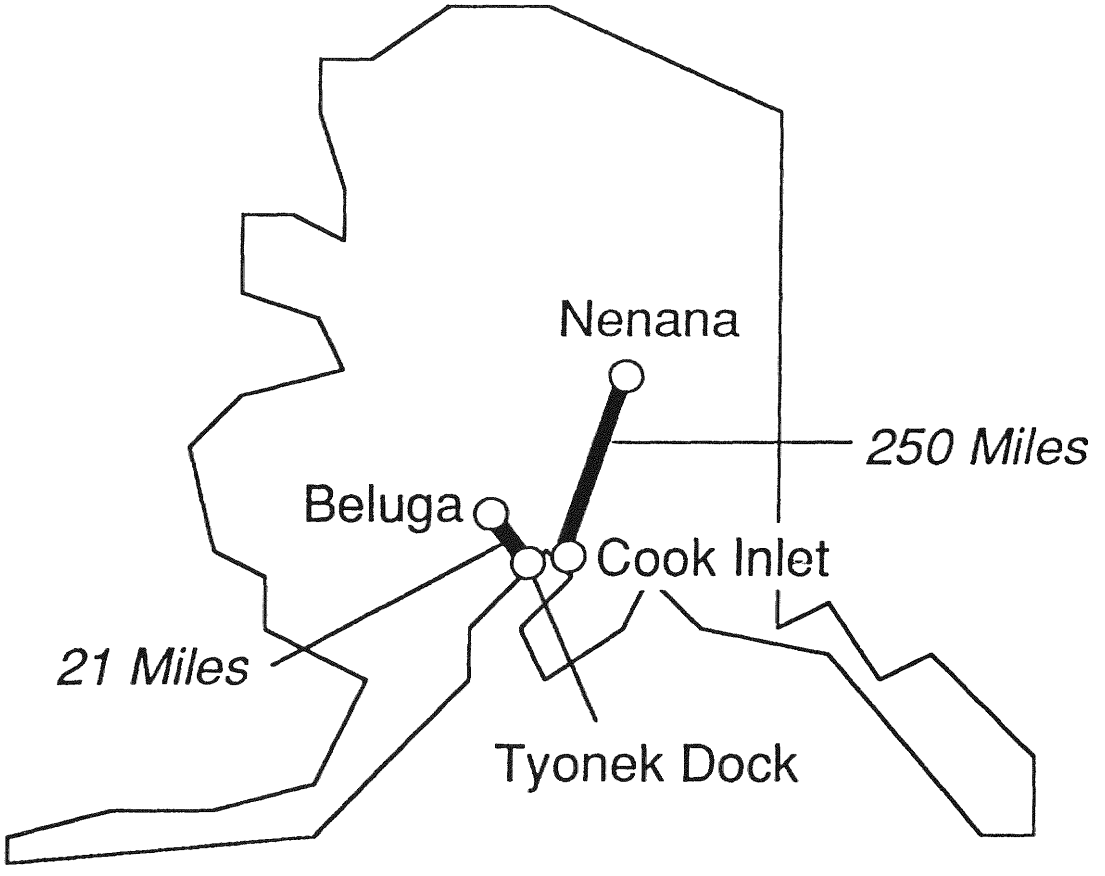
UTAH TO CALIFORNIA PORTS



POWDER RIVER BASIN TO PUGET SOUND



ALASKA RESERVES TO LOADING DOCKS



CONVENTIONAL COAL/WATER SLURRY

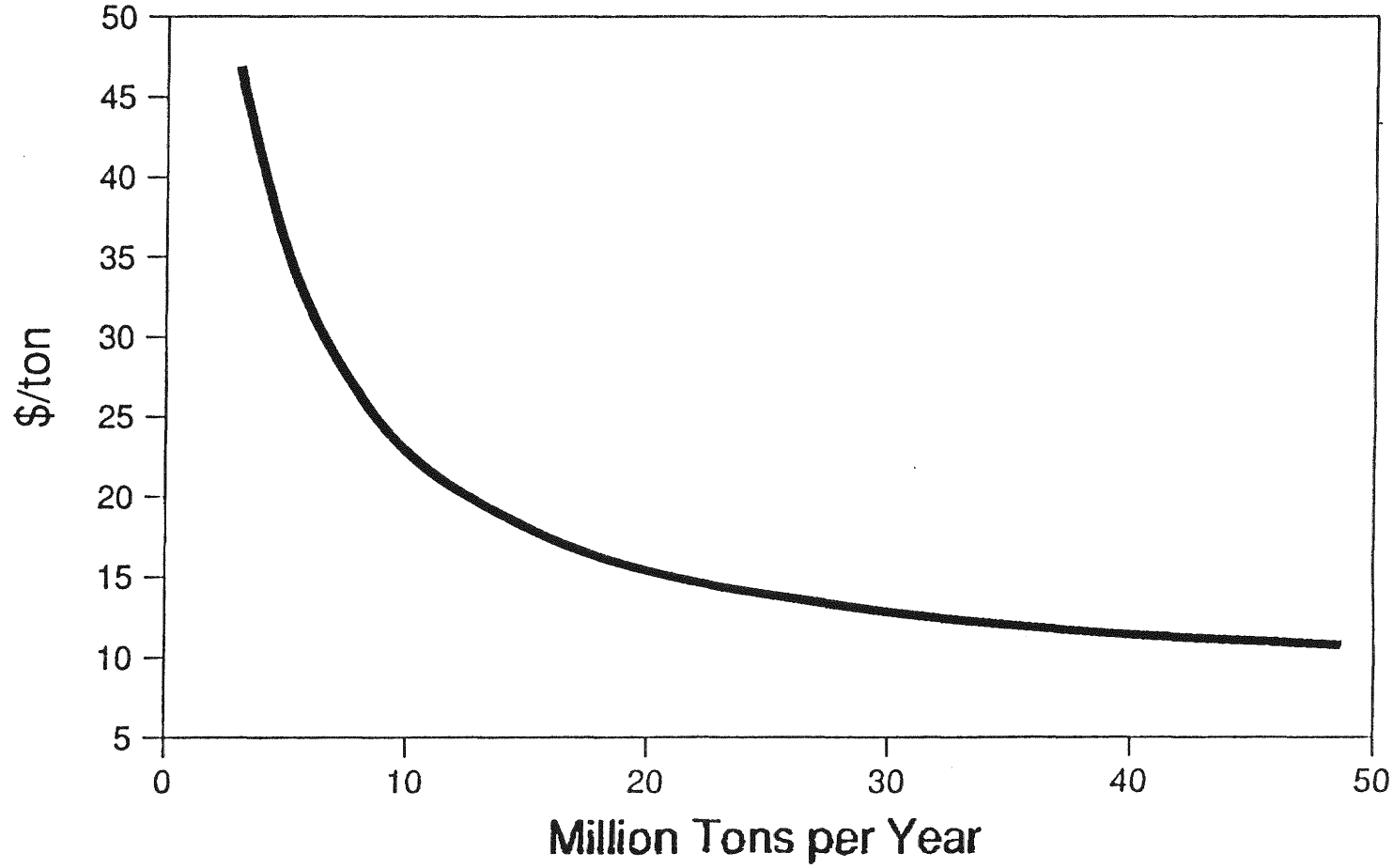
(10 MTPY)

	Pipeline ($/ton)	Total Delivered ($/MBtu)
Four Corners - Stockton	18.32	2.32
Four Corners - Los Angeles	15.85	1.99
Utah - Stockton	17.38	2.30
- with water recycle	21.70	2.48
Utah - Los Angeles	18.34	2.13

COAL WATER FUEL (10 MTPY)

	Pipeline ($/ton)	Total Delivered ($/MBtu)
Four Corners - Stockton	36.65	2.73
Four Corners - Los Angeles	34.57	2.48
Utah - Stockton	36.55	2.82
Utah - Los Angeles	37.35	2.69
Powder River - Puget Sound	57.10	3.04
Nenana - Cook Inlet	69.96	4.48
Beluga - Tyonek Dock	63.83	4.11

ECONOMIES OF SCALE (CWF Pipeline - Powder River Basin to Puget Sound



COAL-METHANOL

Coal/Methanol Slurry

Coal/Methanol Fuel

COAL METHANOL FUEL (10 MTPY)

	Pipeline ($/ton)	Total Delivered ($/MBtu)
Powder River - Puget Sound	17.92	3.28

CONSIDERATIONS - ECONOMIC

Grinding	CWS and CWF
Handling	CWF
Air Emissions	CWS and CWF

OPPORTUNITIES

Powder River Basin

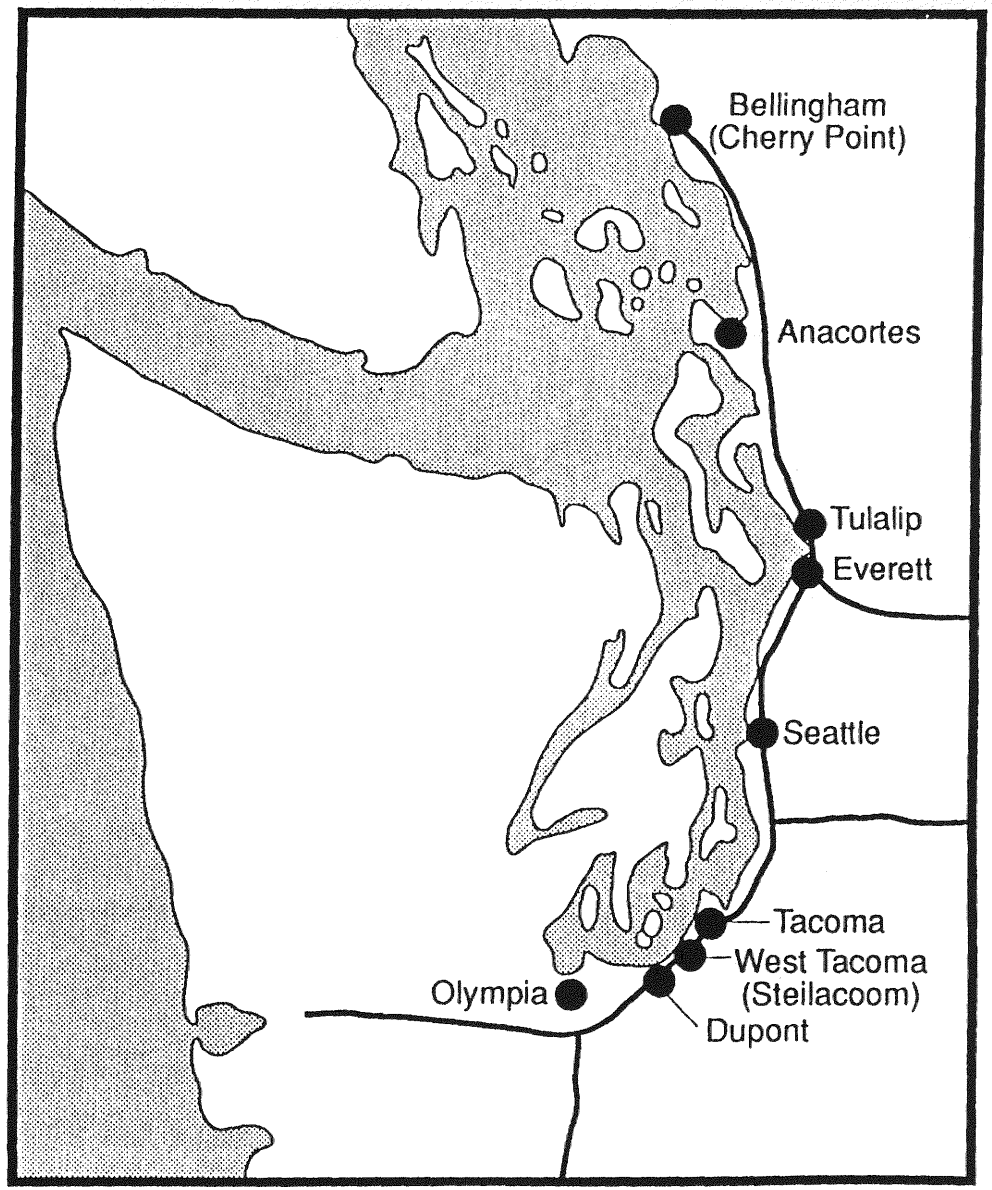
Four Corners

Utah

A Case by Case

EVALUATION

PUGET SOUND - POTENTIAL COAL TERMINAL SITES



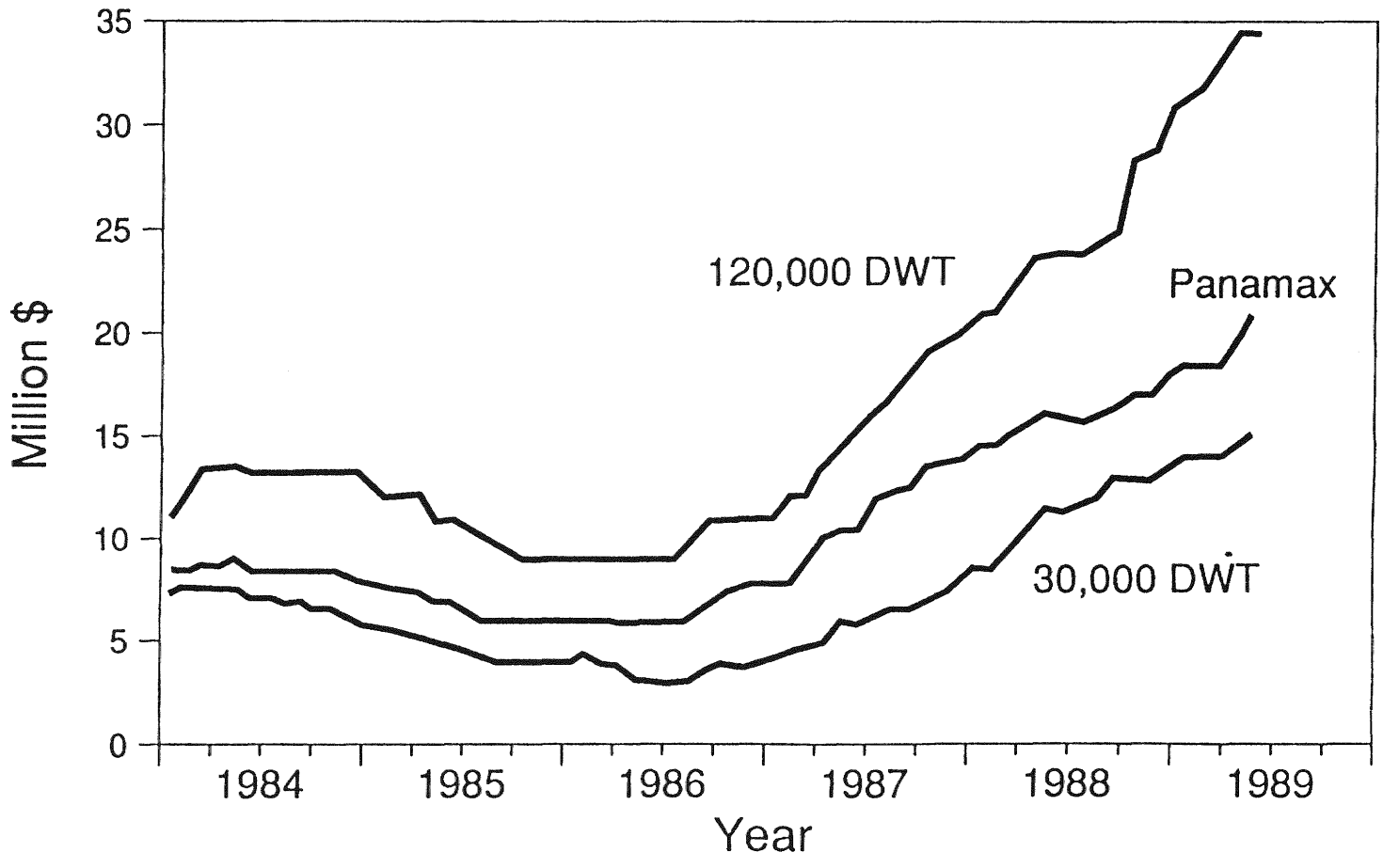
DISTANCES TO ASIA PACIFIC BASIN

From:	Nautical Miles
● Alaska	4,300
● Puget Sound	4,700
● San Francisco Bay Area	5,100
● Los Angeles/Long Beach	5,200
● New Orleans	15,500 *(via CGH)*

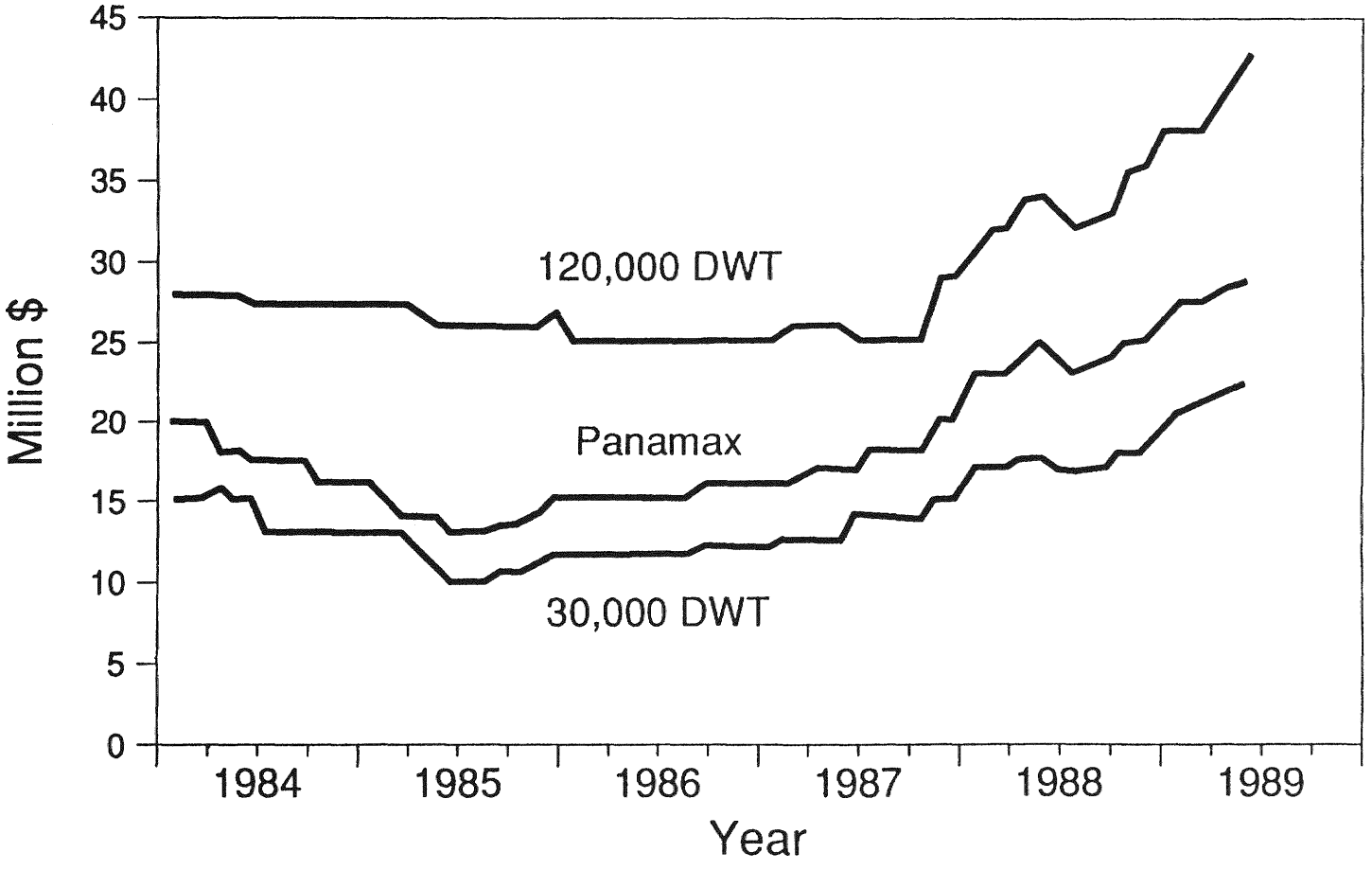
OPTIONS TO LOWER COAL OCEAN TRANSPORT COSTS

- Larger ships
- Supplemental cargos
- CWF tankers

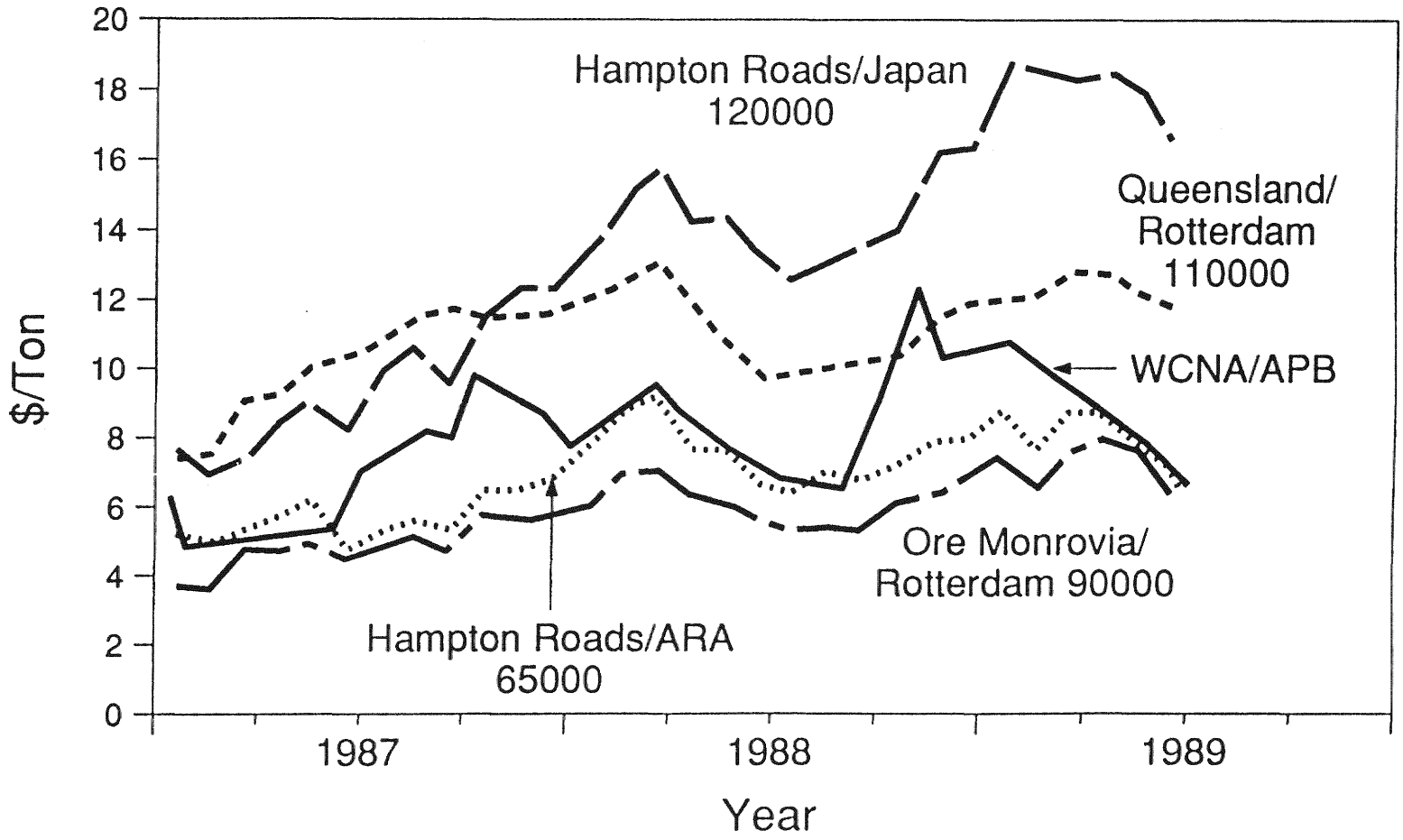
SECOND HAND PRICES - DRY BULK CARRIERS



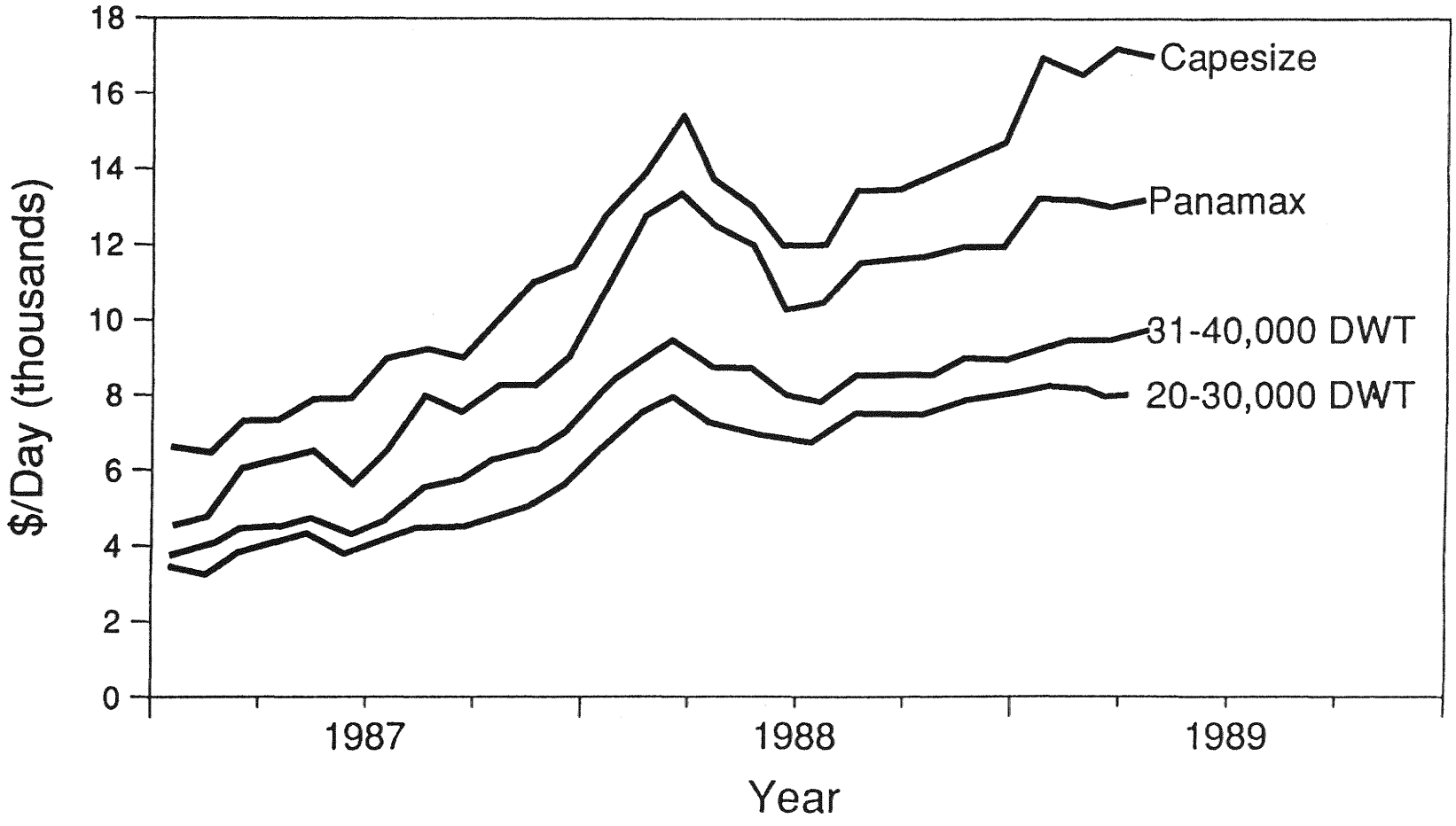
NEW CONSTRUCTION PRICES - DRY BULK CARRIERS



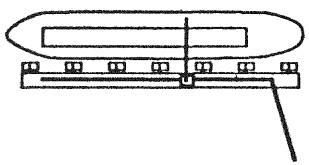
VOYAGE CHARTER RATES - DRY BULK CARRIERS



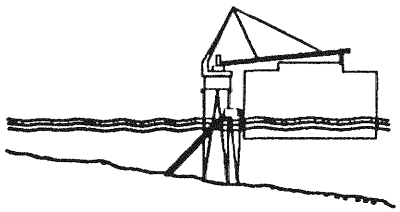
TIME CHARTER RATES - STANDARD DRY BULK CARRIERS

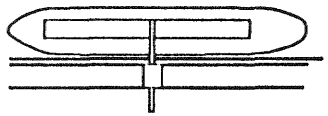


COAL HANDLING EQUIPMENT

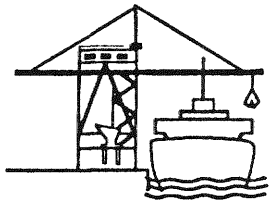


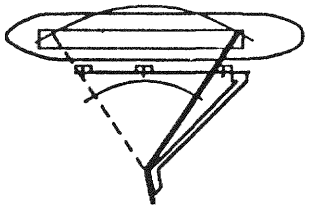
Parallel Loader



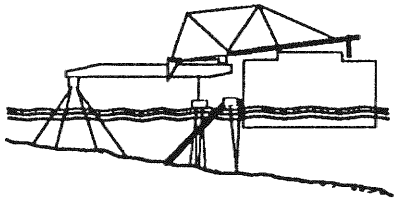


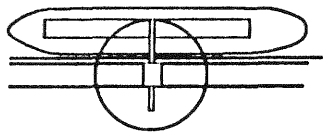
Shuttle Clam



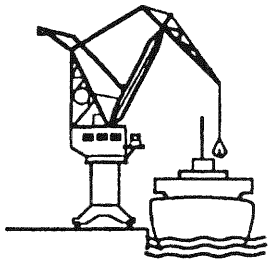


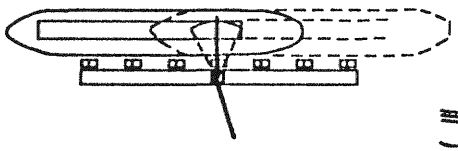
Radial Loader



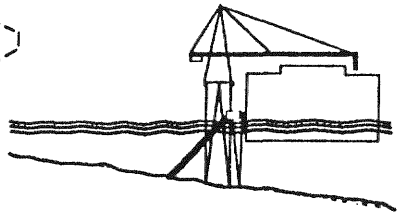


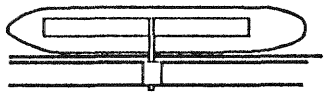
Slewing Clam



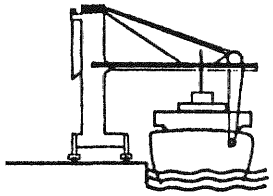


Fixed Loader

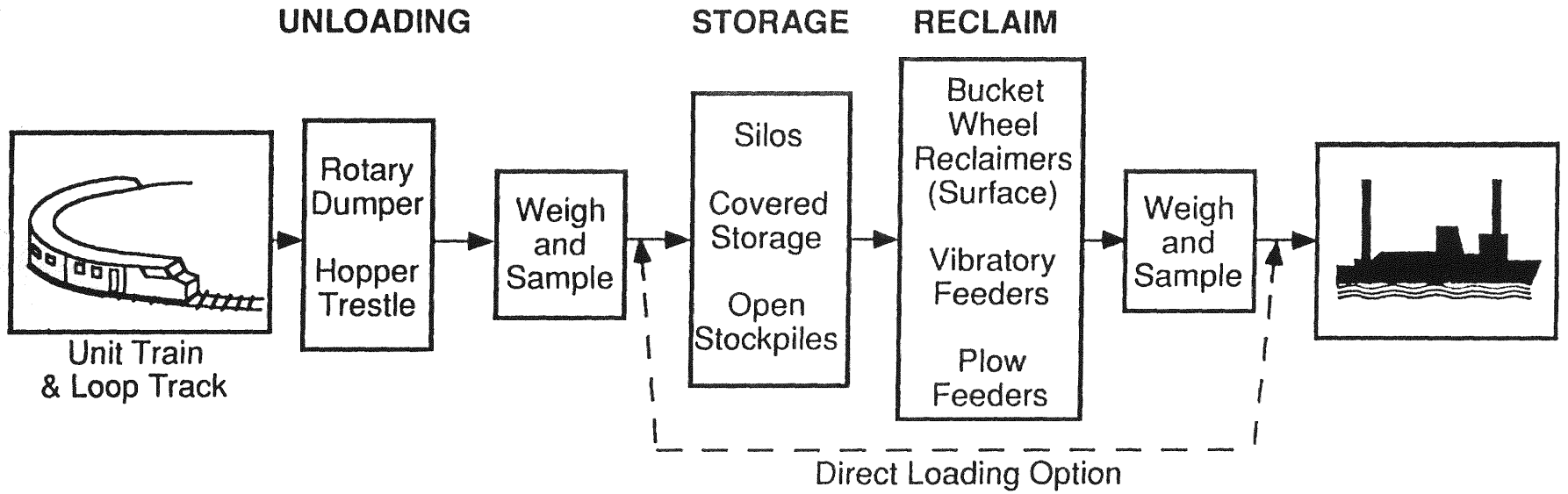




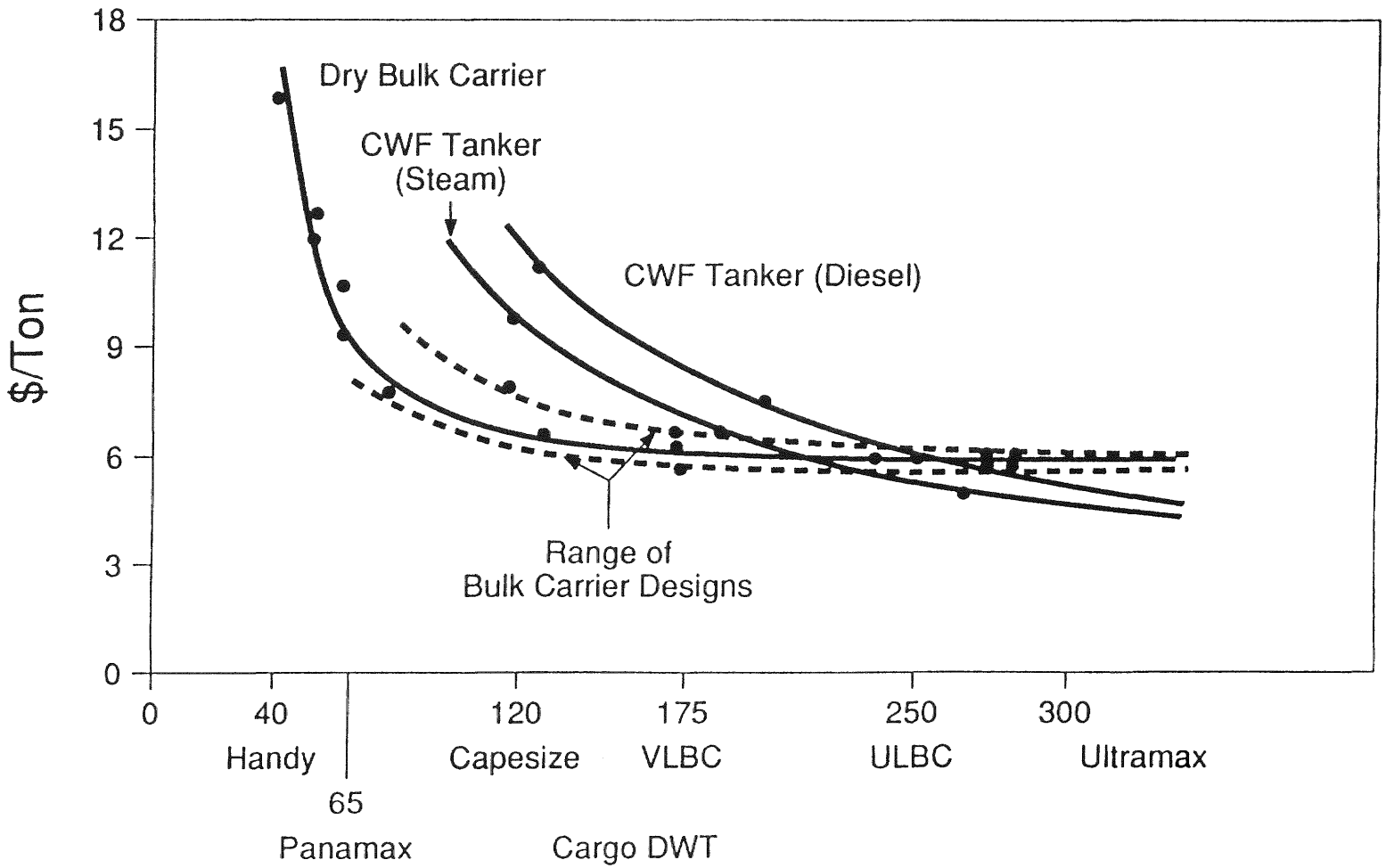
Continuous Unloader



COAL TRANSPORTATION SYSTEM

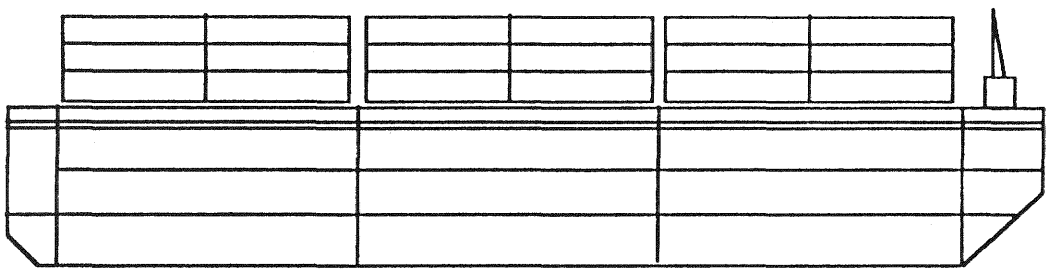


COAL TRANSPORT COSTS VS. VESSEL TYPE AND SIZE

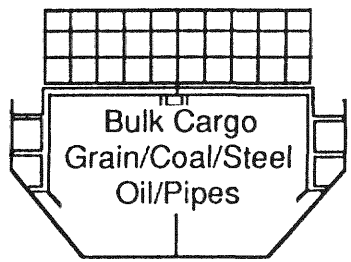


JUMBO BARGE CARRIER - REPRESENTATIVE BARGE ARRANGEMENTS

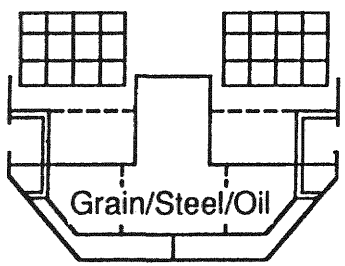
Basic Type of Barge = 10,000 - 30,000 DWT



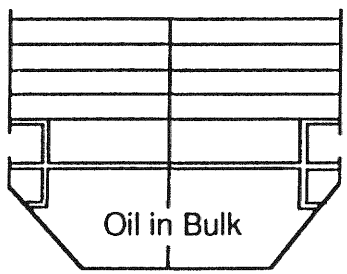
Length - 90 m Width - 32 m Draft - 6.0 - 9.5 m



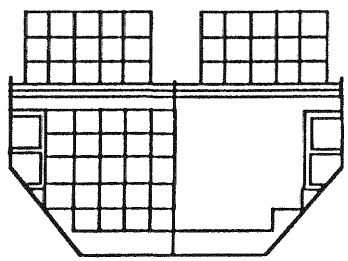
Lift On/Lift Off Barge



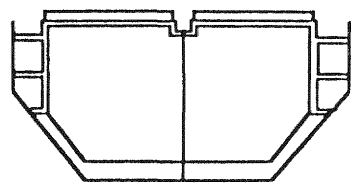
Lift On/Lift Off & RO/RO Barge



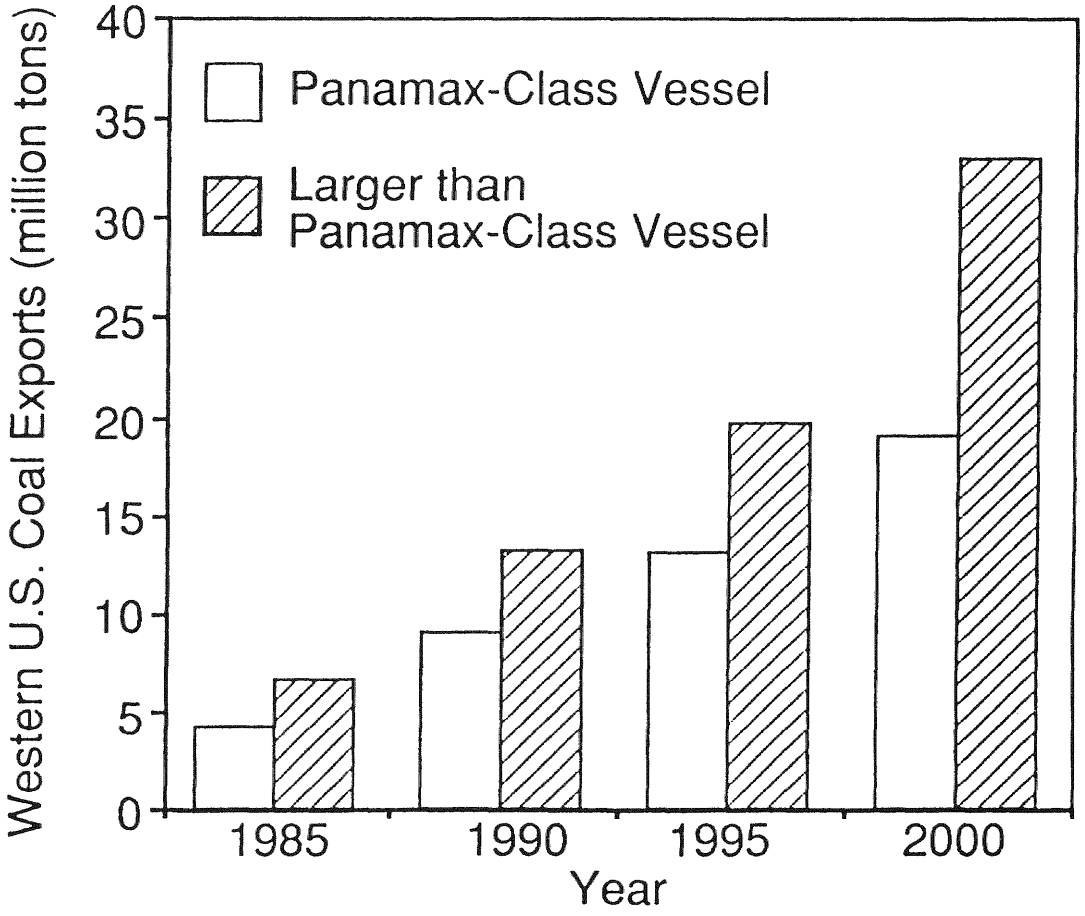
RO/RO Barge



Container Barge Lift On/Lift Off



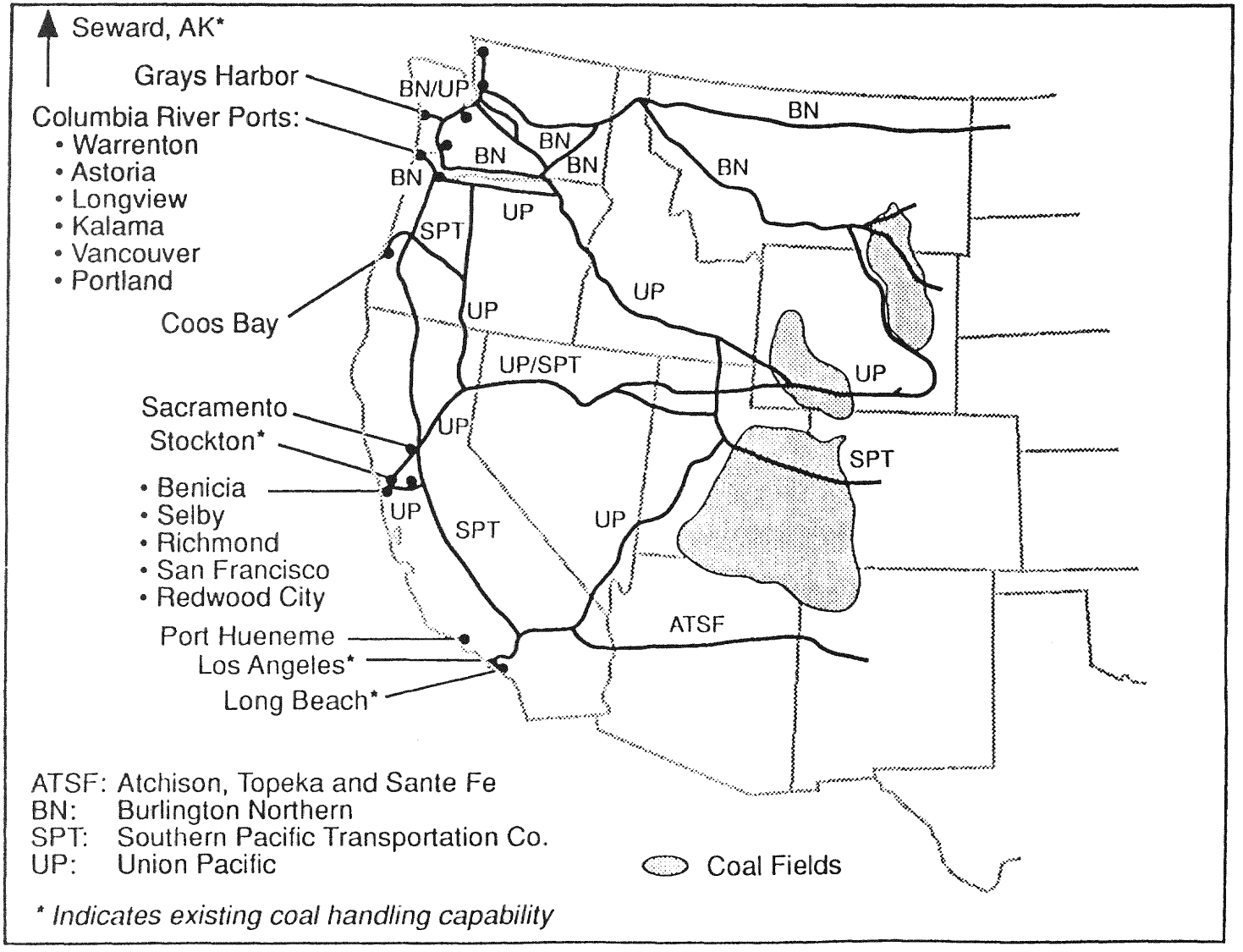
Grain/Steel/Oil Bulk Barge


Western U.S. Coal Exports (million tons)
40
35
30
25
20
15
10
5
0
Panamax-Class Vessel
Larger than
Panamax-Class Vessel
1985
1990
1995
2000
Year

OCEAN SHIPPING COSTS SAVINGS BY:

	Average $/Ton	Maximum $/Ton
Larger ships	2.56	4.86
Supplemental cargos	3.62	8.01
CWF tankers	2.20	4.83

EXISTING AND POTENTIAL U.S. WEST COAST COAL TERMINAL SITES



OTHER ISSUES

- Backhaul cargos
- Freight futures
- Vessel ownership participation
- Port user fees
- Demurrage costs

PAX PER MERCATURAM

U.S. DOE/Office of Fossil Energy

INNOVATIVE/ALTERNATIVE OCEAN TRANSPORT MODES FOR MOVEMENT OF U.S. COAL EXPORTS TO THE ASIAN PACIFIC BASIN

presented by

G. F. Uttmark
President
TransTech Marine Co.

presented at

Asia-Pacific Coal Technology Conference
East-West Center
Honolulu, Hawaii

November 15-16, 1989

GEOFFREY F. UTTMARK
President
TransTech Marine Co.

Geoffrey Uttmark is president of TransTech Marine Company, which he founded in 1979. This company assists ship owners, investment groups and government agencies and in planning and development of new shipping services and port facilities. Responsibilities of TransTech typically encompass analysis of ocean trading patterns, technical design definition of appropriate ships and related equipment, and project financial evaluation and presentation. Specialized computer models have been created to design and evaluate marine transport systems from both the technology and project economics standpoints.

Prior to forming Transtech, Mr. Uttmark was a shipping economist with Sun Shipbuilding Co., Chester, Pennsylvania and naval architect with the design firm of Sparkman and Stephens, Inc., New York. Mr. Uttmark sailed for several years aboard ships ranging from coastal ferries to deep sea liners and tankers. He holds a U.S. Coast Guard Master's license for inland waters and received the U.S. Merchant Marine service ribbon for duty in Viet Nam.

By way of education, Mr. Uttmark holds degrees from the universities of Michigan (1973) and Pennsylvania (1979) where he majored in Naval Architecture/Economics and Finance respectively. In 1982, Mr. Uttmark became a chartered ship broker and in 1986 he became a Registered Investment Adviser with the U.S. Securities and Exchange Commission.

In addition to managing TransTech, Mr. Uttmark instructs the course "SHIPPING VENTURE ANALYSIS & FINANCIAL PLANNING" at the World Trade Institute, New York and he is adjunct professor of transportation at the New Jersey Institute of Technology where he teaches the graduate level course, "PORT DESIGN & PLANNING."

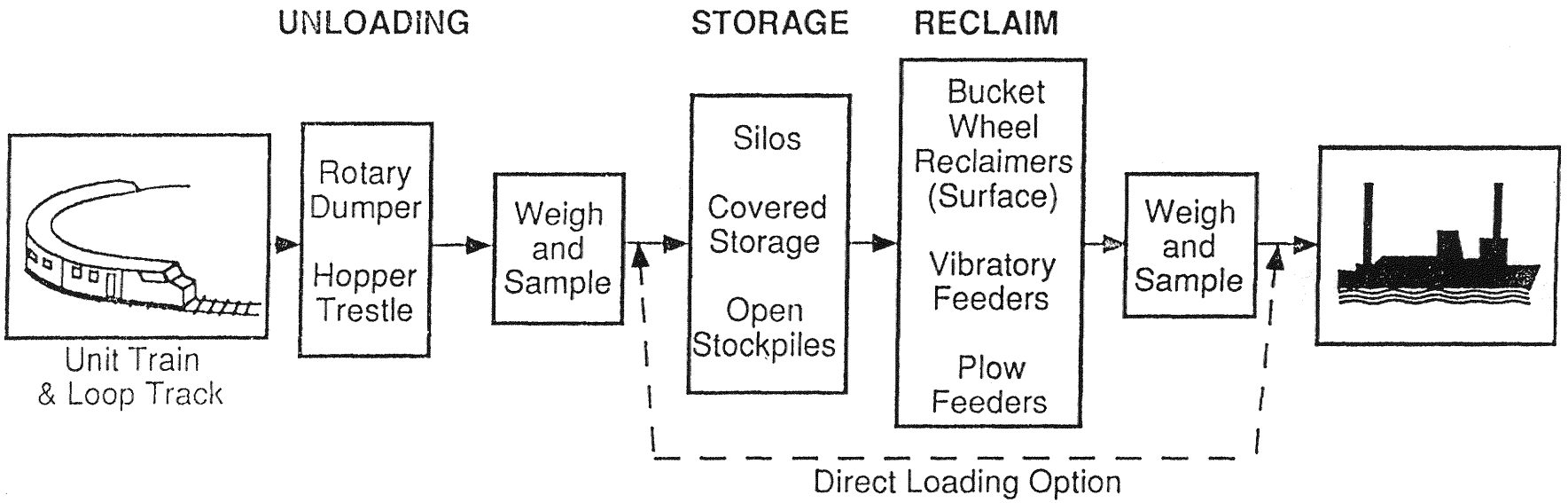
Mr. Uttmark holds active memberships in the Society of Naval Architects and Marine Engineers, the Transportation Research Board of the National Research Council and the International Marine Transit Association. Through these organizations he has authored a number of papers addressing ship design, economics and finance topics. Now making his home in New York City, one of the world's major maritime and financial centers, Mr. Uttmark's goal is to establish through Transtech a global network for merchant shipping investment and development. Such a network, he believes, can combine the strengths of differing regions and cultures to create sound commercial partnerships which will bind the world closer together for peace and prosperity.

INTRODUCTION

Tasks assigned to TransTech Marine Co. included the following:

- To examine port facilities and costs for handling coal
- To determine baseline costs of ocean transport of U.S. coals to Asia
- To identify and quantify potential means to reduce ocean transport costs.

COAL TRANSPORTATION SYSTEM



WEST COAST PORT FACILITIES AND COSTS

Facilities to load coal in the U.S. include:

- Seward, Alaska

  1100 TPH 58' depth 4300 n.m. to Asia
  Max vessel size: Large Panamax (tugboat limitation)

- Stockton, California

  600 TPH 35' depth 5100 n.m. to Asia
  Max vessel size: Handy (40,000 DWT) or small Panamax (55,000-75,000 DWT)

- Long Beach, California

  2500 TPH 50' depth 5200 n.m. to Asia
  Max vessel size: Capesize (120,000 DWT)

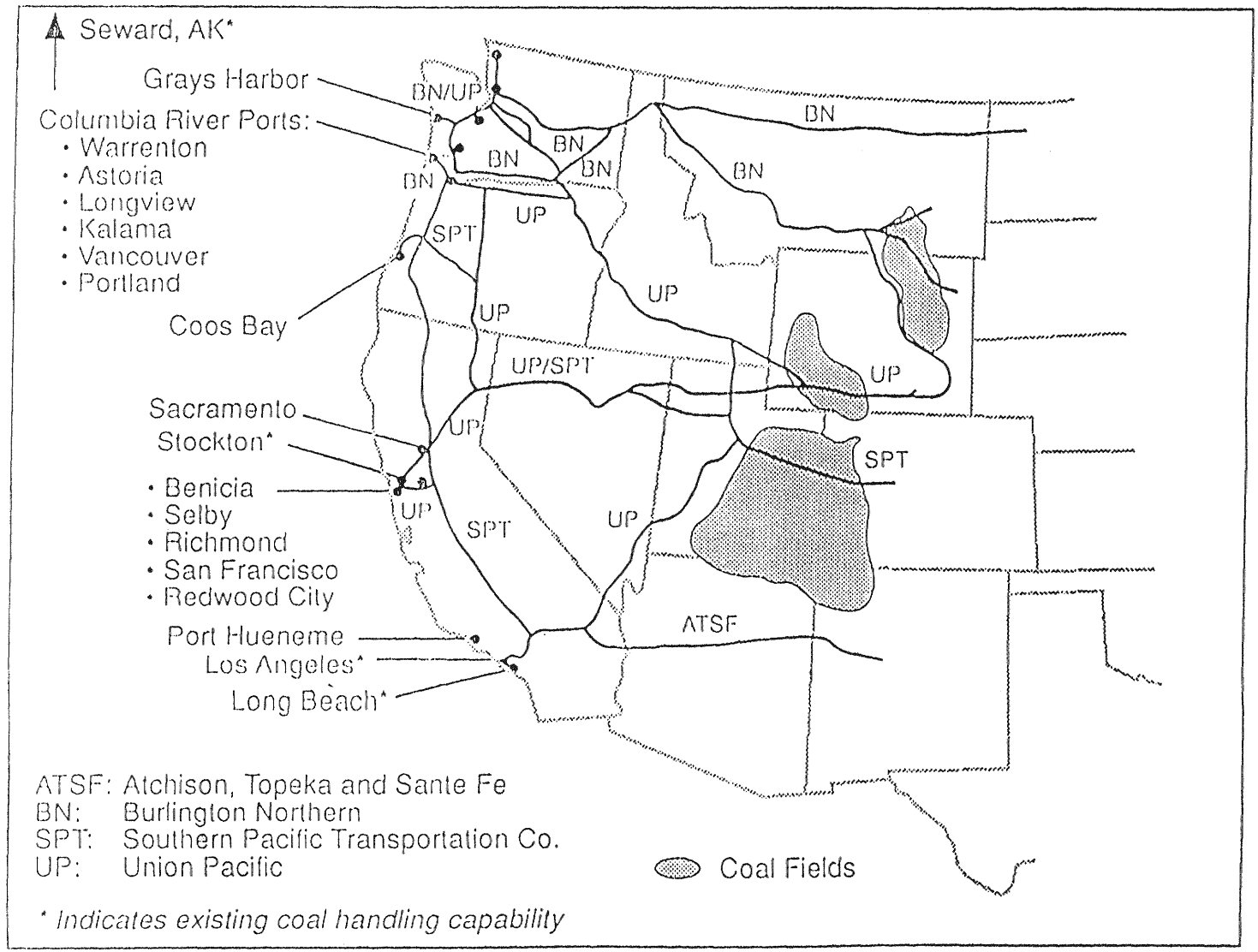
- Los Angeles, California

  1400 TPH 51' depth 5200 n.m. to Asia
  Max vessel size: Capesize (120,000 DWT)

Port costs including stevedoring are between $4 and $5 per ton of coal on the U.S. West Coast.

The port of Los Angeles is constructing a new coal terminal and plans to dredge to 65 feet. This facility will be online in 1992 or 1993 and will enable loading vessels of ULBC class (250,000 DWT) at 5,000 tons per hour.

EXISTING AND POTENTIAL U.S. WEST COAST COAL TERMINAL SITES

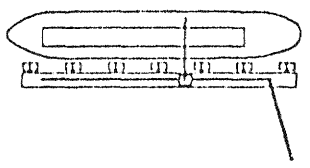


ASIAN PORTS

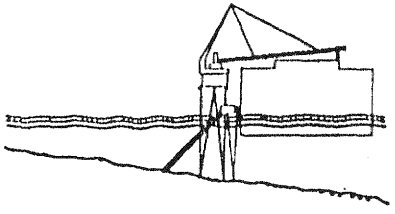
Dramatic improvements in port facilities have and continue to take place, particularly in the four major consuming countries:

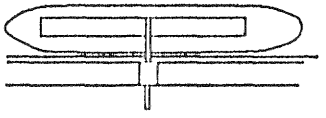
- Japan has now over a dozen Capesize capable ports.
- Hong Kong, Taiwan, and South Korea have upgraded to Capesize capable ports in the last decade.
- Port fees and time in port were found to be comparable in U.S. and Asia. Stevedoring costs in Asia were not included in this investigation since they net out regardless of where coal is sourced.

COAL HANDLING EQUIPMENT

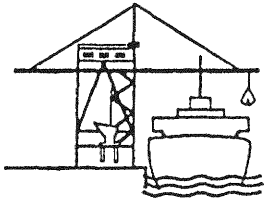


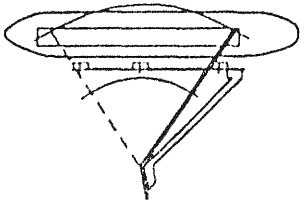
Parallel Loader



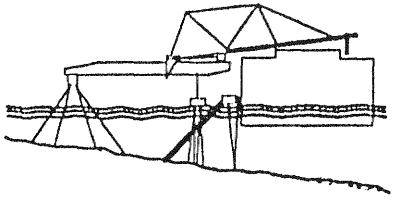


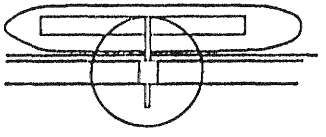
Shuttle Clam



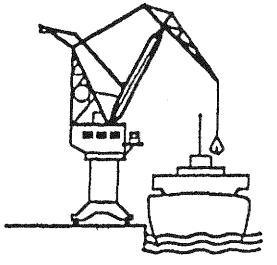


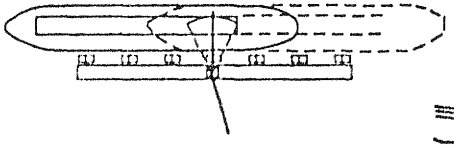
Radial Loader



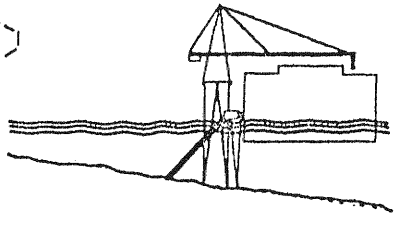


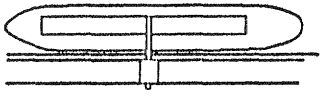
Slewing Clam



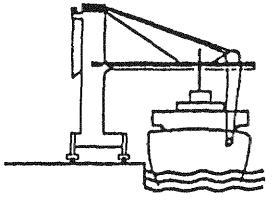


Fixed Loader





Continuous Unloader



OPTIONS TO LOWER COAL OCEAN TRANSPORT COSTS

- Larger ships
- Supplemental cargos
- CWF tankers

SHIPPING SYSTEMS

Investigations of ways to lower ocean transport costs of coal centered on:

- Larger ships: Main advantages are, of course, economics gained from scale. This is the conventional solution.

- Supplemental cargos: Main potential advantage is the unique relationship between the U.S. and APB. The trans-Pacific trade routes carry more tonnage than any other in the world. Were coal to be combined with supplemental higher revenue cargos or backhaul cargos, overall transport costs for coal could be lowered. This is predominately a marketing solution.

- Coal Water Fuel Tankers: The main potential is to connect with CWF shoreside pipelines to offer an export fuel that is competitive with oil. CWF in the general case offers the opportunity to utilize the huge existing infrastructure of land-based oil distribution systems. This is the high technology solution since both CWF pipelines and ships would have to be constructed.

DISTANCES TO ASIA PACIFIC BASIN

From:	Nautical Miles
• Alaska	4,300
• Puget Sound	4,700
• San Francisco Bay Area	5,100
• Los Angeles/Long Beach	5,200
• New Orleans	15,500 *(via CGH)*

OCEAN SHIPPING COST SAVINGS

Larger ships: The Bulk Ocean Shipping-Computer Optimized Economics (BOSCOE) computer model was used to design baseline coal marine transport systems.

- Minimum transport costs to Asia over a 20-year vessel or project life cycle were found to range between $5.12 per ton for a VLBC operating from Seward to $12.76 for a Panamax vessel operating from Stockton.

- Using the largest possible ships yielded on average a potential savings of $2.56 per ton and a maximum savings of $4.86 per ton.

- Using older vessels with paid down mortgages would reduce costs further. Such an approach would not reflect the true long-term shipping economics.

OCEAN SHIPPING COSTS SAVINGS BY:

	Average $/Ton	Maximum $/Ton
Larger ships	2.56	4.86
Supplemental cargos	3.62	8.01
CWF tankers	2.20	4.83

OCEAN SHIPPING COST SAVINGS

Supplemental Cargos: Supplemental cargos comprise carrying backhaul freight in standard bulk carriers or use of multipurpose type ships able to accommodate coal and other cargos simultaneously.

- Average potential savings of $3.62 per ton of coal can be achieved. The amount of savings depends on quantity and mix of supplemental cargos.

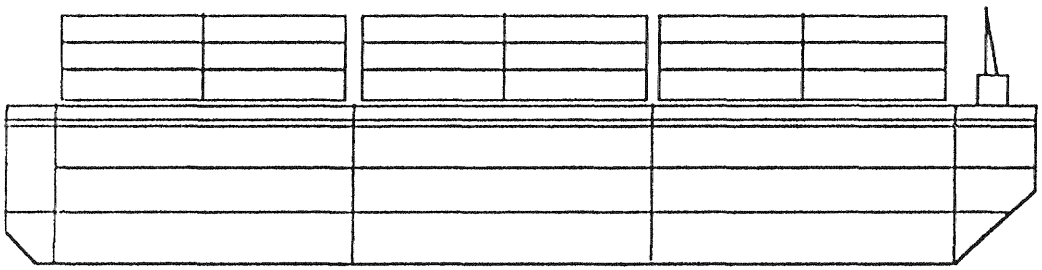
- The maximum potential savings of $8.01 is achieved when a Jumbo Barge Carrier (JBC)-type system is based in San Francisco Bay and loads its barges in Stockton. This converts a draft restricted port to large-scale economics and suggests potential wider applications for JBC-type systems.

- The JBC is a multipurpose design able to effectively and economically transport a variety of bulk, neo-bulk, and general cargos. Some advantages are economy of scale, shallow draft barges, ship-size individual cargo lots, rapid turnaround, stevedoring economies, floating storage in barges, and system adaptability.

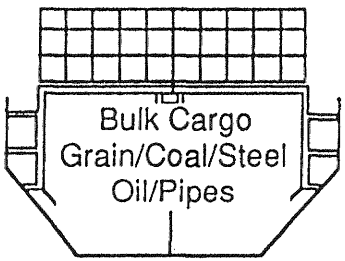
This system requires orientation of the shipowner to the broad cargo constituencies available to him.

JUMBO BARGE CARRIER - REPRESENTATIVE BARGE ARRANGEMENTS

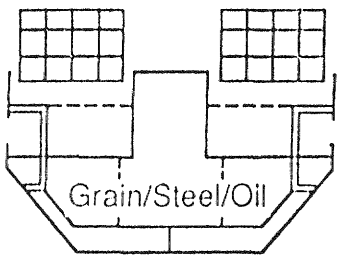
Basic Type of Barge = 10,000 - 30,000 DWT



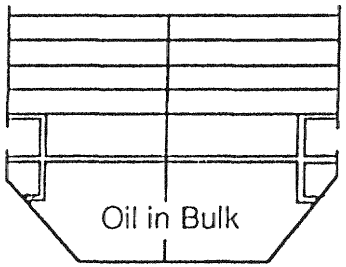
Length - 90 m Width - 32 m Draft - 6.0 - 9.5 m



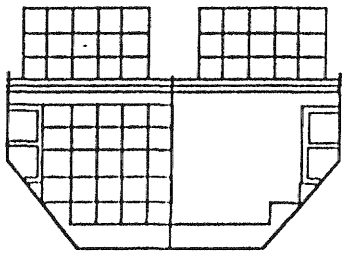
Lift On/Lift Off Barge



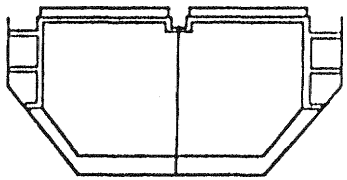
Lift On/Lift Off & RO/RO Barge



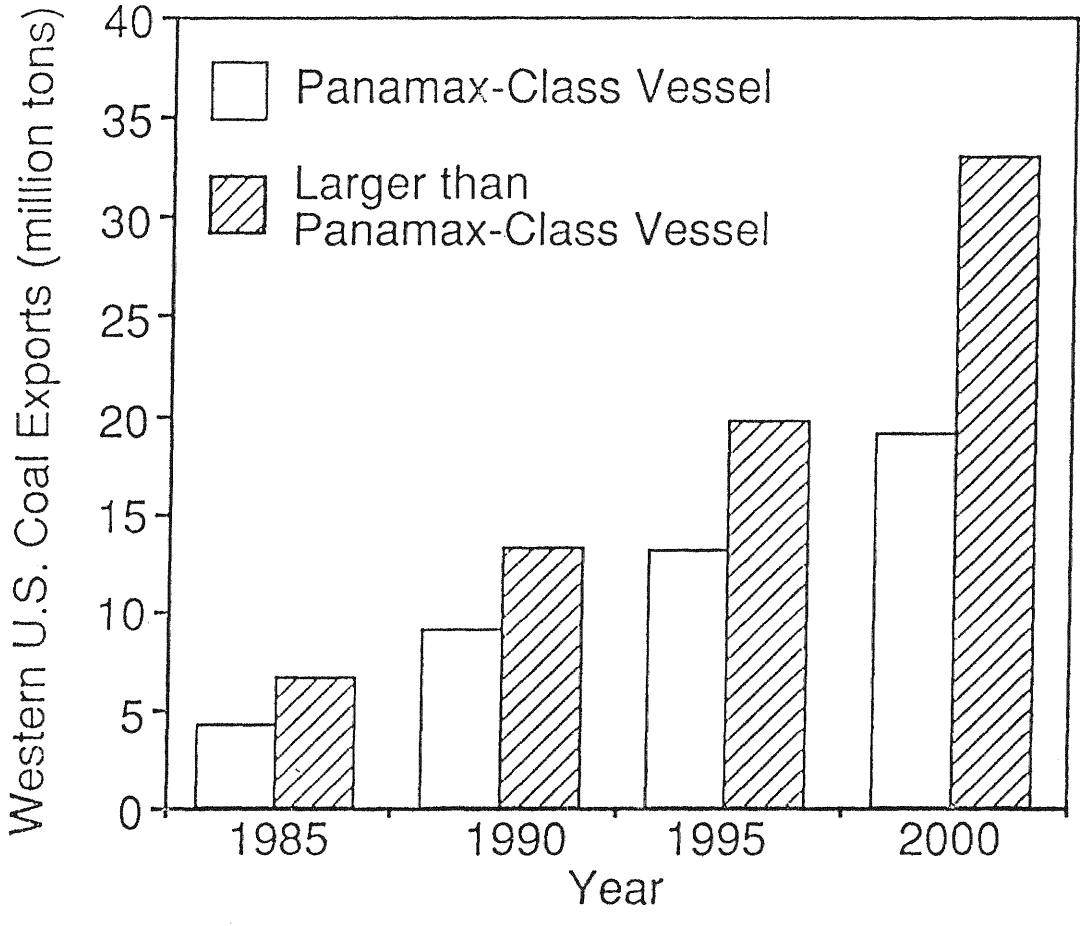
RO/RO Barge



Container Barge Lift On/Lift Off



Grain/Steel/Oil Bulk Barge


Western U.S. Coal Exports (million tons)
40
35
30
25
20
15
10
5
0
Panamax-Class Vessel
Larger than
Panamax-Class Vessel
1985
1990
1995
2000
Year

OCEAN SHIPPING COST SAVINGS

Coal Water Fuel Tankers: CWF tankers transport a mixture on average of about 60% fine coal and 40% water. The CWF is fired directly in boilers.

- Average savings using a 10 million ton per year throughput baseline case are approximately $2.20 per ton and can range up to $4.83 per ton.

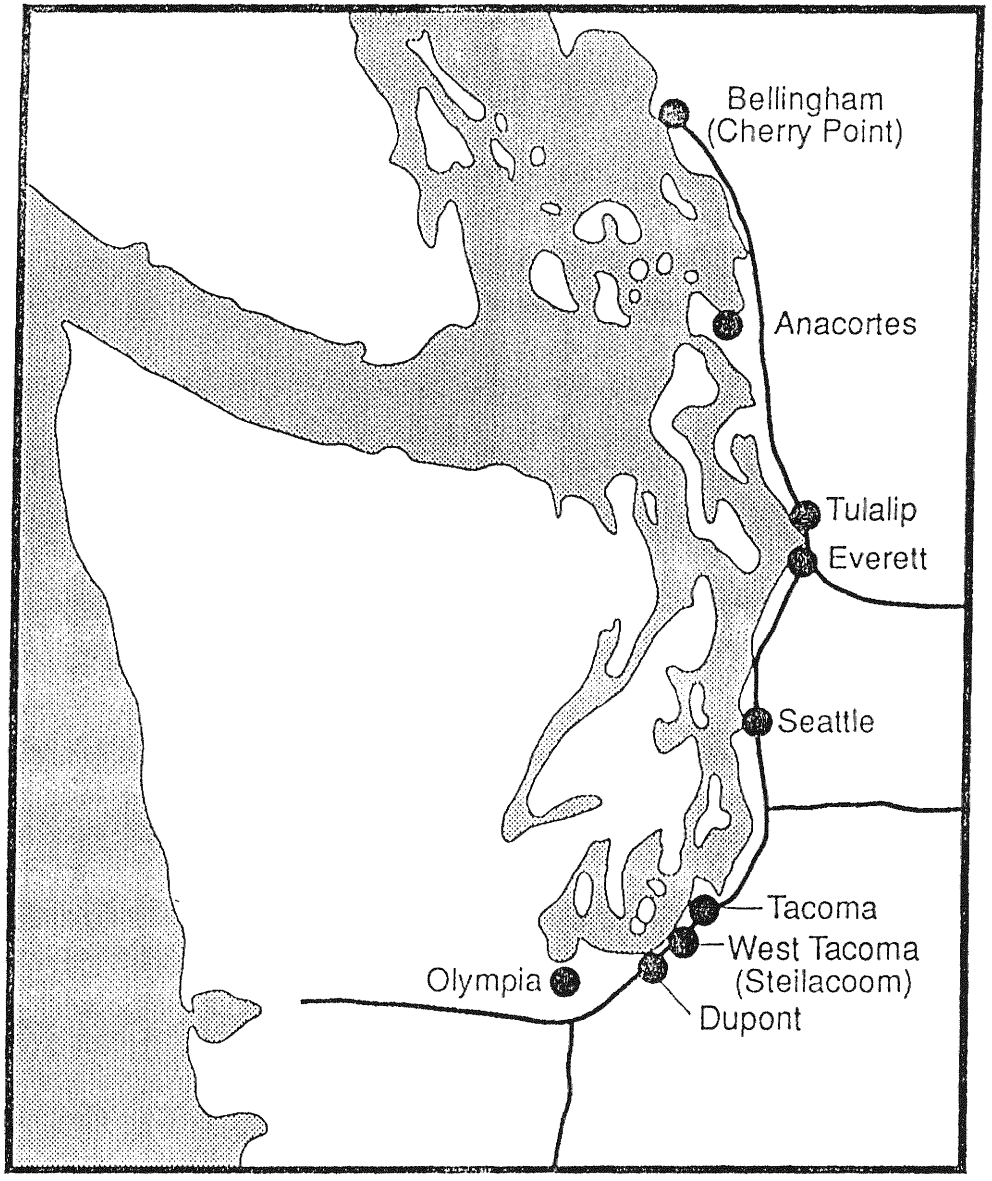
- For even greater throughputs this technology offers increased savings. However, for lower throughputs this system is less competitive due to high initial fixed costs.

- CWF tankers cannot economically be converted from the existing fleet. New vessels will be needed.

- Terminals for CWF tankers can be offshore, single point mooring buoys. These offer lower environmental impact, shorter construction time, and overall lower long-term operating costs. Puget Sound is considered the most suitable location for a West Coast pipeline/ship interface.

This technology requires long-term supply commitments.

PUGET SOUND - POTENTIAL COAL TERMINAL SITES



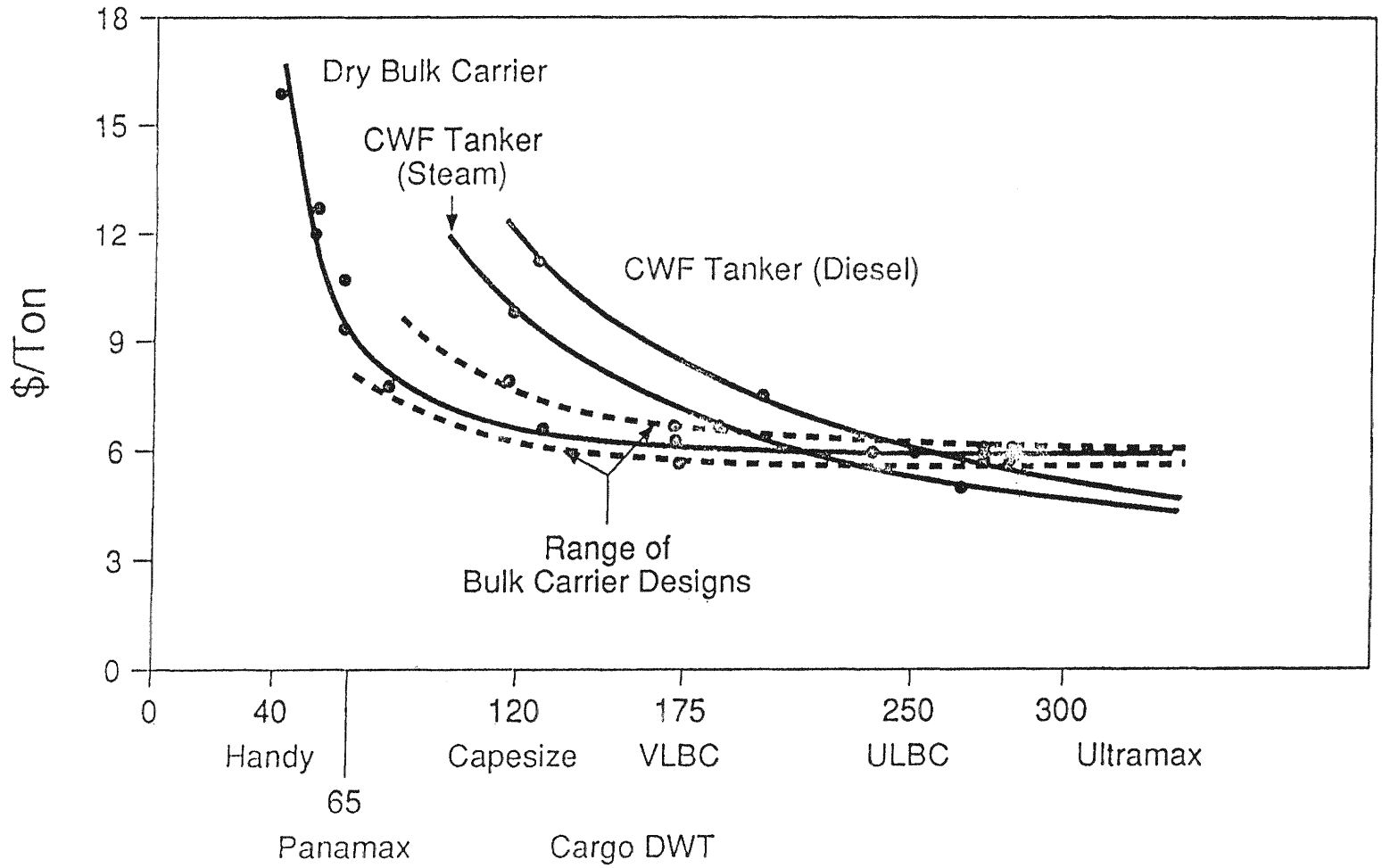
THE DO NOTHING SCENARIO

Shipping costs will rise over the long term:

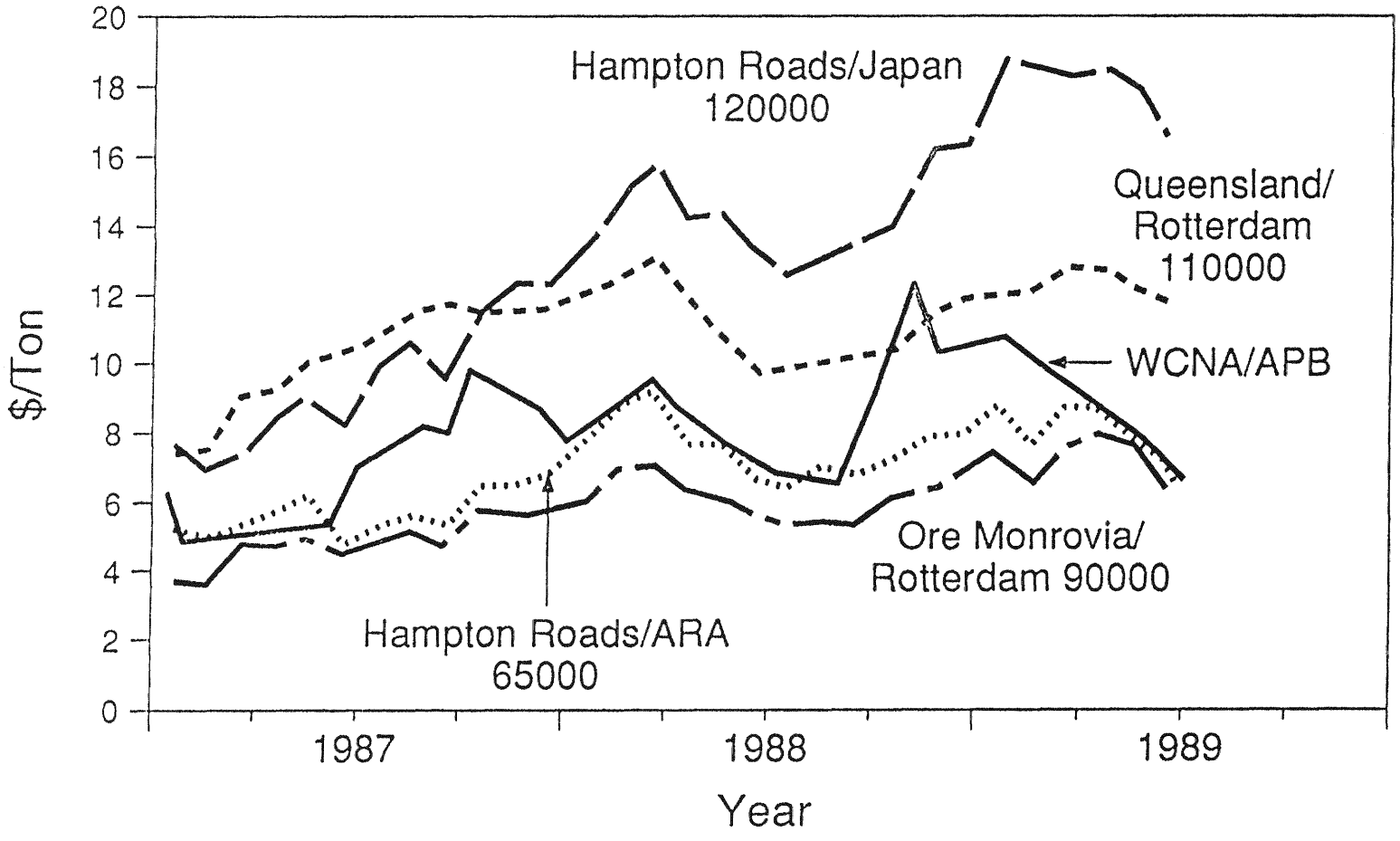
- Rates for both spot and time charters are on the uptrend.
- Earnings power of ships drives the second-hand sale and purchase market.
- Rising second-hand ship values contribute to increases in newbuilding prices.
- Shipbuilding capacity has been reduced globally led by Japan and Western Europe.
- Extremely liberal financing packages by banks and various government agencies have been reduced.
- In addition to rising capital costs, vessel operating costs are rising worldwide.

To do nothing, therefore, will not contribute to improvement of the U.S. position relative to other suppliers of coal to the APB.

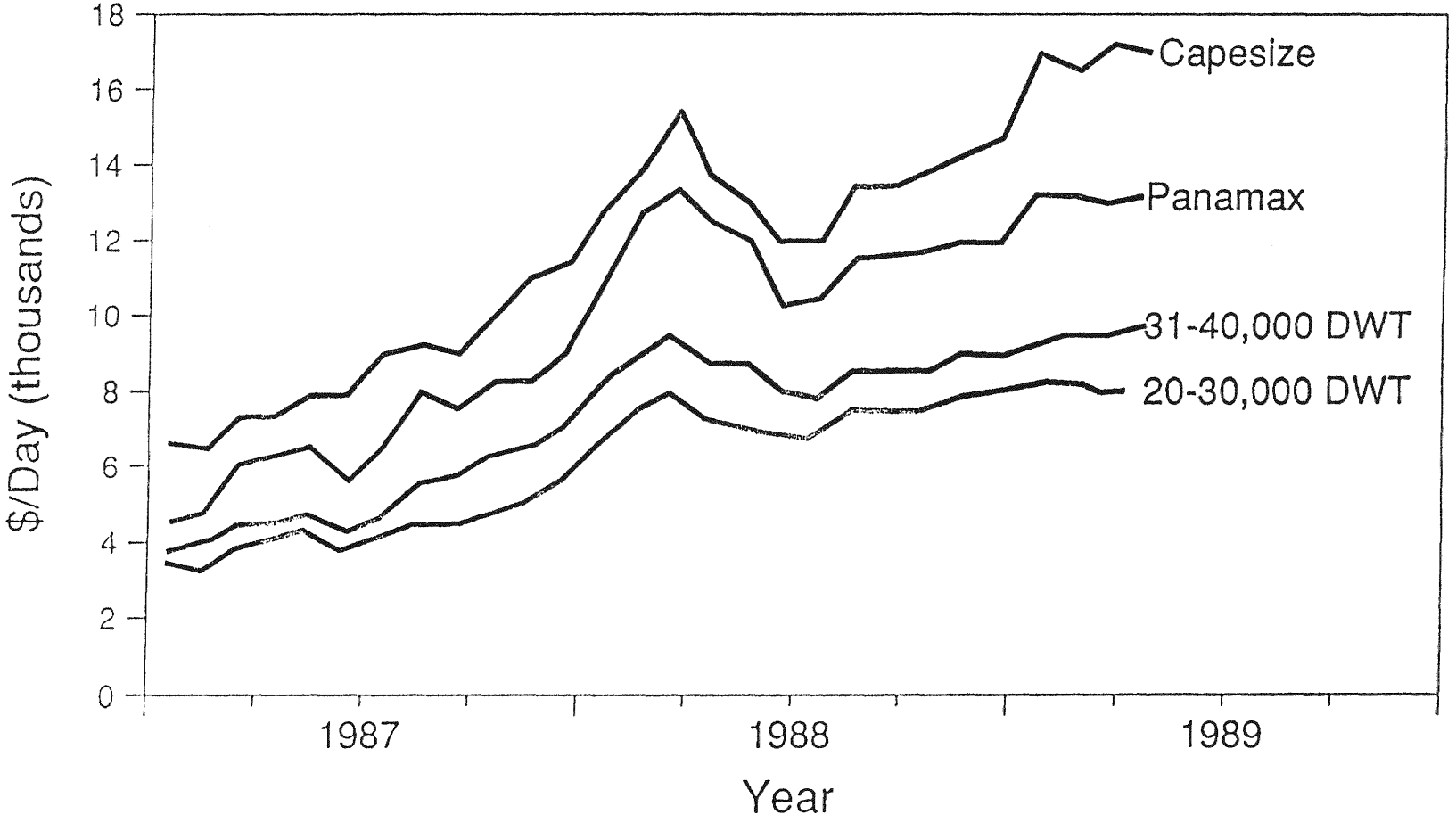
COAL TRANSPORT COSTS VS. VESSEL TYPE AND SIZE



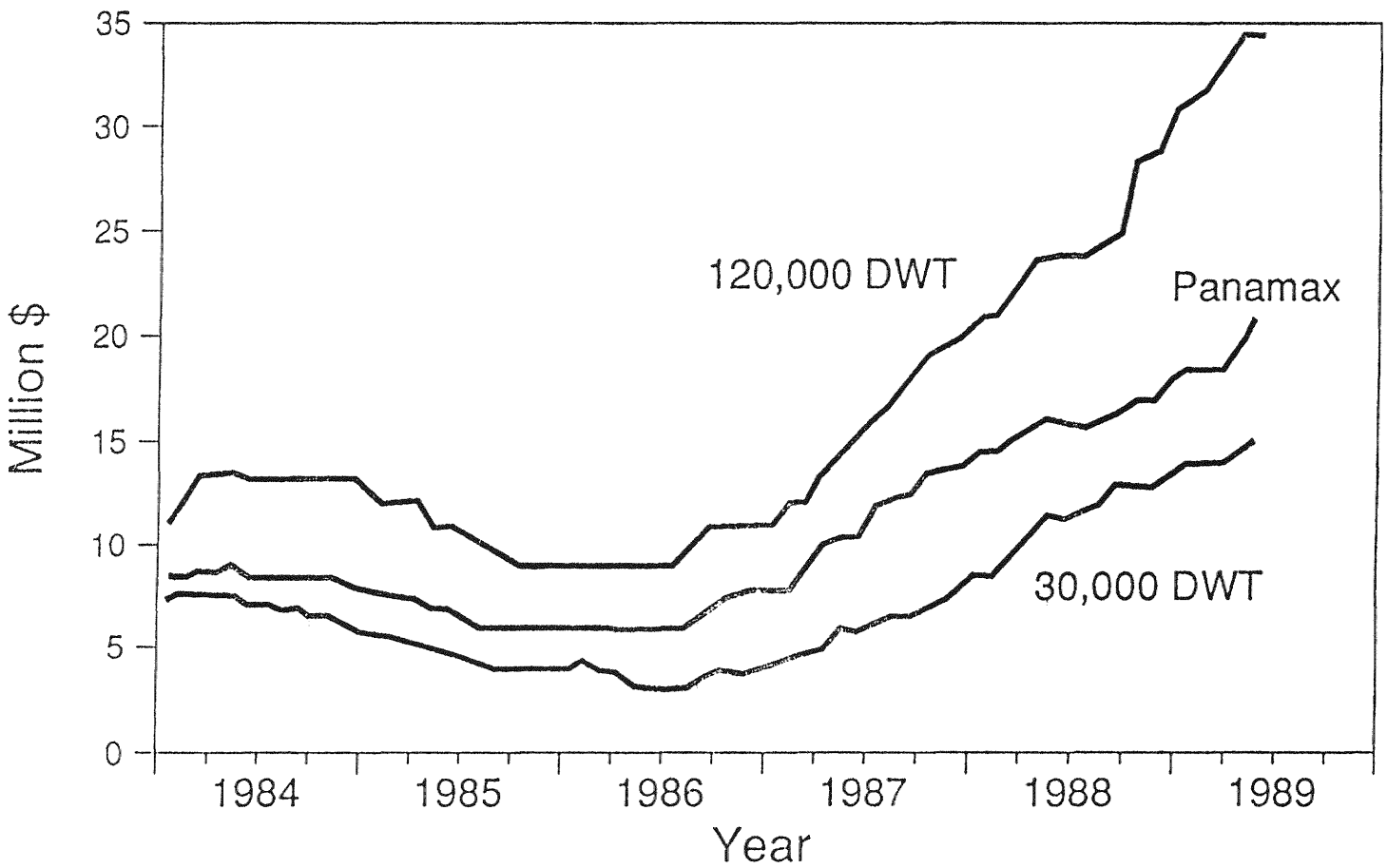
VOYAGE CHARTER RATES - DRY BULK CARRIERS



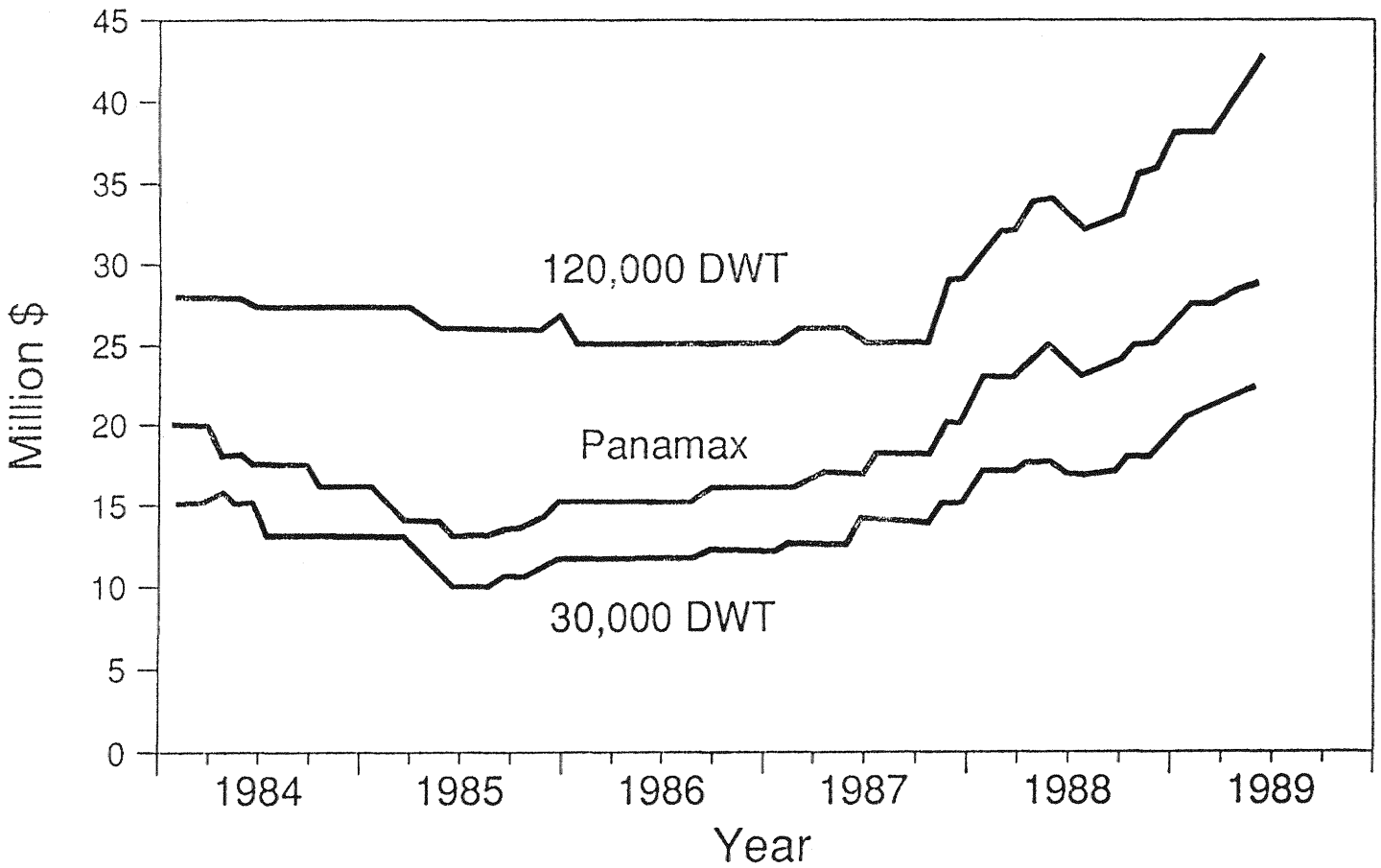
TIME CHARTER RATES - STANDARD DRY BULK CARRIERS



SECOND HAND PRICES - DRY BULK CARRIERS



NEW CONSTRUCTION PRICES - DRY BULK CARRIERS



CONCLUSION

The conclusion is that ocean transport costs of western U.S. coals can be reduced on average by between $2.50 and $3.50 per ton.

Costs to achieve this include harbor improvements coupled with use of larger conventional bulkers and/or broader marketing focus of traditional bulk ship operators and/or investment in higher technology CWF tanker transport systems.

We must continue to explore and commit resources to improving efficiency and competitiveness of U.S. coal exports. While demand for coal is growing, particularly in Asia, there is not a shortage of suppliers able and willing to compete in these trades.

OTHER ISSUES

Additional issues that can impact the costs of shipping coal to Asia were identified as:

- Use of Freight Futures
- Vertical Ownership Participation
  - -- in mines, railroads, pipelines, port facilities, and ships
- Proposed U.S. Port User Fees
- Demurrage Costs

OTHER ISSUES

- Backhaul cargos
- Freight futures
- Vessel ownership participation
- Port user fees
- Demurrage costs

CLOSURE

PAX PER MERCATURAM

Commerce, and the ships which make it possible, are the greatest single contributors to world peace. So we as a global economy and also as a global community must strive to discover ways to make things work that serve our mutual self interests. International trade in U.S. coals is such an opportunity.

Peace through commerce. Thank you very much.

PAX PER MERCATURAM

U.S. DOE/Office of Fossil Energy

HOSSEIN RAZAVI
Senior Energy Economist
World Bank

Hossein Razavi is a Senior Energy Economist at the World Bank. He led studies of the energy sector in the Philippines, Thailand, and Malaysia, and has managed the Bank's energy projects in Korea, Philippines, Thailand, and Malaysia.

Prior to joining the World Bank, Dr. Razavi worked at the Washington office of Ernst and Whinney, carrying out projects in utility management, power systems planning, oil and gas investment analysis.

Hossein Razavi holds a Ph.D in economics and B.S. and M.S. in engineering He has published extensively in the field of energy economics. His recent publications have appeared in the *Energy Journal, Energy Economics, Energy Policy, Energy and Resources, OPEC Review, Applied Energy, Applied Economics*, and *Southern Economic Journal.*

ELECTRICITY GENERATION IN ASIA AND THE PACIFIC: POWER SECTOR DEMAND FOR COAL, OIL, AND NATURAL GAS

Hossein Razavi*
World Bank
Washington, D.C.

Fereidun Fesharaki
East-West Center
Resource Systems Institute
Honolulu, Hawaii

*Opinions expressed here are those of the authors and do not necessarily represent the views of the World Bank or the East-West Center.

I. INTRODUCTION

The Asia-Pacific region contains 17% of world energy resources and produces about 16% of energy supply but consumes 20% of world energy demand. The gap between production and consumption varies for different types of fuel. In non-oil energy, the region maintains a balance between demand and supply. The gap is therefore almost totally reflected in the difference between production and consumption of petroleum, in which case the region produces 10% but consumes 18% of the world's total production. The net import of oil into the region is about 4.5 million barrels per day (mmbd), which still indicates a significant improvement compared with 5.6 mmbd in 1976 and 5.7 mmbd in 1980.

The reduction in oil imports has been achieved through a major effort by almost all countries in the region to reduce their dependence on petroleum. The drive towards such an objective started in the mid-1970s, and the results started to show up in the early 1980s. Neither the drive itself nor its results have yet come to an end. The trend to replace oil is expected to continue well through the 1990s.

A major avenue for shifting away from oil use is to change the fuel mix in the power sector. This possibility has been utilized to its full extent in many Asian countries, resulting in drastic changes in sources of electricity generation. The share of oil in total electricity production declined from 43% in 1975 to 18% in 1987, while the share of coal increased from 29% to 39% and nuclear power and natural gas were introduced and grew to comprise 15% and 11%, respectively, of total generation by 1987. The fuel shares are expected to change further as the ongoing and planned investments in power generating capacity become operational through the next 11 years.

The purpose of this study is to assess the future mix of fuels required for power generation in the Asia-Pacific region. The mechanics of such an assessment are to:

(a) project future electricity demand;
(b) review the present generating capacity to estimate the shortfall in meeting future demand;
(c) appraise the capital and operating costs of electricty generated by oil, coal, gas, hydro and nuclear power;
(d) use the results of (a), (b) and (c) to arrive at a "least-cost" mix and level of generating capacity which would be sufficient to meet future demand;
(e) calculate the level of electricity generation from each type of capacity; and
(f) estimate the quantity of each type of fuel which will be needed to generate the above level of electricity generation.

The study follows the above steps for each country and presents the results accordingly. A detailed, country-by-country analysis is reported

subsequently remained at that level. The share of the residential and commercial sectors grew in the 1970s. The residential sector's share (17% in 1975) reached about 20% in 1980. The sectoral distribution of electricity consumption has remained stable since 1980 and is expected to remain at the current mix during the 1990s.

[TABLE 1 HERE]

Regional Patterns of Electricity Consumption

The regional distribution of electricity consumption presents some interesting patterns in both the total and the per-capita use of electricity. The total consumption of electricity is concentrated among the four largest users--Japan, China, India and Australia. Japan consumed more than 50% of the region's electricity demand until the late 1970s (see Table 2). Its share has now declined to less than 40%. China's share of electricity consumption has grown from about 17% in 1970 to 27% in 1987, while India's and Australia's shares have remained around 9% and 7%, respectively. The four countries together consumed about 90% of the region's electricity in the 1970s and still use about 80% of the total power demand. The decline in the combined share of the largest four consumers has been taken over by several other countries, notably Korea and Taiwan. Korea's electricity consumption increased from 2,463 GWh in 1965 to 63,410 GWh in 1987, while Taiwan's consumption increased from 5,673 GWh to 59,175 GWh. As a result, these countries have become the fifth and sixth largest users of electricity, each representing more than 4% of the total demand.

[TABLE 2 HERE]

The ranking of Asian countries in terms of per-capita consumption of electricity is substantially different from their position in total electricity use. New Zealand, with a per-capita consumption of 7,800 kWh per annum ranks first, followed by Australia (6,500 kWh), Japan (5,500 kWh), Singapore (4,000 kWh), Taiwan (2,600 kWh) and Korea (1,600 kWh) (see Table 2). China and India, with per-capita consumptions of 420 kWh and 260 kWh, rank ninth and eleventh, respectively.

Projected Demand to the Year 2000

The eventual objective of reviewing past trends is to arrive at a reasonable forecast for future growth in electricity demand. Most Asia-Pacific utilities undertake a continuous effort to update their past data and revise their projections of future demand. The forecasts utilized in this study are based on the latest available information for each country.

Table 1 contains the projections of electricity demand for the region's utilities. The overall growth is forecast at an annual rate of 5.8% p.a. This is substantially lower than the rates experienced in the 1960s and 1970s but somewhat higher than the rate of 5% p.a. during 1980-85. The sectoral distribution of demand is expected to remain rather stable through the 1990s.

Regional distribution of the power demand is expected to change

TABLE 2. Historical and Projected Distribution of Electricity Demand in Asian Countries, 1965-2000

Country	Share of Total Consumption (%)				Average Annual Growth Rate 1987-2000 (%)	Per capita electricity consumption in 1987 (kWh)
	1965	1975	1987	2000		
Japan	50.6	53.9	38.3	26.1	2.6	5,500
Korea	0.9	1.8	4.4	5.0	6.8	1,600
Taiwan	2.0	2.9	4.1	4.8	7.0	2,600
Singapore	0.3	0.4	0.7	0.7	5.2	4,000
Philippines	1.2	1.2	1.3	1.7	7.5	400
Thailand	1.4	1.1	1.6	1.8	6.6	510
Malaysia	0.4	0.5	1.0	1.1	7.0	1,012
Indonesia	0.3	0.4	1.2	2.8	13.0	176
China	19.9	19.5	26.7	31.1	7.0	420
India	8.5	7.7	9.5	15.9	10.0	260
Pakistan	-	0.7	1.2	1.5	7.0	250
Bangladesh	0.1	0.1	0.2	0.6	14.0	40
Sri Lanka	-	0.1	0.2	0.2	8.1	150
Nepal	-	-	-	-	9.6	20
Australia	10.5	7.2	7.3	5.2	2.9	6,500
New Zealand	2.8	2.1	1.9	1.2	2.5	7,800

Total electricity demand (GWh)	1965	1975	1987	1995	2000
	284,554	803,836	1,429,149	2,194,955	2,952,044

Notes: Hyphens (-) represent neglible percentages. Percentages may not add to 100 because of rounding error.

TABLE 1. Historical and Projected Electricity Demand by Consumer Group, 1965-2000

Consumer Group	1965	1975	1980	1987	1995	2000
Industrial						
GWh	165,939	393,029	554,778	728,363	1,137,701	1,491,649
% of total	58	49	50	51	51	50
Residential						
GWh	54,743	134,527	198,759	300,116	453,726	605,737
% of total	19	17	19	21	21	20
Commercial and other						
GWh	63,872	276,280	347,045	400,670	603,528	854,658
% of total	23	34	31	28	28	29
Total consumption (GWh)	284,554	803,836	1,100,582	1,429,149	2,194,955	2,952,044

NOTE: Percentages may not total 100 because of rounding error.

substantially. Electricity demand in Japan is projected to grow at 2.6% p.a. (see Table 2). As a result, Japan's share of electricity consumption in the regional context is expected to decline from 38% in 1987 to 26% in 2000. Similarly, Australia's electricity demand is projected to grow at 2.9%, resulting in a decline in its share from 7% to 5%. The other two large consumers--China and India--are both expected to grow faster than the average rate for the region. China's growth rate is projected at 7% p.a. while India's growth rate is forecast at 10% p.a., the highest rate in Asia. Korea and Taiwan are expected to maintain their ranks, respectively, as the fifth and sixth largest consumers. Korea's growth of electricity demand is projected at 6.7% p.a., while Taiwan's growth rate is forecast at 7% p.a.

In summary, electricity demand is expected to grow at substantially different rates (from 2.7% p.a. in Japan to 10% p.a. in India) in different countries of the region, but aggregate regional demand is forecast to grow at a rate of 5.8% p.a.--very close to the average rate experienced during the last ten years.

III. PRESENT GENERATING CAPACITY

A review of the level and the types of present power generating capacity is needed before one can assess the possible shortfalls and the need for future expansion (see Table 3). The total installed capacity of power utilities in the Asia-Pacific region increased from 77,000 MW in 1965 to 388,000 MW in 1987, representing a growth rate of about 8% p.a. The growth during the 1960s and the first half of the 1970s was substantially higher--11% p.a.--than the growth rate of 5.5% p.a. experienced during the 1975-87 period.

[TABLE 3 HERE]

The Aggregate Mix of Generating Capacity

The mix of the region's generating capacity has changed substantially in the last two decades. During the 1965-75 period, the overall tendency was to increase the use of oil-based and gas-based capacity and to cut back on investments on hydroelectric and coal-based power plants. The main reason was, of course, the lower petroleum prices of the 1960s and early 1970s, which made oil- and gas-based electricity generation less costly than other options As a result, between 1965 and 1975 the shares of hydro capacity declined from 32% to 27%, coal-based capacity declined from 38% to 30%, whereas oil- and gas-based capacity increased from 29% to 40% (see Table 4).

[TABLE 4 HERE]

The rapid rise of petroleum prices in the 1970s reversed the trend by stimulating an intensive effort to reduce the dependency on petroleum for power generation. The result was a sharp drop in the share of oil-based capacity from 31% in 1980 to 20% in 1987. The oil share was initially replaced by nuclear power, representing 10% of generating capacity in 1987 compared with 6% in 1980. At a later stage, coal-based power became an even more important source of replacing oil. Its share in total capacity increased

TABLE 3. Regional Distribution of Installed Capacity at End-1987 (MW)

Country	Hydro	Oil	Gas	Coal	Nuclear	Total
Japan	26,123	43,900	30,000	12,000	25,098	137,122
Korea	2,232	4,822	2,550	3,700	5,716	19,020
Taiwan	2,558	4,932	0	3,955	5,144	16,589
Singapore	0	3,371	0	0	0	3,371
Philippines	2,124	2,365	894a	405	0	5,788
Thailand	2,250	1,042	2,720	885	0	6,877
Malaysia	1,316	2,557	900	0	0	4,773
Indonesia	1,262	3,957	378	930	0	6,527
China	28,000	9,000	0	52,000	0	89,000
India	16,196	168	1,178	30,394	1,330	49,266
Pakistan	2,800	2,000	2,000	0	125	6,800
Bangladesh	130	408	1,069	0	0	1,607
Sri Lanka	868	270	0	0	0	1,138
Nepal	140	36	0	0	0	176
Australia	7,143	1,200	2,400	22,100	0	32,843
New Zealand	4,324	0	2,000	1,019	0	7,433

a. Geothermal plants.

TABLE 4. Total Installed Power Generating Capacity in the Asia-Pacific, 1965-87

Type of Capacity	1965	1970	1975	1980	1985	1987
Total capacity (MW)	69,561	117,756	200,856	281,857	365,217	388,329
Hydro						
Capacity (MW)	22,545	34,919	54,020	71,760	90,974	97,466
% of total	32	29	27	25	25	25
Oil-based						
Capacity (MW)	20,350	35,822	63,139	83,860	86,650	80,028
% of total	29	30	31	30	24	20
Gas-based						
Capacity (MW)	258	10,412	17,761	24,705	34,646	46,069
% of total		9	9	9	9	12
Coal-based						
Capacity (MW)	26,408	35,383	60,298	84,690	120,709	127,478
% of total	38	30	30	30	33	33
Nuclear						
Capacity (MW)	0	1,220	5,640	16,842	32,238	37,288
% of total	0	1	3	6	9	10

elsewhere. This paper presents the regional profile by reviewing the power demand, supply and fuel mix for the entire Asia-Pacific region, including 16 countries--Japan, Korea, Taiwan, Singapore, Philippines, Thailand, Malaysia, Indonesia, China, India, Pakistan, Bangladesh, Sri Lanka, Nepal, Australia and New Zealand.

II. HISTORICAL AND PROJECTED DEMAND FOR ELECTRICITY

Although most electricity demand forecasts have not survived the test of time, they are used to draw up plans and to make investments in expanding the generation, transmission and distribution capacities. It is therefore important to acquire a feel of the magnitude of the future power load before assessing the fuel requirements of the power sector.

The growth in electricity consumption in a country is influenced by several factors, including:

(a) the rate at which national income grows;
(b) the increase in access to electricity--the electrification policy;
(c) the rate of electricity penetration--the rate at which electricity replaces other commercial fuels;
(d) the extent to which rising prices of electricity induce a slowdown in electricity use; and
(e) the extent to which electricity consumers may approach a saturation point resulting in slower growth in electricity use.

An interesting feature of electricity use in the Asia-Pacific is that the countries in the region are in various phases of economic development and thus their electricity use represents an entire spectrum of a classical pattern, from an early stage in Nepal and Bangladesh to a saturation stage in New Zealand, Australia, Japan, Taiwan and Singapore.

The total electricity consumption in the Asia-Pacific is presently about 1,500,000 GWh p.a., equivalent to about 7 mmbd of crude oil. Electricity consumption grew at a high rate of about 15% p.a. during the 1960s and 10% p.a. during the first half of the 1970s. The growth slowed down substantially to about 6% p.a. in the second half of the 1970s and to only 5% p.a. in the first half of the 1980s. Since 1985 there has been a noticeable recovery to about 7.5% p.a., and this trend is expected to stabilize at a long-term rate of about 5.8% p.a.

Sectoral Distribution of Electricity Demand

The industrial sector was the dominant consumer of electricity in the late 1960s and early 1970s, accounting for about 58% of the total electricity demand (see Table 1). By 1980 this share was reduced to about 50%, and it has

from 30% in 1980 to 33% in 1987. The major effect of the move towards coal is yet to come, as the share of coal-based capacity will increase to about 40% by the late 1990s.

Capacity Mix Versus Generation Mix

Major decisions by power utilities fall into two categories: (a) long-term capacity expansion and (b) optimum utilization of the available capacity. The long-term decision determines the level and the mix of generating capacity based on some projections of electricity demand and fuel prices. But by the time plants are built and in operation, the demand and fuel prices have often, in the interim, changed differently from what was assumed at the planning stage. The utility, nevertheless, is stuck with the available capacity and must utilize it in the most effective way. Long-term decisions--referred to as 'investment' or 'development' decisions--are normally made to minimize the projected costs. Short-term decisions--referred to as 'dispatch' decisions--are made on an hourly basis (or sometimes minute-by-minute) to determine which generating units should be operating and at what level of capacity. These decisions in turn determine the generation mix--ie, the electricity actually generated by each type of plant.

Figure 1 shows the share of oil-based capacity in total installed capacity, as well as the share of oil-based generation in total power generation. With the low oil prices of the 1960s, the share of oil-based installed capacity rose but at a gradual pace due to the lead time required for building new oil-fired plants. However, the share of oil-based generation increased very rapidly through intensive utilization of the existing plants.

[FIGURE 1 HERE]

After 1975 most power utilities stopped building new oil-fired plants, and the expansion in oil-based capacity was limited to the commissioning of units already under construction. Nevertheless, the share of the installed capacity did not decline significantly because most plants were new and would not retire before the end of their operational life. However, the share of oil-based generation dropped sharply through reduced utilization of oil-based plants.

Figure 2 shows that the shares of coal-based capacity and generation moved in the direction opposite to those of oil-based capacity and generation. Here again, the share in generation reacted more sharply than the share in installed capacity to the variations in the relative fuel prices.

[FIGURE 2 HERE]

In summary, the region's power utilities increased their oil-based capacity from 20,000 MW in 1965 to 63,000 MW in 1975. The utility managers then realized that the decision to build oil-fired plants was wrong but found themselves locked into the oil option. Within the technical limits, they reduced the utilization of oil units while constructing new nuclear and coal-based power plants.

FIGURE 1. Share of Oil-based Capacity and Oil-based Generation

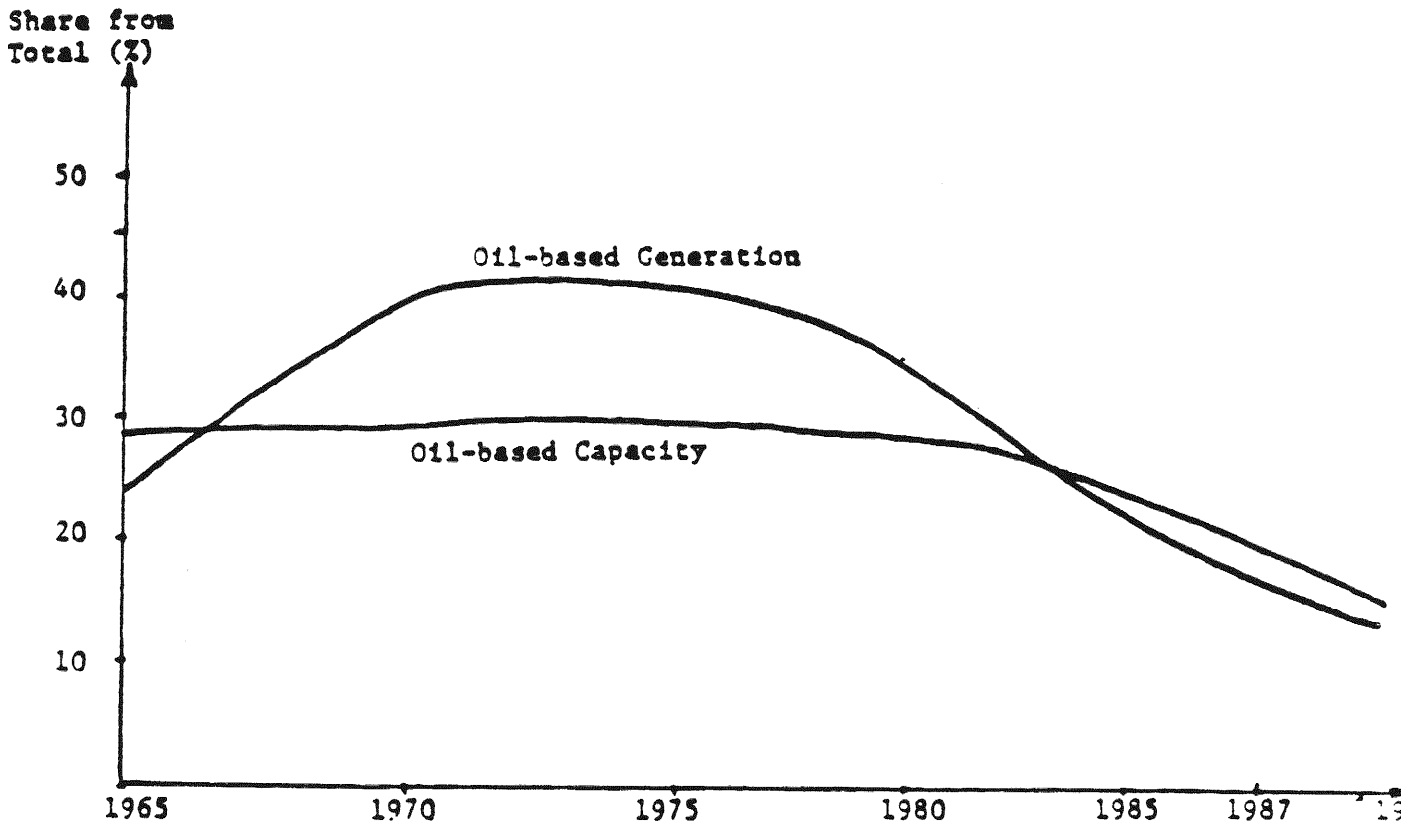


FIGURE 2. Share of Coal-based Capacity and Coal-based Generation

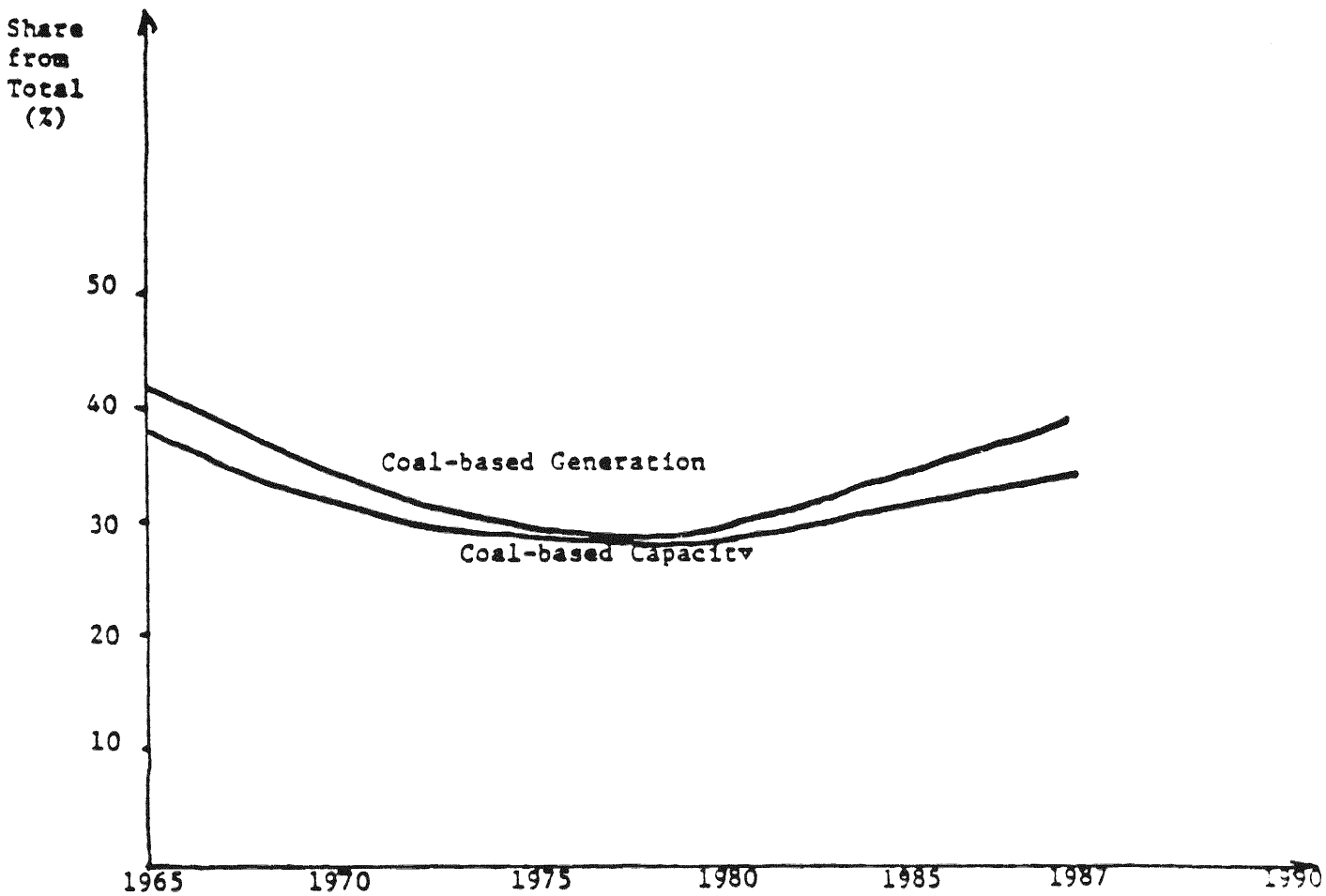


TABLE 5. Most Recent Estimates of Economically Recoverable Energy Resources in the Asia-Pacific

	Crude Oil (million barrels)	Natural Gas (trillion ft3)	Coal (billion) short tons)	Total (mmtoe)
Japan	100	1.1	1.1	610
Korea	0	0.0	0.7	379
Taiwan	0	0.6	0.2	124
Singapore	0	0.0	0.0	0
Philippines	15	u	0.3	164
Thailand	100	7.4	0.4	426
Malaysia	2,800	49.4	0.03	1,715
Indonesia	8,300	49.4	1.4	3,243
China	18,400	30.0	108.9	62,441
India	4,200	17.6	37.7	19,870
Pakistan	100	18.7	0.1	560
Bangladesh	18	12.7	u	179
Sri Lanka	u	u	u	u
Nepal	u	u	u	u
Australia	1,700	18.7	72.4	39,975
New Zealand	200	5.7	0.3	360
Others	1,500	17.4	2.1	2,000
Total Asia-Pacific	37,500	228.7	225.6	132,046
World total reserves	699,800	3,632.3	1,049.3	764,051
% of world reserves	5.4	6.3	21.5	17.2

u = unavailable.

IV. INVESTMENT AND PROJECTED GENERATING CAPACITY

Projections of electricity demand and the review of existing facilities indicate that the generating capacity of the power sector needs to be expanded by about 360,000 MW during 1989-2000. The most important investment decision that the utility companies will make is whether this additional capacity should be based on coal, hydro, nuclear, oil or a certain mix of these options. The decision will be based on two important considerations: first, the availability of domestic sources of energy; second, the economics of building and operating each type of plant.

Indigenous Sources of Energy

The Asia-Pacific region has a wide base, though not evenly distributed, of sources of energy. Table 5 contains the latest (1987) estimates of energy resources by country, compared with total resources worldwide. The region has 17% of the world's energy resources. However, from an approximate total recoverable energy reserve of 132 billion tons of oil equivalent (toe), about 95% is located in three countries alone: China (48%), Australia (31%) and India (16%). In addition to this uneven regional distribution, the resources are also unevenly distributed in form. Oil and gas reserves of the region comprise only 5.4% and 6.3%, respectively, of the world's resources, whereas recoverable coal reserves represent more than 20% of the world's resources. The region's coal reserves are likely to be far greater than the 228 billion tons included in the table, but they have not yet been brought into the estimates of recoverable reserves.

[TABLE 5 HERE]

The above distribution of indigenous resources reveals that: (a) despite the availability of energy resources in the region, most countries need to import their energy requirements either from a few countries within the region or from outside the region; and (b) a large part of oil requirements has to be imported from outside the region. Most energy-importing countries of the region appear to view the supply of resources within the region as more reliable than the supply from the outside. And, of course, they all view the supply of coal to be more reliable than oil. As a result, the energy policy of most countries has aimed at shifting away from oil to coal, with the understanding that coal would be available at relatively stable prices from Australia, China and, possibly Indonesia.

Switching fuels would not only take time and investment expenditures but also is difficult in certain sectors, such as transportation and industry, which have a large demand for petroleum fuels. Table 6 gives a picture of energy supply and demand in Asia-Pacific countries. The largest energy consuming country (China) is self-sufficient in energy production. The second-largest consumer (Japan) has very little domestic production and is almost totally dependent on imports for its energy requirements. The third-largest consumer (India) is 95% self-sufficient. The other large consumers (Korea and Taiwan) are again heavily dependent on imports. Only three

TABLE 6. Energy Production, Import and Consumption in the Asia-Pacific, 1986 (mmtoe)

Country	Production					Net Imports	Consumption
	Oil	Gas	Coal	Nuclear	Total		
Japan	0.65	1.99	9.85	22.00	34.50	299.40	308.11
Korea	0.00	0.00	11.16	2.78	13.94	46.81	47.71
Taiwan	0.00	0.00	0.00	3.00	3.00	30.42	33.42
Singapore	0.00	0.00	0.00	0.00	0.00	7.52	7.52
Philippines	0.34	0.00	0.59	0.91	1.84	8.47	9.62
Thailand	2.23	3.11	1.43	0.47	7.25	9.67	16.49
Malaysia	24.80	8.80	0.00	0.35	33.97	-21.81	11.67
Indonesia	71.00	26.74	1.20	0.62	99.58	-64.05	33.23
China	130.61	13.07	429.28	8.59	581.55	-35.13	519.99
India	31.33	5.00	98.17	5.05	139.57	19.16	147.13
Pakistan	1.92	7.69	0.98	1.21	11.81	6.65	17.93
Bangladesh	0.09	2.78	0.00	0.04	2.92	1.85	4.48
Sri Lanka	0.00	0.00	0.00	0.23	0.23	1.84	2.07
Nepal	0.00	0.00	u	0.00	u	u	u
Australia	27.60	13.60	83.30	1.40	126.00	-51.70	74.50
New Zealand	1.30	3.30	1.30	1.90	7.90	1.50	9.10

u = unavailable.

countries (Australia, Indonesia and Malaysia) are considered to have sufficient resources to remain energy exporters over the long term.

[TABLE 6 HERE]

Economics of Various Fuel Options

Within the context of availability of domestic resources, each power utility examines the eventual cost of generating electricity by various types of fuel before committing to an expansion plan. The examination of the cost takes place in two stages. First, an average discounted cost is calculated to indicate the relative economic position of each option. Second, a least-cost computation is carried out to choose, among alternative types and sizes of power plants, a mix which would meet the future power demand at the minimum cost.

The results presented here are based on least-cost analyses of each utility, but it is useful to start with some average cost numbers for the region in order to provide an understanding about the costs of various options.

Oil Option. Estimating the economic cost of power generation from heavy fuel oil is difficult due to uncertainties associated with the projection of oil prices in the 1990s and beyond. To provide a benchmark for comparison, we calculate the discounted cost of electricity from heavy fuel-oil based on the assumption that the per-barrel real price of crude oil increases from an average of $16.20 in 1988 to $17.25 in 1990, $22.00 in 1995 and $25.66 in 2000. The price of heavy fuel oil is assumed to remain around 85% of the price of crude.

The average discounted cost of electricity generated by fuel-oil-fired steam plant would be as follows:

(a) capital cost = $525 per kW installed capacity, which would result in a cost of US¢0.94 per kWh of electricity generated;
(b) fuel cost = $13.77/bl in 1988, increasing to $21.81/bl by 2000, which would result in a cost of US¢3.01/kWh generated; hence
(c) average discounted cost = US¢0.94 + US¢3.01 = US¢3.95/kWh generated.

Gas Option. From medium- and long-term perspectives, LNG price movements are projected not to depart greatly from those for crude oil on a heating value parity basis. The present expectation is that the price of LNG will stay about 90% of crude oil parity during the 1990s and beyond. For countries which use domestically produced gas, the cost varies substantially and should be calculated on a case-by-case basis.

Until a few years ago, natural gas was used in conventional steam plants to generate electricity. However, with the vast improvements in the operational record of combined-cycle power plants, most countries which use gas are now building this type of plant. The thermal efficiency of a combined-cycle plant is around 45%, compared with a 38% thermal efficiency for steam plants.

The average discounted cost of a combined-cycle gas-based power plant is calculated as follows:

(a) capital cost = $500/kW installed capacity, which would result in a cost of US¢0.91/kWh of electricity generated;
(b) fuel cost priced at 90% of crude oil parity which would result in US¢2.66/kWh generated; hence
(c) average discounted cost = US¢0.91 + US¢2.66 = US¢3.57/kWh generated.

Coal Option. The coal price-cuts of the past few years are expected to increase the demand for coal substantially, thus allowing newly developed coal with higher supply costs to appear on the market. The average CIF price of coal (with 12,000 Btu/lb of heat content) is projected to reach $40/ton by 1990 and thereafter increase at 1% p.a. in real terms. The capital cost of a standard coal-fired plant is about $750/kW installed capacity--higher than that of an oil or gas plant. However, should serious environmental constraints be imposed on the pollution emissions and/or should the quality of coal be inferior, the capital cost may be substantially higher than $750/kW.

The average discounted cost of electricity generated from coal is calculated as follow:

(a) capital cost = $750/kW installed, which results in a cost of US¢1.9/kWh of electricity generated;
(b) fuel cost = $40/ton in 1990, increasing at 1% p.a., which would result in US¢1.54/kWh generated; hence
(c) average discounted cost = US¢1.9 + ¢1.54 = US¢3.44/kWh generated.

Nuclear Option. After the oil crises of the 1970s, nuclear generation was encouraged in all Asia-Pacific countries as a secure and economical source of energy. Today, however, the wisdom of building nuclear plants is being questioned due to (a) safety considerations stemmed from the Soviet Union's Chernobyl accident in 1986 and (b) the lower cost of alternative sources of power generation, particularly coal. The main components of the cost of nuclear electricity are its capital cost and the long construction time, during which investment costs accumulate without producing any output. The capital cost of a pressurized water reactor (PWR) plant is estimated at $1,500/kW installed, which would result in a cost of US¢4.3/kWh generated. In addition, a fuel cost of approximately US¢0.7/kWh should be included to calculate the average discounted cost at US¢5.13/kWh generated.

Hydro Option. Hydroelectric projects are all site-specific, hence no meaningful 'average' cost figure for this type of plant can be provided.

Planning and Decision-making

The utility planning and decision-making environment in the Asia-Pacific region has changed substantially during the last 15 years. In the early 1970s a new move was initiated to modernize the planning practice. Thereafter, most utilities in the region equipped themselves with least-cost planning models, such as the WIEN Automatic System Planning Package (WASP), and convinced their

policy-makers that adhering to the solutions of these models is a symbol of objectivity. This mentality has changed quite rapidly since the early 1980s, as decision-makers realized that a "least-cost" solution may not really be least-cost when things do not happen as assumed. Policy-makers have become increasingly convinced that there is a considerable risk in any decision they take, and they are willing to pay a bit more, in terms of cost, to have the flexibility to deal with the risk. This has, to a large extent, served as a kind of backlash to the use of formal modelling--or at least to the "black-box" approach for minimizing costs. Instead, what is becoming increasingly popular is to choose an investment strategy intended to "minimize future regrets." To minimize future regrets, the utility develops a variety of alternative investment programs, each of which is associated with a particular scenario of future events. It then attempts to identify the similarities among these programs and to arrive at a set of decisions which should perform well under all plausible scenarios.

Many utilities in the region combine the results of least-cost analysis with subjective judgments about various types of risks to devise their generation expansion programs. Indeed, the policy adopted by Japan, Korea and Taiwan of proceeding with nuclear power construction and the policy pursued by China and India of keeping a balanced (hydro-coal) generation mix are aimed more at preserving flexibility rather than minimizing costs.

Future Generating Capacity

The power generating capacity of the region is expected to almost double by the end of the century, reaching some 850,000 MW. The shares in total capacity of hydropower, nuclear and gas-based capacity are expected to remain relatively stable, and only the oil and coal shares will change significantly. Between 1987 and 2000, the oil share is expected to decline from 18% to 7%, whereas the coal share is projected to increase from 30% to 40% (see Table 7). These are continuations of trends which began in 1980 when both oil and coal had equal shares (30%). During 1980-87 the declining oil share was overtaken by three alternatives--coal, natural gas and nuclear power--although in the future the oil share will be replaced almost entirely by coal-based capacity.

[TABLE 7 HERE]

The total installed capacity of hydropower plants is expected to increase by about 118,000 MW, from a level of 97,466 MW in 1987 to 216,165 MW in 2000. The additional capacity will keep the share of hydropower generation in the total power generation stable at about 17%. From the added capacity of 118,000 MW, about 48,000 MW will be built in China, 39,000 MW in India and 10,000 MW in Japan. The remaining 21,000 MW will be built in the rest of the region, notably in Australia, Korea and Taiwan.

The total installed capacity of oil-fired power plants is expected to decline from 80,000 MW in 1987 to 64,000 MW in 2000. No significant new investments in oil-based capacity are planned. A small share of the existing capacity is being converted to use natural gas. Most of the existing capacity is being run for intermediate and peaking purposes. No replacement is planned for oil-fired plants as they gradually retire. Most of the decline of

TABLE 7. PROJECTED LEVELS OF GENERATING CAPACITY

	1987	1990	1995	2000
Total capacity (MW)	388,329	450,826	574,854	775,176
Hydro				
Capacity (MW)	97,466	116,593	150,143	216,165
% of total	25	26	26	28
Oil				
Capacity (MW)	80,028	76,710	71,398	64,199
% of total	21	17	12	8
Gas				
Capacity (MW)	46,069	58,995	75,068	83,803
% of total	12	13	13	11
Coal				
Capacity (MW)	127,478	154,938	221,955	327,630
% of total	33	34	38	42
Nuclear				
Capacity (MW)	37,288	43,590	56,290	83,380
% of total	10	10	10	11

16,000 MW during 1987-2000 in total capacity is due to this retirement. Japan will retire 10,000 MW of oil-fired plants during this period, Korea 2,000 MW, Taiwan 2,000 MW and Malaysia 1,000 MW.

The total installed capacity of gas-fired power plants is expected to increase from 46,000 MW in 1987 to about 84,000 MW in 2000. This increase will leave the share of gas-based power capacity at about 11% in 2000, almost the same as its 1987 level. However, in the interim, the share of gas-based power capacity is expected to increase to about 13% by the mid-1990s and then gradually decline back to 11%. The notable difference between the past and future growth of gas-based generation is that a major part of past capacity was built for the use of imported LNG. Most of the future gas-based plants will be built by countries that own gas. Comprising the 38,000 MW of capacity additions are about 11,000 MW being built in Japan, 3,500 MW in Malaysia, 2,700 MW in Thailand, 2,500 MW in Indonesia and the remainder in Pakistan and Bangladesh.

The total installed capacity of coal-fired power plants is projected to increase from 127,000 MW in 1987 to 328,000 MW in 2000. This huge increase in capacity will raise the share of coal-based power in total electricity generation from 39% to 50%. Almost all countries in the region are planning to undertake substantial investments in coal power plants. Comprising the roughly 200,000 MW of additions to coal-based capacity, China will build 84,000 MW, India 60,000 MW, Japan 11,000 MW, Korea 11,000 MW, Indonesia 10,000 MW, Taiwan 8,000 MW, Thailand 4,000 MW, Australia 4,000 MW and the Philippines 3,000 MW. China, India, Indonesia and Australia are planning to supply the fuel requirements of these plants from domestic coal supplies, whereas Japan, Korea, Taiwan, the Philippines and Thailand will be dependent on imports for the major portion of their additional coal needs.

The total installed capacity of nuclear power plants is expected to increase from 37,000 MW in 1987 to 83,000 MW in 2000. This increase will keep the share of nuclear power stable at about 10% of total installed capacity and 15% of total generation. More than half of the addition of 46,000 MW during this period will be built by Japan (28,000 MW), and the remaining 23,000 MW will be built by India (8,000 MW), Korea (5,000 MW) and Taiwan (4,000 MW).

Regional Distribution of Future Generating Capacity

The regional distribution of generating capacity is expected to shift somewhat, as the share of Japan in total power generating capacity will decline from about 35% in 1987 to about 24% in 2000 and the share of Australia will decrease from 8% to 6% (see Table 8). The declining shares of Japan and Australia will be offset by increases during this period in the shares of China (from 23% to 29%) and India (from 13% to 20%).

[TABLE 8 HERE]

TABLE 8. REGIONAL DISTRIBUTION OF FUTURE GENERATING CAPACITY

	1987	1990	1995	2000
Total capacity (MW)	388,329	450,826	574,854	775,176
Share of individual countries (%)				
Japan	35.3	32.6	28.7	23.9
Korea	4.9	4.7	4.4	4.4
Taiwan	4.3	3.8	4.1	4.0
Singapore	0.9	0.8	0.8	0.7
Philippines	1.5	1.5	1.5	1.5
Thailand	1.8	1.6	1.9	1.8
Malaysia	1.2	1.2	1.1	1.0
Indonesia	1.7	1.9	2.4	2.8
China	22.9	25.5	27.4	28.6
India	12.7	13.1	15.4	20.0
Pakistan	1.7	2.2	2.0	2.1
Bangladesh	0.4	0.5	0.7	0.8
Sri Lanka	0.3	0.3	0.2	0.2
Nepal	-	-	-	-
Australia	8.5	8.1	7.2	6.1
New Zealand	1.9	1.9	1.8	1.7

V. FUEL REQUIREMENTS OF THE POWER SECTOR

The total generation of electricity in the Asia-Pacific region is expected to double by the year 2000--reaching 3,500,000 GWh, equivalent to 15 mmbd of crude oil. The fuel mix of power generation in 1987 was 18% dependent on fuel oil, 39% on coal, 17% on hydro and 15% on nuclear power. This mix is expected to change to 8% fuel oil, 50% coal, 17% hydro and 15% nuclear by the end of the century (see Table 9).

[TABLE 9 HERE]

Utilities use their own estimates of thermal efficiency for each type of plant and the heat content for each type of fuel to determine the fuel requirements of electricity generation. We use the same procedure, but we calculate the physical quantities of coal on the basis of heat content of 12,000 Btu/lb, gas 1,000 Btu/cf and fuel oil 18,500 Btu/lb, to make the fuel requirements of different countries comparable.

Fuel Oil Demand

The fuel oil requirement of the region's power sector is expected to increase slightly during the next two years and then to revert to its trend of gradual decline (Figure 3). The total requirement of fuel oil in 1987 was about 87 billion litres, equivalent to 83 million tons or 1.5 mmbd. This is expected to decline to about 82 billion litres in 1995 and 75 billion litres in 2000 (Table 10). The impact of this decline on total demand--along with cutbacks in other uses of heavy fuel oil--is of critical importance in determing the price of fuel oil in the region.

[FIGURE 3 HERE]

[TABLE 10 HERE]

The share of fuel oil in total consumption of petroleum has consistently declined during the last eight years. In 1987 the region's consumption of major oil products totalled 7.6 mmbd--32% of which was heavy fuel oil. Between 1988 and 1995 demand for total petroleum products is expected to grow at 2.3% p.a. The strongest growth is projected for middle distillates (3.8% p.a.) followed by light products (2.7% p.a.). Demand for heavy fuel oil is expected to decline at 0.1% p.a., which would further reduce the demand share of heavy fuel oil to 26% by 1995.

The decline in demand for heavy fuel oil may result in an increase in the differential between its price and the prices of light and middle distillate products. The differential has in recent years fluctuated substantially as the surplus of heavy fuel oil has kept its price depressed. With a fluctuating crude oil price and fluctuating product price differentials, there may be periods in which the heavy fuel oil price will drop considerably below the price of imported coal. Utilities which have the flexibility to switch to heavy oil will then benefit.

TABLE 9. PROJECTION OF ELECTRICITY GENERATION BY TYPE OF FUEL

	1987	1990	1995	2000
Total generation (GWh)	1,755,565	1,961,536	2,553,366	3,521,203
Hydro				
Generation (GWh)	297,965	334,308	435,808	584,204
% of total	17	17	17	17
Oil				
Generation (GWh)	313,332	334,385	301,387	281,749
% of total	18	17	12	8
Gas				
Generation (GWh)	191,962	239,044	304,750	357,589
% of total	11	12	12	10
Coal				
Generation (GWh)	685,506	774,062	1,124,591	1,746,943
% of total	39	39	44	50
Nuclear				
Generation (GWh)	265,026	277,504	383,246	547,197
% of total	15	14	15	15

TABLE 10. Consumption of Heavy Fuel Oil in the Power Sector, 1987 and 2000 (million tons)

Country	1987	2000
Japan	51.8	43.2
China	15.5	12.2
Singapore	2.9	4.4
Malaysia	2.4	0.2
Pakistan	2.3	5.0
Philippines	2.3	2.0
Indonesia	1.9	1.0
Taiwan	1.6	0.8
Thailand	1.5	0.5
Korea	1.1	1.3
Australia	1.0	3.0
Bangladesh	0.2	0.4
India	0.0	0.0
New Zealand	0.0	0.0

TABLE 11. RESERVE, PRODUCTION, IMPORT AND CONSUMPTION OF NATURAL GAS

	Supply and demand in 1986				Power sector demand	
	Reserves (tcf)	Production (bcf)	Imports (bcf)	Total consumption (bcf)	1987 --- (bcf)	2000 ----
Japan	1.1	81.4	1,530.2	1,611.6	1,220	1,534
Korea	-	-	2.8	2.8	83	128
Taiwan	0.6	-	-	-	0	88
Singapore	-	-	-	-	-	-
Philippines	-	-	-	-	-	-
Thailand	7.4	126.2	-	126.2	83	236
Malaysia	49.4	504.1	-416.7	87.3	26	265
Indonesia	49.4	1,086.7	-818.1	268.6	5	127
China	30.0	533.1	-	533.1	-	-
India	17.6	203.4	-	203.4	30	-
Pakistan	18.7	313.3	-	313.3	50	268
Bangladesh	12.7	113.8	-	113.8	37	175
Sri Lanka	-	-	-	-	-	-
Nepal	-	-	-	-	-	-
Australia	18.7	553.6	-	553.6	105	135
New Zealand	5.7	133.3	-	133.3	39.6	59.4

Natural Gas Demand

The power sector's demand for natural gas in 1987 was about 4,686 mmcfd, equivalent to 0.8 mmbd of crude oil. This is expected to increase to 7,440 mmcfd in 1995 and 8,730 mmcfd in 2000. From the 1987 consumption of 4,686 mmcfd, about 3,400 mmcfd (73%) was used in Japan's power sector. Other large users were Korea, Thailand, Australia and Pakistan.

Table 11 provides a comparison of production and consumption of natural gas in each country. Japan is the largest consumer of natural gas with an annual consumption of about 1,600 bcf, of which about 75% is used in the power sector and the remaining 25% is used in the industrial and residential sectors. Japan imports about 94% of its gas needs--from Indonesia (51%), Malaysia (19%), Brunei (18%), UAE (7%) and the United States (3%). Gas use in the Japanese power sector is expected to increase to about 1,500 bcf by the year 2000. The additional requirement will be imported in the form of LNG from the same sources.

[TABLE 11 HERE]

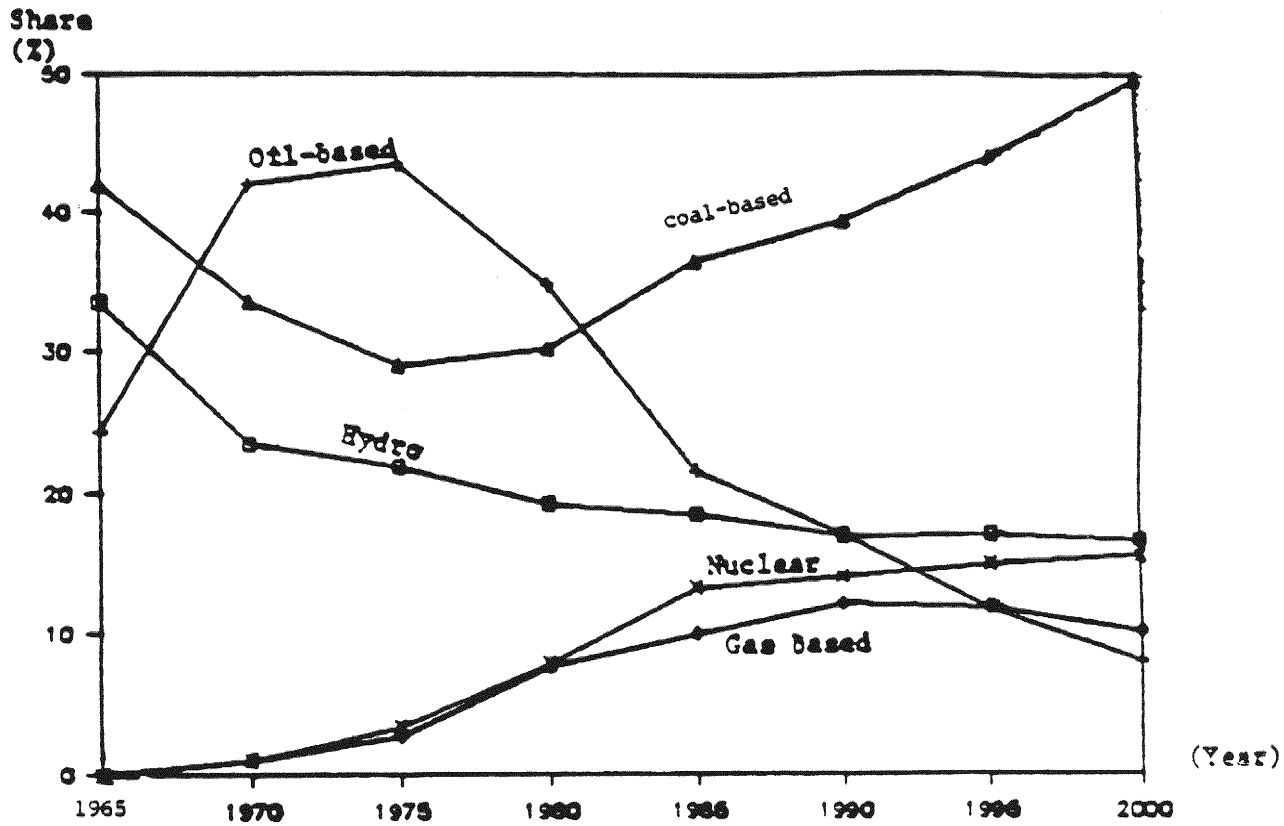
Korea and Taiwan are the only other countries which will increase their gas use by importing it in the form of LNG. Korea started to import LNG from Indonesia in 1986. It currently uses the LNG in 2,500 MW of power plants which were converted from oil to gas in 1985. If Korea proceeds with its current plans to build new gas-based power plants, its gas use in the power sector will increase from 83 bcf in 1987 to 128 bcf in 2000. This requirement, along with the anticipated use of gas in non-power sectors would necessitate the negotiation of a second LNG contract by the mid-1990s. Taiwan is moving along a similar path, preparing to use gas in the power sector and expecting to have about 2,600 MW of gas-based power plants by 2000.

Thailand increased its use of domestic natural gas very rapidly by converting some of its oil-fired plants to burn gas. It also promoted gas use in the industrial sector. It will further increase the use of gas in the power sector by installing combined-cycle power plants. However, there is considerable uncertainty with regard to the timely availability of domestic gas, as production from current fields is expected to fall sharply in the late 1990s and plans for new exploration and development are not being implemented.

Malaysia has embarked on a rather aggressive plan to utilize its large resources of natural gas. Its increased use of gas in the power sector will be supplied easily by domestic resources, and it may become more actively involved in exporting gas to other countries. Its present contract to sell 6 million tons p.a. of LNG tc Japan is likely to be extended in the mid-1990s with an increase in quantity. Its proposed sale of piped gas to Singapore is expected to start by 1992-93.

Indonesia is the largest producer of gas in the region. It exports about 80% of its gas to Japan and Korea and has a contract to supply gas to Taiwan. It is also the most likely candidate for meeting the increased demand for LNG in the 1990s. Indonesia currently uses only a small amount of gas in its

FIGURE 3. Shares of Various Sources of Electricity Generation



power sector but will build about 2,900 MW of gas-based power plants by the year 2000. The non-power use of gas is substantial and is expected to make up a large part of demand through the 1990s.

China and India produce relatively large quantities of gas but use all of it in the non-power sector.

Pakistan and Bangladesh produce considerable quantities of gas, most of which are used in the non-power sector. However, both countries in recent years have embarked on aggressive plans to increase the gas use in the power sector. Pakistan is planning to install 7,000 MW of gas-based power plants by 2000. Bangladesh is aiming at building about 3,000 MW of gas-fired power stations during the same period.

Australia and New Zealand produce about 550 bcf and 113 bcf of gas, respectively, of which about 20% is used in the power sector. For these countries, gas is not the dominant fuel in the power sector.

Coal Demand

The power sector's demand for coal in 1987 was about 233 million tons, equivalent to about 3 mmbd of crude oil. This is expected to increase to about 600 million tons by 2000 (see Table 12). The largest producer and consumer of coal in the region is China. It produces about 900 million tons of coal, of which about 15% is used in the power sector. Its utilization of coal to generate electricity is expected to increase by 150% during the next 12 years. All the coal requirements will be met by domestic production.

[TABLE 12 HERE]

India is the second-largest producer and consumer of coal in the region. It produces about 180 million tons, of which 25% is used in the power sector. India's use of coal to generate electricity will triple during the next 12 years. The country is planning to meet the additional demand by domestic supply.

Japan is the largest importer of coal in the region and in the world. Its coal needs are imported from Australia (47%), Canada (19%), the United States (13%), South Africa (10%), the USSR (6%) and China (4%). Its consumption of coal was about 105 million tons in 1987, of which 35% was used in the power sector. The coal needs of the power sector are expected to increase by about 70% by the end of the century. The additional requirement is expected to be imported from the same sources which are currently supplying coal to Japan.

Korea is the second-largest importer of coal in the world. It imports its coal from Australia (40%), South Africa (25%), Canada (16%) and the United States (14%). Its use of coal in the power sector will quadruple during the next 12 years. All the coal requirement of the power sector will be supplied from increased imports.

The Philippines and Thailand produce some low-quality coal, a large

TABLE 12. RESERVES, PRODUCTION, IMPORT AND CONSUMPTION OF COAL

	Supply and Demand in 1986				Power sector demand	
	Reserves (billion tons)	Production	Net imports	Total consumption	1987	2000
			(million tons)			
Japan	1.0	16.0	90.3	104.6	35.4	59.4
Korea	0.6	24.2	20.3	41.1	7.2	27.3
Taiwan	0.2	1.5	-	-	8.2	25.2
Singapore	0.0	0.0	0.0	0.0	0.0	0.0
Philippines	0.3	1.2	0.9	1.9	0.9	9.6
Thailand	0.4	2.0	0.4	2.4	2.0	12.2
Malaysia	0.03	-	0.4	0.4	0.0	1.2
Indonesia	1.3	1.7	0.4	2.2	1.8	21.5
China	100.0	840.0	-5.7	834.3	106.5	271.3
India	31.5	166.0	2.3	168.3	42.6	133.7
Pakistan	-	-	-	-	-	-
Bangladesh	-	-	-	-	-	-
Sri Lanka	-	-	-	-	-	-
Nepal	-	-	-	-	-	-
Australia	65.8	133.4	-89.9	40.6	31.2	41.2
New Zealand	0.3	2.1	-0.3	1.8	0.5	2.1

proportion of which they use in the power sector. However, the coal used to generate electricity will substantially exceed domestic coal production and will have to be supplemented by imports. These countries are not yet large importers of coal but consider Australia and China as the main potential sources of coal supply.

Indonesia is not currently a large producer or consumer of coal. However, its coal reserves are believed to be much larger than the current estimate of 1.3 billion tons. Its production capacity is expected to expand rapidly. The government expects not only to supply the future coal demand from domestic production but also to export to other countries. This expectation may not be realistic, however, in view of the projected substantial increase in demand for coal by the power sector.

Australia is the world's largest exporter of coal. It produces about 133 million tons of coal, of which it exports 90 million tons. Its domestic use of coal is about 40 million tons, of which 75% is used in the power sector. The production of coal is expected to increase substantially to enable the country to meet anticipated exports.

VI. CONCLUSION

The usual perception is that power utilities choose their capacity expansion plans so that they will be able to minimize the discounted value of their future investment and operating costs. While this remains their eventual objective, most utilities in the Asia-pacific deviate from a strict "deterministic" least-cost development plan to take account of the risk associated with the projection of future prices of fuels. The deviation is either in terms of the choice between primary (hydro and nuclear) versus fossil fuel (oil, gas and coal) power or the choice within the fossil-fuel group.

Nuclear power is by most accounts more costly than coal, gas and even oil-based electricity. Our cost analyses in the previous section indicate a per-unit cost of more than US¢5/kWh for nuclear power compared with US¢3.44/kWh for coal-based and US¢3.95/kWh for oil-based electricity. Nevertheless, several countries--particularly Japan, Korea and Taiwan--are proceeding with considerable investments in nuclear power generation. The justifications for pursuing such a policy is to keep up with nuclear power technology, to utilize the expertise already developed in nuclear industry, and more importantly to cope with the supply and price uncertainties of international fuel prices. The latter reason is also offered to justify investments in some hydro projects which are more costly than coal or oil power plants.

Within the fossil-fuel group, almost all utilities in the region are moving towards increasing use of coal. As a result, the coal requirements of the power sector will increase from about 233 million tons in 1987 to about 600 million tons in 2000. From this 600 million tons, about 450 million tons will be used in China, India and Australia, which are expected to supply their requirements from their own domestic resources. Most of the remaining 150

million tons should be supplied by imports. The majority of utilities use the cost and quality of Australian coal in their planning practices, assuming that the coal will be available when they need it. The coal reserves of Australia and other coal-exporting countries seem to be sufficient to meet the long-term demand of coal-importing countries. However, a rapid increase in demand for coal may create a tight market in the 1990s, and production and shipping constraints may cause a sharp rise in the price. If, at the same time, heavy fuel oil remains depressed due to cutbacks in the power sector's demand, then the coal option may be much more costly than oil. Referring to our cost figures of the previous chapter, we note that the average discounted cost was estimated at US¢3.44/kWh for coal-based and US¢3.95/kWh for oil-based generation. These figures were predicated on the assumptions that (a) the CIF price of coal will be about $40/ton in 1990 and will increase by 1% p.a. thereafter and (b) the heavy fuel oil price will be $14.66/bl in 1990, increasing to $18.70/bl in 1995 and $21.81/bl in 2000. If the price of heavy fuel oil remains depressed--let us say, at $15/bl in 1988 prices (which is about $21/bl in nominal 1995 prices)--the average cost of oil-based power generation would be about US¢3.1/kWh. This is 10% less than the US¢3.44/kWh we estimated for coal-based generation. If the coal price increases faster than assumed above, the difference would be even larger in favour of the oil option.

The policy implication of the above discussion is that, while some investments in hydro and nuclear generation may be justified based on the decision-makers' desire to preserve a flexible balance and to avoid certain risks, the next logical extension of the same theory would be not to lock out the oil option entirely.

Dual-firing (and in certain cases triple-firing) power plants provide substantial flexibility in the economic operation of power systems. Japan and New Zealand already have some fuel-switching capabilities between oil, gas and coal, and Thailand is building triple-firing plants. However, the current motive for maintaining or building dual-firing plants is to be able to cope with possible supply problems rather than economic operation of the generating system. In our view, fuel-switching capabilities offer an effective tool to deal with fuel price uncertainty, and the region's power utilities should investigate the viability of expanding these capabilities.

The fuel price uncertainty should be viewed from two different angles: (1) the differential between coal and petroleum prices, and (2) the differentials among petroleum product prices, in particular the price of heavy fuel oil relative to other products. Present projections indicate that (1) the coal price, after adjusting for capital cost differential and heat content, remains lower than oil, and (2) heavy fuel oil remains some 10-15% cheaper than crude oil. Both patterns are subject to considerable uncertainty. The relative price of coal to oil may increase beyond current expectations due to constraints in coal production and shipping. The relative price of fuel oil may also behave differently from the projected path due to cyclical surpluses and deficits of heavy oil in the regional petroleum products balance. The region's refinery configuration is not presently capable of absorbing all the surplus fuel oil--in particular, high-sulphur residual fuel. This will continue to depress the price of heavy oil but, at the same time, will trigger investments in refinery upgrading. As a result,

the region's refinery configuration will become capable of absorbing more heavy fuel oil, leading to stronger fuel oil prices and smaller incentives for further refinery upgrading. This cyclical pattern in fuel oil prices is an inherent phenomenon in the economics of refinery upgrading.

A power utility with reasonable dual-firing capability can switch between fuels if the long-term trends in fuel prices develop differently than assumed at the planning stage. In addition, the utility can take advantage of cyclical patterns of fuel oil prices and random fluctuations of petroleum and coal prices. The switching capability will be utilized in the day-to-day dispatch decisions of the power system in order to minimize the cost subject to the operational constraints. Furthermore, for utilities with access to natural gas, fuel switching capability provides a means of coping economically with environmental constraints. Presently, some American and European utilities use a minimum amount of gas during certain periods of the year as a means of keeping plant pollutant emissions within prescribed standards. This practice offers good potential for many utilities in the region that are under increasing pressure to reduce the environmental impacts of their power plants.

Fuel-switching capabilities can often be installed at a small cost if planned at an early stage. Most utilities in the region are planning substantial additions to gas-fired and coal-fired plants. The gas-fired plants are either conventional steam or higher efficiency combined-cycle. Both types can operate with oil, but a conventional steam plant would use heavy oil whereas a combined-cycle plant would have to use distillate fuel. Steam plants would be perfect candidates for dual-firing. The capital cost of a dual- (oil/gas) fired steam steam plant would be only 1% higher than a single-firing plant. But since the price of distillate fuel is expected to remain substantially higher than heavy oil, combined-cycle plants are not viewed as good candidates for dual-firing. The policy implication would then be to install combined-cycle gas-firing plants only when there is a firm supply of inexpensive gas and to install dual- (oil/gas) firing steam plants when there are uncertainties in the stability of supply or when the gas price is within a limited margin of the fuel oil price. In the latter case, the utility can minimize its cost by adjusting the proportion of gas and oil use in its day-to-day operation.

Dual firing between coal and oil is a somewhat different matter than that of gas and oil. If a plant is intended to use oil, it would be quite costly (about 30-40% increase in capital cost) to make it a dual- (oil/coal) firing plant. However, if the plant is being designed to use coal, it would be quite inexpensive (1-2% additional capital cost) to make it dual- (oil/coal) firing. In the Asia-Pacific region, almost all the candidates for oil/coal-firing fall into the latter category. Most utilities are planning vast additions to their coal-firing capacity, and they can add the oil-firing option at a small cost.

JACK S. SIEGEL
Deputy Assistant Secretary for Coal Technology
Office of Fossil Energy
U.S. Department of Energy

Jack S. Siegel was named Deputy Assistant Secretary for Coal Technology, Office of Fossil Energy, U.S. Department of Energy (DOE) in June 1986. In this position he is responsible for managing the $5 billion dollar industry/DOE clean coal technology demonstration program and DOE's research and development on a wide variety of coal-based precombustion, combustion, post-combustion and conversion technologies to enable coal to be used more economically, more efficiently and more cleanly. In addition, Mr. Siegel is the designated Federal official to the National Coal Council and the Technical Subcommittee Chairman of the Innovative Control Technology Advisory Panel.

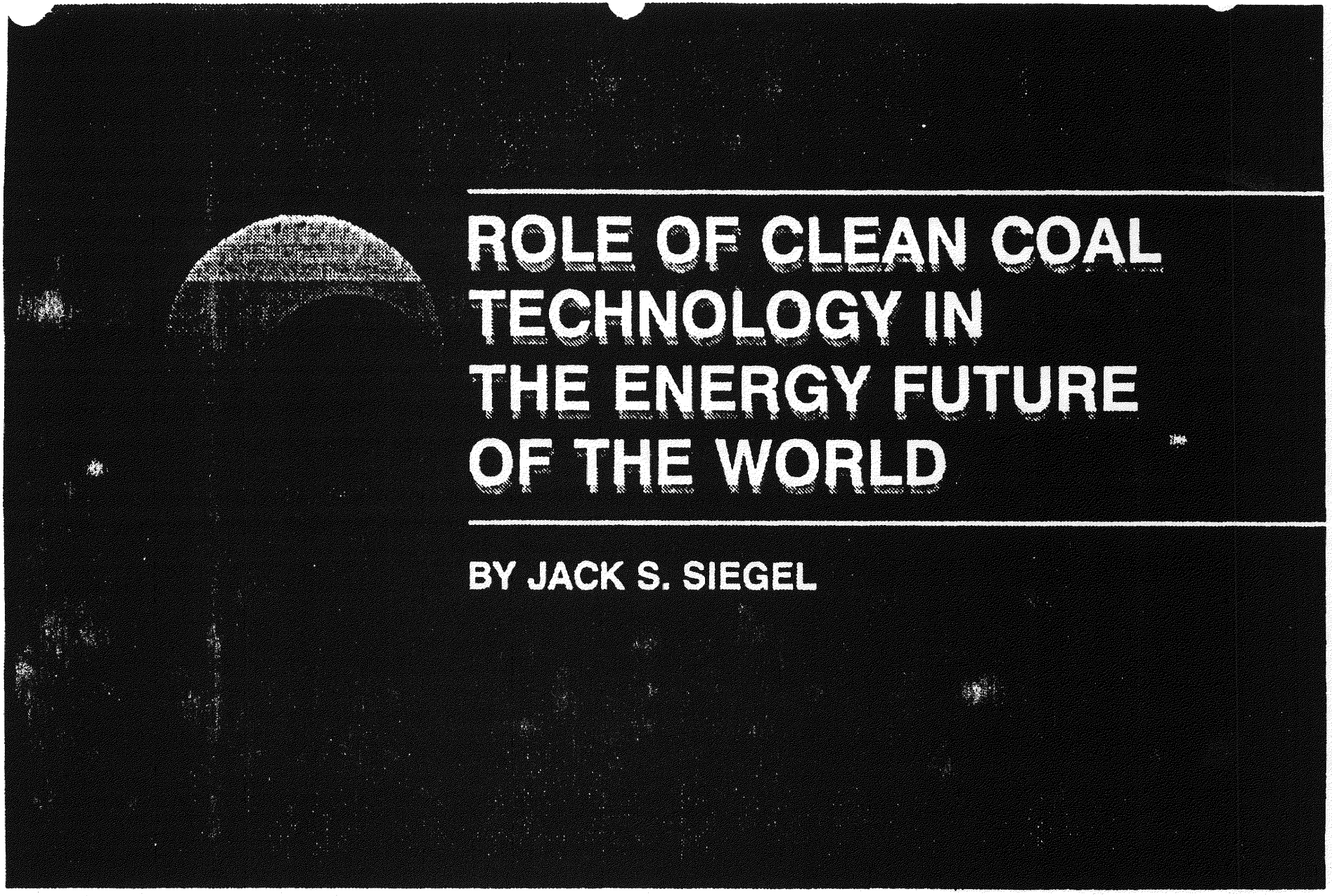
Previously, Mr. Siegel served as Deputy Director for Coal Utilization, Advanced Conversion and Gasification, Office of Fossil Energy, from March 1983 to June 1986. He was responsible for guiding the research and development in emerging coal technologies in the areas of fluidized bed combustion, coal preparation, gas cleanup, coal gasification, fuel cells, heat engines and magnetohydrodynamics.

From late 1979 to March 1983, Mr. Siegel was Director of Environmental Policy in the Office of Policy and Evaluation (PE), where he was responsible for formulating DOE's policy positions on a range of environmental issues which applied to energy systems and overviewing DOE's environmental planning, budgeting and research activities. Throughout 1979, he was PE's Director, Division of Environmental and Institutional Impacts Evaluation. Mr. Siegel served as the focal point for analyzing environmental/energy issues and developing DOE's policies on the role of state and local governments in energy.

Prior to 1979, Mr. Siegel held various positions at the Department of Energy and its predecessor agency, the Energy Research and Development Administration, the Environmental Protection Agency, and the Department of the Navy.

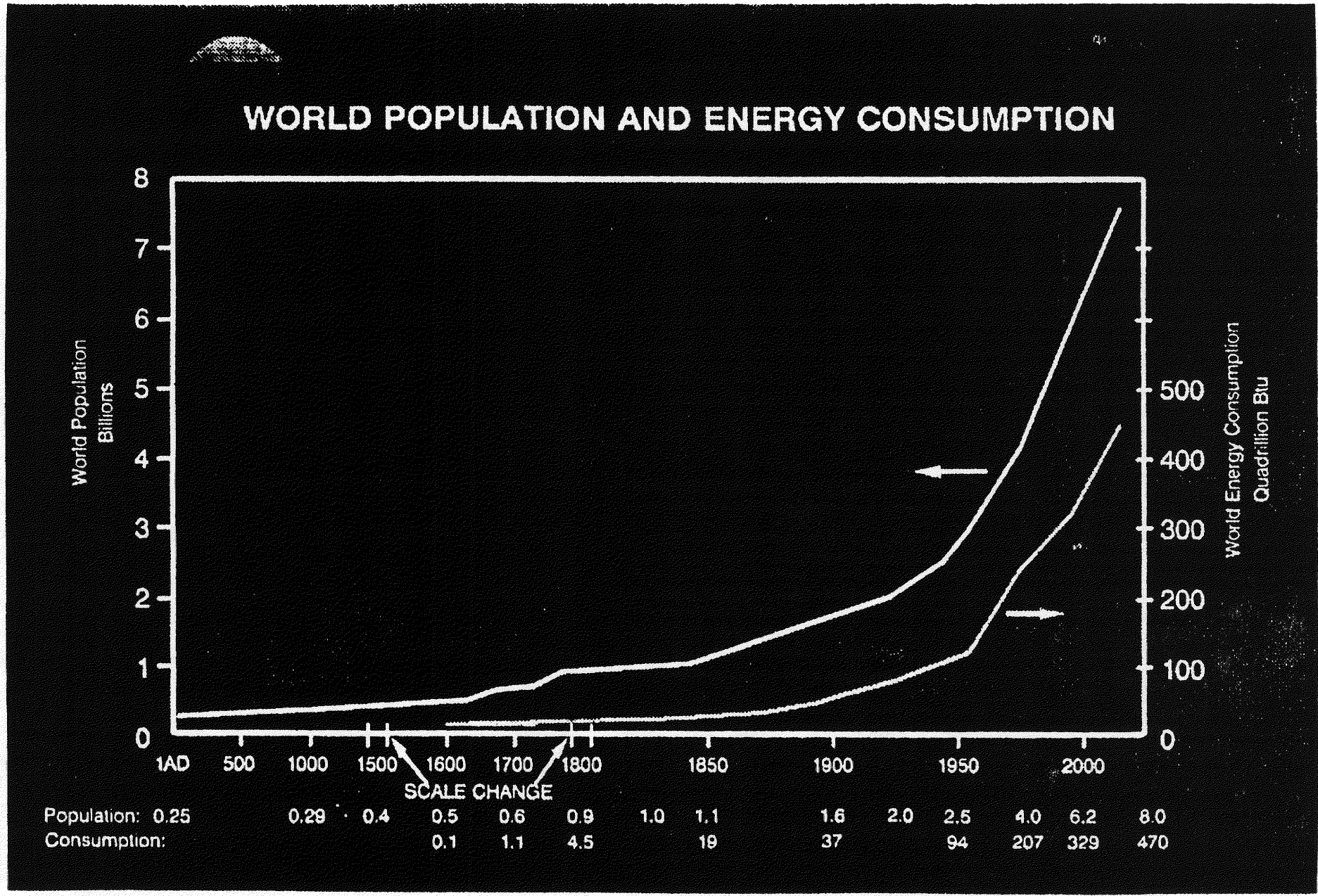
Mr. Siegel received a B.S. in chemical engineering from Worcester Polytechnic Institute in 1968. Since then, he has acquired graduate credits at George Washington University.

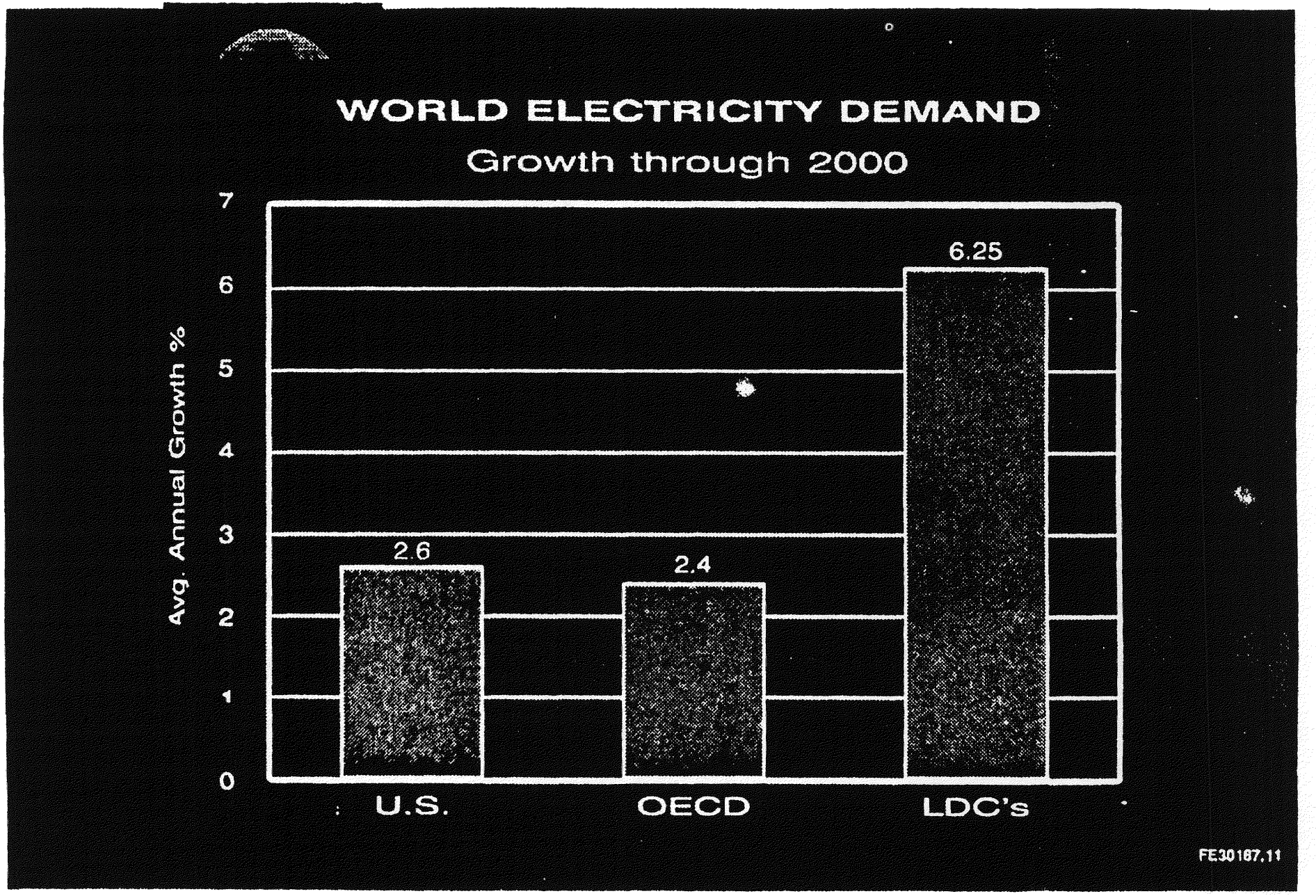
Mr Siegel resides with his family in Bethesda, Maryland.

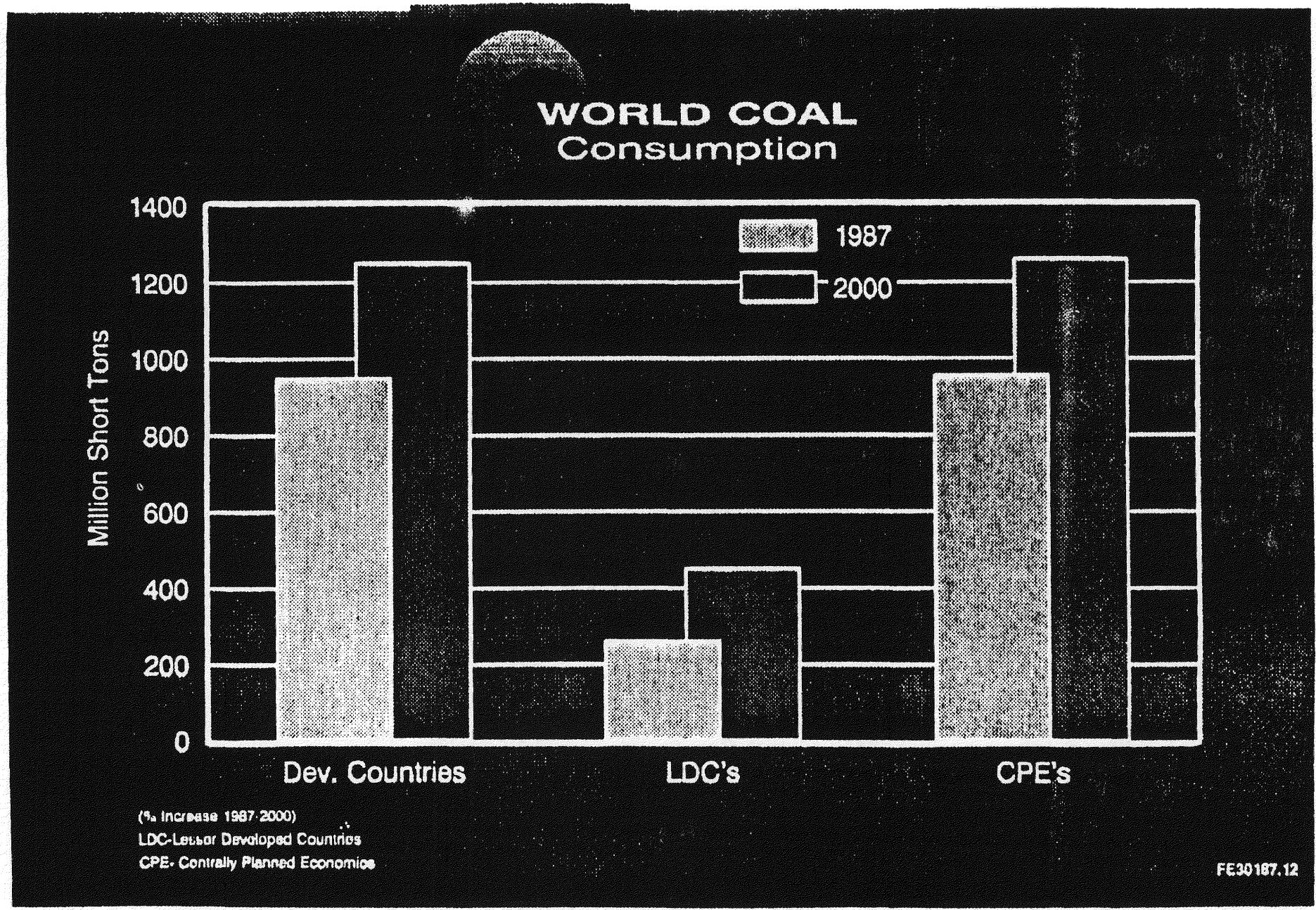


ROLE OF CLEAN COAL TECHNOLOGY IN THE ENERGY FUTURE OF THE WORLD

BY JACK S. SIEGEL


WORLD POPULATION AND ENERGY CONSUMPTION
World Population
Billions
World Energy Consumption
Quadrillion Btu
0
1
2
3
4
5
6
7
8
0
100
200
300
400
500
1AD
500
1000
1500
1600
1700
1800
1850
1900
1950
2000
SCALE CHANGE
Population: 0.25 0.29 0.4 0.5 0.6 0.9 1.0 1.1 1.6 2.0 2.5 4.0 6.2 8.0
Consumption: 0.1 1.1 4.5 19 37 94 207 329 470

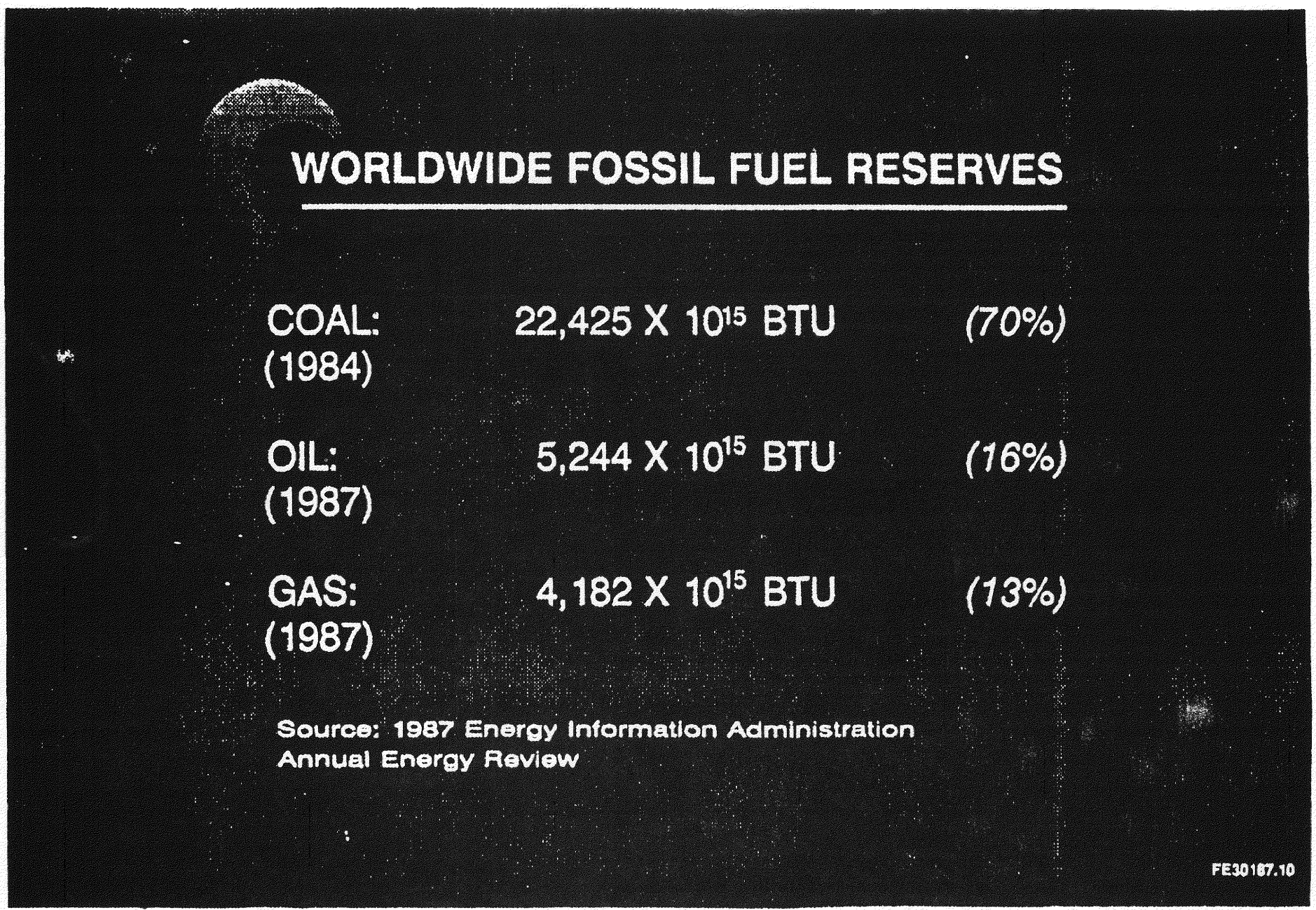

WORLD ELECTRICITY DEMAND
Growth through 2000
Avg. Annual Growth %
7
6
5
4
3
2
1
0
2.6
2.4
6.25
U.S.
OECD
LDC's
FE30167.11

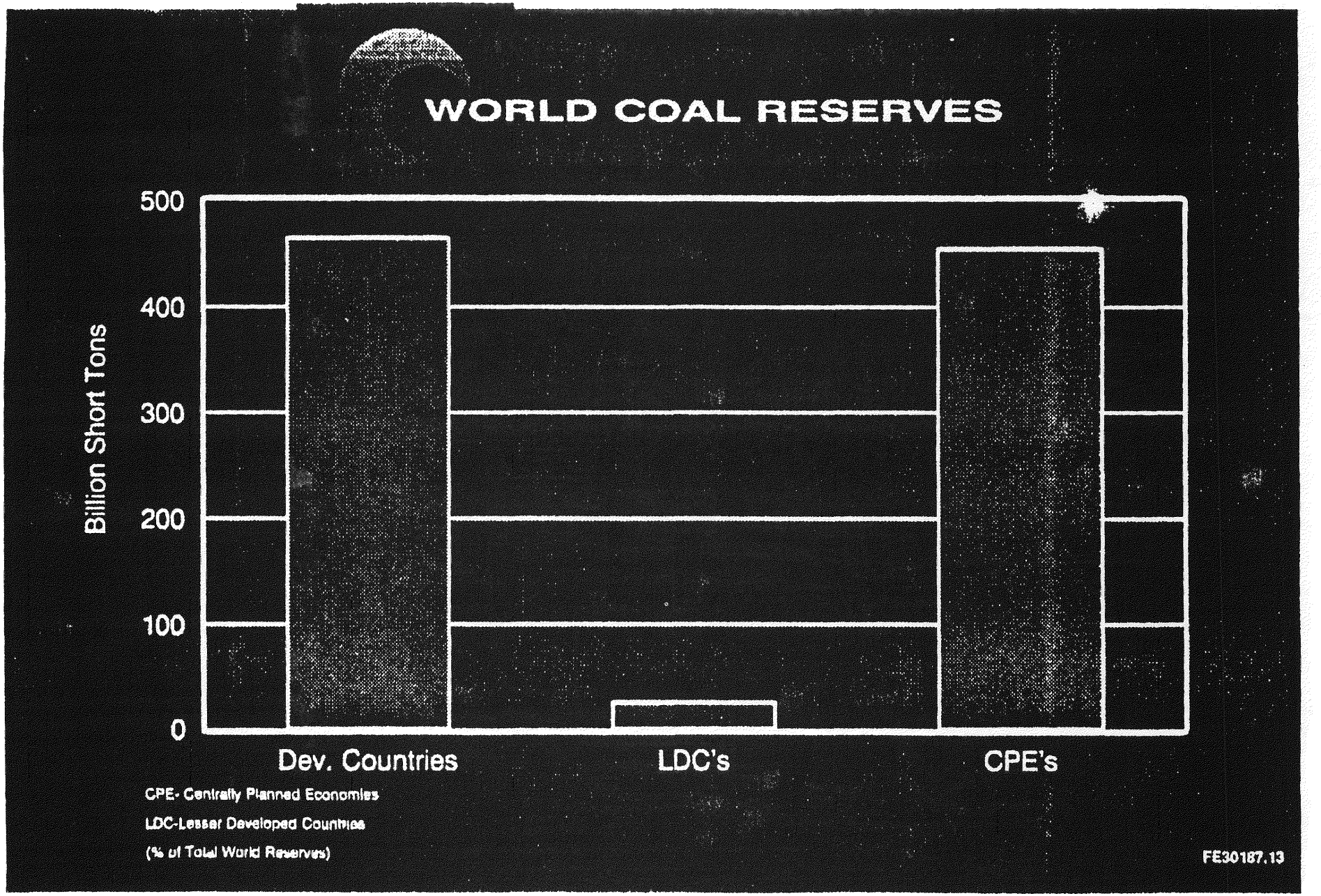

WORLD COAL
Consumption
1400
1200
1000
800
600
400
200
0
Million Short Tons
1987
2000
Dev. Countries
LDC's
CPE's
(% Increase 1987-2000)
LDC-Lesser Developed Countries
CPE- Centrally Planned Economies
FE30187.12

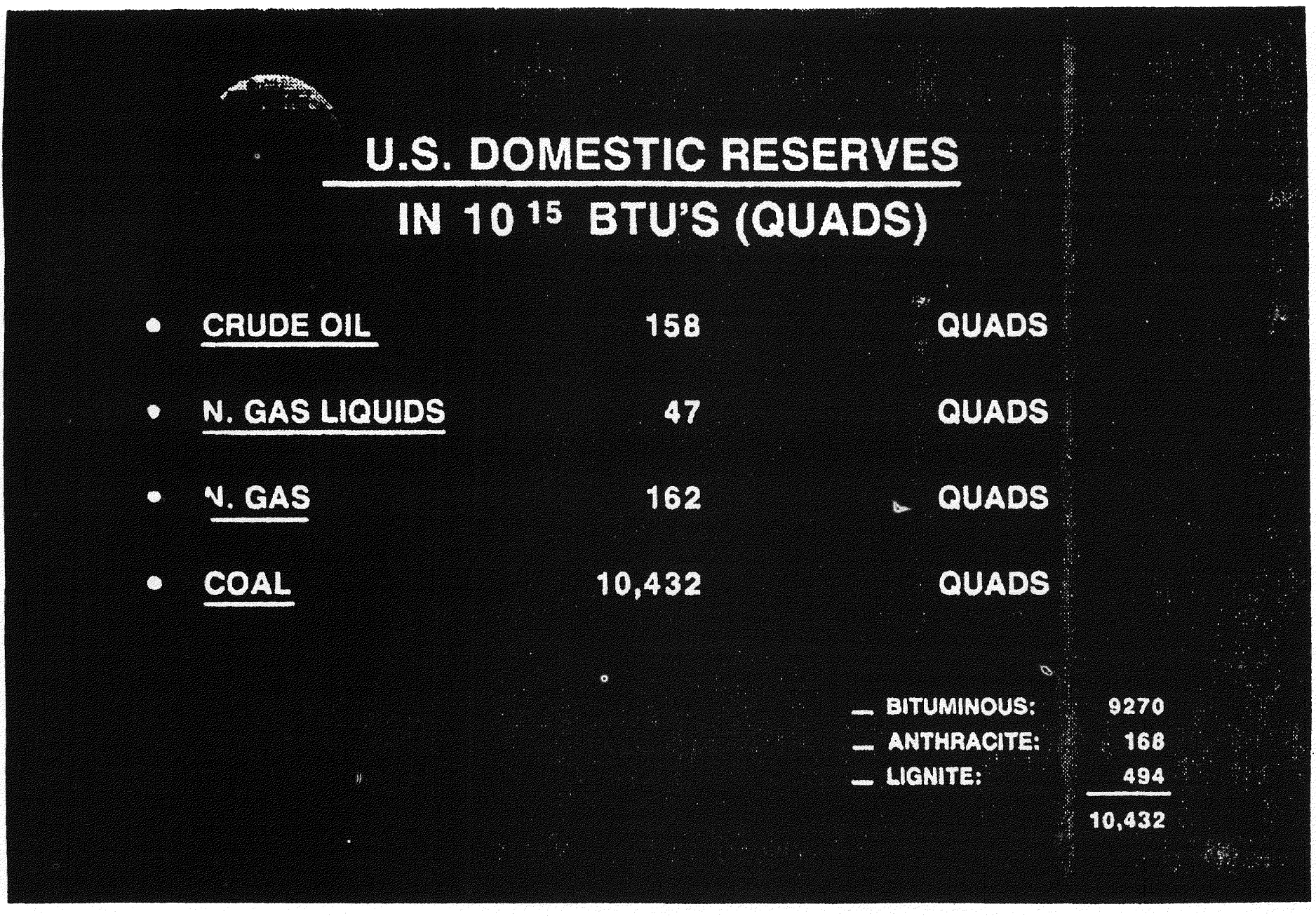
COAL AND CLEAN COAL TECHNOLOGIES CAN HELP

- COAL READILY AVAILABLE
- COAL REASONABLY PRICED
- NEW TECHNOLOGY CAN
  - MAINTAIN EXISTING MARKETS
  - CREATE NEW MARKETS
  - IN AN ENVIRONMENTALLY RESPONSIBLE MANNER

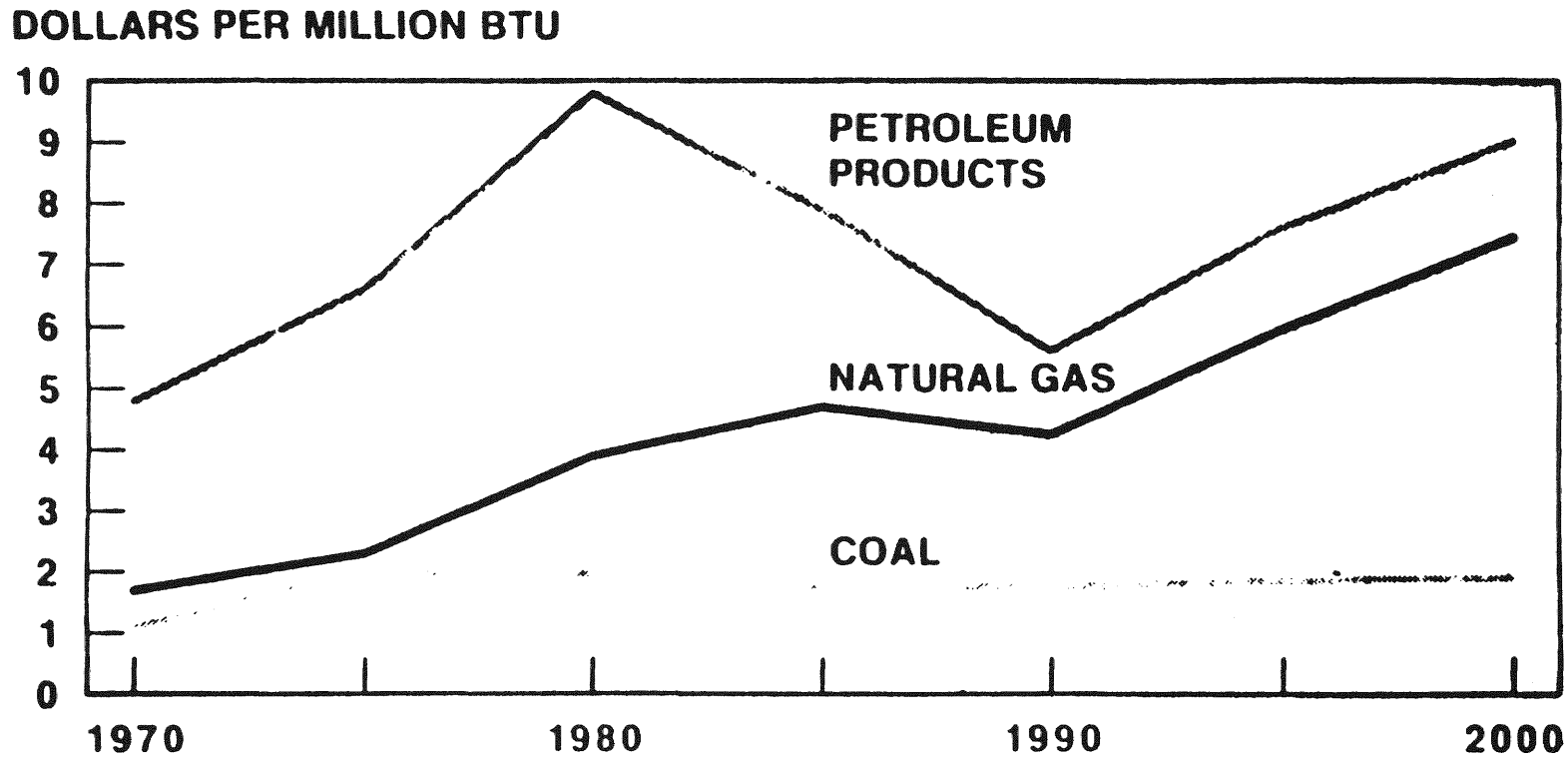
FE21920.04


WORLDWIDE FOSSIL FUEL RESERVES
COAL: (1984) 22,425 X 10^15 BTU (70%)
OIL: (1987) 5,244 X 10^15 BTU (16%)
GAS: (1987) 4,182 X 10^15 BTU (13%)
Source: 1987 Energy Information Administration Annual Energy Review
FE30187.10


WORLD COAL RESERVES
Billion Short Tons
500
400
300
200
100
0
Dev. Countries
LDC's
CPE's
CPE- Centrally Planned Economies
LDC-Lesser Developed Countries
(% of Total World Reserves)
FE30187.13


U.S. DOMESTIC RESERVES
IN 10 15 BTU'S (QUADS)
• CRUDE OIL 158 QUADS
• N. GAS LIQUIDS 47 QUADS
• N. GAS 162 QUADS
• COAL 10,432 QUADS
— BITUMINOUS: 9270
— ANTHRACITE: 168
— LIGNITE: 494
10,432

COAL PRICES ARE LOW AND STABLE (AVERAGE PRICE TO ALL USERS, 1970-2000, 1986 DOLLARS)



SOURCE: ANNUAL ENERGY OUTLOOK 1986, FEBRUARY 1987, TABLE A3, BASE CASE
NOTE: 1987-2000, FORECAST

FE21920.14

ENVIRONMENTAL CONCERNS EXPANDING

- GLOBAL CLIMATE CHANGE
- ACID RAIN
- OZONE DEPLETION
- TOXIC/HAZARDOUS WASTES
- NUCLEAR SAFETY

FE21920.03

CLEAN COAL TECHNOLOGIES CAN OPEN NEW COAL MARKETS

- NEW ELECTRIC UTILITIES
  - AFBC
  - PFBC
  - IGCC
  - MHD
- LIGHT INDUSTRIAL, COMMERCIAL AND RESIDENTIAL SECTORS
  - AFBC
  - ADVANCED COMBUSTORS
  - COAL WATER MIXTURES
- TRANSPORTATION
  - MILD GASIFICATION
  - COAL LIQUEFACTION
    - -- DIRECT
    - -- INDIRECT
  - COAL-FIRED TURBINES AND DIESELS
- FOREIGN
  - COAL DRYING
  - MILD GASIFICATION

FE21920.07

CLEAN COAL TECHNOLOGIES CAN OPEN NEW COAL MARKETS

- NEW ELECTRIC UTILITIES
  - AFBC
  - PFBC
  - IGCC
  - MHD
- LIGHT INDUSTRIAL, COMMERCIAL AND RESIDENTIAL SECTORS
  - AFBC
  - ADVANCED COMBUSTORS
  - COAL WATER MIXTURES
- TRANSPORTATION
  - MILD GASIFICATION
  - COAL LIQUEFACTION
    - DIRECT
    - INDIRECT
  - COAL-FIRED TURBINES AND DIESELS
- FOREIGN
  - COAL DRYING
  - MILD GASIFICATION

FE21920.07

CLEAN COAL TECHNOLOGIES -- CAN MAINTAIN EXISTING COAL MARKETS

- ELECTRIC UTILITIES NEED TECHNOLOGY THAT
  - IS EFFICIENT
  - IS LOW IN CAPITAL COST
  - CAN BE INSTALLED IN MODULES
  - CAN BE SHOP FABRICATED
  - CAN BE USED TO RETROFIT OR REPOWER EXISTING FACILITIES AND
  - USED IN GRASSROOTS APPLICATIONS
  - CAN MEET INCREASINGLY MORE STRINGENT ENVIRONMENTAL REQUIREMENTS
    - -- SO_2
    - -- NO_X
    - -- SOLID WASTE

FE21920.06

CLEAN COAL TECHNOLOGIES CAN MEET OR EXCEED ENVIRONMENTAL REQUIREMENTS

- REDUCE SO_2 EMISSIONS FROM HIGH AND LOW SULFUR COALS
- REDUCE NO_x EMISSIONS
- SOME CONTROL FINE PARTICULATES
- ALL ARE MORE EFFICIENT (LESS CO_2 EMITTED)
- ALL PRODUCE MARKETABLE, REGENERABLE OR EASILY DISPOSABLE WASTES

FE21920.08

CARBON DIOXIDE EMISSIONS FROM FOSSIL - FUELED FACILITIES

TECHNOLOGY	EFFICIENCY	TOTAL CO_2 (10^6 T/Y)	% CHANGE
CONV. PC W/O FGC	36%	2.75	---
CONV. PC W/FGC	33%	3.07	+ 12
AFB	36%	ESSENT. NO CHANGE	0
PFB	40%	2.48	-10
IGCC	42%	2.36	-14
IGCC (FUEL CELL)	50%	1.98	-28
CONV. PC/ADV. FGC	35%	2.83	+3
CLEANED COAL	36%	ESSENT. NO CHANGE	0
MHD	55%	1.80	-34

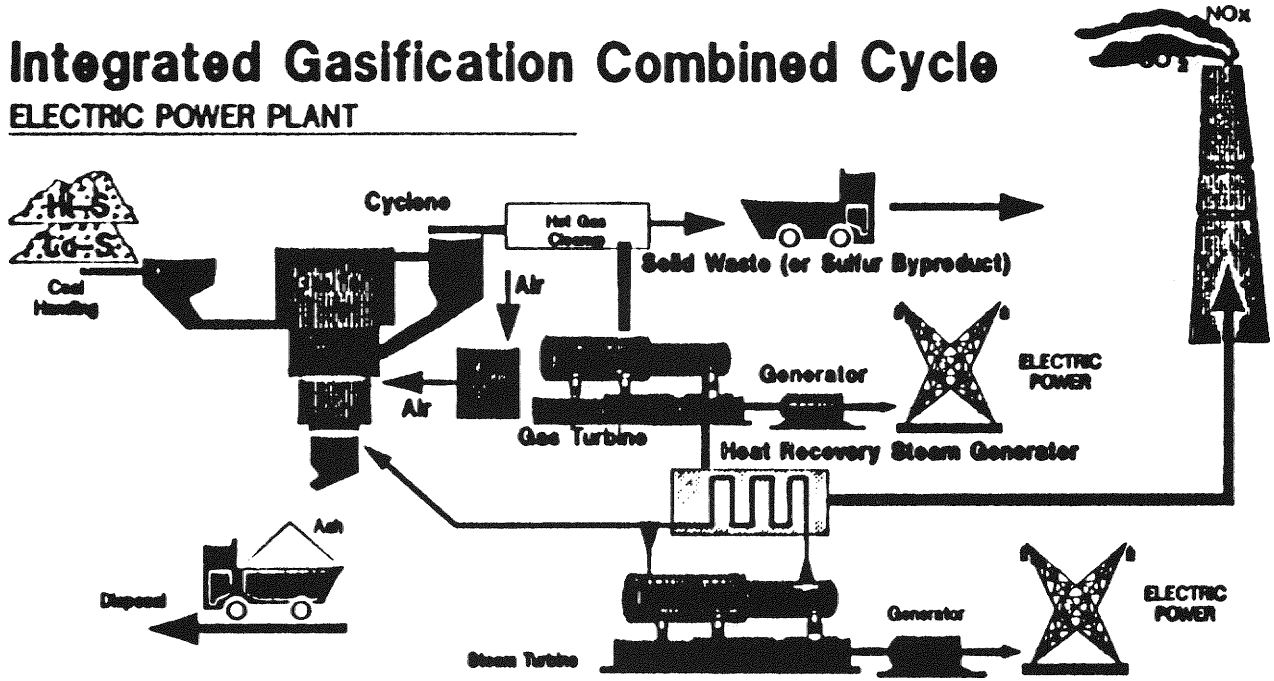
WHAT ARE CLEAN COAL TECHNOLOGIES?

ADVANCED COAL-BASED SYSTEMS FOR:

- POWER GENERATION
  - IMPROVED ECONOMICS
  - IMPROVED THERMAL EFFICIENCIES
  - MODULAR CONSTRUCTION
  - IMPROVED ENVIRONMENTAL PERFORMANCE
  - CAPABLE OF REPOWERING EXISTING FACILITIES
  - CAN USE VARIETY OF COALS
- POLLUTION CONTROL
  - CONTROL SO_2 AND NO_X
  - IMPROVED ECONOMICS
  - RETROFIT AND NEW SOURCE APPLICATIONS
  - IMPROVED WASTE CHARACTERISTICS
- OTHER USES
  - PRODUCE COAL-BASED FUELS TO REPLACE OIL OR GAS
  - USE COAL IN INDUSTRIAL, COMMERCIAL AND RESIDENTIAL SECTORS

Integrated Gasification Combined Cycle

ELECTRIC POWER PLANT



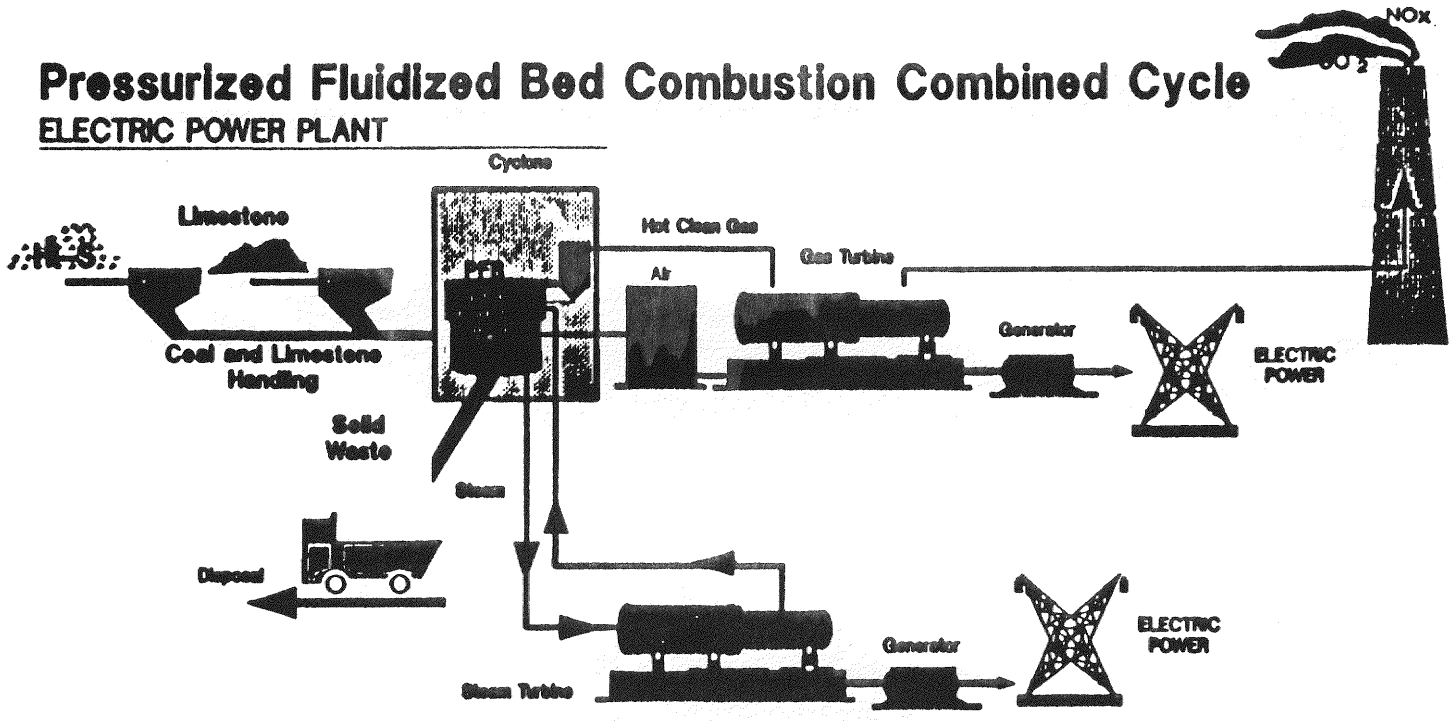
*COMPARED WITH CONVENTIONAL TECHNOLOGY**

SO_2 EMISSION REDUCTION	NO_x EMISSION REDUCTION	PLANT EFFICIENCY	POWER OUTPUT	PLANT LIFE	INCREMENTAL ELECTRICITY COST	CAPITAL COST
95–99%	Moderate	Moderate Increase	50–150% Increase	Moderate Extension	1–2 MILLS/KWH	$1,100–1,300 PER KW

**CONVENTIONAL COAL-FIRED ELECTRIC POWER PLANT*

Pressurized Fluidized Bed Combustion Combined Cycle

ELECTRIC POWER PLANT



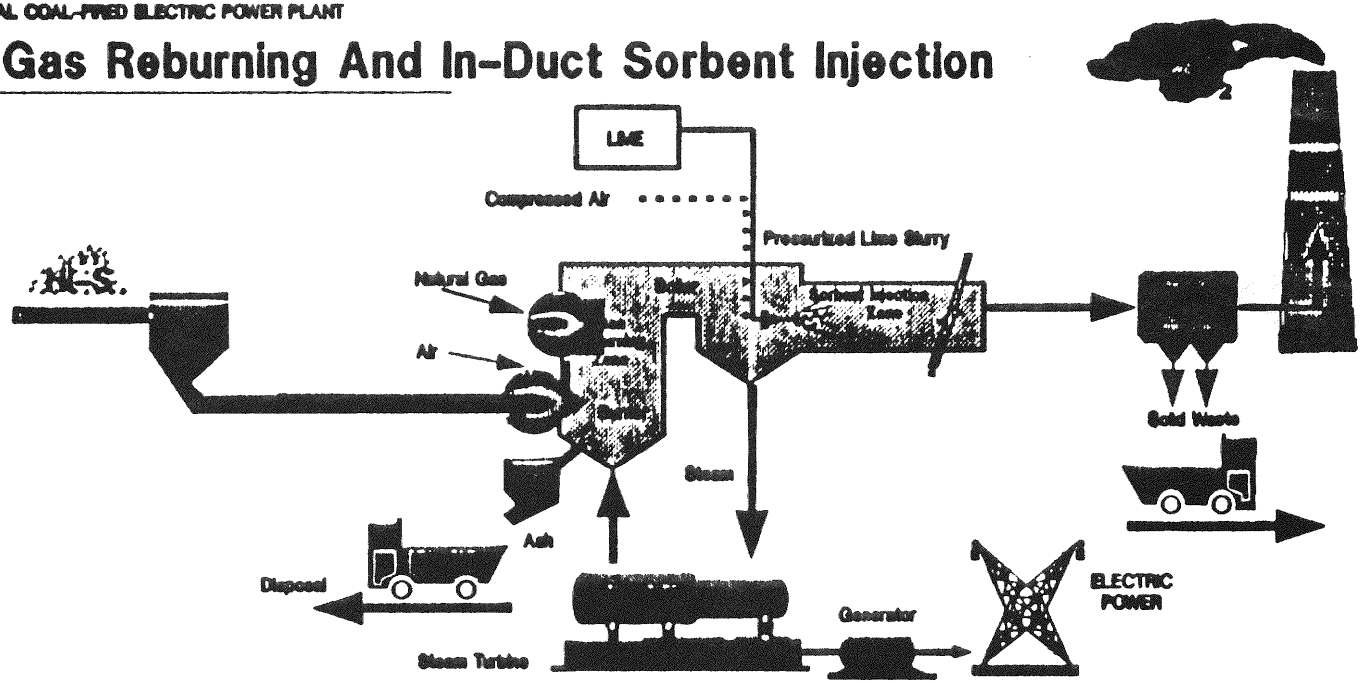
*COMPARED WITH CONVENTIONAL TECHNOLOGY**

SO_2 NO_x EMISSION REDUCTION		PLANT EFFICIENCY	POWER OUTPUT	PLANT LIFE	INCREMENTAL ELECTRICITY COST	CAPITAL COST
90–95%	Moderate	Slight Increase	40–50% Increase	Moderate Extension	4–6 MILLS/KWH	$800–1,000 PER KW

**CONVENTIONAL COAL-FIRED ELECTRIC POWER PLANT*

CONVENTIONAL COAL-FIRED ELECTRIC POWER PLANT

With Gas Reburning And In-Duct Sorbent Injection



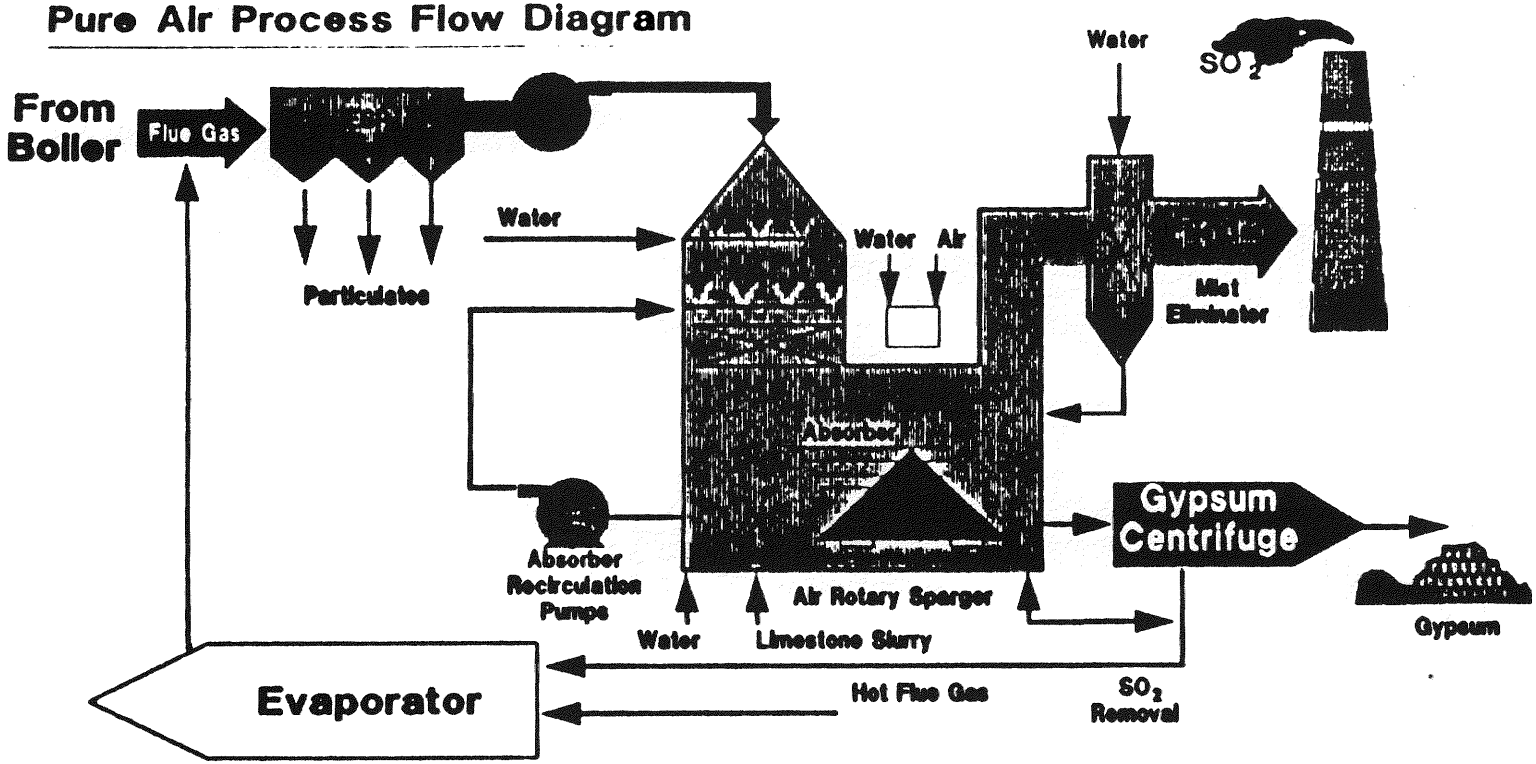
COMPARED WITH CONVENTIONAL TECHNOLOGY*

SO_2 EMISSION REDUCTION	NO_x REDUCTION	PLANT EFFICIENCY	POWER OUTPUT	PLANT LIFE	INCREMENTAL ELECTRICITY COST	CAPITAL COST
55–75%	Moderate	Small Decrease	Small Decrease	Slight Extension	2–4 MILLS/KWH Plus Gas Price Factor For Reburning	$50–110 PER KW

*CONVENTIONAL COAL-FIRED ELECTRIC POWER PLANT

Advanced Limestone Scrubber FGD Demonstration Project

Pure Air Process Flow Diagram



*COMPARED WITH CONVENTIONAL TECHNOLOGY**

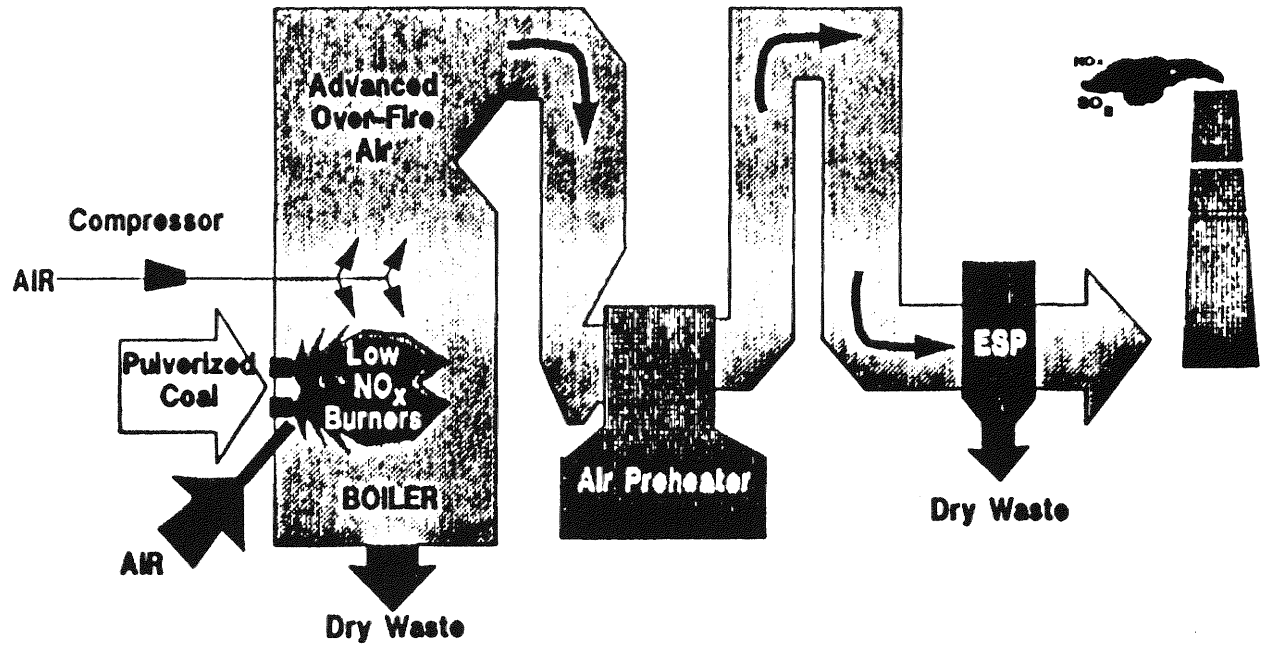
SO_2 EMISSION REDUCTION	NO_x REDUCTION	PLANT EFFICIENCY	POWER OUTPUT	PLANT LIFE	INCREMENTAL ELECTRICITY COST	CAPITAL COST
90% And Higher	No Change	Small Decrease	Small Decrease	No Change	2-4 MILLS/KWH	$150-200 PER KW

*CONVENTIONAL COAL-FIRED ELECTRIC POWER PLANT

Advanced Wall-Fired Combustion Demonstration Project

Southern Company Services, Inc.

Process Flow Diagram



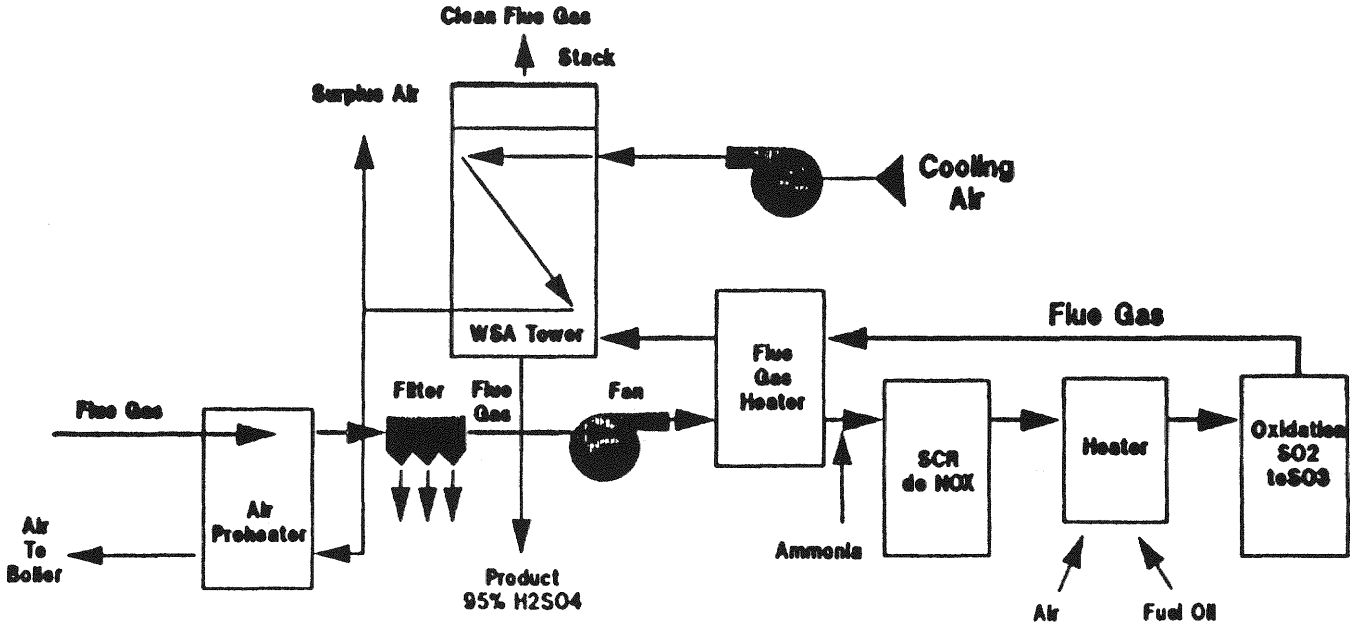
*COMPARED WITH CONVENTIONAL TECHNOLOGY**

SO_2 EMISSION REDUCTION	NO_x REDUCTION	PLANT EFFICIENCY	POWER OUTPUT	PLANT LIFE	INCREMENTAL ELECTRICITY COST	CAPITAL COST
No Change	55-60%	No Change	No Change	No Change	<1 MILLS/KWH	$5-15 PER KW

*CONVENTIONAL COAL-FIRED ELECTRIC POWER PLANT

WSA-SNOX Flue Gas Cleaning Demonstration Project

Combustion Engineering, Inc. Snamprogetti U.S.A. Inc
Process Flow Diagram



*COMPARED WITH CONVENTIONAL TECHNOLOGY**

SO_2 EMISSION REDUCTION	NO_x EMISSION REDUCTION	PLANT EFFICIENCY	POWER OUTPUT	PLANT LIFE	INCREMENTAL ELECTRICITY COST	CAPITAL COST
90% and Higher	90% and Higher	Decrease	Small Decrease	No Change	9-11 MILLS/KWH	$300-400 PER KW

*CONVENTIONAL COAL-FIRED ELECTRIC POWER PLANT

DOE'S CLEAN COAL TECHNOLOGY PROGRAM

OBJECTIVES:

- o BUILD AND OPERATE CLEAN COAL TECHNOLOGIES AT COMMERCIAL SCALE BY MID-90'S
- o OBTAIN DATA NEEDED FOR COMMERCIAL DECISIONS

ROLES OF DOE:

- o REDUCE FINANCIAL RISK OF FIRST-OF-A-KIND PROJECTS - $2.5 BILLION FEDERAL FUNDS
- o ENSURE ATTEMPT MADE TO COMMERCIALIZE TECHNOLOGIES DEMONSTRATED

ROLES OF INDUSTRIAL TEAM:

- o DEFINE AND CARRY OUT PROJECTS
- o COMMERCIALIZE

CLEAN COAL TECHNOLOGY PROGRAM FUNDING

($ Million)

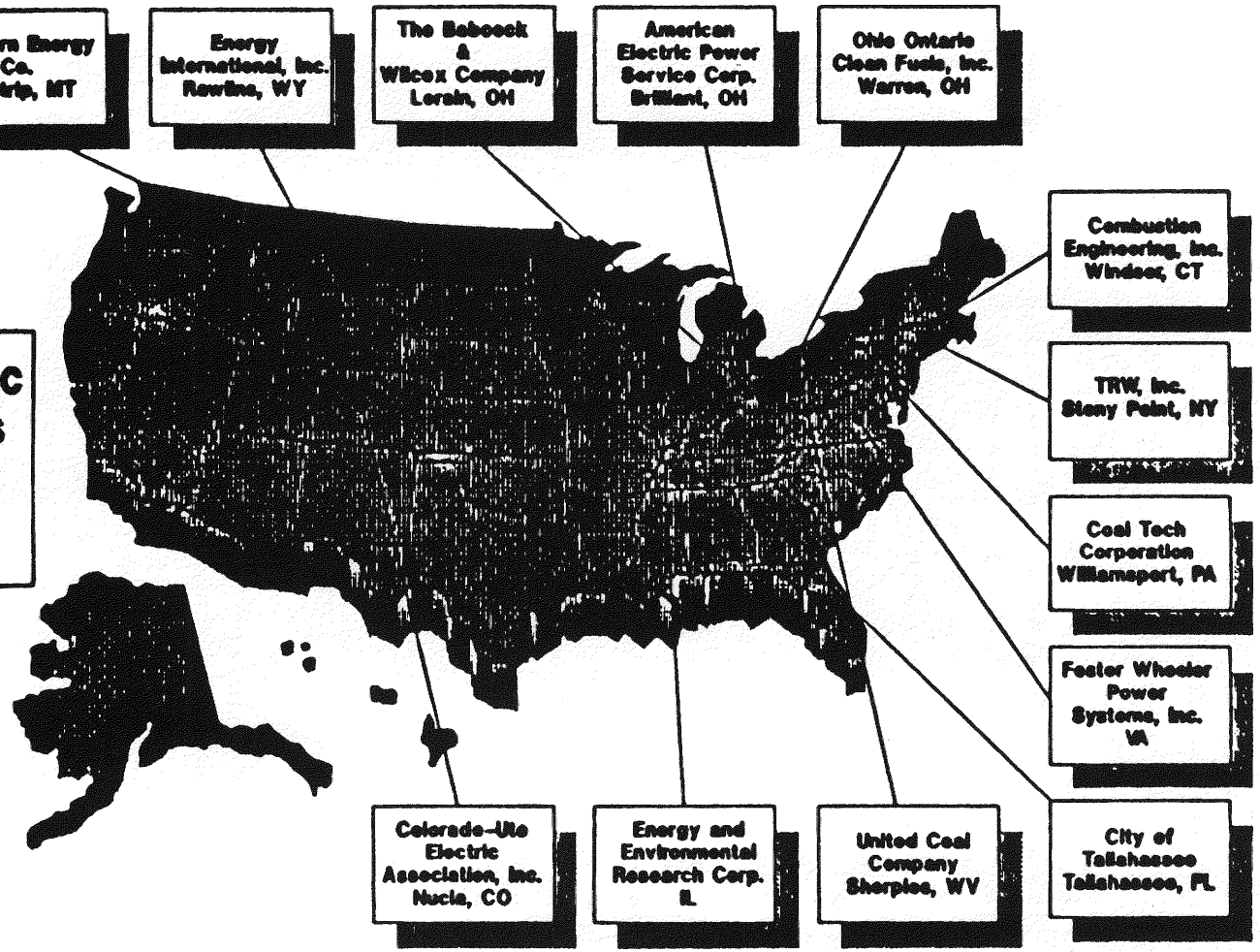
PROGRAM PHASE	FISCAL YEAR 1986	1987	1988	1989	1990	1991	1992	TOTALS
CCT-I:	$ 100	$ 150	$ 150					$ 400
CCT-II:			50	190	135	200		575
CCT-III:					450	125		575
CCT-IV:						600		600
CCT-V:							600	600
TOTALS	$ 100	$ 150	$ 200	$ 190	$ 585	$ 925	$ 600	$ 2750

CLEAN COAL TECHNOLOGY PROGRAM

OVERVIEW STATUS

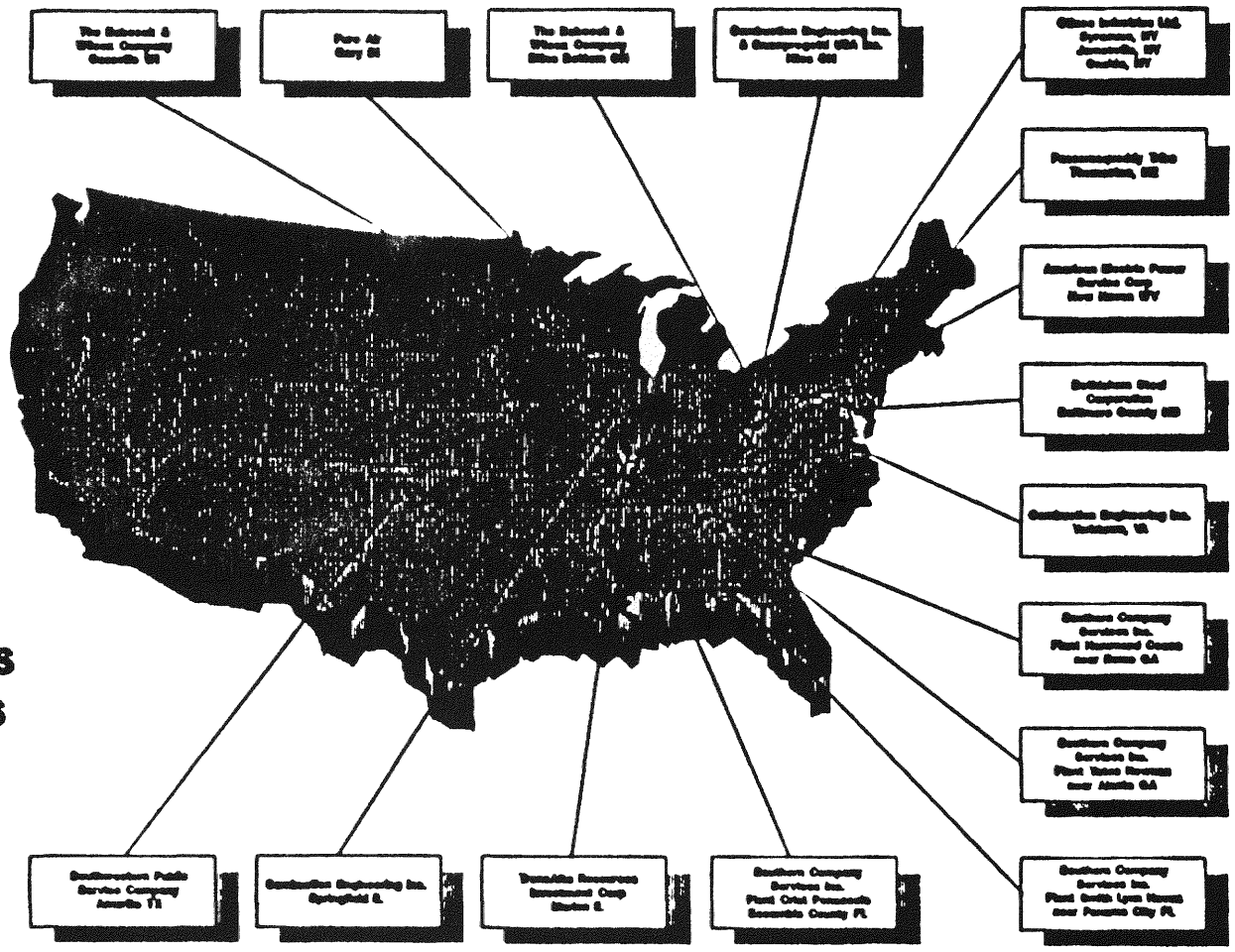
- TWO SOLICITATIONS COMPLETED.
- NINE COOPERATIVE AGREEMENTS SIGNED.
- TWENTY PROJECTS IN FACT FINDING/NEGOTIATION PROCESS.
- THIRD SOLICITATION ISSUED MAY 1989
- PRESIDENT REQUESTED FUNDING FOR REMAINDER OF PROGRAM.

Geographic Locations of CCT-I Projects

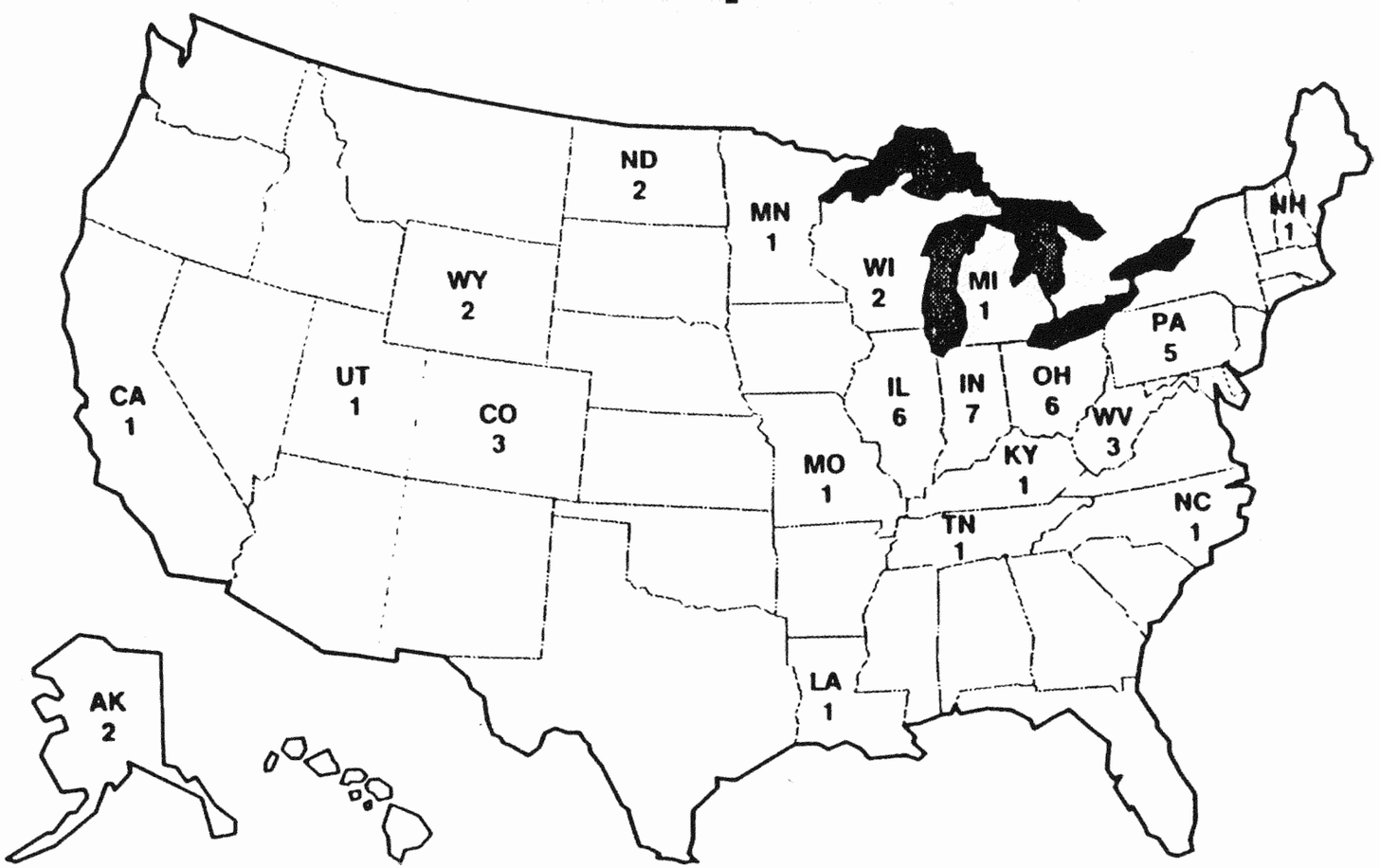


Clean Coal Round #2

Selected Proposers and Sites



CCT III Proposal Sites



FE22755.01

COMMERCIAL READINESS OF CLEAN COAL TECHNOLOGIES

TECHNOLOGY	No. of Units	Average Size (MW) < 100	100-300	>300	Tons of Coal/Day	Date of Initial Operation
IGCC						
OPERATING	2					
COOL WATER			X		907	1984-1989
DOW			X		2,300	1987-1994
PLANNED	4					
FLORIDA POWER & LIGHT				X	4,000	Planning only
FOSTER-WHEELER CCI		X			500	TBD-before 1994
COMBUSTION ENGINEERING CCII		X			480	TBD-before 1998
SHELL-NETHERLANDS			X		2,000	1993
LIQUEFACTION						
COPROCESSING	1 (Planning)				800	TBD-approx. 1997
OHIO-ONTARIO DIRECT LIQUEFACTION	2 (Actual)					
JAPAN-AUSTRALIA					50	1986-1990
WILSONVILLE					6	Current
INDIRECT LIQUEFACTION	1 (Actual)					
ONCE-THROUGH METHANOL LAPORTE					12	1988-1989

COMMERCIAL READINESS OF CLEAN COAL TECHNOLOGIES

TECHNOLOGY	NO. OF UNITS	AVERAGE SIZE (MW) <100	100-300	>300	DATE OF INITIAL OPERATION
AFBC					
- BUBBLING	2 (BLACKDOG, TVA)		135		IN OPERATION
- CIRCULATING	2 (COL. UTE, SCOTT PAPER)	100			IN OPERATION
- CIRCULATING	3 (TNP, SWP, TALLAHASSEE)		230		1990, 1993
PFBC					
DOMESTIC	1	70			1990
	1			330	1995
FOREIGN	2	70			1989, 1990
SORBENT INJECTION					
EER	2	80 MWe, 40 MWe			1990
LIMB/COOLSIDE	1	105 MWe			IN OPERATION
YORKTOWN	1	180 MWe			TBD

ROBERT L. KANE
Environmental Protection Specialist
Office of Planning and Environment
Office of Fossil Energy
U.S. Department of Energy

In April, 1984 Robert L. Kane began his duties as the senior technical and policy advisor for Global Climate change, acid rain legislation, acid rain effects research, and other air quality related issues in the Office of Planning and Environment, Office of Fossil Energy, U.S. Department of Energy. These responsibilities include providing direction, management and coordination of these issues and sharing policy development insights with other major organizations and international groups that are involved in these activities.

Prior to his present position, Mr. Kane served as an environmental specialist in the Office of Environment within the U.S. Department of Energy. In this position, Mr. Kane performed detailed technical assessments of new and existing environmental regulations to determine potential impacts on fossil fuel use. He has represented DOE on several Interagency working groups (Interagency Task Force on Acid Precipitation, U.S. Transboundary Workgroup on Acid Precipitation).

Mr. Kane's professional background also includes positions with the National Oceanic and Atmospheric Administration (Global Climate Program) and the U.S. Federal Energy Regulatory Commission. In this position, Mr. Kane worked extensively with air quality computer models to determine the impacts of electric generating facilities on the environment and worked extensively on environmental impact statements.

Mr. Kane received a B.S. in Meteorology from Penn State University and a M.S. in Air Pollution Resource Management from the University of Pittsburgh. He is a member of the Air and Waste Management Association.

Mr. Kane resides in Burke, Virginia with his wife and son.

GLOBAL CLIMATE CHANGE: A FOSSIL ENERGY PERSPECTIVE

R. Kane
Office of Fossil Energy
Office of Planning and Environment
U.S. Department of Energy

D. W. South
Environmental Assessment and Information Sciences Division
International Coal and Environmental Studies
Argonne National Laboratory

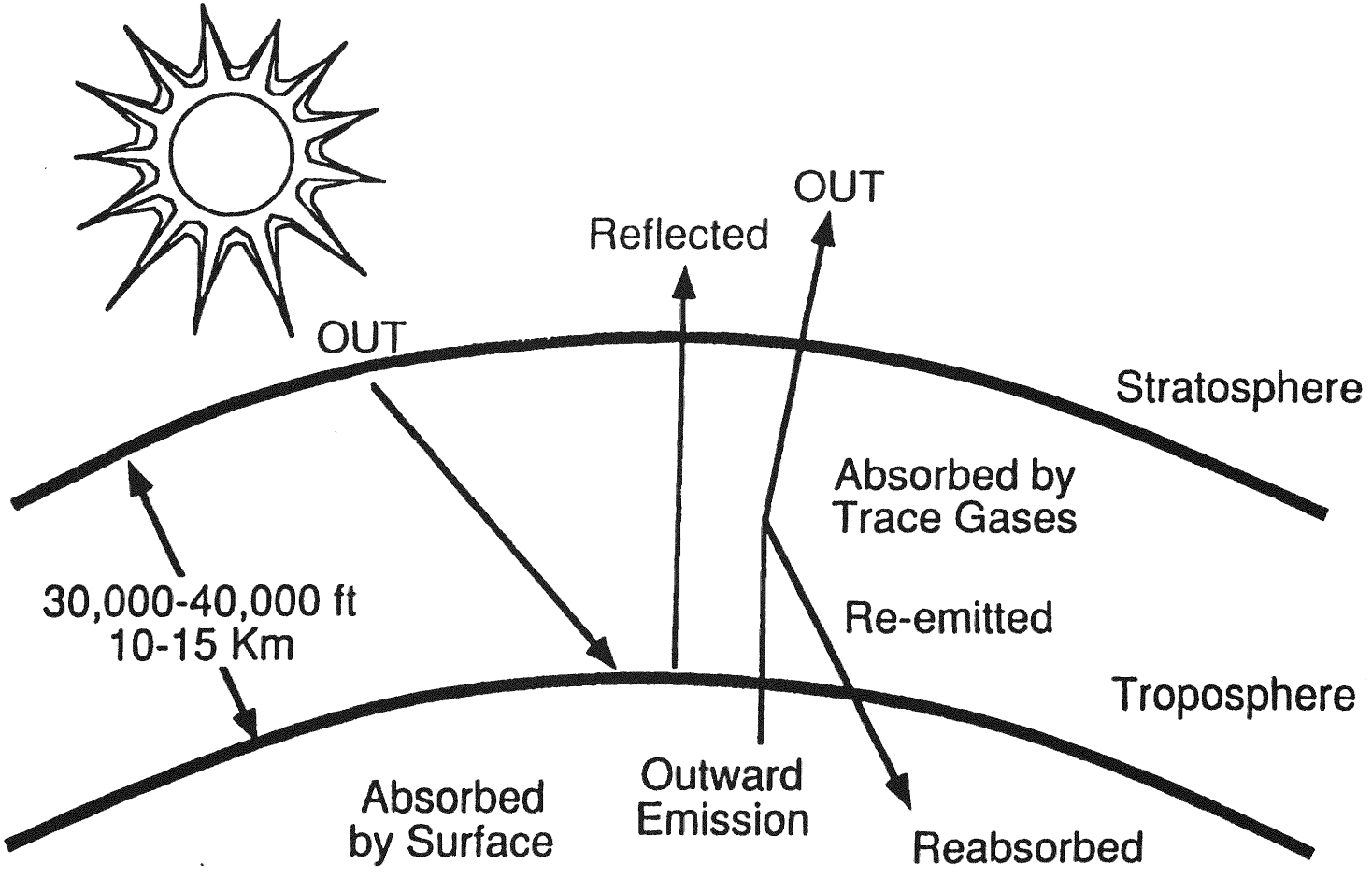
presented at:
Asia Pacific Coal Technology Conference

Honolulu, Hawaii
November 15-16, 1989

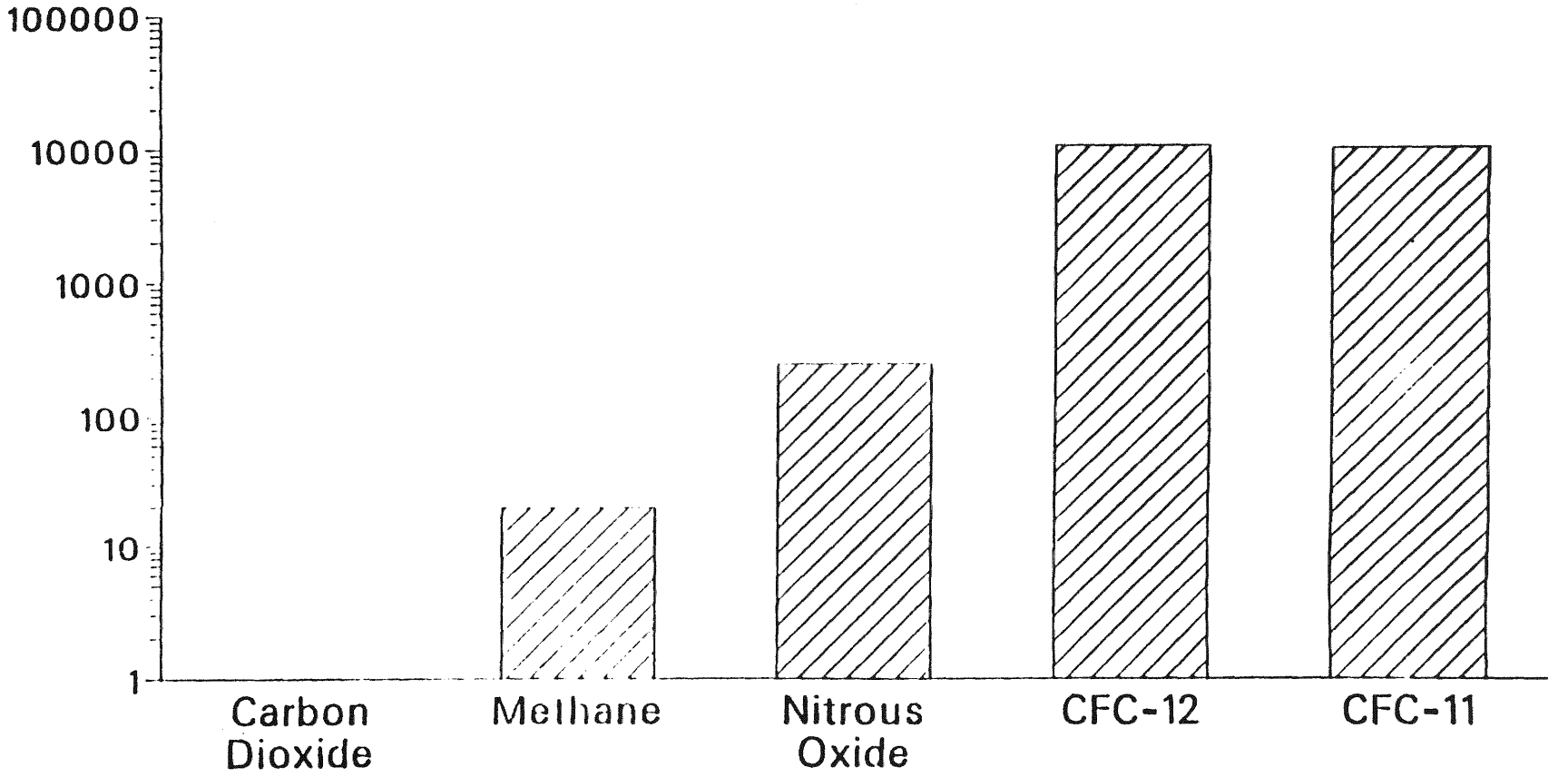
FOSSIL FUEL TECHNOLOGIES CAN PLAY A ROLE IN REDUCING GREENHOUSE GAS EMISSIONS

- One factor contributing to the growth of atmospheric greenhouse gases is fossil fuel consumption
- However, the worldwide fossil energy resource base, economic development policies and energy/economic growth relationships indicate continued reliance on these fuels
- If it is determined that greenhouse gas emissions should be reduced, more efficient fossil energy technologies can play a role
- Deployment of advanced fossil fuel technologies would reduce global fossil fuel consumption and greenhouse gas emissions relative to conventional technologies

WHAT IS THE GREENHOUSE EFFECT?



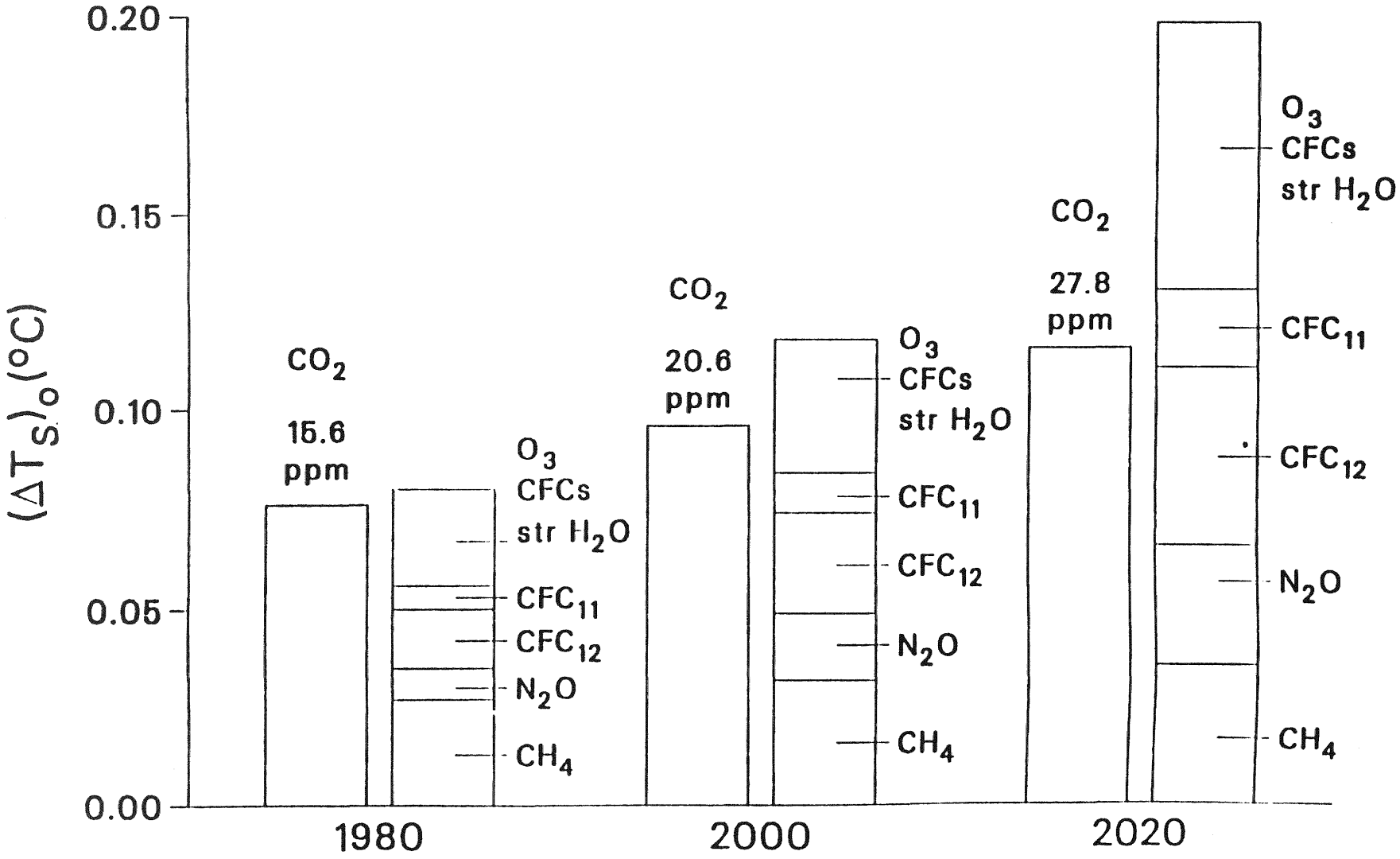
CO_2 IS THE LEAST "POTENT" GREENHOUSE GAS ON A MOLECULAR BASIS



Ratio of global warming effect to changes in concentration (normalized to carbon dioxide = 1)

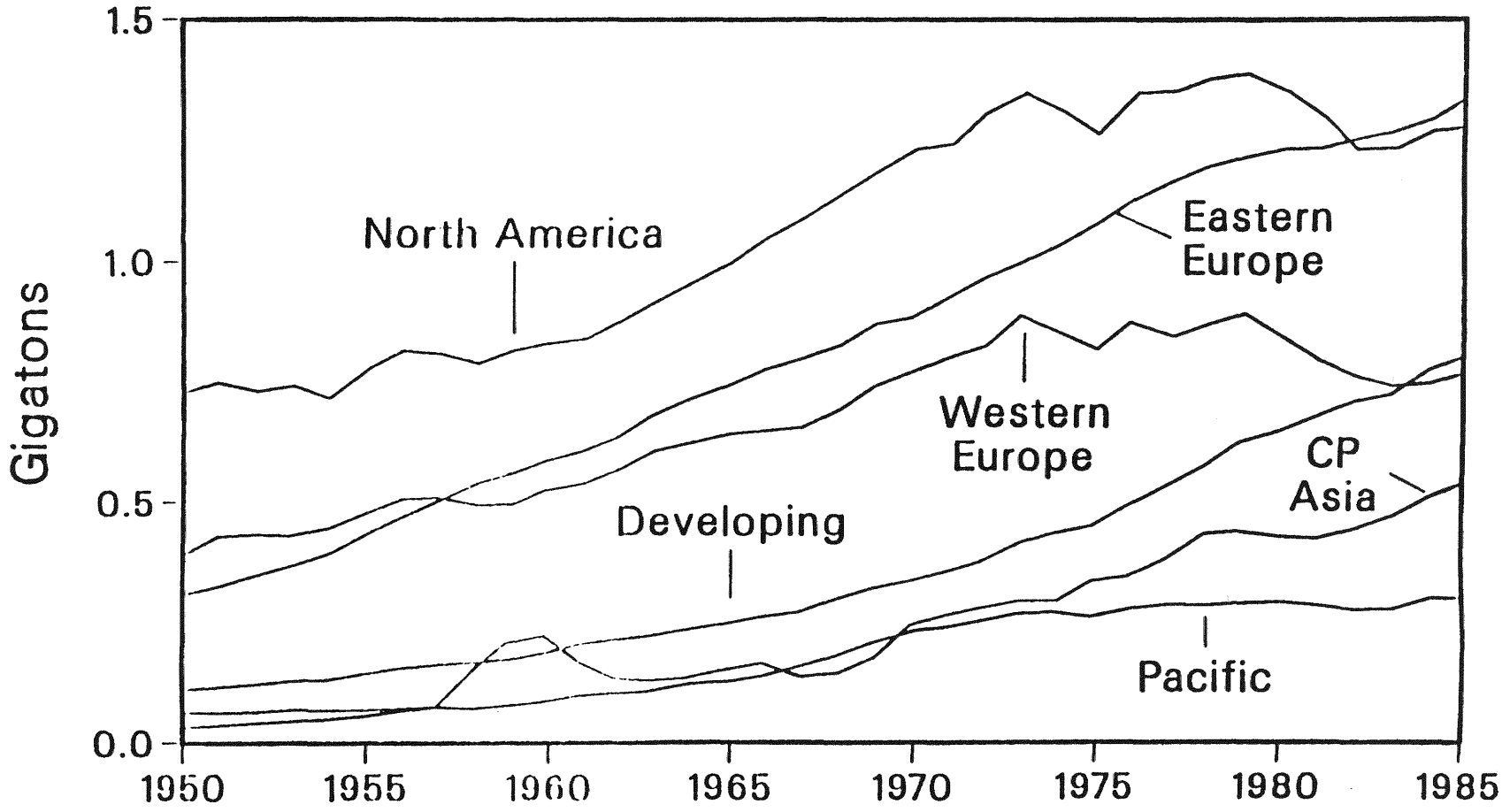
Source: Derived from Ramanathan (1988)

WHILE OTHER GREENHOUSE GASES ARE OF GROWING IMPORTANCE, ONLY CO_2 IS EXAMINED HERE DUE TO ITS LARGE (> 70%) FOSSIL FUEL CONTRIBUTION



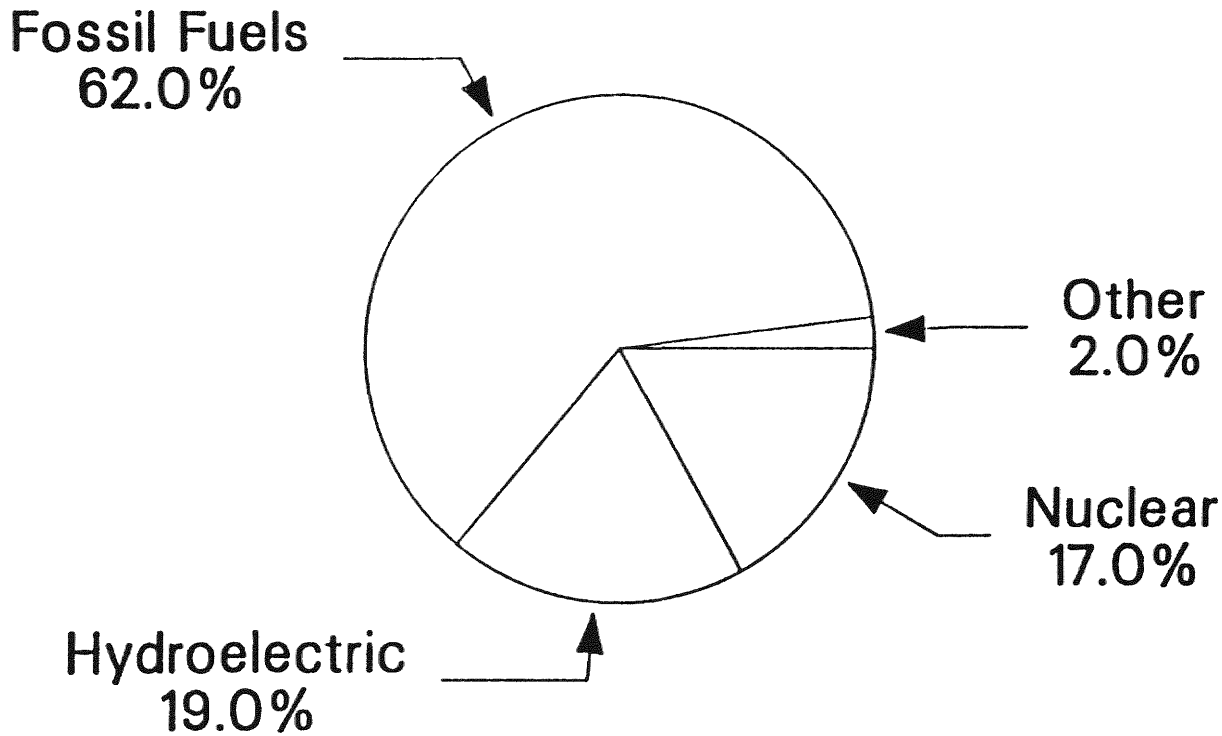
Source: Ramanathan (1988)

ANNUAL FOSSIL FUEL-RELATED CO_2 EMISSIONS ILLUSTRATE SHIFTING PATTERN OF GLOBAL SOURCES



Source: USEPA, Policy Options for Stabilizing Global Climate (1989)

FOSSIL FUELS PRODUCE MORE THAN 60% OF WORLD-WIDE ELECTRICITY



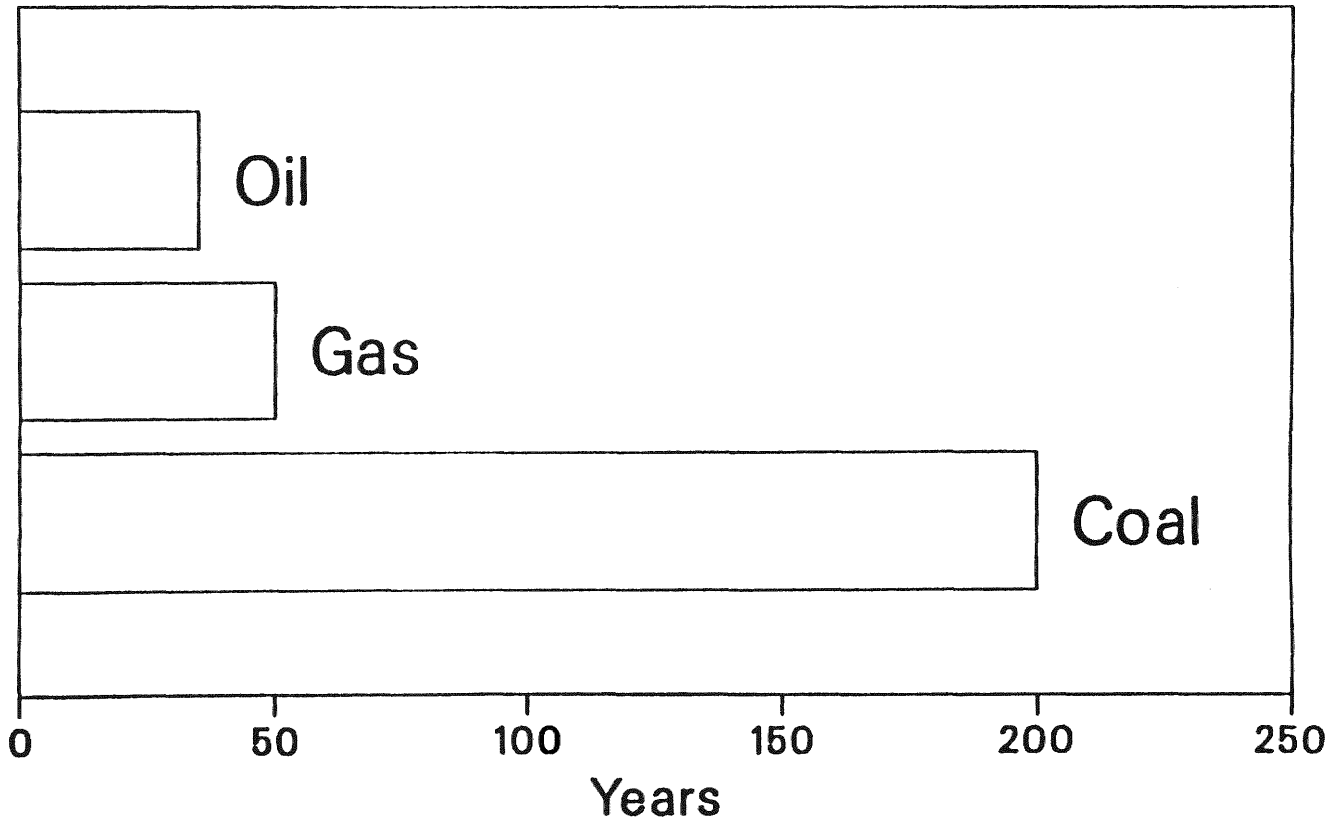
Source: USDOE/EIA, International Energy Annual 1987;
IEA Energy Statistics Annual

NATURAL GAS GENERATES ABOUT TWICE AS MUCH ELECTRICITY PER UNIT OF CO_2 AS COAL

	Heat Content (Btu/lb)	CO_2 Generated lb CO_2/MMBtu	Energy Generated kWh_e/lb CO_2
Bituminous Coal	12,700	204	0.56
Fuel Oil/Gasoline	17,600	178	0.70
Natural Gas	24,000	115	1.01
SNG from Coal Gas	24,000	329	0.34

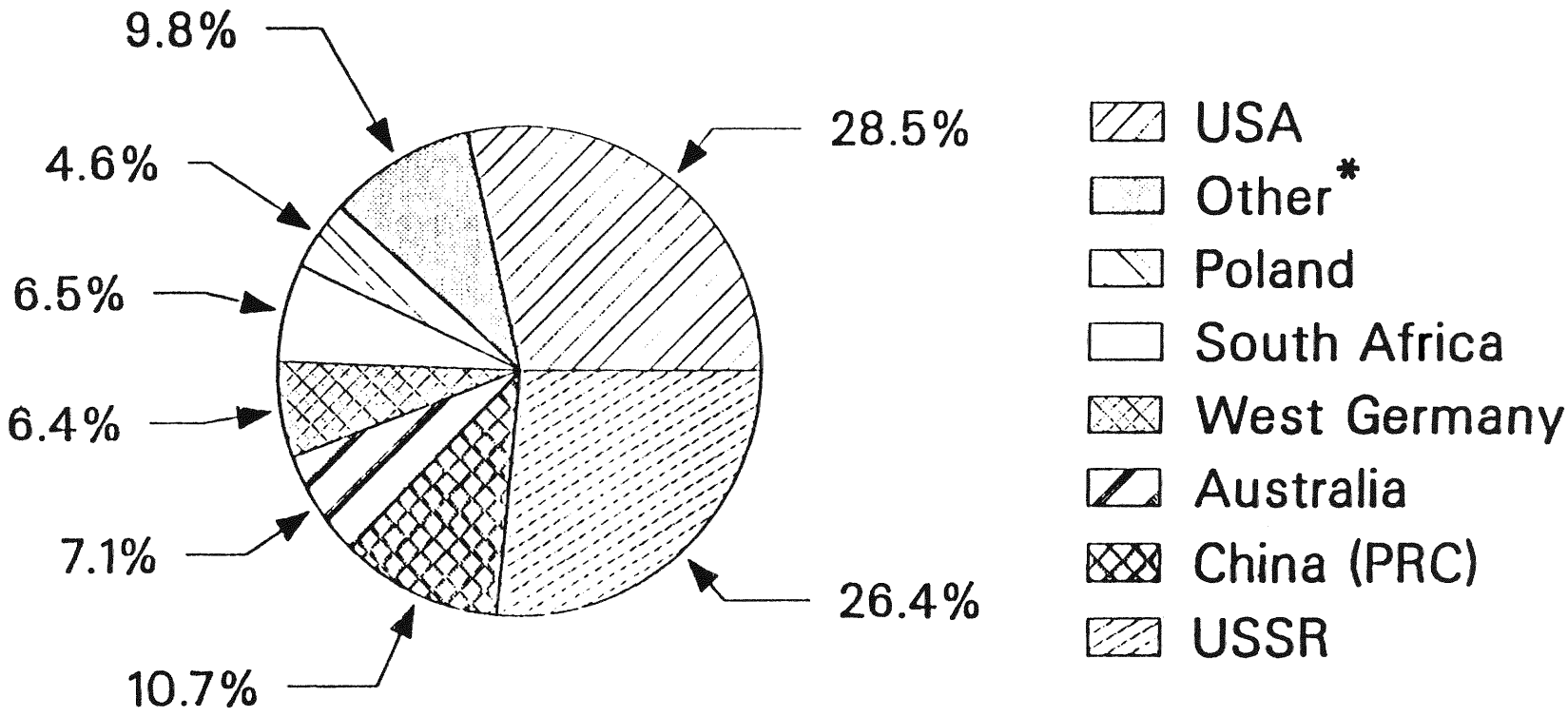
Source: Steinberg, et al., Air Pollution Control Association Meeting (June 1988)

RECOVERABLE WORLD-WIDE FOSSIL ENERGY RESERVES ARE EXTENSIVE; AT CURRENT PRODUCTION RATES EXISTING OIL/GAS RESERVES WOULD LAST <50 YEARS



Source: USDOE/EIA, International Energy Annual 1987

SEVEN COUNTRIES ACCOUNT FOR OVER 90% OF ESTIMATED WORLDWIDE RECOVERABLE COAL RESERVES



*represents 33 countries

Source: USDOE/EIA, International Energy Annual, 1987

ADVANCED FOSSIL ENERGY (FE) TECHNOLOGIES WILL REDUCE GREENHOUSE GAS EMISSIONS RELATIVE TO CONVENTIONAL FE TECHNOLOGIES

- U.S. Department of Energy, Office of Fossil Energy (USDOE/FE) is developing clean coal technologies (CCT) for greenfield and repowering applications
  - pressurized fluidized bed combustion (PFBC)
  - atmospheric fluidized bed combustion (AFBC)
  - integrated gasification combined cycle (IGCC)

- CCT demonstration program designed to make technologies available by 2005

ADVANCED FOSSIL ENERGY (FE) TECHNOLOGIES (cont'd)

- CCT conversion efficiencies will be in 40-45 range, conventional coal-fired power plants with scrubbers have 30-35 efficiencies

- For each 5 percentage point improvement in conversion efficiency, CO_2 emissions are reduced by 10-15%

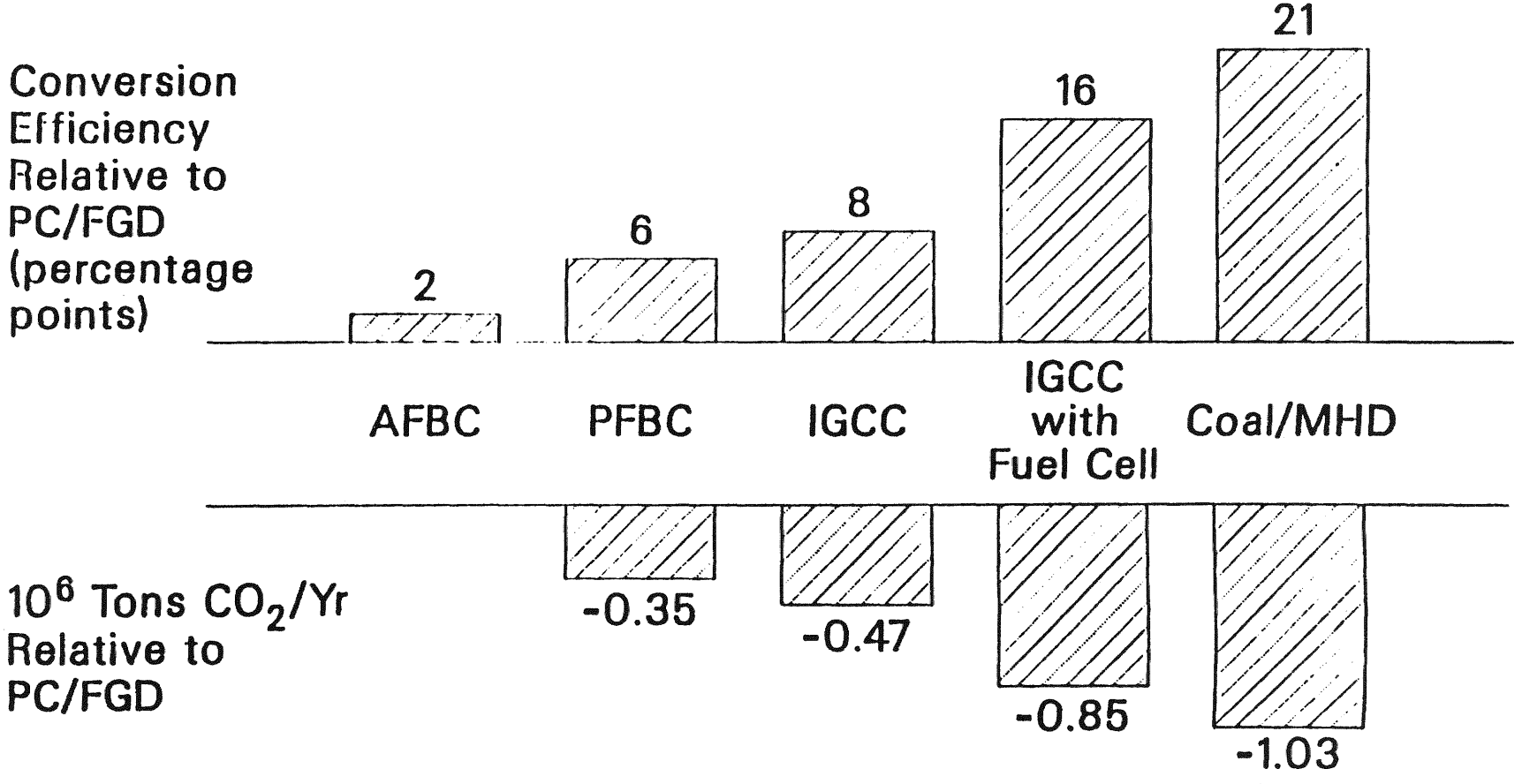
- In the more distant future, fossil energy based fuel cells and magnetohydrodynamics will be available with thermodynamic efficiencies of 45-60%

USDOE/FE INTERNATIONAL PROGRAM IS EXAMINING ROLE FOR CCT TECHNOLOGIES WORLD-WIDE

- Program consists of dilateral and multi-lateral research and information exchange projects. Projects directed toward:
  - collaborative R&D to increase utilization of CCTs with industriallized countries
  - deployment of CCTs in developing countries (e.g., technical cooperative agreement with Coasta Rica)

- On-going projects include:
  - set of initiatives to determine potential competitiveness of U.S. coal and CCTs in Pacific Basin
  - an initiative to promote/coordinate intra- and inter-agency activities related to coal and CCT exports

ADVANCED FOSSIL ENERGY TECHNOLOGIES WILL REDUCE CO_2 EMISSIONS THROUGH IMPROVED CONVERSION EFFICIENCIES



Basis: 500 MWe power plant, 65% capacity factor, 11,600 Btu/lb coal

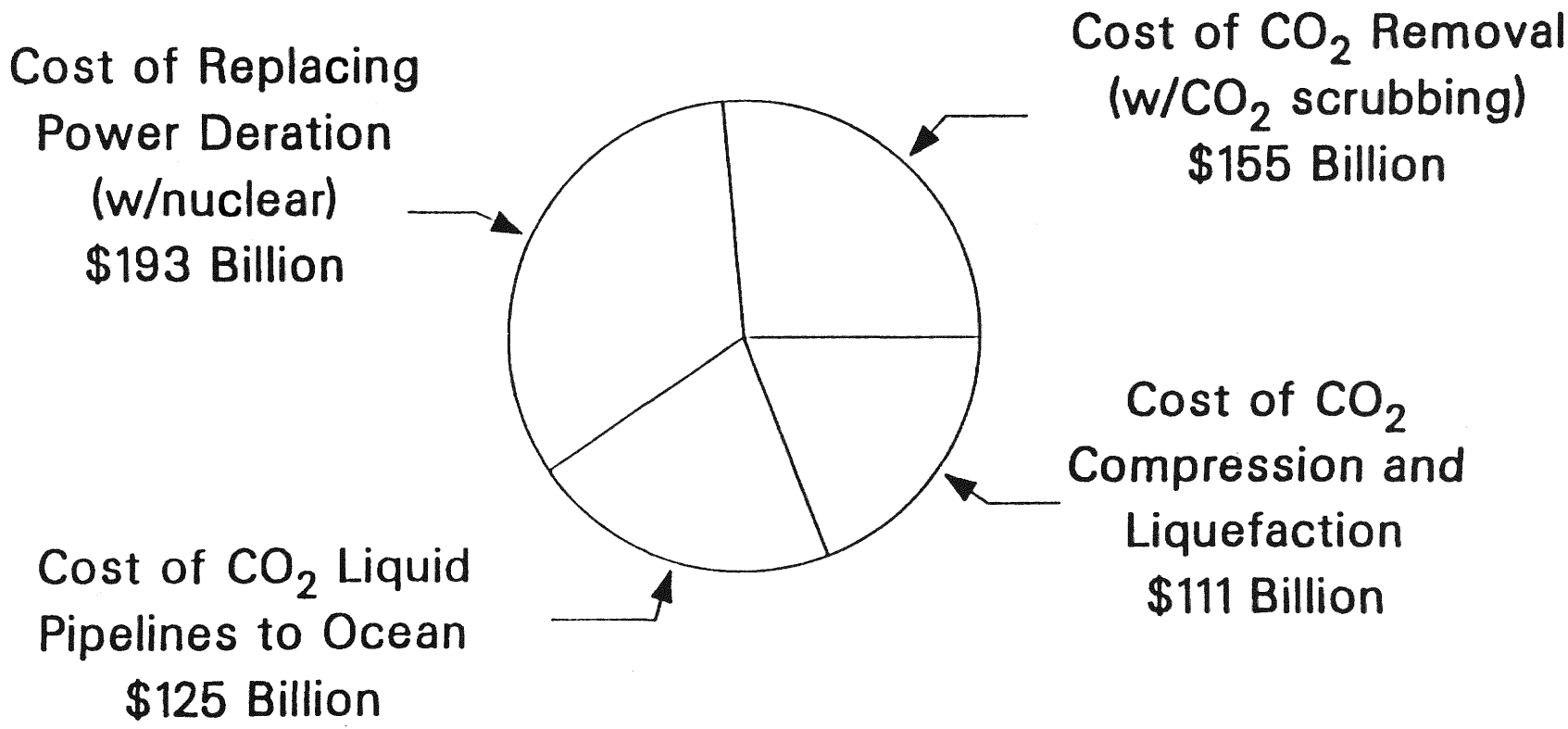
Source: USDOE/FE (1988)

IF *IMMEDIATE* CO_2 REDUCTIONS ARE REQUIRED, FOSSIL ENERGY TECHNOLOGY OPTIONS ARE LIMITED AND PROBLEMATIC

- Tail-gas cleanup (CO_2 scrubbing) is only present technological option
  - requires adaption of acid gas removal technologies used by petroleum/petrochemical industries

- 4 CO_2 Scrubbing Steps - Recovery, Concentration, Liquefaction, Disposal/Reuse
  - concentration important, flue gas typically 10-15% CO_2 by volume
  - power requirements substantial, 20-50% derating
  - CO_2 disposal/reuse constrained by access and storage/market size

EPRI ESTIMATES CAPITAL COST OF CO_2 CONTROL ON U.S. POWER PLANTS TO BE $584 BILLION, $1230/kW



Source: Torrens, Conf. on Global Climate Change Linkages (1988), Derived from Steinberg and Cheng (1984)

CONTROL (cont'd)

Intergovernmental Panel on Climate Change (IPCC)

- Preparing 3 assessment reports,
  September 1990 delivery date
  - State of Science (Chair-UK)
  - Climate Change Impacts (Chair-USSR)
  - Response Strategies (Chair-USA)

WHILE GCC INITIATIVES ABOUND, CONSIDERABLE UNCERTAINTIES EXIST

- Link between atmospheric greenhouse gas concentrations and climate change uncertain
  - June 1989 report found that factors other than greenhouse effect principal cause of 0.5°C temperature rise in last century

- Rate of greenhouse gas concentrations strongly depend on:
  - technical development, economic factors, policy decisions
  - net uptake of CO_2 by vegetation and oceans
  - net effect of earth system interactions

CONCLUSIONS

- Deployment of advanced fossil fuel technologies can reduce global fossil fuel consumption and greenhouse gas emissions relative to conventional technologies

- Combustion efficiency improvements in countries currently using fossil energy technologies, together with reliance on advanced fossil technologies in developing countries, could acheive long-term reductions in greenhouse gas emissions

THE ROLE OF COAL IN MEETING HAWAII'S POWER NEEDS

Richard K. McQuain
Vice President, Engineering
Hawaiian Electric Company, Inc.

Asia-Pacific Coal Technology Conference 1989
East-West Center

November 16, 1989

Outline of talk for East-West Center

Title: The Role of Coal In Meeting Hawaii's Power Needs

1. Introduction

2. History of coal for power generation in Hawaii
   a. HECO incorporated in 1891
   b. Existing plant converted from coal to oil in 1903 (economics)
   c. Honolulu Plant first steam unit in 1907
   d. Alakea Street Plant in 1917 (coal convertible)
   e. Supplemental fuel for plantations burning bagasse

3. HECO organization - HECO, MECO, HELCO, HERS

4. Primary technologies currently utilized on each island

   a. Oahu - oil-fired steam - 1180MW
      combustion turbines- 100MW
      Oahu & Waialua Sugar (bagasse) - 26MW
      HPower (refuse derived fuel) - 64MW
      Wind - 12MW
      Methane from dump- 3MW

   b. Maui - oil-fired steam - 37.6MW
      diesels- 105.7MW
      wind- 75KW
      photovoltaic- 20KW
      HC&S & Pioneer Sugar(bagasse) - 16MW

   c. Lanai - diesels- 3.7MW

   d. Molokai - diesels - 5.2MW
      combustion turbine - 2.0MW
      Onsite biomass plant - 4.0MW

   e. Big Isle - oil-fired steam- 71MW
      combustion turbines- 26MW
      diesels- 37MW
      hydro- 3.2MW
      wind- 15MW
      geothermal(HGPA) - 2.4MW
      HCPC & Hamakua Sugar (bagasse) - 28MW

5. Projected growth rates for HECO- 2.4%
   MECO- 5%
   HELCO- 4.6%

6. Generation expansion plans (near-term)
   a. HECO - AES(fluid-bed coal-fired) - 180MW
      Kalaeloa(LSFO-fired combined-cycle) - 180MW
      Geothermal- 500MW

RICHARD K. McQUAIN
Vice President, Engineering
Hawaiian Electric Company, Inc.

Years of Service: 10 years

Education:

B.S. in Analytical Chemistry, University of Florida, 1969

Mechanical Engineering Courses, University of South Florida, 1970-1971

M.S. in System Management, University of Southern California, 1983

Public Utilities Executive Courses, University of Idaho, 1985

Financial Decision Making for Public Utilities, University of California, Berkeley, 1987

Previous Positions:

Hawaiian Electric Company, Inc.

2/87 - 6/88	Executive Assistant
6/85 - 2/87	Manager, Production Department
6/83 - 5/85	Manager, Systems Operation Department
7/81 - 5/83	Manager of Technical Services, Production Department
4/79 - 6/81	Maintenance Superintendent, Production Department
6/78 - 3/79	Maintenance Supervisor, Production Department

Tampa Electric Company, Tampa, Florida

10/73 - 5/78	Maintenance Supervisor, Production Department

U.S. Army

4/71 - 10/73	Captain

ROBERT LEE KESSLER

Executive Director and General Consul
Western Coal Transportation Association

Bob Kessler has served as Executive Director and General Consul for the Western Coal Transportation Association for 11 years. The WCTA, a 14-year old organization, consists of approximately 60 corporate members, half of which are utilities, and the other half western coal producers. It holds three regular annual meetings, including its highly rated operations and Maintenance Seminar, each year.

Additionally, Bob engages in the private sector practice of law, with a concentration on negotiation of transportation agreements for both utilities and coal producers. He negotiated such contracts even prior to the passage of the Staggers' Act.

From 1977 (when he left the United States Department of Transportation) to 1984, he was Professor of Civil Engineering at the University of Colorado, and served as Director of its Center for Transportation Studies, and Chairman of all graduate work in transportation at the university.

Prior to that, Bob served as Chief Counsel, then Deputy Administrator and Acting Administrator, of the Federal Railroad Administration from 1969 to 1972. Subsequently, from 1972 to 1977, as Regional Representative of the Secretary of Transportation for the Mountain Plains Region, headquartered in Denver.

Prior to that time, Bob Kessler served as General Counsel and Assistant Attorney General for the Colorado Public Utilities Commission for some five years.

He served in many engineering positions as a Design Engineer, Propulsion Engineer, and Safety Engineer, for such companies as United States Rubber, Celanese Corporation of America, Martin-Marrietta Corporation.

He has received many awards, including the Department of Transportation's Secretary Award twice, first from Secretary John Volpe, and then from Secretary William Coleman. He has received Distinguished Service awards from the National Multiple Sclerosis Society, American Institute of Aeronautics and Astronautics, among others. The WCTA awarded him its Distinguished Service award in 1987, and the Director of the Transportation Test Center, at Pueblo, Colorado, bestowed upon Bob the prestigious "Rattlin' Turtle Degree" for his "efforts in the advancement of transportation."

He has authored numerous articles and papers throughout his career, in both technical and legal publications in respect to transportation and energy (primarily coal and shale oil).

Bob studies chemistry and chemical and metallurgical engineering at the Universities of Michigan and Colorado, receiving a B.S. in Chemical Engineering. His Bachelor of Laws (LL.B.) was received from the University of Denver, from which he also later received a Juris Doctorate (J.D.).

He is a member of the American, Inter-American, Colorado and Denver Bar Associations, as well as the International Institute of Space Law, and is admitted to practice before the Bars of the Supreme Court of the State of Colorado, United States District Court for the District of Colorado, and the Tenth Circuit and District of Columbia Circuit Courts of Appeals, U.S. Court of Appeals, as well as the United States Supreme Court. He is also a very active member in the American Institute of Aeronautics and Astronautics, and the American Chemical Society, among others.

Bob served three years in the U.S. Army in the Counter Intelligence Corps, and the Chemical Corps.

Workshop on Asia-Pacific Coal Technology Trade Issues, November 16, 1989

Red Group: Chairperson -- Mr. Robert Lee Kessler
Western Coal Transportation Association
Scribe -- Mr. Thomas A. Sarkus
Pittsburgh Energy Technology Center

Introduction

The workshop discussion focused on methods of achieving U.S. exports of Clean Coal technology and/or coal by effectively helping the developing countries of the Asia-Pacific region to meet their rapidly growing energy needs, within the context of specific and local technical, political, and economic requirements. To this end, the discussion centered around how to maximize the mutually beneficial impacts of future U.S. trade in the Asia-Pacific region. The basic approach calls for a United States proposal team to be created for each possible project. These teams would review existing material, including the papers presented at this conference, and would identify whatever additional information is required for the preparation of a comprehensive proposal package. To the extent that additional information commends itself to information gathering by the Department of Energy (DOE), that should be accomplished in a timely fashion. If the information is to be gathered on the local scene, including the exploration of particular technical requirements or coal specifications, together with policy or other constraints, then the team may wish to mount a trade mission for that specific purpose -- but not as a shotgun measure. After the specific information required for preparation of the proposal has been gathered, the team would reform from time-to-time within the United States and put together the comprehensive package. Then, the team may mount another trip to make a formal presentation of the proposal.

Trade Team Homework

It was generally agreed that this conference served as a good starting point for introducing U.S. Clean Coal technologies to the Asia-Pacific region. Inevitably, the question arose, "Where do we go from here?" Strangely enough, the best path toward success might begin by taking a small step backward -- and reviewing the materials which were presented at this conference. Collectively, the conference speakers devoted a great deal of effort to preparing these materials. For example, the Asia-Pacific country speakers have outlined the future energy plans and concerns of their respective countries. This is invaluable background information which must be built upon in the future.

Although the presentations were detailed, in each case they necessarily covered an extremely large amount of material constituting the electric power resources of an entire country. Therefore, considerable work, on the part of U.S. parties that wish to participate in trade teams to these countries, needs to be done. Specific details will have to be gathered. These details may include the applicability of various technologies to existing plants, site selection for the introduction of new technology facilities, the nature of locally available fuels, the potential for importing U.S. coal, and governmental concerns with respect to economic development in different areas. Without such comprehensive exploration of specific details, building upon the information brought to the U.S. parties at this conference, proposals will be unsuccessful. In this sense, the trade mission teams may be likened to professional

study groups, chartered to develop the best solutions for specific energy-related problems or situations.

Trade Teams (Mission)

There was considerable discussion about who should be members of the trade teams. Suggestions included the Clean Coal technology vendor/entrepreneur, coal vendor (where appropriate), bankers, guaranty agencies (e.g., Export-Import Bank, Multilateral Investment Guaranty Agency, Overseas Private Investment Corp., etc.), DOE and some other U.S. government agencies, and perhaps even electric utility/industrial companies that have had first-hand experience with the proposed technologies. It may also be wise to designate a liason person or group within the foreign utility/industry, to ensure that the customer's needs and concerns are fully addressed.

Team activities should include gathering the specific noted information, targeting appropriate candidate technologies for the Asia-Pacific country, setting goals, and identifying the specific roles to be played by each team member in achieving those goals. The various team activities should be coordinated by a team leader. The technology vendor, coal vendor (where appropriate), banker, guaranty agency, and DOE all play pivotal roles. Naturally, the technology belongs to its vendor, and he has the most vested interest in its promotion. But money is also key, and this financial importance is heightened by the fact that the Asia-Pacific countries often have very little capital to invest.

Lastly, it was expressed that the Asia-Pacific countries would look more favorably toward future trade missions simply by virtue of DOE's active involvement and technical expertise. They are already used to getting sales calls from various entrepreneurs, and it was said that DOE support would be taken more seriously.

Of primary importance is the identification of those tasks that must be accomplished within the team concept. The following tasks appear to be of major, possibly prime, importance:

1. DOE could perform country market assessments and technology feasibility studies to identify some of the most appropriate candidate technologies for each Asia-Pacific country.

2. Vendors of the candidate technologies and/or coal could prepare technical proposals designed to meet the developing country's energy needs.

3. Bankers and guaranty agencies could assemble financing options tailored to fit specific economic needs.

Comprehensive Turnkey Packages

Once sufficient information has been gathered, the trade teams can begin to prepare comprehensive turnkey packages -- with emphasis on the word comprehensive. Again, these integrated packages must have three major components: technical, financial, and policy. Candidate technologies must be appropriate for a given country's energy and economic situation. The Asia-Pacific countries are justifiably cautious about buying technology which is not specifically applicable to the conditions in their particular country. Therefore, serious consideration must be given to the fact that a candidate technology can be ideal for one country and, at the same time, unsuitable for another. It was noted that candidate technologies must be relatively proven, before

they will be considered by the Asia-Pacific countries. The technical component must also recognize that support services (i.e., education, hands-on training, maintenance, parts & supplies) play an extraordinary role in developing countries. Good technical support is vital to ensuring the long-term success of each project.

The financial component is particularly important, because developing countries often have little cash to invest in energy projects. Funding of a clean coal technology facility by the foreign government was described as "not really an alternative." So the Asia-Pacific utility/industry must borrow money, and then generate a sufficient rate of return in order to pay back the loan and to stay profitable. Thus, financing options and commercial guarantees become vitally important. While there are some exceptions, it was noted that U.S. technology vendors and financial institutions are often weak when it comes to preparing integrated technology/financing packages for the international marketplace.

Policy was cited as the third major component of a fully integrated package. It must be recognized that Asia-Pacific electric utilities are often government-owned agencies. As such, they are especially prone to include policy issues and concerns within their operational and business plans. It was noted that high-level U.S. government involvement can help to ease these concerns -- both abroad and in the United States. In future trade missions, a need was cited for the various U.S. government agencies to act more cohesively, expediently, and decisively than they have at certain times in the past. It was also noted that U.S. government funding would be appreciated, perhaps in the form of market studies and technical assessments. To some extent, portions of these activities may have to precede the preparation of comprehensive turnkey packages. Of course, these efforts must recognize the Asia-Pacific country's specific concerns -- e.g., the preference for using domestic energy resources where available, the desire for import diversification, and the need for cost-effective and reliable sources of electricity.

Conclusion

This conference provided an excellent point of departure. Future DOE-sponsored functions, including conferences and trade missions, have excellent potential for assisting U.S. Clean Coal technology exports and coal exports while effectively helping other Asia-Pacific countries to meet their growing energy needs. These needs tend to express themselves as a total, integrated problem. Therefore the trade teams should be viewed, at least initially, as problem-solving teams. Potential solutions for these multidisciplinary problems must necessarily address the appropriate technology, potential fuel sources, financial and economic considerations, environmental concerns, etc. Future activities need to be disciplined within a team concept, with a very strong focus and intent to follow through for the long term. Mere ad hoc activities lend themselves simply to fracturing of the focus that has been established by this particular conference, and by the series of DOE-sponsored conferences and activities which led to this event. Much detail work is now required, and a decision to get on with that work should be made immediately at DOE's senior management level. Attempts to form trade teams should also be made quickly while the effects of past work can still be felt.

MANFRED G. RASCHKE
President
International Strategic Information Services

Manfred G. Raschke, PhD, is a consultant specializing in international energy markets. For clients such as oil, gas, and coal producers, railroads, tanker operators, steel companies, electric and gas utilities, governmental agencies, banks, and high technology firms, Dr. Raschke provides management and economic counsel, litigation support, and database development.

Prior to founding International Strategic Information Services, Dr. Raschke was a vice president of Dun & Bradstreet Corporation and a consultant at Temple, Barker & Sloane, Inc. He held faculty positions at Harvard University, Duke University, and the University of California, Davis. He received his PhD from Harvard University and his B.A. from the University of Toronto. His postgraduate education included periods of study at universities in England and Italy.

Dr. Raschke is the author of numerous articles and monographs on oil, gas, and and coal issues, as well as a frequent speaker at domestic and international conferences.

WORKSHOP SUMMARY

Facilitator: Manfred Raschke -- International Strategic Information Services

Scribe: Sue Ellen Walbridge -- Office of Planning & Environment, U.S. Department of Energy

The session began by the observation that none of the papers focused on the demand side electricity gap and that it was too bad that the Japanese were not in attendance as they have experience in the demand side. It was also stated that since the U.S. is a world leader in the expertise of surface mining there should have been manufactures in attendance as it all should be packaged together from the mine mouth.

The rest of the session focused on the three topics: capital, training, and selling/information gathering skills of U.S. companies and the Foreign Commercial Service.

Capital:

This issue was not discussed/presented at the conference. The necessity to package coal, technology, and the capital to buy it need to be together. Examples given: PLN (Indonesia) 10 years ago contracted to have and energy study done which projected a large energy demand. However, there was no discussion in the study as to how to pay for the increased demand. In the meantime, current demand has not met what was projected. In the Philippines they are trying to have the participation of the private sector through investment in the industry. This participation occurs in the generation end of the industry where a project sponsor builds the power plant and the rate structure is set to service the project loans. The Philippines like the BOOST (system (build, own, operate, sell, transfer), which is more commonly known as BOOT.

In general, it was stated that it is necessary to mix projects so that certain parts of a project may receive financing from multilateral sources.

Training:

As an example of a successful training program, it was noted that France has a radar product and when it is bought they tie 5 year forgiveness on the loan with a 30 year pay back. They have a training program that teaches the individual not only to operate but to maintain the equipment. The U.S. should have a massive training program on its technologies (clean coal technology program). The training program would need to be a 50/50 split between the government and industry. It was generally agreed that not many U.S. companies are willing to do training programs.

One company went to China and brought 45 engineers to the U.S. and succeeded in constructing a world class surface mine using the trainees in China in five years.

It was suggested, for example, that technicans from Third World nations be brought here on a three week study tour of the Pulverized Fluid Bed Combustion technology and to show them who all the suppliers are. It was also suggested that their be a two-tier training program. A short-term program for management (3 weeks) and a long-term (6 months) program for the technical people.

Marketing:

There was general agreement that non U.S. companies have much better sales staff since most of the countries live from their exports. It was suggested that U.S. coal companies do not care or are interested in focusing on steam coal exports. U.S. equipment manufacturers are better staffed in terms of exports than the coal companies. U.S. coal companies live off their domestic contracts. The U.S. government is more interested in coal exports than the producers. There is a better future in exporting the clean coal technology. It is difficult to get the coal producers to focus on selling in foreign countries, except for Europe. The U.S. steam coal producers do not seem interested in exporting to the Asia Pacific Basin.

For example, Hawaii is buying coal from Indonesia. Part of the problem in selling coal is the management philosophy. If the U.S. coal producers banded together with the transportation sector and decided to sell at a loss they could put Australia out of business. However, it was stated that the coal industry is fragmented. The U.S. energy industry is not organized enough to push for a government policy because it is so competitive. The U.S. energy industry needs to be more organized if they desire to become major exporters.

The U.S. government could play a key role in exporting but the Foreign Commercial Service (FCS) does not see any necessity to push U.S. goods. The Department of Commerce (DOC) does not see its role as selling American products. DOC should identify marketing and business information and to mate that information with products the U.S. has available to sell.. American embassies are not knowledgeable about coal producers and the clean coal technologies being utilized. For example, the Canadian FCS goes out to find out what a particular industry needs and then tries to sell products of specific companies since the FCS officer knows which companies and products they have to sell.

Facilatator: Dan Gerkin, Senior Vice President
National Coal Association

Scribe : Robert Kane, Office of Planning & Environment
U.S. Department of Energy

Trade Opportunities

Given the significant growth projection in energy consumption for Pacific Rim countries, it seems clear that opportunities exist, both for the export of combustion technologies and coal from the U.S. Two major interests were expressed by Pacific Rim representatives:

- The development and availability of combustion technologies that will allow countries to develop and exploit indigenous, low-grade fuel.
  Opportunities for circulating fluidized bed technologies seemed particularly applicable for Indonesia, Thailand, Malaysia and the Phillippines, all of which has substantial reserves of low-grade fuels, the export of these technologies should be expedited.
- Importing countries with no indigenous reserves articulated two obvious priorities; that they maintain diversification of supply and that imported fuels be price competitive.

Target countries expressed frustration that the U.S. was not familiar enough with their needs, and that often the U.S. was trying to sell technology exporters work more closely with target countries in order to better understand their needs. Interested companies should visit these countries to evaluate their indigenous fuel reserves, production/ transportation infrastructure, and existing combustion methodologies and capacity. This evaluation should provide prospective technology exporters the necessary information to suggest new combustion methods that will best suit the overall needs of the target country.

One technology vendor discussed its practice of test-burning indigenous fuels from target countries. These tests allow for the development of a boiler design for specific fuels. The vendor revealed his company had tacit agreement with 39 countries for this type activity.

Regarding the potential for U.S. coal exports, the following points were made:

- Growing energy demand in the Pacific Rim countries will offer significant opportunity for exporters, but it will be a highly competitive market.
- Much U.S. coal (particularly high-quality Appalachian coal) is not price competitive because of high U.S. transportation costs.
- Delegates supported passage of eminent domain legislation in the U.S. that would allow construction of coal slurry pipelines. This could lead to coal slurry exports and the development of coal/ water combustion technology in the Pacific Rim. Coal/water fuels

could replace existing oil capacity in the region and substantially expand markets for U.S. coal. However, none of the participants knew the extent of that potential market. One commentor indicated he was impressed with the magnitude of coal export opportunities in the region, however, participation by the Japanese in the conference would have been beneficial.

Trade Barrier

The major trade barrier discussed by participants was the high cost of transportation and its impact on the competitiveness of U.S. coal in international markets. Support for passage of eminent domain legislation and the construction of coal slurry pipelines was voiced by several participants. Several examples of U.S. export deals thwarted by high transportation costs were discussed.

The subject of financing was discussed only briefly, but clearly the lack of low-cost financing for U.S. projecting could be a major obstacle to technology exports. Several delegates discussed the need for more creative private sector financing as well as expanded low-cost financing from the World Bank.

In order to minimize the impact of Barriers it was suggested that:

1) Exporting countries should become familiar with the unique problems of importing countries;
2) Specific coal boiler designs must be designed for each country;
3) The price of the exports must be cost competitive and
4) Exporters should be aware that importing countries need to diversify their sources and resources for energy production.

Trade Missions

On the question of a continuing role for the U.S. government in promoting technology and coal exports, there were mixed support. Pacific Rim representatives seemed receptive to an expanded role by the U.S. government, particularly in the area of technology transfer. Regarding coal exports, U.S. delegates said that U.S. political pressure was the most beneficial government activity.

The group expressed measured support for trade missions, with seemingly more interest exhibited for technology exports than coal exports. But it was emphasized that any trade missions must be properly structured to be successful.

One suggestion for steps in the process was:

1) Conduct a trade mission;
2) Determine specific, directed needs; and
3) Conduct a reverse trade mission, in which people from developing countries would be brought to the U.S.; perhaps twice/year to participate in small workshops near clean coal technology demonstration plants.

Additional Topics for DOE Studies

- Conduct a market analysis of the potential opportunities for coal/water fuels as a replacement for oil in the Pacific Rim.
- Expand ICT Study to see how these fuels might then compete in the region.
- Study the diversification of coal exports from the U.S. to see where they match up best in Pacific Rim countries.

INNOVATIVE/ALTERNATIVE TRANSPORT MODES FOR MOVEMENT OF U.S. COAL EXPORTS TO THE ASIAN PACIFIC BASIN

EXTRACT

for release at
Asia-Pacific Coal Technology Conference 89

November 15-16, 1989

U.S. Department of Energy
Assistant Secretary for Fossil Energy
Office of Planning and Environment

INNOVATIVE/ALTERNATIVE TRANSPORT MODES FOR MOVEMENT OF U.S. COAL EXPORTS TO THE ASIAN PACIFIC BASIN*

EXTRACT

1 SUMMARY

With rich endowments of coal that can be mined at low cost, the U.S. is positioned to play an expanding role in meeting the energy demands of the Asian Pacific Basin (APB). Coal reserves in the U.S. are among the world's largest, with billions of tons of surface-mineable coal in the western states, as well as significant volumes of relatively low-cost midwestern reserves. However, the U.S. has achieved less than a 10% share of the rapidly growing steam-coal market in the APB (Fig. 1). High inland transportation costs, combined with the relatively low calorific value of some western coals, have resulted in prices exceeding world market levels in recent years. Because of these higher delivered coal prices, the U.S. remains a marginal or "swing" supplier in a market which now receives one-third of world steam-coal exports.

The purpose of this study is to identify and describe transport innovations and alternatives which may reduce the delivered cost of U.S. steam coals in APB markets. This study emphasizes alternative transportation modes from four U.S. coal-producing regions and mentions blending combinations involving a fifth region:

- subbituminous coals of the Powder River Basin in Wyoming and Montana,
- bituminous coals of central Utah and Colorado,
- bituminous and subbituminous coals of the Four Corners Region (southeastern Utah, southwestern Colorado, northwestern New Mexico, and northeastern Arizona),
- bituminous and subbituminous coals of Alaska, and
- bituminous coals of the Illinois Basin (Illinois, Indiana, and western Kentucky).

The western coals generally move by rail to ports in California and the Pacific Northwest, while Illinois Basin coals generally move by barge to Gulf Coast ports.

The Free World APB steam coal market consists of the large rapidly growing markets (majors) of Japan, Hong Kong, South Korea, and Taiwan and the smaller, developing markets (minors) of the Philippines, Indonesia, and, possibly, Malaysia and Thailand. Steam coal import demand for the APB majors has increased from 48.4 Mt (metric tons or tonnes) in 1985 [equivalent to 53.4 MT (tons or short tons)] to an estimated 63.0 Mt

*This report includes a presentation of work supported by the U.S. Department of Energy, Assistant Secretary for Fossil Energy, under Prime Contract No. W-31-109-Eng-38 with Argonne National Laboratory.

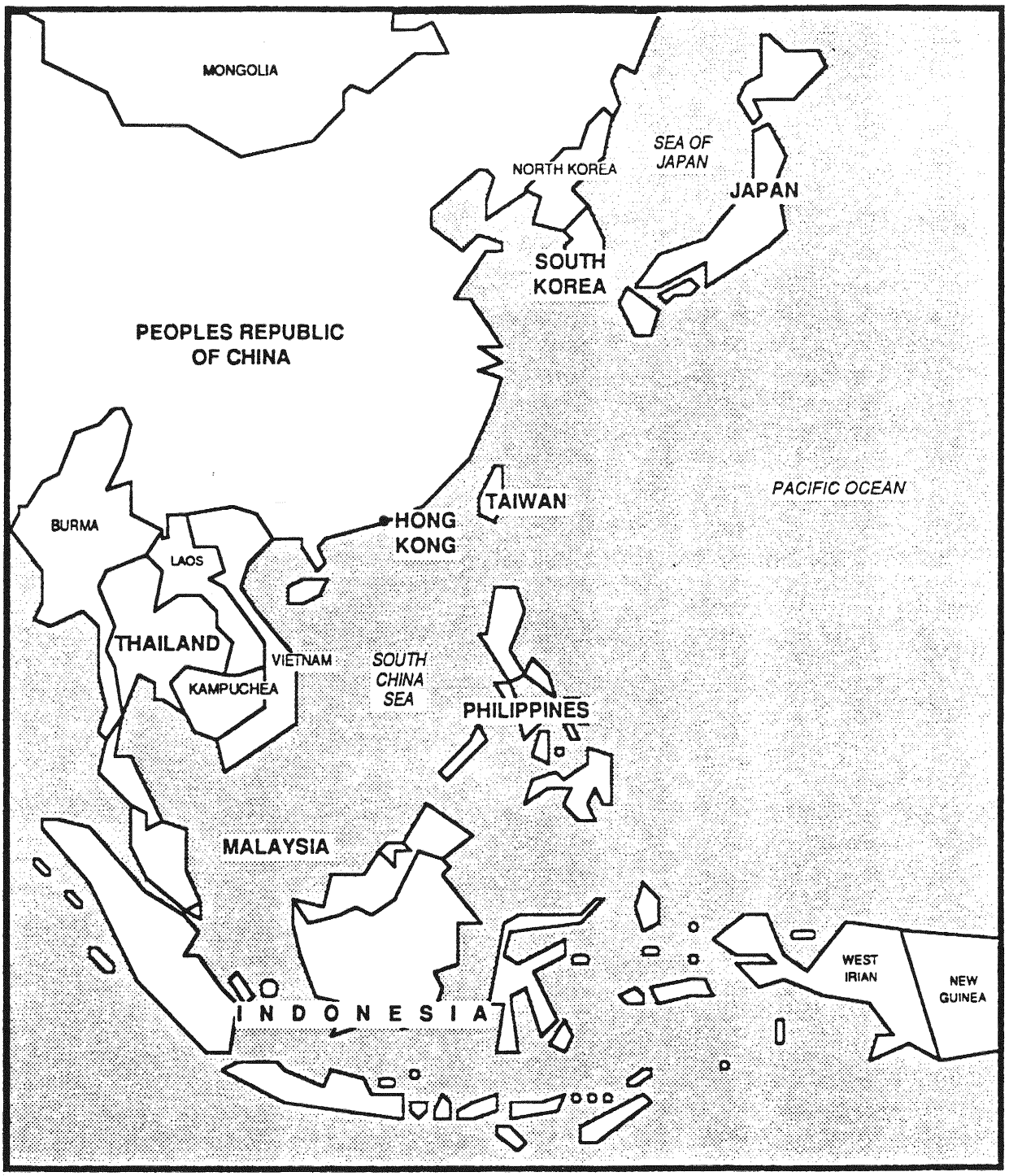


Figure 1 Asian Pacific Basin

[69.4 MT] in 1989; steam coal imports for the majors are expected to exceed 82 Mt [90 MT] by the year 2000, for an average annual growth rate of 3.6% over the 15-year period. The minors imported only 800 kt [880 kT] in 1985, increasing to an expected 2.2 Mt [2.4 MT] in 1989, and, possibly, 4.5 Mt [5.0 MT] by the year 2000, for an average annual growth rate of 12.2%.

Australia currently supplies more than 52% of the APB steam coal imports. Market studies suggest that current Australian coal supplies are delivered to the APB @ $1.80 to $2.05/MBtu. This delivered price is the target that U.S. coal exporters must meet to be competitive in today's APB steam coal market, equivalent to delivered prices of $43.90 to $50.00/T @ 12,200 Btu/lb, $39.60 to $45.10/T @ 11,000 Btu/lb, or $28.80 to $32.80/T @ 8,000 Btu/lb. This target is ambitious, but thought to be attainable when innovative transport approaches are applied. In fact, a single current actual U.S. delivered price reported for Utah coal is $1.88/MBtu, well within this target range. (Table 1 notes recent delivered prices for APB coal supplies.)

This study examines a range of transportation options available to U.S. coal exporters. Alternatives investigated include innovative approaches to rail and ocean transportation, coal-slurry pipeline transportation, and coal-blending possibilities, as well as unconventional transport modes such as long overland conveyors and intermodal moves in containers. The study includes a comparison of possible delivered prices for the coals of interest, based on a variety of transportation-combination scenarios.

TABLE 1 Delivered Price of Selected Asian Pacific Basin Utility Coal Supplies

	U.S. $/MBtu	
	1987-1988	1988-1989
Australia	1.55-1.73	1.82-2.05
South Africa	1.50-1.55	1.66-1.88
Canada	1.48-1.79	1.86
China	1.09-1.43	1.44-1.61
Indonesia		1.59
U.S.S.R. -- Chernogorsky		1.75
U.S. -- Cyprus	1.92	
U.S. -- Utah		1.88

2 INLAND TRANSPORTATION ALTERNATIVES (ex Slurries)

Rail is generally the most costly component of the transportation chain from U.S. western coal mines to the APB. It is also the element of the transportation chain that generally receives the most criticism in terms of pricing practices. Nevertheless, rail carriers have and will continue to make major strides in improving productivity and reducing costs. To the extent that the market requires it, these productivity improvements and cost reductions may result in lower coal-export rates. Among the possibilities for reducing U.S. rail-transportation costs, innovations can be grouped into regulatory aspects, technological innovations, and changes in railroad-marketing approaches.

Regarding regulatory aspects, the Staggers Rail Act (1980) removed many regulatory constraints and provided productivity gains for many rail carriers. The emergence of regional railroads has served to significantly lower operating costs by reducing labor requirements, as evidenced by the Montana Rail Link.

Technological innovations in rail transportation include the use of lighter, corrosion-resistant aluminum rail cars; aerodynamic cars that reduce fuel consumption when empty; and covered cars that prevent loss of fines, mitigate freezing, and reduce return-trip air drag. Use of coal-fired locomotives to replace diesel engines has also been suggested, although diesel fuel currently enjoys a low price. A new generation of 4000-hp microprocessor-controlled locomotives is being placed in service, which will tend to lower capital and maintenance costs, as well as fuel costs.

Because railroad freight represents a substantial part of the delivered price of export coal, and because export-rail movements are viewed as quite profitable, much attention has been focused upon the role which the rail carriers can play in boosting U.S. coal exports through marketing innovations. The idea of U.S. carriers participating actively in the export market in more ways than just hauling coal, has been practiced to various degrees by some of the carriers for many years. The Norfolk Southern Railroad in the East and the Burlington Northern Railroad in the West, for example, have been very aggressive in marketing coals for export.

Steam coal exports to the APB from the western U.S. have traditionally originated in Utah and, occasionally, Colorado, and have been shipped overseas from the bulk-cargo terminals of Los Angeles and Long Beach. During the period of elevated international coal prices in the late 1970s and early 1980s, some coal from New Mexico was also shipped from these ports and from Stockton. Over the past two years, the Burlington Northern Railroad has shipped coal from the Powder River Basin to terminals in the Vancouver (British Columbia) area.

Where available, barge movement in general is currently the most economical long-distance inland method of transporting export coal. While this study focuses on western coal movements, other coals are exported from marine terminals on the lower Mississippi River. These coals reach barge docks on the Ohio/Mississippi Waterway by truck, rail, and conveyor.

Movement of coal by long overland-belt conveyors represents an alternative to transporting coal by truck and, in some instances, rail. Conveyors are attractive for carrying tonnages of over 2 MT/yr over distances between 1 and 15 miles and are used to greatest advantage in areas of rough or mountainous terrain, which would necessitate a much longer road or rail route. Large tonnages are required to justify conveyor route construction because of the high capital costs of such projects. Like slurry pipelines, they can only serve predetermined origins and destinations, making them less flexible than rail or truck alternatives. At the Diamond Chuitna Mines in Alaska, a 12-mile overland-conveyor system to connect the coal sites to shiploading facilities in Cook Inlet is being planned. Maxus Energy, the developer, plans to use truck-haul roads to port until production reaches about 5.5 MT/yr, at which point the trucks would be replaced by a conveyor system.

3 COAL-SLURRY PIPELINES

Slurry pipelines are economical in carrying large planned volumes of coal over long distances in which the comparatively low cost of pipeline transport helps offset the cost of preparing the coal slurry. For any investment in the construction of a slurry pipeline and associated facilities to occur, long-term commitments from coal importers would need to be obtained. This reduced flexibility is a trade off for long-term cost stability.

Several forms of coal transportation by pipeline are possible. Conventional coal-water slurries (CWSs) are 50/50 mixtures of ground coal and water; the coal is dewatered at the pipeline terminus. There is only one long-distance coal-slurry pipeline now in operation, the 273-mile Black Mesa Pipeline in Arizona. Coal-water fuels (CWFs) have coal loadings of 60-75% and can be shipped as stable slurries for direct firing into boilers. Other coal-carrier possibilities include methanol, liquid petroleum gas (LPG), oil, and liquid carbon dioxide.

Water availability in the western U.S. may be of concern, but solvable on a project-by-project basis. Water-recycle pipelines could help alleviate water-use concerns associated with western coal-slurry projects, without adding significantly to the delivered price of the coal. CWFs and reuse of water captured in a hot-water drying process are other possibilities for water conservation. A major issue which requires resolution is the need for federal eminent domain legislation allowing slurry pipelines the same rights as railroads, which have traditionally opposed pipeline projects.

The most interesting possibilities for slurry pipelines appear to be in the Powder River Basin, Utah, and the Four Corners areas, where steam coal delivered via CWSs might be delivered @ $2.00/MBtu and CWFs might be delivered @ less than $2.90/MBtu (relative to a currently delivered fuel-oil price of $2.90 to $3.25/MBtu).

4 COAL PORTS

Operational U.S. West Coast coal-export terminals are located in Long Beach, Los Angeles, and Stockton, California and Seward, Alaska. Greatly expanded coal-handling capability is expected to be available in Los Angeles by 1992, when a new facility located on Terminal Island is expected to be brought on stream. Currently, only Los Angeles and

Long Beach can accommodate up to Capesize-bulk carriers (120 kDWT). A 51-foot draft restriction is the limiting factor. The new terminal in Los Angeles is expected to have 65 feet of water along side and will be able to handle ultra large bulk carriers (ULBCs @ 250 kDWT).

Stockton is draft-restricted to 35 feet, limiting the port to small or light-loaded Panamax-class (65 kDWT) vessels. New coal-exporting capacity on the West Coast beyond that already planned could be developed at Puget Sound, which offers deep water and closer proximity to the Powder River Basin in Wyoming.

Seward, Alaska actually has deeper water presently than Los Angeles or Long Beach. At 58 feet, Seward can theoretically accommodate very large bulk carriers (VLBCs @ 175 kDWT). However, insufficient tug-boat capacity limits present tonnage to Panamax-size vessels. This size penalty is somewhat offset by Seward's geographic advantages, being relatively closer to both its coal shippers and northern APB markets than other West Coast ports.

In addition, two other export terminals could be utilized for coal exports to the APB. New Orleans can load ULBC-class vessels with offshore topping off, and Puget Sound, although it currently has no coal-export terminals, could conceivably load ULBC vessels.

Asian ports have undergone dramatic improvements in the past decade. Each of the majors (Japan, Hong Kong, Taiwan, and South Korea) can accommodate vessels of at least Capesize class. Japan alone has over a dozen Capesize-capable ports, several of which can accommodate ULBCs, serving as iron-ore and coal-import centers for smaller regional ports.

Port fees for handling coal, including stevedoring, range between $4.00 and $5.00 per ton at U.S. West Coast ports. Asian port fees are found to be similar to those in the U.S. Port time in excess of actual cargo-stevedoring time was found to be comparable between the U.S. and Asian ports for coal ships.

5 OCEAN TRANSPORT

Dry-bulk shipping of coal occurs in the form of either fine or lump coals. Lump coal is typically transported to the terminal by railroad-hopper cars, while fine coals would usually arrive via slurry pipeline and then be dewatered prior to ocean transport. While both may utilize similar ship technology, additional safety features may be required for fines during handling.

Over the longer term, bulk ocean-freight rates are projected to increase from current levels, reflecting decreased worldwide shipbuilding capacity, less speculative new construction, and increasing vessel-operating costs. Using a proprietary computer model, TransTech Marine's Bulk Ocean Shipping - Computer Optimized Economics (BOSCOE), the minimum cost of moving coal out of the West Coast in various standard classes of bulk carriers has been computed. Calculated minimum transport costs are compared with historical data on trans-Pacific freight rates. A good correlation is exhibited between the model results and actual fixtures.

A breakthrough in lowering trans-Pacific costs of moving coal may be achievable with the jumbo barge-carrier (JBC) system. Incorporating a multi-purpose design, the JBC can readily supplement bulk cargos with other higher paying freight, without incurring penalties normally associated with diverse operations. A combination bulk coal/ container service, for example, could conceivably reduce the delivery cost of coal to the APB by about $3/T [on average]. Further investigation of the JBC potential to expand U.S. coal exports appears warranted by initial findings.

Transport of coal in slurry form or as CWF is investigated as a possible economical extension of shore-based pipelines. Coal-water fuel and slurries normally contain between 25 and 40% water. Hence, a larger vessel is needed to transport an equivalent tonnage of coal in this form. Additionally, tanker designs are technically more complex than standard dry-bulk carriers. Nevertheless, the BOSCOE model indicates that CWF sea-transport systems are competitive with conventional dry-bulk systems, but only at high (10 MT+) throughputs. The advantage of CWF carriers increases at even higher throughput volumes. Steam propulsion is found to be preferable for these designs because of availability of and ability to use more economical coal as ship's fuel in steam boilers. Coal would be bunkered at the loading port. Further investigation in this new area of ship design also appears warranted.

6 CONTAINERIZATION

Containers offer the possibility of integrating the inland- and ocean-transportation routes, thus reducing handling requirements, and, thereby, streamlining coal delivery to foreign markets. Containers also offer cargo protection, such that coal carried by this mode would not be subject to the generation of fines and oxidation that occur when coal is transported conventionally. For these reasons, coal-in-container services for short-sea hauls have achieved limited acceptance in the U.K., where coal shippers have found the substantial investment required to be justified by the higher quality of the delivered product.

However, in the U.S., the costs of containerizing coal are prohibitive. Container lines and lessors are reluctant to commit equipment to low-value bulk commodities such as coal. Freight forwarders have estimated the cost of shipping coal via container at over $162 per ton for a route from Chicago through Long Beach to Japan or $204 per ton from Salt Lake City via Long Beach to Taiwan. Concessionary stevedoring rates for bulk-load containers could make this shipping option more attractive in special circumstances.

7 COAL EXPORT BLENDING AND BENEFICIATION

Much of the U.S. coal available for export to APB steam-coal consumers is subbituminous in rank and, therefore, low in calorific content. Other things being equal, the higher the energy content per unit, the greater the value to the consumer. Thus, subbituminous coal faces an inherent disadvantage in that markets are distant from production centers. The two simplest methods of improving the long-distance marketability of low calorific coal are blending and drying. For the subbituminous coals of Alaska, the Powder River Basin, and the Four Corners Region, both techniques offer the possibility of more exportable products.

The Burlington Northern Railroad has recently exported a blend of high-grade Canadian Elk River Valley coal with less expensive, low-sulfur Powder River Basin subbituminous coal. The resulting blend compares favorably in delivered price and quality with competing Australian and South African coals on a dollar-per-million-Btu basis. Investigation of the economics of blending 11,500 - 12,000 Btu/lb Utah coals with Powder River Basin coals at the terminal in Los Angeles reveal that the high cost of moving Powder River Basin coal to Los Angeles would prevent the formation of a competitively priced blend. The Burlington Northern has also considered blending Powder River Basin coals with central Appalachian coals that are higher in calorific and sulfur contents. While the current market for a medium-sulfur Illinois Basin/Powder River Basin blend is limited by its cost, more stringent environmental regulations in the future may improve the market opportunities for such a blend.

8 CONCLUSIONS

The objective of this report is to identify innovative coal-export transport approaches and activities that could increase the marketability of U.S. western and midwestern steam coals in the APB. Selected scenarios are highlighted in Tables 2-5. The following represents the highlights of our findings:

For the **Powder River Basin**, appropriate estimated costs of coal production and innovative transport are highlighted (Table 2), resulting in an expected, calculated delivered-cost range of $30.35 to $34.75/T, equivalent to $1.78 to $2.04/MBtu. This estimate is well within our current target range. If Powder River Basin coals were moved as CWFs by pipeline to the Puget Sound and shipped via specialized tanker to the APB, the resulting delivered-cost range is estimated at $2.54 to $3.04/MBtu. This delivered cost compares very favorably with a current delivered fuel-oil price of $17 to $19/barrel, equivalent to $2.90 to $3.25/MBtu (*Platt's Oilgram*, October 16, 1989).

For the **Utah** coals, appropriate estimated costs of coal production and innovative transport (Table 3) result in an expected, calculated delivered-cost range of $44.80 to $48.75/T, excluding the Panamax shipments, equivalent to $1.84 to $2.20/MBtu. Again, these costs meet our target range. If Utah coals were moved by slurry pipeline, dewatered at Los Angeles/Long Beach, and shipped to the APB, the resulting delivered-cost range is estimated at $2.05-$2.13/MBtu, just missing our target. However, if Utah coal is delivered as a CWF through Stockton or Los Angeles/Long Beach, the delivered-cost range is estimated at $2.62 to $2.82/MBtu. These delivered CWF costs also compare very favorably relative to fuel oil.

For **Four Corners** coals, no rail scenarios are highlighted because of the greater inland distances from minemouth to port and the circuitous rail routes currently in place that would need to be employed (Table 4). If these coals were moved by slurry pipeline, dewatered at Los Angeles/Long Beach, and shipped to the APB, the resulting delivered-cost range is estimated at $1.90-$1.99/MBtu, meeting our target. If delivered as a CWF through Stockton or Los Angeles/Long Beach, the delivered-cost range is estimated at $2.41 to $2.73/MBtu. Again, these delivered CWF costs also compare very favorably relative to fuel oil.

For Alaskan coals, appropriate estimated costs of coal production and innovative transport (Table 5) result in an expected, calculated delivered-cost range of $35.07 to $38.50/T, equivalent to $2.12 to $2.41/MBtu. None meets our delivered-cost target currently, although Beluga is close (see Table 5, footnote k). But inland-transportation costs are expected to decrease as coal production and coal exports increase, thereby reducing the upper end of the range. Alaskan coals moved as CWFs and shipped to the APB @ $4.41 to $4.48/MBtu are not expected to be competitive with fuel oil.

In all scenarios, employment of a jumbo barge carrier (JBC) system could potentially reduce existing ocean-transport costs of coal by about $3 to $4/T. Hence, the broader-based marketing approach of the JBC concept and the technologically advanced CWF-tanker systems offer comparable transportation economic improvements that are achieved quite differently.

Thus, appropriate coals from the Powder River Basin, Utah, and, possibly, Alaska delivered to the APB appear to be able to compete with internationally traded coals TODAY! And CWFs also appear attractive, even though they represent a heavy capital investment. Therefore, what do we, as a country, need to do to get our U.S. coal exporters a larger share of the APB steam coal market?

TABLE 2 Highlighted Coal-Transportation Scenarios -- Powder River Basin Coal to the Asian Pacific Basin

Inland Mode	Port of Exit	Marine Transport Mode	Minemouth Cost[a] ($/Ton)	Inland Transport to Port ($/Ton)	Port Cost[b] ($/Ton)	Marine Cost[c] ($/Ton)	Estimated Delivered Cost ($/Ton)	($/MBtu)
Rail	Vancouver	Panamax[d]	4.00	15.00	3.50	7.85	30.35	1.78
	LA/LB	Capesize[d]		18.00	4.80	7.95	34.75	2.04
	LA/LB	ULBC[d]		18.00	4.72	6.05	32.77	1.93
	LA/LB	JBC[e]		18.00	5.80[g]	3.00	30.80	1.81
CWF Pipeline 10 MT/Yr	Puget Sound	Steam Tanker 220 kDWT	4.00	57.10[f]	1.37	8.80	71.27	3.04[h]
20 MT/yr	Puget Sound	Steam Tanker 280 kDWT	4.00	49.10[f]	0.88	8.03	62.01	2.65[h]
30 MT/yr	Puget Sound	Steam Tanker 290 kDWT	4.00	46.87[f]	0.72	7.84	59.43	2.54[h]

[a] 8,500 Btu/lb run of mine (ROM); 11,700 Btu/lb moisture free (MF)
[b] Includes stevedoring
[c] Marine costs optimized using new-vessel costs; older vessels with paid-down mortgages can yield lower short-term freight rates
[d] Diesel powered
[e] Jumbo barge carrier, proposed combination bulk liner service
[f] Includes CWF preparation
[g] Includes towing
[h] Relative to a current delivered oil price of $17-$19/barrel (*Platt's Oilgram*, October 16, 1989), equivalent to $2.90-$3.25/MBtu

TABLE 4 Highlighted Coal-Transportation Scenarios -- Four Corners Coal to the Asian Pacific Basin

Inland Mode[a]	Port of Exit	Marine Transport Mode	Minemouth Cost[b] ($/Ton)	Inland Transport to Port ($/Ton)	Port Cost[c] ($/Ton)	Marine Cost[d] ($/Ton)	Estimated Delivered Cost ($/Ton)	($/MBtu)
CWS Pipeline	LA/LB	Capesize[e]	15.90	15.85	4.80	7.95	44.50	1.99
10 MT/yr		ULBC[e]		15.85	4.72	6.05	42.52	1.90
CWF Pipeline	Stockton	Steam Tanker	15.90	36.65[f]	1.36	14.97	68.88	2.73[g]
10 MT/yr		130 kDWT						
	LA/LB	Steam Tanker	15.90	34.57[f]	1.37	10.80	62.64	2.48[g]
		180 kDWT						
20 MT/yr	LA/LB	Steam Tanker	15.90	34.57[f]	0.88	9.84	61.19	2.43[g]
30 MT/yr	LA/LB	Steam Tanker	15.90	34.57[f]	0.72	9.60	60.79	2.41[g]

[a] No rail scenario(s) - Four Corners coal is not expected to be moved by rail

[b] 11,200 Btu/lb ROM; 12,600 Btu/lb MF

[c] Includes stevedoring

[d] Marine costs optimized using new-vessel costs; older vessels with paid-down mortgages can yield lower short-term freight rates

[e] Diesel powered

[f] Includes CWF preparation

[g] Relative to a current delivered oil price of $17-$19/barrel (*Platt's Oilgram*, October 16, 1989), equivalent to $2.90-$3.25/MBtu

TABLE 3 Highlighted Coal-Transportation Scenarios -- Utah Coal to the Asian Pacific Basin

Inland Mode	Port of Exit	Marine Transport Mode	Minemouth Cost[a] ($/Ton)	Inland Transport to Port ($/Ton)	Port Cost[b] ($/Ton)	Marine Cost[c] ($/Ton)	Estimated Delivered Cost ($/Ton)	($/MBtu)
Rail	LA/LB	Panamax[d]	21.00	15.00	4.84	10.79	51.63	2.12
	LA/LB	Capesize[d]			4.80	7.95	48.75	2.00
	LA/LB	ULBC[d]			4.72	6.05	46.77	1.92
	LA/LB	JBC[e]			5.80[h]	3.00	44.80	1.84
	Stockton	Panamax[d]	21.00	15.00	5.03	12.76	53.79	2.20
	Stockton	JBC[e]			7.03[h]	2.75	45.78	1.88
CWS Pipeline	LA/LB	Capesize[d]	21.00	18.34	4.80	7.95	52.09	2.13
10 MT/yr		ULBC[d]		18.34	4.72	6.05	50.11	2.05
CWF Pipeline	Stockton	Steam Tanker[f]	21.00	36.55[g]	1.36	14.97	73.88	2.82[i]
10 MT/yr		130 kDWT						
	LA/LB	Steam Tanker	21.00	37.35[g]	1.37	10.80	70.52	2.69[i]
		180 kDWT						
20 MT/yr	LA/LB	Steam Tanker	21.00	37.35[g]	0.88	9.84	69.07	2.64[i]
30 MT/yr	LA/LB	Steam Tanker	21.00	37.35[g]	0.72	9.60	68.67	2.62[i]

[a] North central Utah coal, 12,200 Btu/lb ROM; 13,100 Btu/lb MF
[b] Includes stevedoring
[c] Marine costs optimized using new-vessel costs; older vessels with paid-down mortgages can yield lower short-term freight rates
[d] Diesel powered
[e] Jumbo barge carrier, proposed combination bulk liner service
[f] CWF steam tanker may exceed length restriction at Stockton
[g] Includes CWF preparation
[h] Includes towing
[i] Relative to a current delivered oil price of $17-$19/barrel (*Platt's Oilgram*, October 16, 1989), equivalent to $2.90-$3.25/MBtu

TABLE 5 Highlighted Coal-Transportation Scenarios -- Alaskan Coal to the Asian Pacific Basin

Inland Mode	Port of Exit	Marine Transport Mode	Minemouth Cost ($/Ton)	Inland Transport to Port ($/Ton)	Port Cost[a] ($/Ton)	Marine Cost[b] ($/Ton)	Estimated Delivered Cost ($/Ton)	Estimated Delivered Cost ($/MBtu)
Rail	Cook Inlet	Panamax[d]	16.60[f]	5.25	4.00	9.35[k]	35.20	2.12
	Seward	Panamax[d]	16.00[g]	9.00[h]	4.15	9.35	38.50	2.41
	Seward	Capesize[d]		9.00[h]	4.15	6.61	35.76	2.24
	Seward	VLBC[d]		9.00[h]	4.15	5.92	35.07	2.19
	Seward	JBC[e]		9.00[h]	[j]			
CWF Pipeline	Cook Inlet/	Steam Tanker	16.00[g]	69.96[i]	1.37	7.73	95.06	4.48[l]
10 MT/yr	Seward[c]	260 kDWT						
20 MT/yr		Steam Tanker	16.00[g]	69.96[i]	0.88	6.98	93.82	4.42[l]
30 MT/yr		Steam Tanker	16.00[g]	69.96[i]	0.72	6.87	93.55	4.41[l]

[a] Includes stevedoring
[b] Marine costs optimized using new-vessel costs; older vessels with paid-down mortgages can yield lower short-term freight rates
[c] Inland transportation costs provided are Nenana to Cook Inlet, while port and marine costs are Seward to APB. Because of the proximity of Seward and Cook Inlet, transportation cost estimates are combined for an approximate Alaska-to-APB route
[d] Diesel powered
[e] Jumbo barge carrier, proposed combination bulk liner service
[f] 8300 Btu/lb ROM; 10,900 Btu/lb MF (Beluga)
[g] 8000 Btu/lb ROM; 10,600 Btu/lb MF (Nenana)
[h] As production increases at Alaskan coal mines, inland transportation costs can be expected to decrease as a result of the higher volumes carried
[i] Includes CWF preparation
[j] Includes towing
[k] A spot quote of $7.35 would result in a delivered cost of $2.00/MBtu
[l] Relative to a delivered oil price of $17-$19/barrel (*Platt's Oilgram*, October 16, 1989), equivalent to $2.90-$3.25/MBtu

ASIA-PACIFIC COAL TECHNOLOGY CONFERENCE
FINAL LIST OF PARTICIPANTS

Ernesto M. **ABOITIZ**
President
National Power Corporation
P.O. Box 10183
Corner Quezon Ave & Agham Road
Diliman, Quezon City
Philippines
Tel: (63-2) 921-2998
Fax: (63-2) 922-4339
Telex: 40120

Thomas **ALBRACHT**
Market Analyst
BHP-Utah Minerals International
550 California Street
San Francisco, California 94104
Tel: (415) 774-2357
Telex: 6712202 BHP UTAH
Fax: (415) 774-2213 or (415) 398-0154

Ian K. **ANDERSON**
Manager, Marketing & Sales
Babcock & Wilcox
581 Coronation Blvd.
P.O. Box 310
Cambridge, Ontario N1R 5V3
Canada
Tel: (519) 621-2130
Fax: (519) 621-2142
Telex: 069-59360

Aloysius **ANDOYO**
Director, Electric Power Planning
& Development
Directorate General of Electric Power
and New Energy
Ministry of Mines and Energy
Jalan H.R. Rasuma Said
Blok X2, Kaveling 07
Jakarta Selatan 12950, Indonesia
Tel: (62-21) 516034, 516073
Fax: (62-21) 516044
Telex: 62319 energi ia

Howard **AU**
Fuel Supply Engineer
China Light and Power Company, Ltd.
147 Argyle Street
Kowloon, Hong Kong
Tel: (852-3) 760-6160
Fax: (852-3) 760-1884
Telex: 51555 FUSUP HX

Robert A. **BEBOUT**
Energy International, Inc.
135 William Pitt Way
Pittsburgh, Pennsylvania 15238
Tel: (412) 826-5355
Fax: (412) 826-5378

Gregory K. **BRAND**
Manager, Coal Strategic Planning
Shell Mining Co.
200 N. Dairy Ashford
Houston, Texas 77379
Tel: (713) 870-2835
Fax: (713) 870-3273

Lesley **BREY**
Manager, Planning & Analysis
PRI International, Inc.
P.O. Box 3379
Honolulu, Hawaii 96842
Tel: (808) 547-3164
Fax: (808) 547-3606
Telex: (ITT) 7430292

Henry **BROLICK**
Vice President
Williams Technologies, Inc.
320 South Boston, Suite 831
Tulsa, Oklahoma 74137
Tel: (918) 582-5811
Fax: (918) 584-0474

O. B. **BUCKLEN**
Vice President, Mining and Development
A.T. Massey Coal Company, Inc.
4 N. Fourth Street
P.O. Box 26765
Richmond, Virginia 23261
Tel: (804) 788-1800
Fax: (804) 788-1870
Telex: 2405036 (892)

Si-Min **CHANG**
President
Taiwan Power Company
242, Roosevelt Road, Section 3
Taipei, Taiwan 10763
Tel: 396-8001
Fax: (886-2) 396-8593
Telex: 11520 TAIPOWER
Cable: TAIPOWER

Anthony A. **CHURCHILL**
Director, Industry and Energy Department
The World Bank
1818 H Street, N.W.
Washington, D.C. 20433
Tel: (202) 473-3241
Fax: (202) 477-0547

Peter **COVER**
Program Manager
Coal and Technology Exports
Office of Planning & Environment
DOE Office of Fossil Energy (FE-4)
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
Tel: (202) 586-7297
Fax: (202) 586-5146

Eugene R. **CRIPPA**
President
Color Cable Inc.
9033 Clear View Drive
Anderson, California 96007
Tel: (916) 365-9232 or 365-1135
Fax: (916) 365-9232 (6 rings)

George D. **CURTIS**
Consultant
Methacoal Corp.
Bornham, Texas
Tel: (808) 941-9015
Telex: 1650 370-3216

Wencelsao R. **DE LA PAZ**
Executive Director/Under Secretary
Office of Energy Affairs
Office of the President of the Republic
P.O. Box 1031, MCC
Merrit Road, Fort Bonifacio
Makati, Metro Manila, Phillipines
Tel: 851-021 to 851-031
Telex: 22666 EDC PH
Fax: (632) 817-8603

John J. **DONOHUE**
Director, Coal Marketing
Southern Pacific Transportation Co.
P.O. Box 5482
Denver, Colorado 80217
Tel: (303) 595-2320
Fax: (303) 595-2694

Carolyn C. **DRAKE**
Washington Representative
Southern States Energy Board
444 No. Capital Street, N.W., Suite 240
Washington, D.C. 20001
Tel: (202) 624-5391
Fax: (202) 624-7797
Telex: 259 0040 MCI

Alan M. **DUNN**
Deputy Assistant Secretary
for Basic Industries
International Trade Association
U.S. Department of Commerce
14th & Constitution Ave., N.W.
Washington, D.C. 20230
Tel: (202) 377-0614
Fax: (202) 377-8836

Bronek **DUTKIEWICZ**
President
Intratech Inc.
6711 Melrose Drive
McLean, Virginia 22101
Tel: (703) 679-3282
Fax: (703) 448-8332

Richard J. **ELSTON**
Assistant Vice President-Coal
1515 Arapahoe St., Suite 1105
Denver, Colorado 80202
Tel: (303) 595-2321
Fax: (303) 595-2694

Samuel H. **ESLEECK**
Manager, Washington Liaison
Babcock & Wilcox
1850 K Street, N.W., Suite 950
Washington, D.C. 20006
Tel: (202) 296-0390
Fax: (202) 296-2868

Ernest P. **ESZTERGAR**
President/Technical Director
SGI International
3366 N. Torrey Pines Ct, #220
La Jolla, California 92037
Tel: (619) 452-0841
Fax: (619) 452-9953

Miriam B. **FERNANDEZ**
Administrative Assistant
AES Transpower
1000 Bishop Street, Suite 810
Honolulu, Hawaii 96813
Tel: (808) 538-6346
Fax: (808) 538-3147

John P. **FITZPATRICK**
Washington Representative
Pyropower Corporation
4000 Cathedral Avenue, #532 B
Washington, D.C. 20016
Tel: (202) 337-0255, 337-0256
Telex: 4971251 JAFITZ

Don **GASPER**
Consultant
Resource Dynamics Corporation
103 White Gate Road
Pittsburgh, Pennsylvania 15238
Tel: (412) 828-8684
Fax: (412) 826-1101

Daniel **GERKIN**
Senior Vice President
Public and Constituent Relations
External Affairs
National Coal Association
1130 17th Street, N.W.
Washington, D.C. 20036
Tel: (202) 463-2659
Fax: (202) 463-6152

James R. **GEURTS**
President
General Electric Environmental Services, Inc.
200 N. Seventh Street
Lebanon, Pennsylvania 17603
Tel: (717) 274-7201
Fax: (717) 274-7045

Christy L. **GRAYSON**
Assistant to the President
Mississippi Valley Coal Exporters Council
1013 World Trade Center
New Orleans, Louisiana 70130
Tel: (504) 566-1001
Fax: (504) 588-1441

Morgan A. **GREENWOOD**
President
Williams Technologies, Inc.
320 South Boston, Suite 831
Tulsa, Oklahoma 74103
Tel: (918) 582-5811
Fax: (918) 574-0474

Thad **GRUNDY, Jr.**
Deputy Assistant Secretary
for International Affairs
U.S. Department of Energy
Office of International Affairs
Forrestal Building, 1E-10
1000 Independence Avenue, S.W.
Washington, D.C.
Tel: (202) 586-5918

Loyd J. **GUIDRY**
Manager of Training
Utility Fuels, Inc.
P.O. Box 539
Houston, Texas 77001
Tel: (713) 888-4702
Fax: (713) 888-4539

Herbert (Bert) H. **HAUKE**
General Manager-Coal Sales
ARCO Coal Australia Inc.
15-23 Adelaide Street
Brisbane, Queensland, 4000 Australia
Tel: (61-7) 299-9500
Fax: (61-7) 229-1741
Telex: 42420

James **HELLER**
President
The Fieldston Company, Inc.
1920 N Street, N.W., Suite 210
Washington, D.C. 20036
Tel: (202) 775-0240
Fax: (202) 467-0768

E. Chipman **HIGGINS**
Program Analyst
Hawaii Natural Energy Institute
University of Hawaii at Manoa
2540 Dole Street
Honolulu, Hawaii 96822
Tel: (808) 536-0711
Fax: (808) 537-4517
Telex: 6502782483 MCI

Eugene Thomas **HOLMES**
Attorney and Consultant
4630 IBM Tower
1201 W. Peachtree Street
Atlanta, Georgia 30309
Tel: (404) 881-8545
Fax: (404) 881-0319

John C. **HSU**
Oak Steamship Co. Ltd.
1002, Great Eagle Centre
23 Harbour Road
Hong Kong
Tel: (852-5) 893-3485
Fax: (852-5) 834-5172

Steve G. **HSU**
Chairman and Manging Director
Oak Steamship Co., Ltd.
23 Harbour Road
Hong Kong
Tel: (852-5) 893-3485
Fax: (852-5) 834-5172
and
Chairman
Sincere Navigation Corporation
P.O. Box 1608
14th floor, Yue-Tai Building
368 Fu Hsing S. Road, Section 1
Taipei, Taiwan
Tel: (886-2) 703-7055
Fax: (886-2) 700-3374
Cable: NAVIGATON TAIPEI
Telex: 11250 NAVIGATION
11955 OKTWN

Kun **JEONG**
General Manager
Electricity Economics Department
Korea Electric Power Corporation
107 Samseong-dong, Kangnam-ku
Seoul 135-791, Korea
Tel: (82-2) 550-3704
Fax: (82-2) 550-6679
Telex: 24287 kelecco

Robert **KANE**
Environmental Protection Specialist
Office of Planning & Environment
DOE Office of Fossil Energy (FE-4)
U.S. Department of Energy
Washington, D.C. 20585

James **KERBER**
Director - Tech Services
Hawaiian Electric Company
P.O. Box 2750
Honolulu, Hawaii 96840
Tel: (808) 543-4747
Fax: (808) 543-4649

Robert Lee **KESSLER**
Executive Director and General Consul
Western Coal Transportation Association
P.O. Box 176
Denver, Colorado 80201
Tel: (303) 694-6611
Fax: (303) 220-1891
Telex: 255545 MAC UR

Jeanne **KESSLER**
Western Coal Transportation
Association Conference Coordinator
P.O. Box 176
Denver, Colorado 80201
Tel: (303) 694-6611
Fax: (303) 220-1891
Telex: 255545 MAC UR

Se Jong **KIM**
Director General
Electric Power Bureau
Ministry of Energy and Resources
United Government Complex, Bldg. 4
Kwachon City, 427-760
Korea
Fax: (82-2) 503-9649

Yoon Hyung **KIM**
Advisor on International Affairs
Korea Electric Power Corporation
107 Samseong-dong, Kangnam-ku
Seoul 135-791, Korea
Tel: (82-2) 556-6647
Telex: 24287 KELECCO

Bernd **KNOLL**
Director
Bernd Knoll Ltd.
83 Headland Drive
Discovery Bay
Lantau Island, Hong Kong
Fax: (852-5) 987-8397

Paul **KOENDERMAN**
Vice President and General Manager
Babcock & Wilcox International
581 Coronation Blvd.
Cambridge, Ontario
NIR 5V3, Canada
Tel: (519) 621-2130
Fax: (519) 622-2409
Telex: 069-59341

Hon C. **LEE**
Director - Sales & Service
AMAX Coal Sales Co.
160 Spear Street, Suite 260
San Francisco, California 94105
Tel: (415) 543-7877
Fax: (415) 543-9986
Telex: 156233421 ACSSFO

Roger W.A. **LEGASSIE**
Vice President for Energy and Environment
Technology and Management Services, Inc.
20201 Century Blvd.
Germantown, Maryland 20874
Tel: (301) 353-0535
Fax: (301) 353-0514

Alan S. **LLOYD**
Executive Staff Engineer
Hawaiian Electric Company, Inc.
P.O. Box 2750
Honolulu, Hawaii 96840-0001
Tel: (808) 543-7000
Fax: (808) 536-5619

Rolf **MANFRED**
Manager, TRW/CBU Project
TRW Combustion Business Unit
One Space Park, Bldg. 146C
Redondo Beach, California 90278
Tel: (213) 535-8358
Fax: (213) 535-4150

Kuntoro **MANGKUSUBROTO**
President
PT. Tambang Batubara Bukit Asam
Setiabudi Building II, Lantai 2
Jalan H.R. Rasuna Said, Kuningan
Jakarta Selatan, 12940 Indonesia
Tel: (62-21) 514446
Fax: (62-21) 514014
Telex: 27376 taba ia

Richard K. **McQUAIN**
Vice President
Engineering
Hawaiian Electric Company, Inc.
P.O. Box 2750
Honolulu, Hawaii 96840-0001
Tel: (808) 543-5660
Fax: (808) 543-7519

Garrett L. **MORRISON**
Director
Passamaquoddy Technology
P.O. Box 350
Thomaston, Maine 04851
Tel: (207) 594-5555
Fax: (207) 594-8339

Vimla **MULCHAND**
Institute for International Research
Golden Wall Centre
89 Short Street, Suite 0803
Singapore 0718
Tel: (65) 338-3521
Fax: (65) 336-4017
Telex: 34834 IIR RS

Jay **MULKI**
Manager, Marketing
Hawaiian Electric Company, Inc.
P.O. Box 2750
Honolulu, Hawaii 96840-0001
Tel: (808) 543-4770
Fax: (808) 543-4649

Naswar **NAZARUDDIN**
Division Head, Program and Development
Planning Bureau
Ministry of Mines and Energy
Jl. Merdeka Selatan 18
Jakarta 10110, Indonesia
Tel: (62-21) 380-4242 ext 250
Fax: (62-21) 347-461
Telex: 44363 DEPTAM IA
Cable: DEPERTAMBEN

Donald **NELSON**
Special Assistant to the Assistant Secretary
Office of Fossil Energy
U.S. Department of Energy
1000 Independence Avenue, S.W.
Room 4B 084
Washington, D.C.
Tel: (202) 586-6660

Kenneth J. **NEMETH**
Executive Director
Southern States Energy Board
3091 Governors Lakes Drive, Suite 400
Norcross, Georgia 30071
Tel: (404) 242-7712
Fax: (404) 242-0421

Bhasker **PATEL**
Co-Chairman
Center for Energy & Environmental
Research Services for Asia & Africa
c/o EERC
Box 8213, University Station
Grand Forks, North Dakota 58201
Tel: (701) 777-5169
Fax: (701) 777-5181
Telex: 332537 A/B UNDERC

John **PHILIPP**
President
Power Tech Associates
P.O. Box 42
Oradell, New Jersey 07649
Tel: (201) 265-1327
Fax: (201) 265-3908

Manfred G. **RASCHKE**
President
International Strategic Information Service
207 High Street
Newburgport, Massachusettes 01950
Tel: (508) 462-2733
Fax: (508) 465-4395

Mohd Ariffin bin Abdul **RAHMAN**
Deputy General Manager
Corporate Planning
National Electricity Board of the
States of Malaya
Head Office
P.O. Box 11003
50732 Kuala Lumpur, Malaysia
Tel: (60-3) 274-3979
Fax: (60-3) 274-6754
Telex: 30426 TRANG MA;
33714 ELELEN MA
Cabel: TRANG

Hossein **RAZAVI**
Senior Energy Economist
Asian Region
The World Bank
1818 H Street
Washington, D.C. 20433
Tel: (202) 477-5325
Fax: (202) 477-8451

David G.M. **REGAN**
Vice President-General Manager Marketing
ARCO Coal Australia Inc.
15-23 Adelaide Street
Brisbane, Queensland, 4000 Australia
Tel: (07) 229-9500
Telex: 42420
Fax: (07) 229-1741

Thomas J. **REGAN**
Director, Marketing, Fossil Systems
Combustion Engineering, Inc.
1000 Prospect Hill Road
Windsor, Connecticut 06095
Tel: (203) 285-5049
Fax: (203) 285-4250
Telex: 99297

Thomas A. **SARKUS**
Project Manager
U.S. Department of Energy
Pittsburgh Energy Technology Center
P.O. Box 10940, Mail Stop 920
Pittsburgh, Pennsylvania 15236
Tel: (412) 892-5981
Fax: (412) 892-4604
Telex: 812500 EVHMF PGH UD

William **SHEFFIELD**
Arctic Slope Consulting Group
P.O. Box 650
Barrow, Alaska 99723
Tel: (907) 852-4556
Fax: (907) 852-5733

Mr. Jack **SIEGEL**
Deputy Assistant Secretary for
Coal Technology (FE-20)
Office of Fossil Energy
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
Tel: (202) 586-1650

Dale R. **SIMBECK**
Vice President of Technology
SFA Pacific, Inc.
444 Castro Street, Suite 920
Mountain View, California 94041
Tel: (415) 969-8876
Fax: (415) 969-1317
Telex: 269336 SFAP UR

James N. **SOWERS**
President
INTEX International Trading Company
2401 Fountainview, Suite 910
Houston, Texas 77057
Tel: (713) 789-2170
Fax: (713) 783-6661
Telex: 62911980

Mr. Indracahya K. **SUBRATA**
Consultant
Redecon
Gedung Patra, 1st floor
Jalan Jenderal Gatot Subroto 32-34
Jakarta, Indonesia
Tel: (62-21) 510-215 or 511-821
Fax: (62-21) 515-133
Telex: 62182 RECON IA

James B. **SULLIVAN**
Director
Office of Energy
U.S. Agency for International Development
SA-18, Room 508
Washington, D.C. 20523-1810
Tel: (703) 875-4203
Fax: (703) 875-4053

Terry **SURLES**
Director
Environmental Assessment and Information
Sciences Division
Argonne National Laboratory
9700 S. Cass Avenue, Bldg. 362
Argonne, Illinois 60439
Tel: (312) 972-3759
Fax: (312) 972-5217

Charmon **SUTHIPHONGCHAI**
Deputy General Manager
Thermal Power and Mine Development
Electricity Generating Authority of Thailand
Rama 6 Bridge
Nonthaburi 11006, Thailand
Fax: 66-2-4336317

Jack **SUYDERHOUD**
Associate Professor of Decision Sciences
College of Business Administration
University of Hawaii at Manoa
2404 Maile Way, E303B
Honolulu, Hawaii 96822
Tel: (808) 948-7446

Carole B. **SZPUNAR**
Section Manager
International Coal & Environmental Studies
Argonne National Laboratory
9700 South Cass Avenue, Building 372
Argonne, Illinois 60439
Tel: (312) 972-7788
Fax: (312) 972-4259

Denise **SWINK**
Director, Office of Planning and Environment
DOE Office of Fossil Energy (FE-4)
U.S. Department of Energy
Washington, D.C. 20585

Anne **TELLIER**
International Program Manager
Energy & Technology Initiative
Los Alamos National Lab
P.O. Box 1663, MS F643
Los Alamos, New Mexico 87545
Tel: (505) 667-4960
Telex: 660-495
Fax: (505) 667-8873

Jack D. **TENNANT**
Vice President-Technology
Williams Technologies, Inc.
320 South Boston, Suite 831
Tulsa, Oklahoma 74103
Tel: (918) 582-5811
Fax: (918) 584-0479

Steve Y. **TSAI**
Director
Environmental Pathway and Remedial
Analysis Group
Argonne National Laboratory
EID/EPRA, Building 362-C305
9700 South Cass Avenue
Argonne, Illinois 60439
Tel: (312) 972-7798
Fax: (312) 972-4611

Geoffrey F. **UTTMARK**
President
TransTech Marine Company
771 Carrol Street, Floor 2
Brooklyn, NY 11215
Tel: (718) 857-5722/875-5754
Fax: (718) 622-8373 Attn: TTMC

Rodillo **VELASQUEZ**
Operations Manager
Global Minerals (Sarawak) Sdn. Bhd.
P.O. Box 559
114 Green Road
937 Kuching, Sarawak
Malaysia
Tel: 082-245125/6
Fax: 082-423316
Telex: 70036 LTCKG MA

Sue Ellen **WALBRIDGE**
Policy Analyst
Office of Planning & Environment, FE-4
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
Tel: (202) 586-7735
Fax: (202) 586-5146

William M. **WALLACE**
Senior Management Advisor to
PT Tambang Batubara Bukit Asam (Persero)
Bechtel International Inc.
Setiabudi Building 2, 2nd floor
Jl. Hr. Rasuna Said, Kuningan
Jakarta 12940, Indonesia
Tel: (62-21) 514-446 or 514-014
Fax: (62-21) 514-014
Telex: 62671 PTBA IA

Tom **WILSON**
Consultant, Comp 2000 Division
Marathon Systems
Seven Waterfront Plaza, Suite 400
500 Ala Moana Blvd.
Honolulu, Hawaii 96813
Tel: (808) 522-6150
Fax: (808) 522-6159

E. Allen **WOMACK**, Jr.
Vice President
Research and Development Division
Babcock & Wilcox
1562 Beeson Street
Alliance, OH 44601
Tel: (216) 829-7600
Fax: (216) 823-0639

Alexander **WONG**
General Manager
Global Minerals Sarawak Sdn. Bhd.
P.O. Box 559
114 Green Road
93712 Kuching, Sarawak
Malaysia
Tel: 082-25126
Fax: 082-423316
Telex: 70036 LTCKG MA
Cable: LIMTRADECO

Richard **WONG**
Managing Director
Global Minerals Sarawak Sdn. Bhd.
P.O. Box 559
114 Green Road
93712 Kuching, Sarawak
Malaysia
Tel: 082-45125/6/7
Fax: 082-423316
Telex: 70036 LTCKG MA

Richard M. **WOOD**
Area Manager
Babcock & Wilcox Canada
581 Coronation Boulevard
Cambridge, Ontario, Canada
N1R 5V3
Tel: (519) 621-7130
Fax: (519) 621-2142
Telex: 069-59360

Ignacio **WU**
Director of International Operation
Sargent & Lundy
55 E. Monroe Street
Chicago, Illinois 60603
Tel: (312) 269-6743
Fax: (312) 296-3478 or (312) 968-3873

EAST-WEST CENTER

Dr. Norton Ginsburg
Director
Environment & Policy Institute

Dr. Toufiq Siddiqi
Research Associate
Environment & Policy Institute

Mr. Michael Manson
Assistant Director
Resource Systems Institute

Dr. Allen Clark
Minerals Policy Program Leader
Resource Systems Institute

Dr. Trent Bertrand
Research Associate
Development Policy Program
Resource Systems Institute

Dr. Charles Johnson
Research Associate
Minerals Policy Program
Resource Systems Institute

Dr. James Dorian
Research Associate
Minerals Policy Program
Resource Systems Institute

Mrs. Mendl Djunaidy
Program Officer
Resource Systems Institute

Ms. Lynn Haramoto
Assistant Program Officer
Resource Systems Institute

Energy Program Members

Dr. Fereidun Fesharaki
Energy Program Leader
Resource Systems Institute
East-West Center
1777 East-West Road
Honolulu, Hawaii 96848
Tel: (808) 944-7527
Fax: (808) 944-7298
Telex: 989171 EWC UD

Dr. Lisa Totto
Conference Coordinator

Mr. Jack Kulp
Conference Coordinator

Ms. Jane Smith-Martin
Energy Program Secretary

Ms. Gayle Sueda
Energy Program Secretary

Dr. Hisashi Amagai
Mr. Nadeem Baseer
Ms. Robin Brandt
Dr. Kennon Breazeale
Mr. Tilak Doshi
Mr. David Fridley
Mr. James Hansen
Mr. David Hayes
Ms. Sharon Hoffman
Dr. David Isaak
Ms. Li Jie
Mr. Babak Kiani
Mr. Jin Miranda
Mr. Jacob Naeb
Mr. Widhyawan Prawiraatmadja
Mr. Saeed Taeb
Ms. Patricia Wilson
Mr. Wu Kang
Dr. Nancy Yamaguchi

FIGURE 2

EGAT POWER DEVELOPMENT PLAN

POWER DEVELOPMENT PLAN

SYSTEMS PLANNING DEPARTMENT

ELECTRICITY GENERATING AUTHORITY OF THAILAND

RUN DATE SETEMBER 6, 1989

PEAK AND CAPACITY (MW)

(OCT 1989) - 2ND PPB 75 MW
(NOV 1989) - MAE MOH #8 300 MW

(FEB 1990) - 2ND CSTL (270) MW

(MAY 1990) - BANG PAKONG GT(3) 100 MW
(JUN 1990) - BANG PAKONG GT(3) 100 MW
(JUL 1990) - BANG PAKONG GT(4) 100 MW
(AUG 1990) BANG PAKONG GT(4) 100 MW - MAE MOH #9 300 MW
(SEP 1990) - RAYONG CC. GT(1)2X100 MW
(OCT 1990) - RAYONG CC. GT(2)2X100 MW
(NOV 1990) - NAM PHONG CC.GT(1) 2X100

(JAN 1991) - RAYONG CC. GT(3)2X100 MW

(APR 1991) - SRINAGARIND #5 180 MW

(JUN 1991) - BANG PAKONG ST(3) 100 MW

(AUG 1991) - BANG PAKONG ST(4) 100 MW
(SEP 1991) - RAYONG CC. ST(1) 100 MW
(OCT 1991) - RAYONG CC. ST(2) 100 MW

(DEC 1991) - NAM PHONG CC.ST(1)100 MW
(JAN 1992) - RAYONG CC. ST(3) 100 MW
(FEB 1992) - MAE MOH #10 300 MW
(MAR 1992) - BB RENOVATION (2X70) MW

(MAY 1992) - BANG PAKONG TH #3 600 MW

(OCT 1992) - KRABI RETIRED 2X20 MW
(NOV 1992) - KRABI #4 75 MW

(FEB 1993) - MAE MOH #11 300 MW

(MAY 1993) - BANG PAKONG TH #4 600 MW

(AUG 1993) - NB RENOVATION (237.5) MW

(OCT 1993) - MAE MOH #12 300 MW
(NOV 1993) - PAK MUN #1-4 4X34 MW
(DEC 1993) - R2 GT RETIRED 2X15 MW

(APR 1994) - MAE MOH #13 300 MW

(OCT 1994) - MAE MOH #14 300 MW

(DEC 1994) - KAENG KRUNG #1-2 2X40 MW
(JAN 1995) - R3 GT RETIRED 6X15 MW

(APR 1995) - MAE MOH #15 300 MW

(JUN 1995) - MAE TAENG #1-2 18+8 MW

(OCT 1995) - SABA YOI #1 150 MW
(NOV 1995) - MAE MOH #16 300 MW
(DEC 1995) - SB RENOVATION (1300) MW
(JAN 1996) - BHUMIBOL #8 178 MW
(FEB 1996) - LOWER SIRIKIT #1 15 MW& SIRIKIT #4 125 MW

(APR 1996) - SABA YOI #2 150 MW

(OCT 1996) - SABA YOI #3 300 MW
(NOV 1996) - MAE MOH #17 300 MW

(APR 1997) - MAE MOH #18 300 MW

(OCT 1997) - NEW THERMAL #1 600 MW
(NOV 1997) - MAE MOH #19 300 MW

(FEB 1998) - SRT #1 RETIRED 30 MW

(JUL 1998) - LOWER MAE PING #1-2 2X20

(OCT 1998) - NEW THERMAL #2 600 MW
(NOV 1998) - SABA YOI #4 300 MW

(JAN 1999) - NAM KHEK(1) 2X25 MW&
(FEB 1999) - NAM KHEK(2) 2X35 MW

(OCT 1999) - NEW THERMAL #3 600 MW
(NOV 1999) - NAM CHERN #1-4 4X100 MW

(JAN 2000) - LKB GT RETIRED 3X15 MW

(OCT 2000) - NEW THERMAL #4 600 MW

(DEC 2000) - SB #1 RETIRED 200 MW
(JAN 2001) - NEW THERMAL #5 600 MW

TOTAL CAPACITY 18409 MW

INSTALLED CAPACITY

DEPENDABLE CAPACITY

FIRM CAPACITY

PEAK GENERATION

FIRM ENERGY

MONTHLY ENERGY GENERATION

----- PEAK GENERATION +15 %

MONTHLY ENERGY FORECAST AND FIRM ENERGY GENERATION (GWH)

0 2500 5000 7500 10000 12500 15000 17500 20000 22500 25000

YEAR MON 1988 SEP OCT NOV DEC 1989 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1990 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1991 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1992 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1993 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1994 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1995 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1996 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1997 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1998 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 1999 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 2000 JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC 2001 JAN FEB MAR APR MAY JUN JUL AUG SEP

POWER SYSTEM PLANNING DIVISION

CASE PDP88025/2

WORKING GROUP'S LOAD FORECAST-JULY 1988(BASE CASE)

POWER SYSTEM PLANNING DIVISION

RUN DATE SETEMBER 6, 1989

FIGURE 2

EGAT POWER DEVELOPMENT PLAN

POWER DEVELOPMENT PLAN

SYSTEMS PLANNING DEPARTMENT
ELECTRICITY GENERATING AUTHORITY OF THAILAND
RUN DATE SETEMBER 6, 1989

PEAK AND CAPACITY (MW)

PREVIOUS PLANTS 6894 MW

(OCT 1989) -- 2ND PPB 75 MW
(NOV 1989) -- MAE MOH #8 300 MW

(FEB 1990) -- 2ND CSTL (270) MW

(MAY 1990) -- BANG PAKONG GT(3) 100 MW
(JUN 1990) -- BANG PAKONG GT(3) 100 MW
(JUL 1990) -- BANG PAKONG GT(4) 100 MW
(AUG 1990) -- MAE MOH #9 300 MW
(SEP 1990) -- RAYONG CC. GT(1)2X100 MW
(OCT 1990) -- RAYONG CC. GT(2)2X100 MW
(NOV 1990) -- NAM PHONG CC.GT(1) 2X100 MW

(JAN 1991) -- RAYONG CC. GT(3)2X100 MW

(APR 1991) -- SRINAGARIND #5 180 MW

(JUN 1991) -- BANG PAKONG ST(3) 100 MW

(AUG 1991) -- BANG PAKONG ST(4) 100 MW
(SEP 1991) -- RAYONG CC. ST(1) 100 MW
(OCT 1991) -- RAYONG CC. ST(2) 100 MW

(DEC 1991) -- NAM PHONG CC.ST(1) 100 MW
(JAN 1992) -- RAYONG CC. ST(3) 100 MW
(FEB 1992) -- MAE MOH #10 300 MW
(MAR 1992) -- BB RENOVATION (2X70) MW

(MAY 1992) -- BANG PAKONG TH #3 600 MW

(OCT 1992) -- KRABI RETIRED 2X20 MW
(NOV 1992) -- KRABI #4 75 MW

(FEB 1993) -- MAE MOH #11 300 MW

(MAY 1993) -- BANG PAKONG TH #4 600 MW

(AUG 1993) -- NB RENOVATION (237.5) MW

(OCT 1993) -- MAE MOH #12 300 MW
(NOV 1993) -- PAK MUN #1-4 4X34 MW
(DEC 1993) -- R2 GT RETIRED 2X15 MW

(APR 1994) -- MAE MOH #13 300 MW

(OCT 1994) -- MAE MOH #14 300 MW

(DEC 1994) -- KAENG KRUNG #1-2 2X40 MW
(JAN 1995) -- R3 GT RETIRED 6X15 MW

(APR 1995) -- MAE MOH #15 300 MW

(JUN 1995) -- MAE TAENG #1-2 18+8 MW

(OCT 1995) -- SABA YOI #1 150 MW
(NOV 1995) -- MAE MOH #16 300 MW
(DEC 1995) -- SB RENOVATION (1300) MW
(JAN 1996) -- BHUMIBOL #8 178 MW
(FEB 1996) -- LOWER SIRIKIT #1 15 MW& SIRIKIT #4 125 MW

(APR 1996) -- SABA YOI #2 150 MW

(OCT 1996) -- SABA YOI #3 300 MW
(NOV 1996) -- MAE MOH #17 300 MW

(APR 1997) -- MAE MOH #18 300 MW

(OCT 1997) -- NEW THERMAL #1 600 MW
(NOV 1997) -- MAE MOH #19 300 MW

(FEB 1998) -- SRT #1 RETIRED 30 MW

(JUL 1998) -- LOWER MAE PING #1-2 2X20

(OCT 1998) -- NEW THERMAL #2 600 MW
(NOV 1998) -- SABA YOI #4 300 MW

(JAN 1999) -- NAM KHEK(1) 2X25 MW&
(FEB 1999) -- NAM KHEK(2) 2X35 MW

(OCT 1999) -- NEW THERMAL #3 600 MW
(NOV 1999) -- NAM CHERN #1-4 4X100 MW

(JAN 2000) -- LKB GT RETIRED 3X15 MW

(OCT 2000) -- NEW THERMAL #4 600 MW

(DEC 2000) -- SB #1 RETIRED 200 MW
(JAN 2001) -- NEW THERMAL #5 600 MW

TOTAL CAPACITY 18409 MW

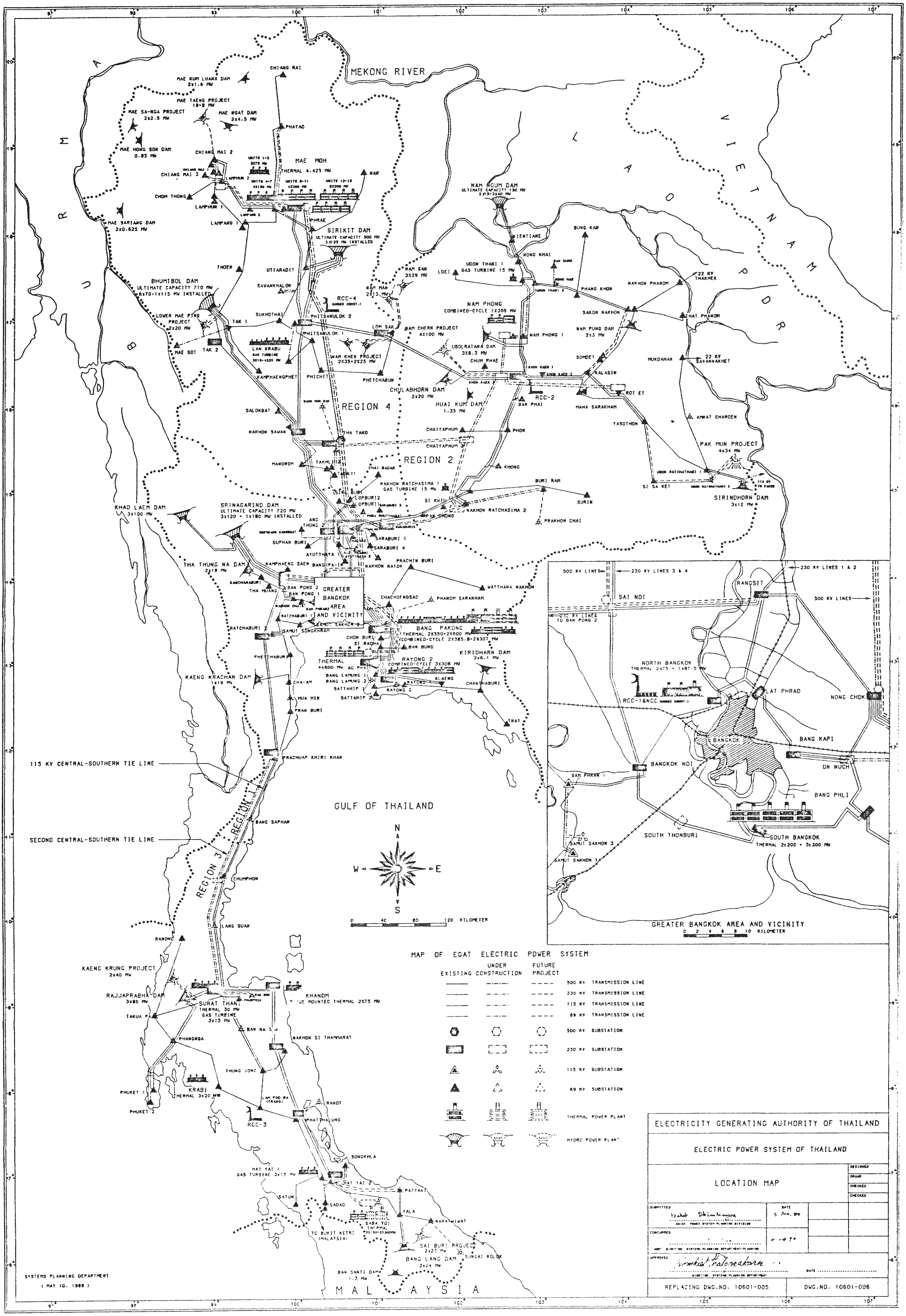
INSTALLED CAPACITY
DEPENDABLE CAPACITY
FIRM CAPACITY
PEAK GENERATION
FIRM ENERGY
MONTHLY ENERGY GENERATION
----- PEAK GENERATION +15 %

MONTHLY ENERGY FORECAST AND FIRM ENERGY GENERATION (GWH)

YEAR MON

POWER SYSTEM PLANNING DIVISION
CASE PDP88025/2
WORKING GROUP'S LOAD FORECAST-JULY 1988 (BASE CASE)

POWER SYSTEM PLANNING DIVISION
RUN DATE SETEMBER 6, 1989


MEKONG RIVER
MYANMAR
LAO PEOPLE'S DEMOCRATIC REPUBLIC
VIETNAM
CHIANG RAI
MAE KUM LUANG DAM 2x1.6 MW
MAE TAENG PROJECT 18+8 MW
MAE SA-NGA PROJECT 2x2.5 MW
MAE NGAT DAM 2x4.5 MW
PHATAO
MAE HONG SON DAM 0.85 MW
CHIANG MAI 2
CHIANG MAI 3
MAE MOH THERMAL 4,423 MW
CHOM THONG
LAMPHUN 1
MAE SARIANG DAM 2x0.625 MW
LAMPANG 1
PHRAE
SIRIKIT DAM ULTIMATE CAPACITY 500 MW 3x125 MW INSTALLED
NAM NGUM DAM ULTIMATE CAPACITY 130 MW 2x15+3x40 MW
VIENTIANE
BUNG KAN
NONG KHAI
UDON THANI 1 GAS TURBINE 15 MW
LOEI
NAM SAN 2x29 MW
NAM MAN 2x3 MW
THOEN
UTTARADIT
BHUMIBOL DAM ULTIMATE CAPACITY 710 MW 6x70+1x115 MW INSTALLED
SAVANKHALOK
RCC-4
NAM PHONG COMBINED-CYCLE 1X355 MW
PHANG KHON
NAKHON PHANOM
22 KV THAKHEK
LOWER MAE PING PROJECT 2x20 MW
TAK 1
SUKHOTHAI
PHITSANULOK 2
LOM SAK
NAM CHERN PROJECT 4X100 MW
SAKON NAKHON
THAT PHANOM
PHITSANULOK 1
NAM PHONG 1
NAM PUNG DAM 2x3 MW
MAE SOT
TAK 2
LAN KRABU GAS TURBINE 2x19+4x25 MW
WANG KHER PROJECT 2X35+2X25 MW
UBOLRATANA DAM 3X8.3 MW
CHUM PHAE
SOMDET
MUKDAHAN
22 KV SAVANNAKHET
KAMPHAENGPHET
PHICHIT
PHETCHABUN
KALASIN
CHULABHORN DAM 2x20 MW
HUAI KUM DAM 1.35 MW
RCC-2
ROI ET
BAN PHAI
MAHA SARAKHAM
SALOKBAT
REGION 4
NAKHON SAWAN
THA TAKO
CHAIYAPHUM
PHON
YASOTHON
AMNAT CHAROEN
PAK MUN PROJECT 4x34 MW
MANOROM
TAKHLI
CHAI BADAN
REGION 2
KHONG
NAKHON RATCHASIMA 1 GAS TURBINE 15 MW
BURI RAM
SURIN
SI SA KET
SIRINDHORN DAM 3x12 MW
SING BURI
LOPBURI 2
LOPBURI 1
SI KHIU
NAKHON RATCHASIMA 2
PRAKHON CHAI
KHAO LAEM DAM 3x100 MW
SRINAGARIND DAM ULTIMATE CAPACITY 720 MW 3x120 + 1x180 MW INSTALLED
ANG THONG 2
SUPHAN BURI
SARABURI 1
SARABURI 4
AYUTTHAYA
THA THUNG NA DAM 2x19 MW
KAMPHAENG SAEN
BANGPA-IN
PRACHIN BURI
NAKHON NAYOK
KANCHANABURI
THA MUANG
BAN PONG 2
BAN PONG 1
GREATER BANGKOK AREA AND VICINITY
WATTHANA NAKHON
CHACHOENGSAO
PHANOM SARAKHAM
RATCHABURI 1
SAMUT SAKHON 2
RATCHABURI 2
SAMUT SONGKHRAM
BANG PAKONG THERMAL 2X550+2X600 MW COMBINED-CYCLE 2X385.8+2X307 MW
CHON BURI
SI RACHA
BAN BUNG
PHETCHABURI
THERMAL 4x600 MW AO PHAI
RAYONG 2 COMBINED-CYCLE 3X308 MW
KIRIDHARN DAM 2x6.1 MW
KAENG KRACHAN DAM 1x19 MW
BANG LAMUNG 1
BANG LAMUNG 2
RAYONG
KLAENG
CHANTHABURI
SATTAHIP
RAYONG 3
CHA-AM
HUA HIN
SATTAHIP 2
PRAN BURI
TRAT
500 KV LINES
230 KV LINES 3 & 4
230 KV LINES 1 & 2
SAI NOI
RANGSIT
500 KV LINES
230 KV LINES TO BAN PONG 2
NORTH BANGKOK THERMAL 2x75 + 1x87.5 MW
RCC-1&NCC
LAT PHRAO
NONG CHOK
BANGKOK
BANG KAPI
115 KV CENTRAL-SOUTHERN TIE LINE
PRACHUAP KHIRI KHAN
BANGKOK NOI
ON NUCH
SAI PHRAN 1
BANG PHLI
GULF OF THAILAND
REGION 1
BANG SAPHAN
SECOND CENTRAL-SOUTHERN TIE LINE
REGION 3
SOUTH THONBURI
SOUTH BANGKOK THERMAL 2x200 + 3x300 MW
SAMUT SAKHON 3
SAMUT SAKHON 1
CHUMPHON
LANG SUAN
RANONG
KAENG KRUNG PROJECT 2x40 MW
RAJJAPRABHA DAM 3x80 MW
SURAT THANI THERMAL 30 MW GAS TURBINE 3x15 MW
KHANOM
TAKUA PA
PHANGNGA
BAN NA SAN
NAKHON SI THAMMARAT
THUNG SONG
KRABI THERMAL 3x20 MW
PHUKET 1
PHUKET 2
RCC-3
RANOT
PHATTHALUNG
SONGKHLA
HAT YAI 1 GAS TURBINE 3x15 MW
HAT YAI 2
PATTANI
SATUN
SADAO
TALA
NARATHIWAT
SABA YOI THERMAL 2x150+3x300MW
TO BUKIT KETRI (MALAYSIA)
SAI BURI PROJECT 2x23 MW
SUNGAI KOLOK
BANG LANG DAM 3x24 MW
BAN SANTI DAM 1.3 MW
MALAYSIA
N
S
W
E
0 40 80 120 KILOMETER
GREATER BANGKOK AREA AND VICINITY
0 2 4 6 8 10 KILOMETER
MAP OF EGAT ELECTRIC POWER SYSTEM
EXISTING
UNDER CONSTRUCTION
FUTURE PROJECT
500 KV TRANSMISSION LINE
230 KV TRANSMISSION LINE
115 KV TRANSMISSION LINE
69 KV TRANSMISSION LINE
500 KV SUBSTATION
230 KV SUBSTATION
115 KV SUBSTATION
69 KV SUBSTATION
THERMAL POWER PLANT
HYDRO POWER PLANT
SYSTEMS PLANNING DEPARTMENT
(MAY 10, 1988)
ELECTRICITY GENERATING AUTHORITY OF THAILAND
ELECTRIC POWER SYSTEM OF THAILAND
LOCATION MAP
DESIGNED
DRAWN
CHECKED
CHECKED
SUBMITTED
DATE
CONCURRED
APPROVED
DATE
REPLACING DWG.NO. 10601-005
DWG.NO. 10601-006