INTERNATIONAL MARKETS FOR COAL

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1. "World Oil Price and How It Relates to Future Coal Mine Development"

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2. "Synfuels in Japan"

   by: Mr. Nobuo Nagata
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3. "German Coals; Utilisation Now and in Future"

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4. "The Outlook for Coal in Korea"

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5. "Coal Opportunities in Eastern Europe"

   by: Dr. Blazo Ljubicic
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6. "Canadian Coal Export Future"

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7. "The Future of Coal in Southeast Asia"

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by: Dr. R. (Bob) A. Durie
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by: Dr. Luigi Carvani
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10. "U.S. Coal Export Opportunities"

by: Mr. Herbert G. Lesnoy
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"WORLD OIL PRICE AND HOW IT RELATES TO FUTURE COAL MINE DEVELOPMENT"

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ABSTRACT

Canada has extensive resources of coal ranging from lignite to anthracite. 97 per cent of this coal is low in sulphur averaging less than 0.5% SO_2. Canadian coal is utilized domestically and internationally. The paper describes the Canadian coal industry and its potential with specific comments on environmental concerns both nationally and globally. A discussion on how world oil price relates to coal development is included.

INTRODUCTION

Good morning, ladies and gentlemen. It is indeed a pleasure for me to have the opportunity to visit the fine state of North Dakota once again and to speak on one of my favorite topics -- coal.

When I received a copy of the preliminary program, I noted that my presentation was to be entitled "World Oil Price and How it Relates to Coal Development". Well, that certainly is an interesting topic, but it is also a very complex one and, one that is open to all sorts of philosophical debate. It brought to mind the old saying..."Those who live by the crystal ball had better learn how to digest glass".

Acceding to the request, I have used this title, but I have also taken the liberty of expanding the topic somewhat, because I do not believe one can address the subject of coal development these days without also considering environmental concerns.

Being a Canadian and having just stepped down as President of The Coal Association of Canada, I feel compelled to talk a little bit about Canada's coal industry.

Therefore, my plan for this morning is to present a very brief overview of the Canadian coal industry, then delve into some of the global environmental issues with specific reference to the Canadian position and finally put forward some views about oil price relationships with coal and to tie this into coal and synfuels development.

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THE CANADIAN COAL INDUSTRY

If, instead of a sector of the economy, energy were a social club, then the coal industry would be its most senior member. The first producing coal mine in Canada commenced operation in the year 1720 on Cape Breton Island in what is now the eastern seaboard province of Nova Scotia. The first coal exports out of Canada were, believe it or not, to Boston, Massachusets in 1724. On a historical note, this was fifty years before the Boston Tea Party.

I don't know what happened, but Canada must have missed a marketing opportunity because today, we import some 15 million tonnes from the United States, while our return exports are only a little over 1.0 million tonnes per year.

From the industry's modest beginnings coal production in Canada rose steadily to a peak of 29 million tonnes in 1948. By then however, Alberta's oil boom was underway. With the new found abundance of petroleum the railways switched to diesel fuel. Shortly, the domestic market of coal virtually evaporated - - for a while.

With the advent of coal fired on-site electric power stations on the prairies followed by the Japanese demand for metallurgical coal and the growing seaborne coal trade, the Canadian coal industry experienced a phenomenal rise in production.

Today Canada produces over 70 million tonnes of coal annually of which 28 million is metallurgical and 42 million is thermal. We export 32 million tonnes to some twenty odd countries.

Today we have 11 companies producing 70 million tonnes of coal from 27 mines with 11,500 employees. Obviously there has been a significant change to the modus operandi of our industry. (Figire 1) Until the 1960s the bulk of Canadian coal was produced from underground mines, whereas today 94 percent of Canada's coal is recovered via surface mining operations.

We have 3 underground mines in Nova Scotia, one in Alberta and one under development in British Columbia. The balance of our production is from surface mines, most of which are located in British Columbia, Alberta, Saskatchewan and New Brunswick (Figure 2). All of these mines, whether surface or underground, are efficient, safe and employ the latest technologies.

Our coal reserves generally follow this same geographical pattern. (Figure 3 & Figure 4). More than 90 per cent of Canada's recoverable reserves of six billion tonnes are located in British Columbia and Alberta. In situ reserves of coal are estimated to be 475 billion tonnes.

Canada's production figures and reserves may appear small when compared to the U.S.S.R., China and the U.S.A., but we are significant in the world scene.

Living next to the U.S.A., we seem suffer from a 10 percent syndrome. Our population is 10 percent of the U.S.A.'s, our coal production is 10 percent of the U.S.A.'s, our reserves are 10 percent and I am sure we have Canadian mines selling in U.S. dollars who wouldn't mind our exchange rate being 10% lower than it is now. Canada's coal industry may only be 10 percent of that of the U.S.A., but we are a vibrant group and a major factor in the international markets. It reminds me of the time when I was with Fording Coal Ltd., a Division of Canadian Pacific Railway, and visiting one of your coal mines in Alabama. The company had their own incorporated railway from mine to the barge terminal some twenty miles away. The owner reminded me that my company, the CPR, may own one of the longest railways in the world, but his tracks were just as wide. Canada's coal production may be 10 percent of that in the U.S. but our product is just as good.

We in Canada have achieved success by overcoming obstacles to development such as a long distance from tidewater, cold winters and many mines operating in mountainous terrain. We have a complete range of coals in our resource base from lignite through to anthracite. To succeed in the market place, we had to learn to be responsive to change and be innovative in our thinking. I believe on the whole we have done this well, however, there exist geographic factors that make some markets more attractive than others. It is for this reason that we import much of the coal used in Ontario and we concentrate on offshore markets.

Of course, we participate in the Ontario market where we can compete. But in many instances U. S. coals are closer and have been the traditional suppliers of both met and thermal coal, satisfying the bulk of Ontario's coal requirement. Due to a more favorable tax regime for the U.S. railways, Wyoming coal can compete in Ontario with our western Canadian coals.

Even though we have a longer average rail haul to get our coal to tide water than many of our worthy competitors, through technological advancement, we have developed systems that keep us competitive. This is an on-going process and a fact that we never lose sight of. (Figire 5).

GLOBAL ENVIRONMENTAL ISSUES

Of all the issues the coal industry has had to deal with this century, I view the concern over the environment as being one of the greatest. Over the last twenty odd years the coal industry has led the way in Canada in dealing with environmental considerations to the point that mine site environmental concerns today are only a shadow compared to that of a few years back. Through diligent efforts with respect to developing environmental protection programs and mine site reclamation practices, looking after the environment has become standard operating procedure. I am personally delighted to see individual mines now vigorously competing to have the best programs with respect to environmental protection.

The challenge today has moved from the mine site to users of coal, specifically to emissions of radiative gasses. Consequently, acid rain, greenhouse gasses and global warming have become household terms in the developed world. Unfortunately for us in the business, coal is fingered as the major culprit.

Again, I am not saying that global warming is not a threat. We know that CO_2 is building up in the atmosphere...but when you stop to consider that CO_2 is an extremely abundant gas and we do not know at this point how our ecosystem can or will handle such a build-up.. and when you realize the costs involved in radical change, you must, I repeat, MUST, make the crucial decisions in an extremely careful fashion. To get caught up in an international competition to see who can be the most "environmentally friendly" nation in the world will be ruinous.

One of the greatest concerns the coal industry in Canada has is that hastily developed legislation could be enacted as a result of public pressure prior to clearly understanding the cause of the problem. This will not effectively deal with the issue, but worse still, it could have serious economic implications affecting the welfare of the country.

Let me provide you with an example; a local magazine made the following comment:

"Nearly a quarter of the 385.8 million tonnes of CO_2 emitted into the atmosphere in Canada in 1988 resulted from the burning of coal, making it a significant contributor to global warming, in the opinion of some scientists".

Now, without even questioning the accuracy of the numbers, let me restate that slightly differently:

Coal burning in Canada contributes less than 0.25% of man-made gases which may contribute to global warming.

What is my point? My point is that is a tremendous amount of sensationalism put forward by the media that tends to confuse the public, this then leads to a search for quick and easy solutions to an extremely complex problem, and one of the easiest exercises in finger pointing is to say that coal emits more CO_2 per unit of energy produced than oil or gas. This, then, seems to have become the basis for assuming that reducing the burning of coal is the answer to all our problems. It isn't.

The first reason I say that relates to the problems of acid rain and particulate emission. When these problems became apparent, technology was developed to handle them, and I believe it is fair to say that these problems are now under control, notwithstanding intergovernmental problems with getting the technology put into place. The parallel situation exists with CO_2.

I believe that the coal industry can develop the technology required if it is established that the role of CO_2 in atmospheric change and potential climate change demands high level attention. Indeed, research in this direction has already begun.

The second reason that I say that reducing the burning of coal is not the answer to our worries about potential climate change is simply this: Like it or not, the world is going to be burning more coal 20 years from now than it is today. A lot more.

Let's look for a moment at its current use. Worldwide, close to 5 billion tonnes of coal are consumed each year and coal produces 31% of the world's primary energy, second only to oil as a source of energy worldwide. More specifically, coal generates 44% of the world's electricity and is used in the production of about 75% of the crude steel produced every year.

In many countries, coal is still essential for cooking and heating, and around the world over 250,000 consumer products are produced from chemicals derived from coal.

Now let's look at what kind of growth we can expect in the demand for energy. In 1987, global population was about 5.6 billion people. By 2025, the world's population is forecast to be 8.2 billion, and 90% of this growth will take place in the developing world. Every one of those additional people is going to consume energy and at the same time be striving for an improved quality of life met by an increasing use of energy. Where is this energy going to come from?

Looking at global resources of energy, there is worldwide about a 40 year supply of oil, a 60 year supply of natural gas, and at least a 220 year supply of coal. Not only is there plenty of coal, it is distributed in such a way that the developing nations have easy and low cost access to much of it.

With something as easy to mine, in such abundance, and located in regions where it will be required, combined with its economics and a relatively simple technology needed to use coal, is it any wonder that I say we are going to burn more coal 20 years from now than we do today? Can you honestly believe that the newly developing countries will use oil and gas for much more than domestic use and transportation fuel, or that they can afford - and cope with - nuclear technology? Personally I doubt it.

Therefore, not only can we not live without coal today, you can be sure we will be living with it in the future as well. What we do need to do today is to learn how to live with it.

We have seen the photos coming out of Eastern Europe of coal blackened landscapes. We're told about the high acid rain causing emission levels from old technology power plants burning high sulphur coal in the U.S. mid-west. We know in China close to a billion tonnes of coal are burned each year at efficiency levels that are lucky to reach 10%. These are certainly not the ways to live with coal.

But, there are ways to live with coal and Canada is a good example. I'm not going to say that coal is, or even can be, totally environmentally benign - no large scale energy source is. But in Canada, with coal, we are moving in the right direction to minimize coal's impacts. Let me cite some examples of where we are headed.

Firstly, we have embarked on a public awareness program targeted to those who influence public opinion, to foster a better understanding of the role coal plays in society. It is a modest program; however, it is a beginning.

Secondly, and more importantly, we are moving forward on the technical side with developments that will lead to the reduction in emission of radiative gasses.

The Coal Association in conjunction with the federal government and a number of provincial governments have embarked on the first phase of developing an IGCC demonstration plant. Now IGCC technology is not new, and there are already a number of demonstration plants in the world. But in addition to having the capability of testing Canadian coals, what is unique about our plant is that we are incorporating a pilot CO_2 recovery plant in the process. Thus in addition to removing and/or reducing SOx and NO_x, we are also going after CO_2.

The third initiative we have underway is the development of a low NOx /SOx burner by TransAlta Utilities Corporation. A 3 year project was initiated this year to demonstrate the application of a LNS burner for use in heavy oil recovery near Cold Lake, Alberta.

The principal objectives of the project are to demonstrate:

- the ability to burn coal in an existing heavy oil recovery (HOR) steam generator using the LNSB. A stand-alone, 52.7 GJ/h steam generator will be built for this purpose;

- the capability of the LNSB to control SO2 and NOx emissions at satisfactory levels while firing Alberta subbituminous coals at a commercial scale under regular operating conditions, and

- the reliability and durability of auxiliary systems operating with the burner and steam generator.

Thus far, detailed engineering has been completed to allow the LNSB to be retrofitted to a heavy oil recovery steam generator. Approval for the design has been received from the Energy Resources Conservation Board, and other permits have been received to allow construction to begin. The demonstration plant is scheduled to begin operation in early 1990.

These actions alone will not eliminate the perception that coal and global warming are synonymous, but if we in the developed world can advance these technologies, we will then be in a position to exchange this knowledge with the lesser developed economies. This is very positive action which enhances the use of coal in the longer term.

To confirm this point let me quote from the Japanese Steel Mills report of this past month wherein the Subcommittee on Coal of the Advisory Committee for Energy in forecasting Japan's coal consumption in the fiscal year 2000 stated:

"Coal is now regarded as a major source of CO_2 emission which causes global greenhouse effects. Coal consumption is thus cautiously received in many countries. Coal is however, superior to other sources of energy such as oil and natural gas, both in supply and economy. Advanced technologies related to coal in Japan will be able to support coal utilization especially by the use of clean coal etc. in the future. In order to control CO_2 emissions, coal use efficiency should be improved." unquote.

I am glad you are sitting down, because I would not want you to fall over with my next statement which is:

I believe the issues of global warming, and greenhouse effect are a blessing in disguise for the coal industry...Why? Because it is moving technology that we were developing for use early in the next century forward some ten to fifteen years. This is good.

Also, it is focusing public attention on the use of coal and this will force the industry to ensure the public has the true facts about coal and its role in society. Already, programs through the World Coal Institute and your own National Coal Association are focused to achieve this objective.

If coal is going to achieve the role it should and can play in the world economy, the public must understand what coal is all about.

WORLD OIL PRICE AND HOW IT RELATES TO FUTURE COAL DEVELOPMENT

Let me now try to address the topic of the relationship between world oil price and future coal development.

There are those who argue strongly that the price of coal is directly related to the price of oil. If oil prices go up, coal prices follow and the converse is true, should oil prices fall.

There are also those who argue equally as strongly that it is coal that impacts or tends to stabilize the price of oil.

I cannot say which position is correct or if either is incorrect. I firmly believe there does exist an interrelationship between oil and coal price, but it is not clear cut or easily defined in terms of dollars and cents. It is the market place that determines the price of each energy commodity. One must remember that oil is what I refer to as a convenience fuel. It is easy to use, easy to transport and easy to handle. Characteristics that coal in solid form does not have. So what does coal have going for it? Well, the reserves of coal in the world far outstrip all other energy sources. It is also fairly evenly distributed around the world and thus cannot be held up to ransom. Therefore it tends to be priced lower than oil.

Let us not disillusion ourselves. If oil had the reserves and global distribution that coal has, we wouldn't be producing much coal and the price of oil wouldn't even be as high as it is today. Therefore it comes down to a question of supply and demand. If you are a large energy consumer who must be able to predict fuel costs for a long time into the future, tied to the requirement of having a stable predictable fuel source and the ability to store solid fuel, you will probably go with coal if it can be delivered at a cost equal to or less than that of oil.

Should the aforementioned criteria not apply, and you are prepared to pay the price for oil to have its conveniences, you will obviously prefer oil.

With this simplistic description, I return to the question, "Does oil price dictate coal price, or vice versa?" I believe to some extent both are true because you are dealing in a competitive market.

This, then, leads us to the question, "How does oil price relate to future coal development?" Obviously the answer is that oil prices can and do have a direct impact on coal mine development because we are in competition to supply energy but in different forms.

We all know it takes "X" number of dollars to explore for, develop, produce and transport coal to any given point on the globe. When we can do this and effectively compete with the price of oil, and apply some of the previously mentioned criteria, we normally end up using coal. However, I mentioned that oil is a convenience fuel and has uses that for some time will displace coal. For example, fuel and lubricants for the auto industry. It is the preferred fuel for space heating when available. Therefore there are situations where premiums can be paid to use oil.

The area where we most frequently compete is in base load energy requirements. There it becomes a function of price, availability and reliability.

In the scenario of oil being the premium fuel, with lesser reserves that through conservation should be extended over time, then coal becomes the favoured choice for many industrial applications. Having then established the market opportunity, I believe a more important factor affecting price is the creation of an oversupply situation in coal. We then end up with two factors impacting the price of coal -- the price of oil and the price of competing sources of coal. Therefore, to maintain a viable oil and coal industry, prices for both are going to have to be such to provide a reasonable return to the investor. At the same time to maintain realistic prices for coal, development of new supply sources must be carefully examined.

There are certain fundamental criteria that must be met:

1. An adequate economic return must be achieved for the use of the resource;

2. Natural resources must be conserved with realistic development policies;

3. Environmental considerations have to be included in the use and cost/price of the resource.

With this in mind, I see a future where all our energy resources will be used.

- Oil and gas as premium, convenience fuels

- Coal and nuclear for large base load requirements

- Renewable energy where applicable, but to a lesser degree than with the above; and

- Coal synfuels in specific applications and circumstances

Synfuels is one area of development that can be related directly to the price of oil. This is because they compete directly with oil or its by-products. At current values oil from oilsands is fully commercial at about $25.00 per barrel of oil. I was advised recently that coal liquefaction would also be competitive if costs could be reduced to $25.00 to $30.00 per barrel.

With oil prices where they are at the moment then the synfuels, in pure economic terms have difficulty competing with oil. There are other factors that come into play, however, and these are site specific situations, national security and the requirement to prove technology today for use in the future.

I know you are well aware of this situation here in the U.S. Worldwide there is an adequate supply of oil in the short term but the sources are concentrated. At current consumption levels and if the trend continues, the United States, it is reported, will have to buy nearly two-thirds of its oil requirements from abroad by the end of this century.

This places increased importance on the development of synfuels in the U.S.A. and I am sure the same applies to many other countries.

The latter must be good news for this gathering. Clean coal technologies including coal/water fuels, coal gasification, IGCC, coal liquefaction, etc. will all play an increasingly important role, in meeting the future energy requirements of the world cognizant of environmental objectives.

If there is a direct relationship between the price of coal and coal snyfuels with that of oil, it will result in a cap being placed on the maximum price for oil. This cap will be determined by the lowest cost synfuel used to replace oil. Recent events confirm this.

This morning I have attempted to present a brief description of the Canadian coal industry. I have also attempted to bring some perspective to current environmental issues and finally, although having not answered any questions, have given you something to think about with respect to coal mine development and world oil prices.

I only hope in doing this that I have been able to create a base that leads into the many excellent papers that follow.

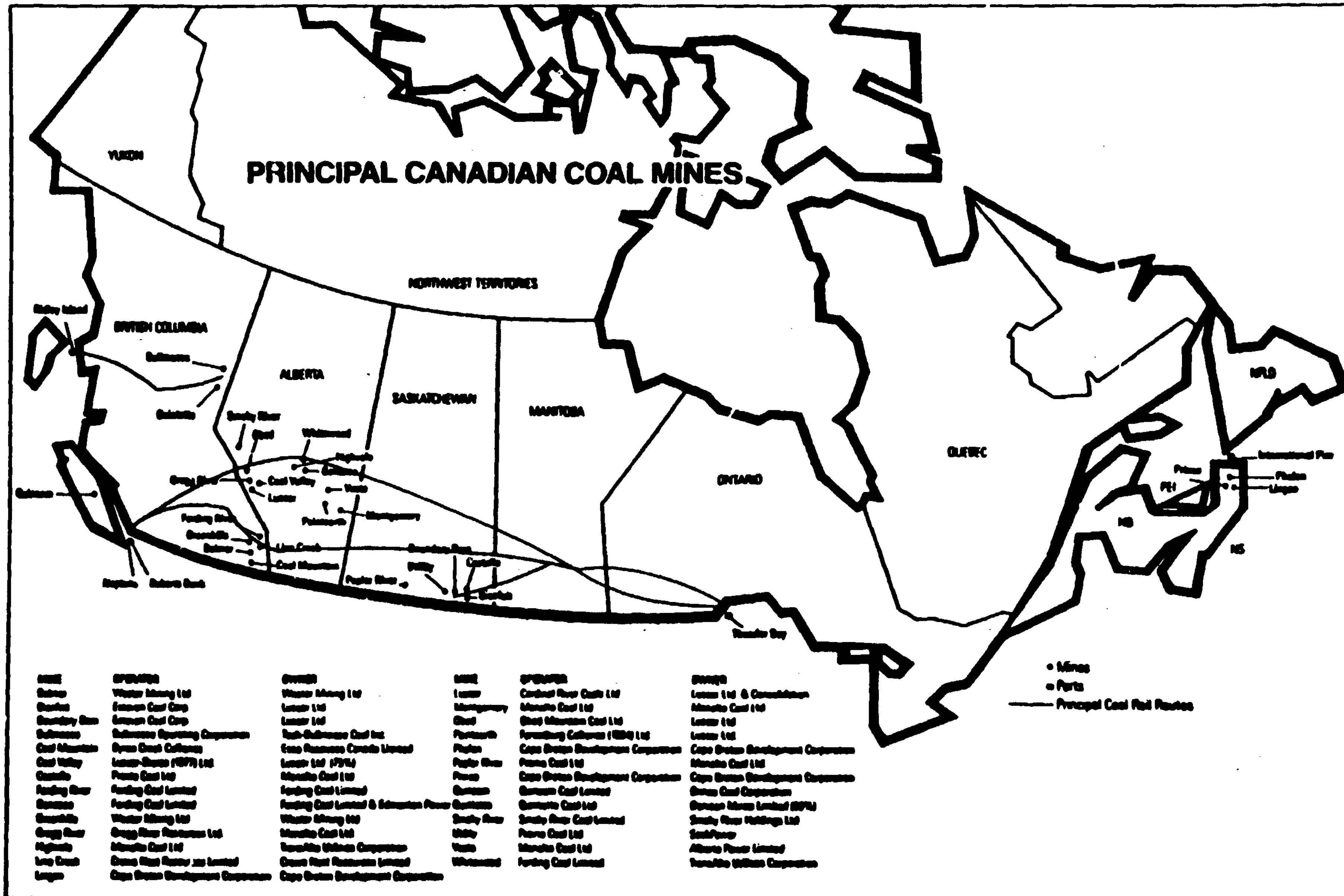
FIGURE 1

CANADIAN COAL PRODUCTION

YEAR	ANNUAL PRODUCTION	NUMBER OF EMPLOYEES	NUMBER OF MINES	NUMBER OF COMPANIES
1948	29 million tonnes	24,000	360	340
1989	70.5 million tonnes	11,500	27	11

June 1990

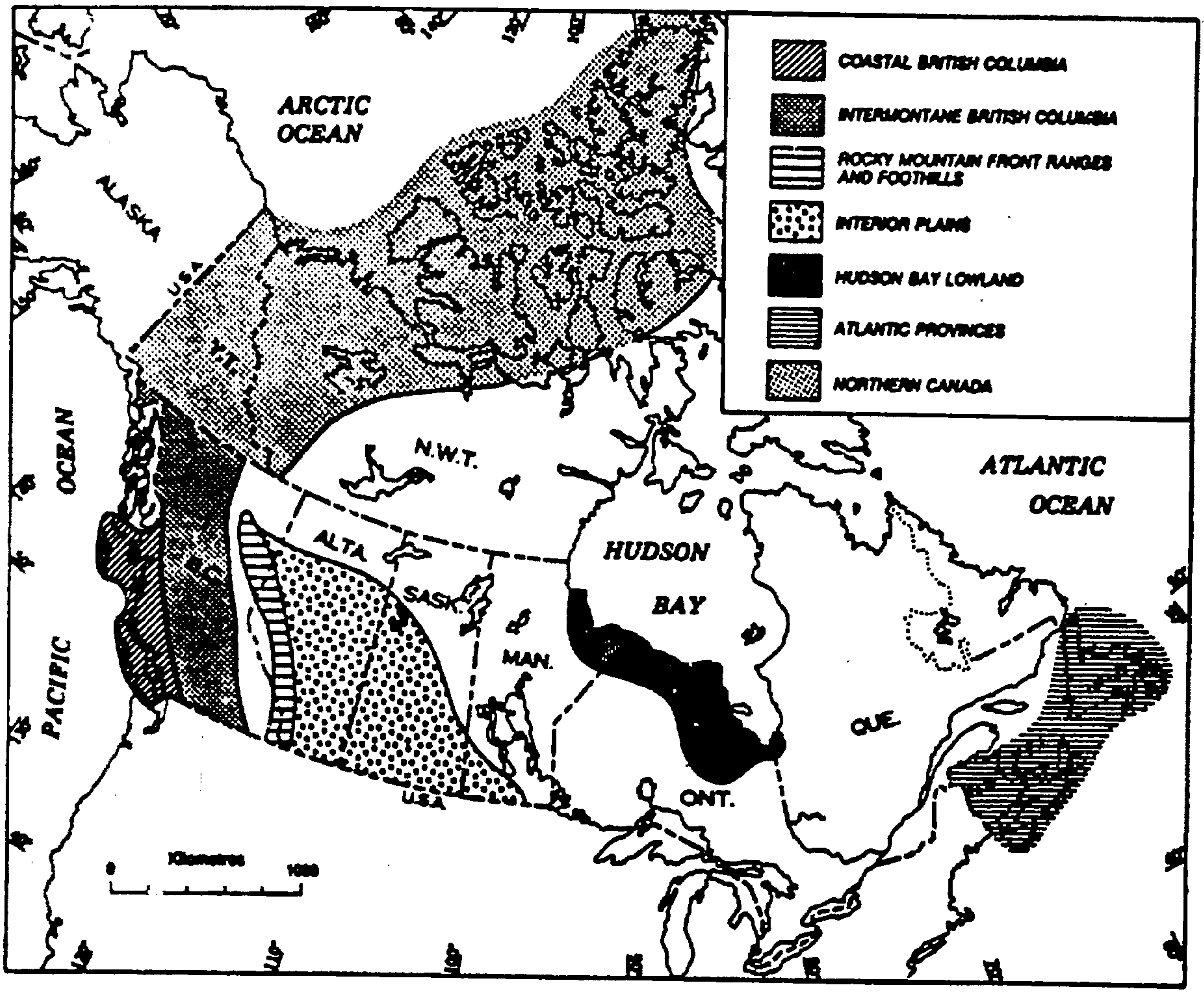
FIGURE 2



Courtesy of The Coal Association of Canada

FIGURE 3

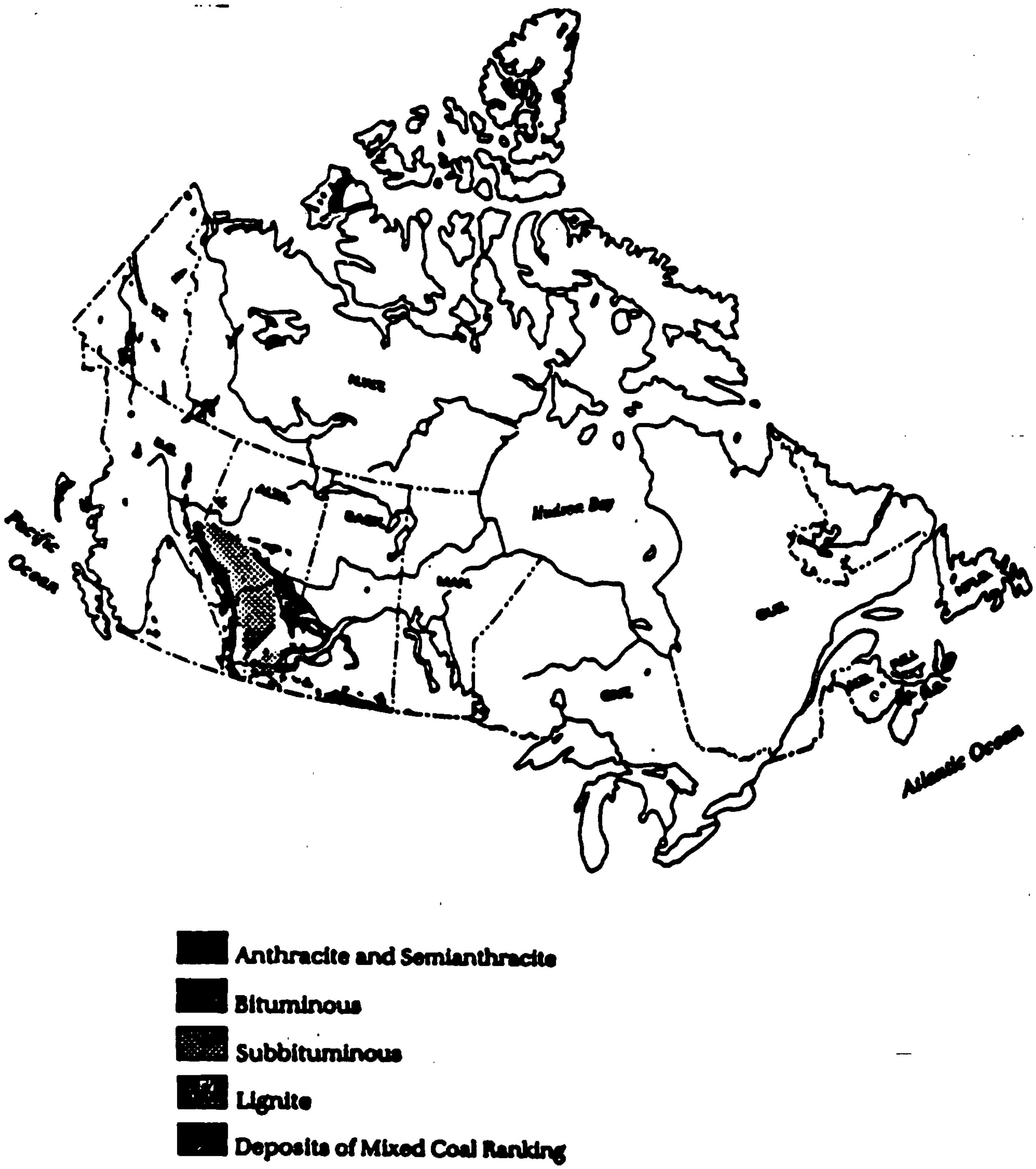
COAL REGIONS OF CANADA



Courtesy of the Geological Survey of Canada

FIGURE 4

PRINCIPAL CANADIAN COAL DEPOSITS



Courtesy of The Coal Association of Canada

FIGURE 5

AVERAGE RAIL HAUL - COAL

AUSTRALIA	200 Km.
SOUTH AFRICA	533 Km.
U.S.A.	700 Km.
CANADA	1060 Km.

"SYNFUELS IN JAPAN"

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SYNFUELS IN JAPAN

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ABSTRACT

Since the second oil shock, NEDO has been engaged in extensive R&D and demonstrations related to increasing coal utilization in an environmentally consistent manner. Support for coal gasification and liquefaction, has been an important component of this program. This includes participation in the brown coal liquefaction project in Australia, and a series of bituminous coal liquefaction and gasification projects in Japan.

Reflecting the importance of coal in the total energy mix of Japan, NEDO has also provided extensive support for a series of projects expected to make coal a more convenient fuel for a range of industrial consumers. Numerous private companies and the Japanese government have cooperated to develop CWM technology and to promote its commercialization in Japan. This paper describes these development activities, including some aspects involving international cooperation.

Despite the unfavorable effect of current world oil prices, CWM is expected to become a reliable alternative fuel. The importance of supply stability for encouraging commercial development is discussed. The need for further technical cooperation and industrial effort is noted to ensure competitiveness of CWM with both oil and pulverized coal.

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JAPAN'S ENERGY SITUATION AND ROLE OF NEDO

In 1973, at the time of the first oil shock, Japan imported 289 million kiloliters of oil, and enjoyed a high level of economic growth, based partly on the use of abundant and low cost oil, 92% (266 M kl) of which was imported from the OPEC countries. Even though oil represented 65% of Japan's total energy requirement, domestic oil production was less than 0.2% of oil imports.

In response to the oil shock, the Japanese government adopted three countermeasures in order to stabilize economic growth and national security:

1) Stabilization of oil supply by stockpiling,

2) Restriction of energy demand and conservation of energy based on rational use, and

3) Development of oil alternative energy sources and establishment of associated infrastructure.

In 1980, the Law for Oil Alternative Energy Development and Promotion of its Introduction (Oil Alternative Law) was enacted and the New Energy Development Organization (NEDO) was created. Simultaneously, the system of special accounts was increased, and tax and investment/loan programs were strengthened to ensure financing would be available. As a result of these initiatives, oil imports decreased significantly to 197 Mkl in 1985, representing approximately 68% of peak imports in 1980. The dependency on OPEC oil decreased to 65%. Since 1986, Japan's energy requirements have again increased. In FY1988, oil demand reached 276 Mkl which was 57.3% of total energy requirements.

More recently, global environmental issues, and CO_2 in particular, have caused the government to deal with the co-existence of environmental protection and economic growth.

Consequently, after considering the potential for alternative energy supply sources, including atomic, geothermal, solar and other non-fossil energy, the government has recently released a revised long-term energy demand/supply forecast as shown in TABLE 1. According to this plan, the emission of CO_2 will be restricted to not exceed the level reached in 2000 thereafter. Subsequently, the oil ratio will be reduced below 46% in 2010. Coal consumption will increase from the level of 114.6 M tonnes in 1988 to 142 M tonnes in 2000, and remain at that level. In this scenario, the coal ratio will be reduced from 18.1% of total energy in 1988 to 15.5% in 2010.

NEDO was established in October,1980, by the Oil Alternative Law as a semi-governmental organization to provide a focus for developing alternative energy sources other than nuclear energy. The president is nominated by the Minister of International Trade and Industry (MITI). The budget is entirely supported by government; management, research and support staff include both permanent employees and staff seconded from industry, national laboratories and government offices.

TABLE 1

LONG TERM ENERGY FORECAST FOR JAPAN

(May 1990)

	Units	FY1988 Actual	%	FY2000 Proj	%	FY 2010 Proj	%
Petroleum	Mkl	276	57.3	308	51.6	306	46.0
(including LPG)	M tonnes	(17.4)		(22)		(23)	
Coal	M tonnes	114.6	18.1	142	17.4	142	15.5
Natural Gas	Mkl	46.1	9.6	65	10.9	80	12.0
Nuclear	Mkw	28.9	9.0	50.5	13.2	72.5	16.7
(generation)	B kwh	(179)		(330)		(474)	
Hydraulic	Mkw	20.3	4.6	22.7	3.7	26.2	3.7
(generation)	B kwh	(92)		(91)		(105)	
Geothermal	Mkl	0.4	0.1	1.8	0.3	6.0	0.9
New Energy	Mkl	6.2	1.3	17.4	2.9	34.6	5.2
Total	Mkl	482	100	597	100	666	100
Energy Conservation Target				6.0%		11.2%	

NEDO's initial work focused on the development and introduction of new energy technologies which usually need long lead times and have higher risk. NEDO has provided the necessary leadership in several areas, including:

1) Development of oil alternative energy technologies,

2) Miscellaneous survey activities in support of these technologies, and

3) Domestic geothermal and overseas coal resource surveys with partial funding through loans and loan guarantees.

NEDO is also involved with the rationalization of the domestic coal industry, alcohol manufacturing (formerly a government monopoly) and research related to industrial technology development. Very recently, in June 1990, a new division for global environmental protection was formed at NEDO to address the technical requirements of important concerns such as the "green-house effect".

STATUS OF THE COAL INDUSTRY AND EXPECTATION FOR COAL UTILIZATION

Japan's coal production in the post WW II period reached a peak of 55.4 million tonnes in 1961. However, the coal mining industry has been losing its competitiveness and most of the traditional collieries have now been closed. Despite the growth in Japan's coal demand since 1980, the current 8th National Coal Mining Plan establishes a target for domestic coal production below 10 million tonnes by FY 1991, including 8.5 million tonnes of steam coal for use by electric power utilities.

FIGURE 1 shows the coal supply trend in Japan for the period from FY1970 through FY1986. Initially, much of the growth in Japan's coal demand resulted from the need for coking coal by the steel industry. However, since the second oil crisis in 1979, demand for steaming coal has increased significantly as the cement and electric power industries switched from petroleum. More recently, the small to medium size users in the general industrial sector have also begun to convert from oil to coal, primarily to realize the associated energy cost savings.

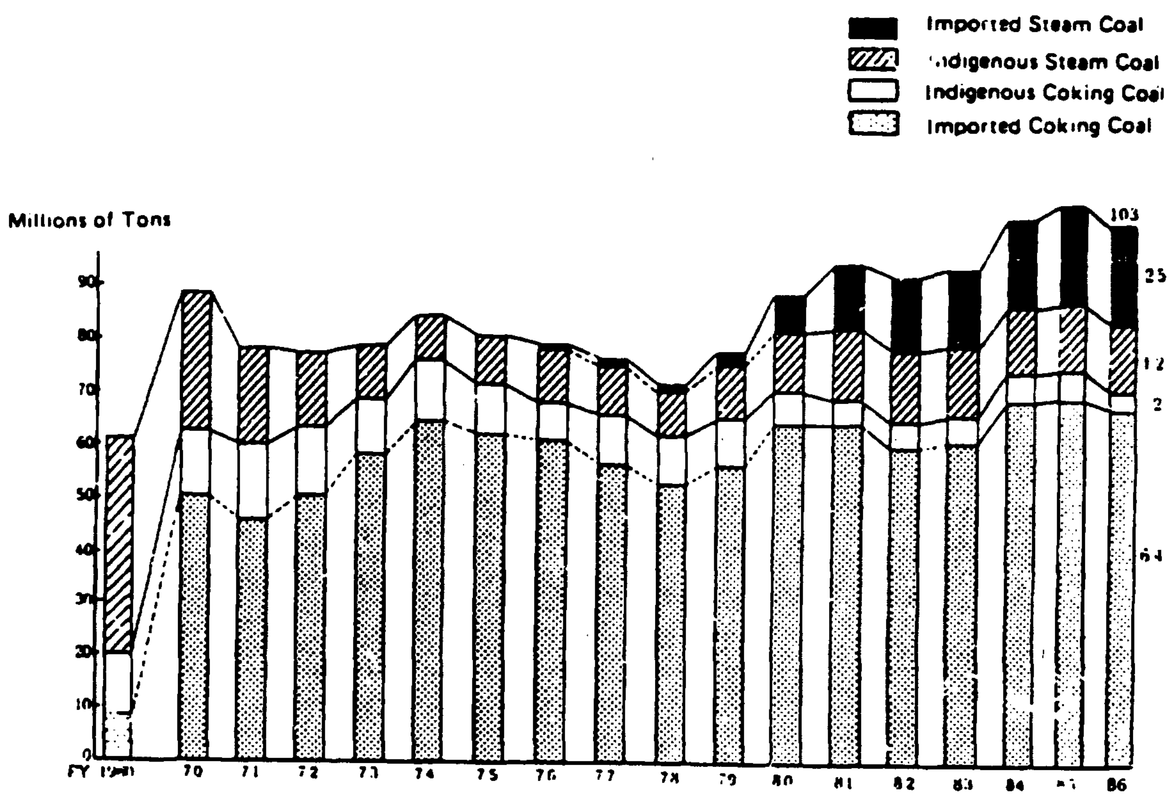


FIGURE 1 - COAL SUPPLY TREND IN JAPAN - 1970 THROUGH 1986

To further encourage this latter trend, a campaign called "Coal Renaissance" was initiated a few years ago to promote the use of coal by improving both processing and delivery of coal.

The anti-pollution rules in Japan are amongst the most severe in the world, partly as a result of Japan's high population density (320 persons/km^2) but also because of the strict environmental regulations of each independent local administration. Consequently, Japan is ranked as one of the leading countries for both the installation and utilization of desulfurization facilities to prevent air pollution.

The world's coal reserves are considered to be more than five times greater than oil reserves and are much more widely distributed. Coal is highly ranked in Japan as an oil alternative energy because of its supply stability and economic advantages in the medium to longer term. We believe that coal will be the most important and reliable energy source for Japan. Coal is necessary to support Japan's long term stabilized energy supply and will be an important component in our pursuit of the so called "best energy mix" under our national policy of energy supply diversification.

DEMAND AND SUPPLY OF COAL IN JAPAN

According to the FY1989 trade statistics issued by the Ministry of Finance, Japan's coal imports of 106.11 million tonnes were the highest ever, and were 1.85 million tonnes higher than FY1988. Japan's domestic coal production in FY1989 was reported by the Agency of Natural Resources and Energy (ANRE) as 9.63 million tonnes. The resulting total coal supply in FY1989 was 115.74 million tonnes, details of which are shown in TABLE 2.

FIGURE 2 shows the growth in imported steam coal consumption in Japan for the seven year period from FY1983 to FY1989, by industrial sector.

The distribution of steam coal markets in FY1989, classified by major customers are shown in TABLE 3. Differences in the totals from TABLE 2, are a result of stockpile changes.

TABLE 4 provides a breakdown of imported steam coal sales by industry sector for FY1989 and the changes from FY1988.

The reduced coal purchased by the cement industry may reflect tighter control of coal inventory and reduced stockpiles, particularly since clinker production increased from 68.46 million tonnes in FY1988 to 71.69 million tonnes in FY1989.

TABLE 2

JAPAN'S COAL SUPPLY - FY1989

		Volume	Ratio (%)	
Coking Coal	Imported	73.612	99.3	63.6
	Domestic	.540	0.7	0.5
	Total	74.152	100.0	64.1
Steam Coal	Imported	30.228	76.9	26.1
	Domestic	9.094	23.1	7.9
	Total	39.322	100.0	34.0
Anthracite	Imported	2.273		1.9
Grand Total		115.747		100

unit = million tonnes

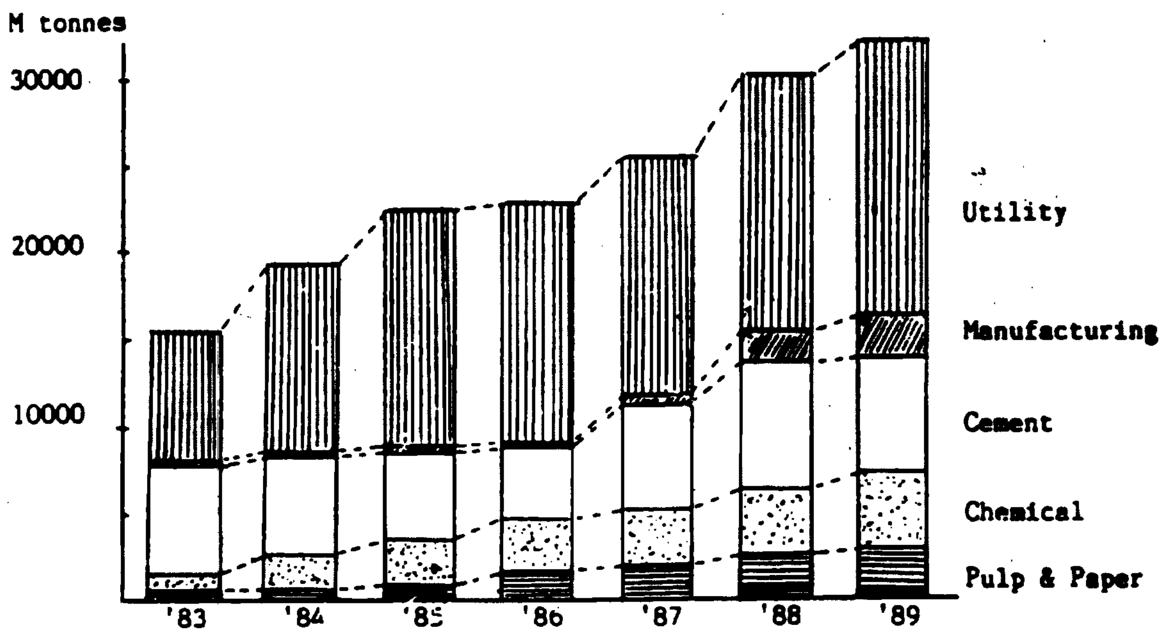


FIGURE 2 - IMPORTED STEAM COAL SALES IN JAPAN 1983 THROUGH 1989

TABLE 3

STEAM COAL MARKET IN JAPAN - FY1989

	Manufacturing	Utilities	Others	Total
Imported Coal	16.160	15.640	0.029	31.829
Domestic Coal	.459	9.452	0.802	10.714
Total	16.659	25.092	0.831	42.543
Ratio (%)	39	59	2	100

units = million tonnes

TABLE 4

UTILIZATION OF IMPORTED STEAM COAL - FY1988/FY1989

	FY 1988	FY1989	%	Changes	
Utilities	14.693	15.640	49.1	+.947	+6.4%
Cement Industry	7.328	6.546	20.6	-.782	-10.7%
Chemical Industry	3.859	4.399	13.8	+.540	+14.0%
Pulp/Paper Industry	2.448	2.811	8.8	+.363	+14.8%
Steel Mills	0.057	0.428	1.3	+.371	+650.9%
Miscellaneous Manufacturing	1.145	1.702	5.3	+.557	+48.6%
Others	0.455	0.303	0.9	-.152	-33.4%
Total	29.985	31.829	100	+1.844	+ 6.4%

units = million tonnes

The rapid growth in coal use by the steel mills suggests a major effort to reduce their heat costs by replacing oil with pulverized steam coal.

The increased requirements for coal, particularly in the miscellaneous manufacturing industry, are expected to continue and result in further demand for imported steam coal.

The use of imported steam coal is dominated by the electric power utilities. The installed capacity of the utilities coal fired power stations, most of which are shown in FIGURE 3, totalled 11 525 MW at March 31, 1990.

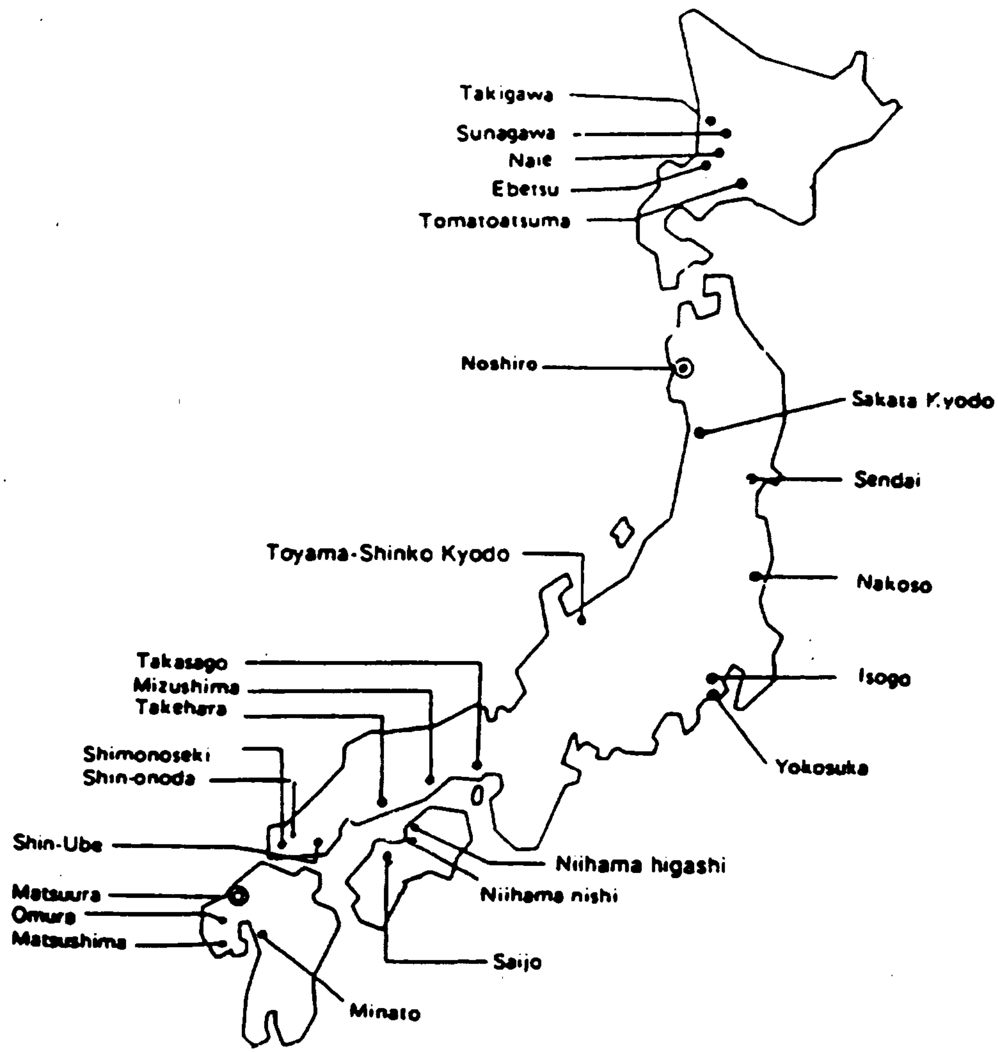


FIGURE 3 - LOCATION OF COAL FIRED POWER STATIONS - OCTOBER 1987

A recent forecast of electric power generation, summarized in TABLE 5, shows a significant increase in coal fired power generation capacity and supply during the next ten year period to FY2000. After FY2000, coal's share of power generation is expected to decrease in favour of nuclear and other new energy sources. Use of oil for power generation will decrease significantly throughout the period.

TABLE 5

FORECAST OF ELECTRIC POWER GENERATION IN JAPAN

	Capacity			Generation		
	FY1988	FY2000	FY2010	FY1988	FY2000	FY2010
Coal	6.7%	13 %	15 %	9.5%	16 %	15 %
Nuclear	17.4	22	27	26.6	35	43
LNG	20.1	22	20	21.2	20	18
Hydro	21.9	20	19	13.3	11	11
Oil	33.8	22	15	29.2	17	9
Others	0.1	1	4	0.2	1	4
	100	100	100	100	100	100
Total (MW)	164 820	227 700	267 000			
(GWH)				665.8	946.0	1109.0

The resulting FY2000 coal fired power generation capacity of 25 031 MW is an increase of 219%.

Total power demand in FY1989 was 713.5 GWH, 6.1% higher than that in FY1988 and exceeded 700 GWH for the first time in Japan. Power demand is expected to increase further in FY1990, with a corresponding increase in coal consumption of approximately 1 million tonnes to 26 million tonnes. Imported coal demand by the utilities is expected to be 17 million tonnes in FY1990, and could increase to 33 million tonnes in FY1994, and to 50 million tonnes in FY1999.

GOVERNMENT SUPPORT FOR CWM FUELS

Since 1980, the Japanese government has provided active support for a number of CWM projects related to development and promotion of commercialization of CWM fuels. Most of these projects have been carried out with various private companies. These projects are highlighted here and some are described in more detail in the following section of this paper. The sites of Japan's major CWM related projects are shown in FIGURE 4.

In FY1980, Japan's national CWM project was started at the Wakamatsu coal utilization test facility of the Electric Power Development Company, Ltd. (EPDC), with financial subsidies from MITI. This project, operated by EPDC, was a 2 tonne/day scale and included both slurry preparation techniques and associated combustion tests.

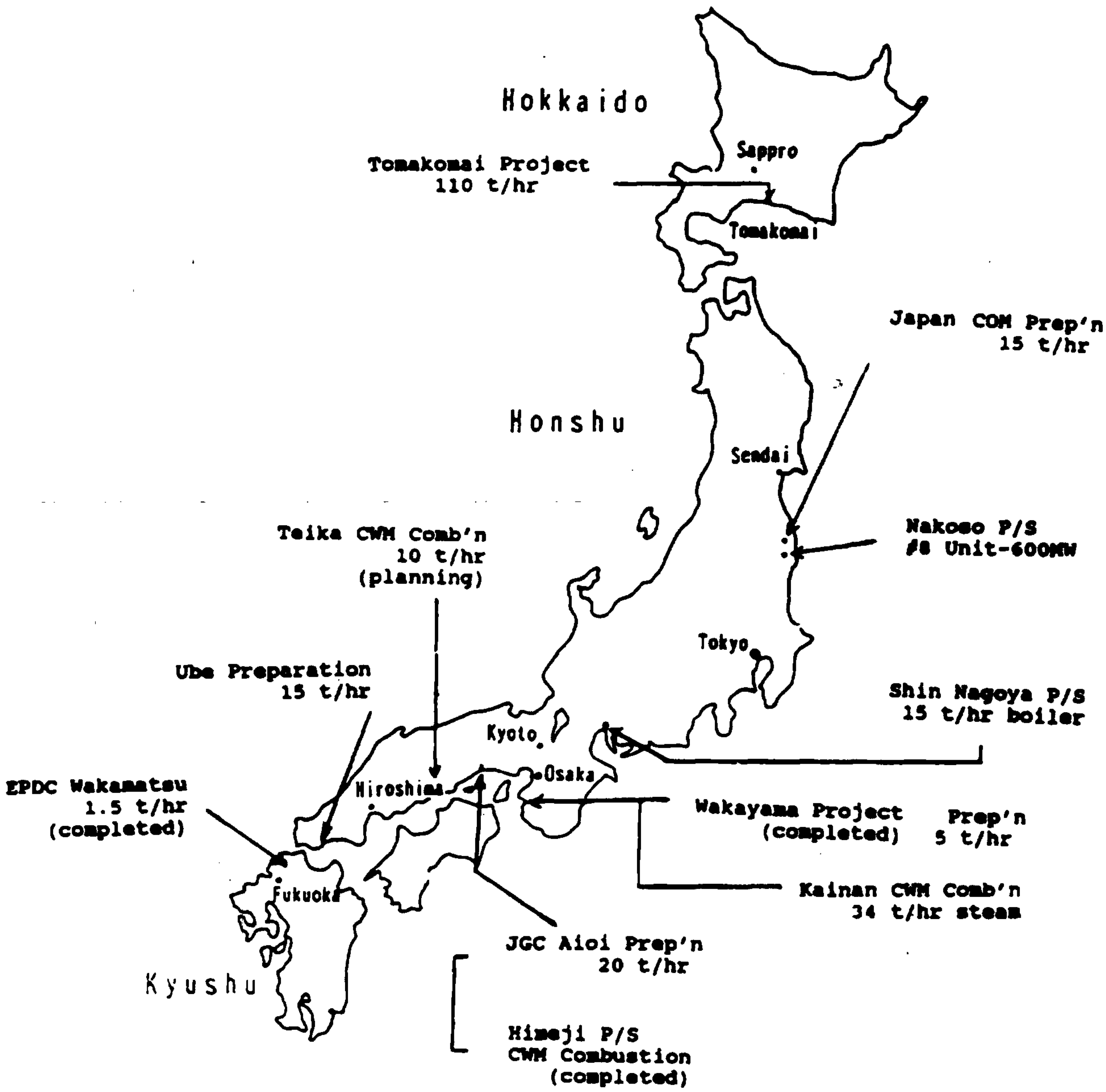


FIGURE 4 - LOCATION OF JAPAN'S MAJOR CWM PROJECTS

In March, 1981, on behalf of Japan, NEDO joined the IEA COM/CLM Implementing Agreement. Since then, NEDO has participated in the IEA activities currently covered by the CLM Annex II agreement, the purpose of which is "international cooperation to exchange information on the basic technology of Coal Liquid Mixtures (CLM) as an oil alternative fuel for business and industrial uses".

In FY1982, Japan initiated a further project at Wakamatsu, called "highly dense coal slurry for big boilers" in which a 1.5 tonne/hour pilot plant was built. Several tests were performed over a four year period beginning in FY1983, related to coal cleaning, slurry preparation, storage, ship transportation, and combustion. This project confirmed the technical feasibility of a total CWM fuel system.

A joint government/industry sponsored national CWM project was initiated in FY1985 at Wakayama, following a feasibility study. The purpose of this project was to demonstrate CWM preparation and combustion for small and medium sized boilers of general industry. Most of the funding for this project was provided by MITI with additional contributions from several companies, including Kubota, Ube, and Hitachi Shipbuilding. The Coal Mining Research Center, Japan (CMRC) managed the project on behalf of the participants.

Two other CWM projects are currently underway in Japan, with funding assistance from MITI. The first is being performed jointly between Japan COM and Idemitsu Kosan Ltd. at Tomakomai in southern Hokkaido. Ultra low ash CWM will be tested in a modified 110 tonne/hour oil burning boiler during a three month combustion trial beginning in August, 1990.

The second project is being performed by Ube Industries Ltd. to demonstrate both the combustion of CWM in a modified 95 tonne/hour oil burning boiler and the preparation of CWM in a modified pre-existing 15 tonne/hour mill. This project, with 67% of the funding provided by MITI, will run from September, 1990 through FY1992 in order to promote the commercialization of CWM.

To further promote the commercialization of CWM, the Center for Coal Utilization, Japan (CCUJ) is performing an economic feasibility study for a domestic CWM preparation and supply system based on a conceptual 250 - 500 000 tonne/year CWM preparation plant sited near Nagoya City in central Japan.

MITI's budget for the promotion of Coal Utilization Technology is shown in TABLE 6.

This budget is assigned to the Coal Industry Administration Division of ANRE, and is part of that division's total FY1990 budget of approximately 25.8 billion yen. It is noteworthy that the coal utilization budget has increased by 9.6% from FY1989, despite a 16.5% drop in the total divisional budget. The 36% increase in the CWM budget allocation is considered to reflect MITI's high expectations for this alternative fuel.

TABLE 6

BUDGET FOR PROMOTION OF COAL UTILIZATION TECHNOLOGY

Budget Item	FY1989	FY1990	Change	Ratio
Fluidized Bed Combustion	1769.4	1817.7	+ 48.3	+ 2.7%
Coal Water Slurry	861.5	1171.5	+310.0	+36.0
Coal Handling	11.4	471.8	+460.4	+403.9
Utilization of Coal Ash	318.1	123.2	−194.9	−61.3
Coal Partial Combustor	487.6	106.0	−381.6	−78.3
Direct Reduction Iron	800.0	965.4	+165.4	+20.7
Total	4248.0	4655.5	+407.5	+ 9.6

unit = million yen

PRIVATE BUSINESS ACTIVITIES IN CWM

The CWM related activities in Japan can be divided easily into four company groupings. Each of them has been involved with CWM demonstration tests related to preparation and/or combustion and are now interested in commercial development, either in Japan or internationally.

The status of the current activities by these groups, according to available information follows.

Japan COM Group

The Japan COM Company Ltd. was established in April, 1981, with capitalization of 13 billion yen of which 51% was provided by Tokyo Electric Power Company, 19% by EPDC and 10% by the Tohoku Electric Company. It has supplied 3.1 million tonnes of coal oil mixture (COM) between the start of production in November, 1984 and March 31, 1990. All of this production was sold to the Yokosuka thermal power station of Tokyo Electric Power Company.

Japan COM constructed two 15 tonne/hour CWM production plants in 1988 at their Onahama factory and has provided 150 000 tonnes of CWM between January, 1988 and March, 1990 to the 600 MW No.8 unit of the Nakoso thermal power station of Joban Joint Thermal Power Company, Ltd.

These fuels are described in TABLE 7.

TABLE 7

COM AND CWM FUELS FROM JAPAN COM COMPANY LTD.

	COM	CWM
Start of Production	Nov. '84	Jan. '88
Coal Selection	5 types	4 types
Total Production (tonnes)	3 100 000	150 000
Heat Content (kcal/kg)	8 500	4 500-5 000
Slurry Density (%)	48-49	67-69
Viscosity (cp)	1 200-1 400(64°C)	900-1 200(25°C)
Average Grain Size(micron)	25	18
Additives (wt %)	0.25	0.45

Initial CWM combustion trials were done using 56 000 tonnes of CWM at the 75 MW No. 4 unit of the Nakoso power station from August, 1985 to March, 1986, prior to the start-up of the current program. Since January, 1988, the Nakoso power station No. 8 unit has been running on a combined fuel of coal (40-45%), heavy oil (50-55%) and CWM (5%). Australian coals from the Warkworth, Mt. Thorley, Bayswater and Leamington mines have been tested to assess their availabilities at the scale of a total 50 000 tonnes of dry coal/year.

In March, 1990, a study was undertaken to determine the potential to increase the use of CWM from the current rate of 70 000 tonnes/year to 100 000 or greater tonnes/year.

Ube Industries Group

Ube Industries consumes 2.5 million tonnes of coal annually. It ranks as one of the largest chemical and resource based companies in Japan, with capitalization of 41.7 billion yen, 7 000 employees and annual revenues of about 500 billion yen.

Ube's main factories for both petrochemicals and fine chemicals and their headquarters are located in Ube City, Yamaguchi Prefecture, where they have large limestone reserves in their Isa Mine, located approximately 30 km northwest of the city. Ube's annual cement production capacity is 12 million tonnes /year. It operates a synthetic ammonia plant based on coal gasification, provides engineering of heavy industrial facilities and imports and distributes coal. Ube has developed a proprietary high density CWM containing less than 3% ash (U-Coal) and has also developed an ultra-low ash CWM, (less than 1%) in the 0.5 tonne/hour pilot plant at Wakayama as part of the national project. In addition, Ube has been testing a small scale, 0.2 tonne/hour CWM burner in its facilities.

Since FY1989, Ube has been engaged in a long term CWM demonstration project subsidized with funding from MITI. The company has refitted an existing grinding facility at a cement plant into a 15 tonne/hour CWM preparation plant (approximately 120 000 tonne/year), and modified a 95 tonne/hour boiler of Ube Chemicals Ltd. to burn CWM. Combustion tests are scheduled to begin in August, 1990, with approximately 20 000 tonnes of CWM expected to be burned during FY1990.

JGC Group

JGC Corporation is a comprehensive engineering company based in the petrochemical industry and has experience in CWM preparation, transportation and storage in cooperation with Kansai Electric Power Company and other heavy industry companies. In 1984, JGC constructed a 4.5 tonne/hour pilot scale CWM preparation plant based on the Carbogel process at Aioi, Hyogo Prefecture. Two years later, this plant was expanded to 20 tonnes/hour and supplied de-ashed CWM to the Himeji thermal power station of Kansai Electric Power Company, located approximately 20 km. from the processing plant, for five years from 1984 to 1988. The 33 MW No. 1 Unit used for these tests began operation in 1955 using pulverized coal combustion, but was converted to oil burning in 1973. It was found from these tests that CWM was fully competitive with oil combustion for both low load and load following conditions.

JGC has compared the use of both Canadian and Japanese coal for producing CWM. The Canadian coal was reported to give higher pulp densities with lower viscosity.

	Canadian	Japanese
Volume Prepared(tonne)	4500	3000
Pulp Density (%)	68	62
Ash Content (%)	8	7
Viscosity (cp)	690	840

Internationally, JGC is actively planning a CWM project in China. X'ing L'ong Zhuang coal, with 9% ash, will be transported 340 km by rail from the mine to the port of Shijui, where CWM will be produced and exported to Japan. In May, 1990, Yan Ri CWM Ltd. was established as a limited company in Shijui, with capital of approximately 1.2 billion yen which is shared among the Chinese partners (51%), Nissho Iwai (34%) and JGC (15%). Construction of the CWM preparation plant is expected to cost 3.8 billion yen. Japan is expected to contribute 83% of this cost, of which 2.36 billion yen will be a loan through the Japan International Cooperation Agency (JICA). Nissho Iwai and JGC Corp share responsibility for this loan, which has a 20 year term.

Coal reserves in the Yanzhou field are reported to be over 7 billion tonnes, of which 10 million tonnes are currently supplied, using modern techniques, to steel mills and power utilities. Plans include expanding the mine production to 30 million tonnes/year in 2000.

The CWM preparation plant is designed with an initial annual capacity of 250 000 tonnes/year. Construction is expected to be completed by Autumn, 1990. Future plans include expanding the production capacity to 1 000 000 tonnes as overseas markets increase.

Specifications of the Yan Ri CWM include a coal concentration of 68 to 72%, heat content of 4 790 to 5 170 kcal/kg, viscosity of 1 000 cp, specific gravity of 1.25, ash of 6%, sulfur of 0.2%, particle size of 75 to 85% minus 200 mesh, and expected stability of longer than 6 months.

The initial production volumes will be transported 1 000 km from Shijui to the Hibiki Coal Center, Kita Kyushu City, using 5 000 tonne class CWM ships and stored in two 10 000 tonne CWM storage tanks. The terminal at the coal center is designed with two slurry unloading facilities and will be capable of handling 10 000 DWT ocean tankers. Nissho Iwai will be responsible for marketing and distribution of CWM to customers.

Teika Company Ltd., a manufacturer of titanium oxide, announced that it will use 50 000 tonnes/year of this product at its Okayama factory to meet an increased power requirement. Teika intends to install a new CWM burning, double walled water tube type boiler of 45 tonne/hour capacity. This boiler will also be able to burn oil or other coal-based fuels. After an initial start-up using heavy oil, the company plans to switch to CWM in January, 1992.

In this case, the CWM will be transported 300 km from the Hibiki Coal Center to the Okayama factory using 500 tonne CWM ships.

In early July, 1990, it was reported that MITI requested the Ministry of Finance (MOF) to allocate budget funding to support the promotion of new markets in Japan for the Yan Ri CWM product. Of particular interest is the development of a commercialized CWM distribution system to stimulate further demand.

Kubota/Hitachi Group

This group has not reported any new CWM related business activities since the completion of the Wakayama CWM demonstration project which ended in FY1989.

The results of the Wakayama project include:

Non-deashed CWM Preparation

A total of 17 850 tonnes of CWM was prepared from three different coals. Typical specifications for these different slurries include slurry density of 63 to 68% coal by weight, viscosity in the range 700 to 1200 cp, and grain size of 83.5 to 88.5% minus 200 mesh.

De-ashed CWM Preparation

A total of 1 150 tonnes of CWM containing between 1 and 2% ash was produced from three different coals by means of an improved oil agglomeration method. Typical specifications of these CWM products include slurry density in the range of 66 to 68%, viscosity in the range of 490 to 1 280 cp, and grain size of 69.3 to 77.2% minus 200 mesh.

CWM Combustion

A total of 17 600 tonnes of CWM were combusted during 4 300 hours of tests from April, 1988 to January, 1989, including a continuous 30 day test. Combustion efficiencies of 98% with NO_x emissions below 185 ppm were attained, as expected. These tests also confirmed the successful development of numerous related component techniques.

Related Technologies

This project resulted in the group members demonstrating the practical application of CWM related techniques including storage, quality control, tank truck transport, flue gas disposal, electrostatic particulate control, wet desulfurization, extraction of molten ash as well as the development of a series of CWM additives.

Other Activities

Currently, the Kansai Electric Co., Ltd. is participating in a three year project to evaluate CWM supplied from the Nagasaki factory of Mitsubishi Heavy Industry Co., Ltd.

Chubu Electric Power Company has been reported to be studying a series of combustion tests on coal, Orimulsion, and CWM at their Shin-Nagoya thermal power station using a newly installed 15 tonne/hour fuel testing boiler.

EXPECTED COMMERCIALIZATION OF CWM

Japan depends almost entirely on overseas energy sources except for hydro power, particularly with the rapid decrease in domestic coal production. As a result, Japan must find stable, economic and diversified supply for oil, coal, natural gas, nuclear and other new energy resources.

In the current age of world peace, which enables global free trade and where economic interdependence becomes universal, Japan is fortunate to have the opportunity to be able to choose the most economic combination of energy resources. It will be necessary that this choice keep pace with advancement in energy technology, evolution of the world economy, global climate change and other environmental issues.

Accordingly, Japan's pursuit of its best energy mix, as summarized in the national long term energy plan, is expected to result in the most reasonable solution.

This national plan is usually revised every two to three years. Successive revisions of the plan need both the collection and analysis of the latest information on world-wide political, economic and technical events on energy supply and demand. Results of the analysis should be considered, not only in terms of Japan, but also the impact on other countries. For example, Japan currently imports over 100 million tonnes of coal, about one third of the world coal trade. This will increase, sooner or later, to the range of 150 million tonnes, which can bring additional benefits to the exporting countries.

The source and form of supply of this coal will be important to Japan. The oil supply situation and the relative price of coal will strongly influence the rate of this increase. CWM has proved to have inherent advantages against coal; its relative price will be the most important factor influencing its success in the Japanese market. Lower price and stabilized supply, under long term contracts, will be key for CWM to achieve a dominant share.

The "Coal Frontier Program" is a domestic initiative, which combines the efforts of both the government and the private companies to promote increased coal use by the general industry. Similarly, the "Clean Coal Program" calls for CWS and CCS (coal cartridge system) to become reliable means for the expanded use of coal all over Japan.

These two initiatives should eventually benefit coal development and utilization throughout the world. At the same time, Japan needs to learn more about other CWM related demonstration and development activities throughout the world in order to promote the commercialization of CWM in Japan through improving both quality and price for industrial use.

Forecast of Electric Power Generation in Japan

Item / End of / Source	Composition of Power Source						Target of Power Supply					
	1980 FY		2000 FY		2010 FY		1988 FY		2000 FY		2010 FY	
Nuclear	2,070	17.4	5,000	22	7,200	27	1,776	26.6	3,290	35	4,730	43
Coal	1,112	6.7	2,960	13	4,000	15	636	9.5	1,560	16	1,630	15
LNG	3,306	20.1	5,030	22	5,300	20	1,414	21 2	1,080	20	2,010	10
Hydraulic	3,613	21.9	4,450	19	5,170	19	886	13.3	1,010	11	1,180	11
General	1,913	11.6	2,150	9	2,500	9	801	12.0	850	9	990	9
Pumped	1,700	10.3	2,300	10	2,670	10	85	1.3	160	2	190	2
Geothermal	18	0.1	100	0.4	350	1	11	0.2	60	1	210	2
Petroleum, etc.	5,563	33.8	5,120	22	4,020	15	1,944	29.2	1,630	17	1,050	10
Methanol	---	--	---	--	100	0.4	---	--	---	—	40	0.3
Fuel cell, Solar Photv and Wind	---	--	110	0.5	570	2	---	—	30	0.3	250	2
Total	16,482	100	22,770	100	26,700	100	6,668	100	9,460	100	11,090	100

Unit: 10 MW

Unit: Hundred Million kwh

Comparison of Imported Coals to Japan

Item / Unit / Country	Coal Brands	Ash (%)	Volat. (%)	Fixed Carbon (%)	Calorie (kcal/kg)	Total S (%)	Melt. pt. (°C)	Crush Ability (HGI)	Fuel Ratio (FR)
Australia	34	13.6	32.4	51.4	6,921	0.51	1,431	49	1.55
South Africa	5	11.2	25.0	60.9	6,960	0.77	1,307	49	3.28
U.S.S.R.	4	13.6	26.[illegible]	57.1	6,808	0.42	1,342	60	2.53
Indonesia	4	6.1	39.6	45.1	6,361	0.45	1,287	50	1.14
P R.C.	2	10.6	26.7	60.0	7,000	0.71	-	50	2.29
U.S.A.	1	10.0	37.7	47.6	6,750	0.60	1,250	49	1.26
Canada	1	11.0	22.0	65.6	7,560	0.30	1,450	78	2.98
Columbia	1	9.6	33.2	48.2	6,560	0.70	1,240	49	1.45

Japan's Coal Import in 1988/1989 FY

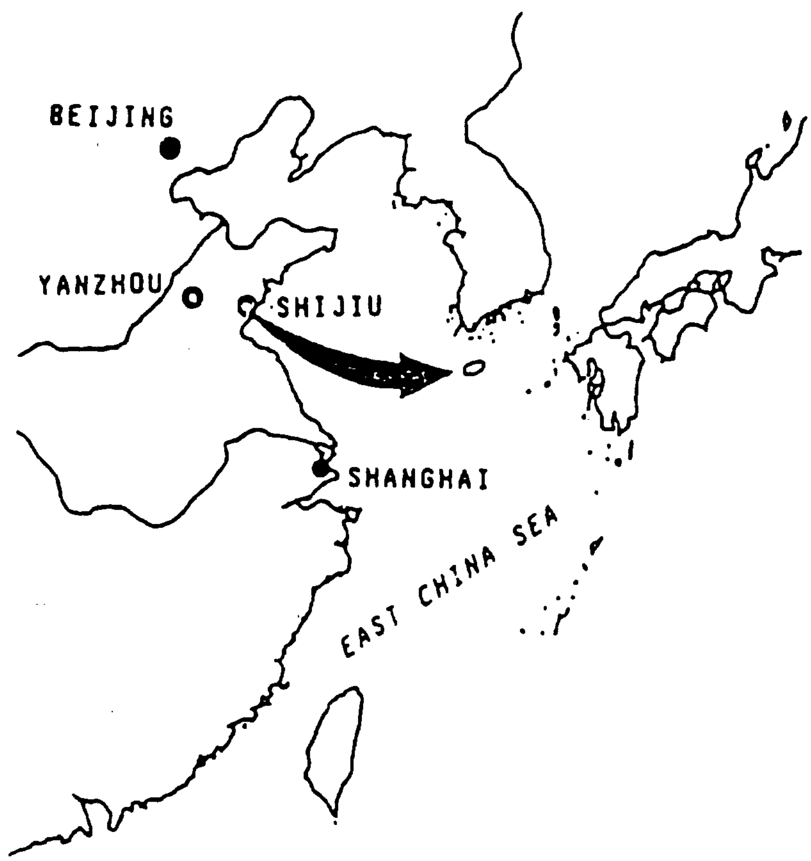
Unit: thousand ton

		1988 FY	1989 FY	'89 FY/'88 FY
Caking Coal	Sub total	74,077	73,612	99.4%
	Australia	30,229	34,183	113.1
	Canada	19,271	17,428	90.4
	U.S.A.	12,504	10,602	84.8
	South Africa	3,791	3,385	89.3
	U.S.S.R.	5,916	5,630	95.2
	Others	2,365	2,385	100.8
Steaming Coal	Sub total	27,698	30,228	109.1%
	Australia	19,046	20,904	109.8
	Canada	1,374	1,350	98.3
	U.S.A.	469	1,418	302.3
	South Africa	2,116	1,533	72.4
	P.R.C.	2,519	2,434	96.6
	U.S.S.R.	2,066	2,450	118.6
	Others	109	138	126.6
Anthracite	Sub total	2,492	2,273	91.2%
	P.R.C.	697	532	76.3
	U.S.S.R.	514	542	105.4
	North Korea	505	551	109.1
	South Africa	466	310	66.5
	Others	310	339	109.4
Total		104,267	106,113	101.8%

MAJOR CONSTRUCTION PROGRAM OF COAL FIRED POWER STATIONS

	End of FY '87	FY '88	FY '89	FY '90	FY '91	FY '92	FY '93	FY '94	FY '95	FY '96	FY '97	FY '98	FY '99	Total	
HOKKAIDO EPC*	2,150	Takigawa (-75)	Takigawa (-150) Sunagawa (-125) Ebetsu (-125)	Ebetsu (-125)	Ebetsu (-125)									2,150 (-725)	
TOHOKU EPC	525	—	—	—	—	—	Noshiro 600	—	—	—	Haramachi 1,000	—	—	2,125	
TOKYO EPC	530	—	—	—	—	—	—	—	—	—	—	—	—	530	
CHUBU EPC	—	—	—	—	Hekinan 700	Hekinan 700	Hekinan 700	—	—	Shimizu 1,000	Shimizu 1,000	—	—	4,100	
HOKURIKU EPC	—	—	—	—	Tsuruga 500	—	Nanao Ota 500	—	—	—	—	—	—	1,000	
KANSAI EPC	—	—	—	—	—	—	—	—	—	—	—	Maizuru 2x900	—	1,800	
CHUGOKU EPC	1,761	Shin-Ube (-75)	Shin-Ube (-75)	Shin-Ube (-156)	—	—	—	—	—	—	—	—	—	1,761 (-306)	
SHIKOKU EPC	406	—	—	—	—	—	—	—	—	—	—	—	—	406	
KYUSHU EPC	312	—	Matsuura 700	—	—	—	—	—	Reihoku 700	—	—	—	Reihoku 700	2,412	
OKINAWA EPC	—	—	—	—	—	—	Gushikawa 156	Gushikawa 156	—	—	—	—	—	312	
EPDC*	3,292	—	—	Matsuura 1,000	—	—	—	—	Takehara 350	—	—	—	—	4,642	
TOYAMA JTP*	500	—	—	—	—	—	—	—	—	—	—	—	—	500	
SAKATA JTP	350	—	—	—	—	Sakata 350	—	—	—	—	—	—	—	700	
JOBAN JTP	1,450	—	—	—	—	—	—	—	—	—	—	—	—	1,450	
SOMA JTP	—	—	—	—	—	—	—	Soma 1,000	—	—	—	Soma 1,000	—	2,000	
SUMITOMO JTP	173	—	—	—	—	—	—	—	—	—	—	—	—	173	
Change in capacity	—	(-150)	700 (-425)	1,000 (-281)	1,200 (-125)	1,050	1,956	1,156	1,050	1,000	2,000	2,800	700	14,612 (-1031)	
Total capacity	11,450	11,300	11,525	12,244	13,319	14,369	16,325	17,481	18,531	19,531	21,531	24,331	25,031	—	

NOTE: EPC* (Electric Power Company) EPDC* (Electric Power Development Corporation) JTP* (Joint Thermal Power)



SHIP TRASPORTATION OF CWM FROM CHINA TO JAPAN

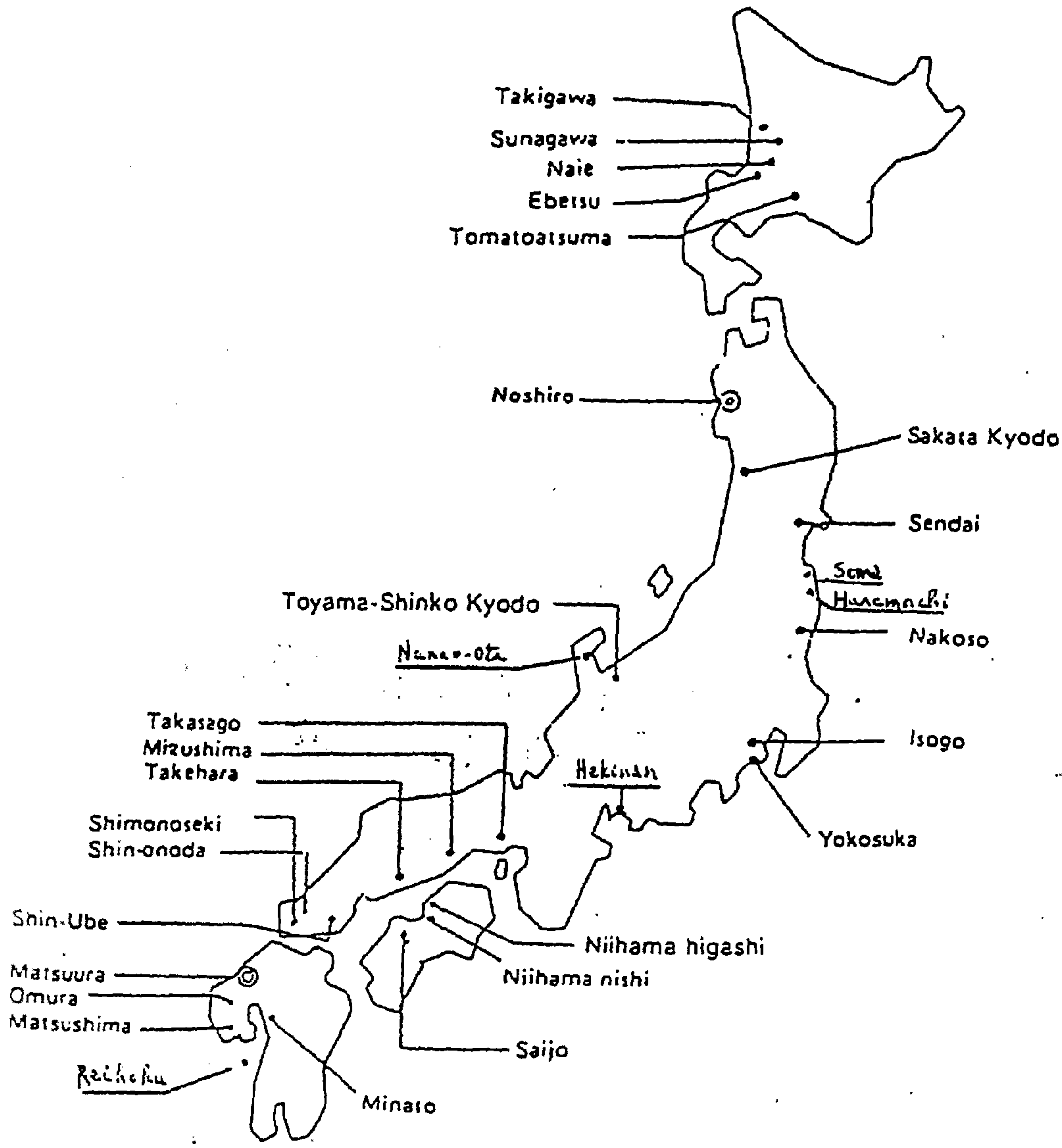


FIGURE 3 - LOCATION OF COAL FIRED POWER STATIONS

"GERMAN COALS; UTILISATION NOW AND IN FUTURE"

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GERMAN COALS; UTILISATION NOW AND IN FUTURE

By:

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THE IMPORTANCE OF COAL

During the last two decades the world wide industrial and domestic utilization of energy has increased drastically world wide. The consumers' demand for usable forms of energy is satisfied, apart from a certain portion of nuclear power, predominandly by the conversion of fossil fuels. Of these at present oil as the most versatile source plays the major role, followed by natural gas, which is in growing demand since the sixties. Coal - having been the most important source of primary energy since the start of industrialization - gained renewed interest during the last 15 years due to the two major oil crisises in the early seventies.

The Federal Republic of Germany (fig. 1), as one of the leading economical countries in the world, holds a 4,2% share of the world energy utilization. This utilization is provided by a variety of primary energy (fig. 2). Coal - bituminous and brown - providing 27,5% of the Republic's primary energy needs, is an important contributor. The significance of coals for the economy of the Republic is emphasized by the fact that the predominant portion of coal is domestically mined which reduces import dependency.

Coal is naturally available in western Germany. The major bituminous coal mining area is in the Ruhr region, with other smaller contributors being the Saar region, near Aachen, and at Ibbenbüren in Westfalia. Brown coals are predominantly mined in the Rhineland region but also near Helmstedt. The annual production distribution is shown in table 1; the typical coal analysis in table 2.

Looking at the development of the coal market in Germany over the past two decades - fig. 3 reports the data for 1973 and 1986 - it can be noted that the production of brown coal remainded almost constant over time, while bituminous coal mining diminished. This has lead to a decrease in total coal output.

Besides changes in markets demand, the main reason for this tendency is the differences in production costs: Brown coal is surface-mined from almost horizontal seams with thicknesses up to 40 m. This allows a specific production of about 90 tons per person per shift. The production costs are low when compared with the underground mining of bituminous coals. Bituminous coals are found in sloped and tectonically heavily distorted seams of 1 - 1,8 m thickness, at a depth of down to 1200 m below the ground. These specific geological features lead to a specific production of about 4 tons per person per shift only resulting in production costs which are, even when having been subsidized, not competable on the world market.

Fig. 3 also indicates a change in coal utilization. The export of bituminous coal decayed drastically due to the above stated reason. In addition, fig. 4 shows that traditional markets, like the application for domestic purposes and use in the steel industry, lost importance in absolute and relative terms. In contrast, the utilization of coal for direct heat generation in industry - although having a small share - increased. However, the major coal application was, and still is, electricity generation. The share of the coal production burnt in utility boilers went up to almost 60% and is still rising. Therefore, the future utilization of coal is strongly linked with the development of electrical power generation technology.

PRESENT STATUS OF COAL FIRED UTILITY BOILERS

At present, utility boilers in Germany are under operation in single unit sizes up to 600 MWe for brown coal and 770 MWe for bituminous coals. The high technical standard is mirrored by the fact that availabilities for base load stations are typically above 90%, with overhaul intervals of up to 3 years. For modern stations, typical steam conditions are 535 °C/250 bar for bituminous coal firing and 542 °C/180 bar for brown coal firing with overall efficiencies (prior to the installations of flue gas treatment plants) close to 40% and 37% respectively.

During recent years all boilers with capacities of 300 MW_{th} and greater had to be retrofitted with gas treatment plants in compliance with emission control standards. Experience has shown, that with the present techniques, efficiencies for fly ash removal of above 99,9% and SO_2 and NO_x-reduction of above 90% can be obtained. However, costs for these retrofit measures were not cheap. Investment costs for single units were as high as 50 % of the total plant costs.

The expected positive effect on the environment can be clearly seen from fig. 5. However, the installation of these plants has led to a reduction of the overall efficiency of the electricy generation unit by 1 - 2%. This decrease, as well as the cost of retrofitting, led to a substantial increase in price of electricity for the customer.

REQUIREMENTS FOR FUTURE COAL UTILIZATION TECHNOLOGY

Emphasized by the discussion of the harmful influence of carbon dioxide (CO_2) on the global climate via the "greenhouse" effect, fossil fuel combustion processes - being one of the major sources of antropogenic CO_2-production - became a topic of controversy in public discussion.

Because of the strong growth of world population, the expected increase in industrialization, and the subsequent rise in living standards - in particular in developing countries - a further increase of fossil fuel utilization and a subsequent rise in CO_2-emision is prognosted. Therefore, the first political and technical actions have already been taken in order to combat the danger of heating of our environment. As formulated by the recent international conference in Toronto, and since adopted by various countries, a 25% reduction of the CO_2-emission should be achieved by 2005.

Due to the nature of fossil fuels, the CO_2-emissions per energy unit converted can vary (fig. 6). The exchange of fuels for reasons of CO_2-reduction is, however, technically and/or economically very limited and other options must be sought of.

Because the utilization of non-carbon fuels is either only locally accessible with small quantities available, and thus economically not attractive (regenerative energies) or suffers from an only limited acceptance (nuclear energy), emphasis must be placed the improvement of fossil fuel, in particular coal based processes.

Based on the presently available optimal power station technique and in consideration of the CO_2-issue, various important requirements are essential for a new concept of coal utilization in electricity production:

- satisfy required demand at any time
- maintain low emissions of noxious species in compliance with present or future control regulations:
- maintain high availability
- provide high safety of operation
- reduce losses
- permit favorable costs for competition
- improve fuel conversion efficiency for
  - reducing the specific costs of the final energy

-- covering losses caused by emission reduction processes

-- saving primary energy resources for the future

-- reducing the CO_2-emission significantly in agreement with political goal settings.

PRINCIPAL OPTIONS AND TECHNICAL REALIZATION

In light of these requirements, the major task of the scientist and engineer is the design of fuel utilization systems which allow for an increase of the present conversion efficiencies. In addition, systems with a reduced impact on the environment and the most cost effective product are preferred.

A critical review of the conventional steam cycle reveals that technical changes, such as multiple steam reheating, further optimization of preheat, reduced condensing pressure, and supercritical operation, will be successful. However, these improvements will only be marginal. Material questions still have to be solved and the costs involved may prove that these technical options may not be economical.

Substantial improvements in fuel conversion efficiencies can only be expected by making better use of the thermodynamics, hence, by providing for energy conversion at elevated temperatures above the ones of the water/steam cycle.

As one option, multiple cycle concepts using other heat transfer media (e.g. alkalines) prior to the steam cycle have been studied but proven to be uneconomical.

However, an attractive solution offers the combination of a gas turbine with a steam turbine, due to an increase of the usable temperture difference. The gas turbine is already widely used for electricity generation. Depending on the gas turbine inlet temperature, efficiencies of 43% and higher have been reached. Also, the combination of a gas turbine with an oil or gas fired boiler is a common technique. In one case the combination of a gas turbine in front of a coal fired boiler has been operating since 1986, having a total capacity of 770 MWe and an efficiency of 42%.

With regard to coal, the discussion about CO_2-emissions caused the known principles of pressurized fuel conversion to become of renewed interest for the integration into a combined cycle. At present, various technical options are proposed which are summarized, in principle, in fig. 7: Coal is gasified under pressure, cleaned and burnt in a gas turbine combution chamber (left). The energy of these gases is to one part converted to electricity in the gas turbine. The sensitive heat of the gases leaving the turbine can furthermore be used for steam raising in a waste heat boiler and subsequent electricity production in the steam turbine.

Coal based combined cycles can alternatively be applied to pressurized combustion instead of gasification (fig.7, right). In these cases, the flue gases from the combustion chamber will, after cleaning, enter the gas turbine. All further process steps remain as described above.

Depending mainly on the fuel properties, the conversion principle and different process parameters (fig. 8 and 9) can be chosen.

Combined cycles, using only coal are in different stages of development (concept studies, research investigations, planning, construction and large scale demonstation respectively). Fig. 10 shows the typical efficiencies as a function of gas turbine inlet temperature for various combined cycle principles. As an example, data for the development of the efficiency increase are given in fig. 11 for German brown coals.

Finally, table 3 shows the state of large scale demonstration plants. As shown, the first coal combined cycles will start their demonstration operation in Europe within the next few years. Successful demonstration provided by the combined cycle technique is expected to be available by the end of this decade.

Concluding, it can be stated that in the Federal Republic of Germany coal is expected to maintain its important role as primary energy source and to expand its already predominant position as the basis for electricity production. The experience to be gained with the new conversion techniques is believed to ensure the envisaged tendency.

Coal type	Area	10 t/a
Bituminous coal	Ruhr	56.4
	Saar	10.0
	Aachen	4.3
	Ibbenbüren	2.3
	Total	72.0
Brown Coal	Rhineland	90.0
	Helmstedt	21.3
	Hessen	19.6
	Total	130.9

TABLE 1: ANNUAL COAL PRODUCTION IN THE FEDERAL REPUBLIC OF GERMANY (DATA BASE 1988)

Area	as received		Moisture- and ash-free								
									HHV	
	% ash	% moisture	% volatiles	% C	% H	% O	% N	% S	Btu/lb	MJ/kg
Ruhr (anthracite)	4-7	3-5	7.7	91.8	3.6	2.6	1.4	0.7	15.440	35.9
Ruhr (Low-Vol.Bit.)	6-9	7-10	10.5	90.8	3.8	2.7	1.7	0.8	15.500	36.0
Aachen (Low-Vol.Bit.)	6-9	8-10	13.8	89.8	4.8	2.8	1.5	0.5	15.410	35.8
Ruhr (Med-Vol.Bit.)	6-9	7-10	24.4	88.7	5.0	4.1	1.6	6.7	15.550	36.2
Saar (Med-Vol.Bit.)	7-9	8-10	32.5	86.9	5.2	5.4	1.3	1.1	15.320	35.6
Ruhr (High Vol.Bit.)	6-7	8-10	33.7	85.9	5.5	6.2	1.6	0.8	15.160	35.2
Saar (Hig Vol.Bit.)	5-8	3-5	38.2	82.7	5.2	9.4	1.2	1.5	14.220	33.0
Helmstedt (Brown Coal)	12-22	42-46	59.4	72.6	5.8	16.7	0.4	4.4	12.790	29.7
Rheinland (Brown Coal)	5-20	50-62	55.0	68.3	5.0	27.5	0.5	0.5	11.340	26.4

TABLE 2: ANALYSES OF TYPICAL COALS

company	project	fuel conversion principle	location	capacity	status
Lurgi	BGL	fixed bed	Westfield (GB)		planning
RWE	KoBra (HTW)	fluidized bed	Go-Werk (FRG)	270 MW	start up 1995
DBA	KRW	fluidized bed			planning
Shell		fluidized bed	Buggenum (B)	285 MW	start up 1993
Texaco		fluidized bed	Freetown (USA)	440 MW	planning
Krupp Koppers	PRENFLO	fluidized bed	Duisburg? (FRG)		planning
VEW	GDK250	fluidized bed	Werne (FRG)	250 MW	planning
DBA	GSP	fluidized bed	Freiberg (DDR)	175 MW	planning

TABLE 3: COMBINED CYCLES WITH INTEGRATED COAL GASIFICATION

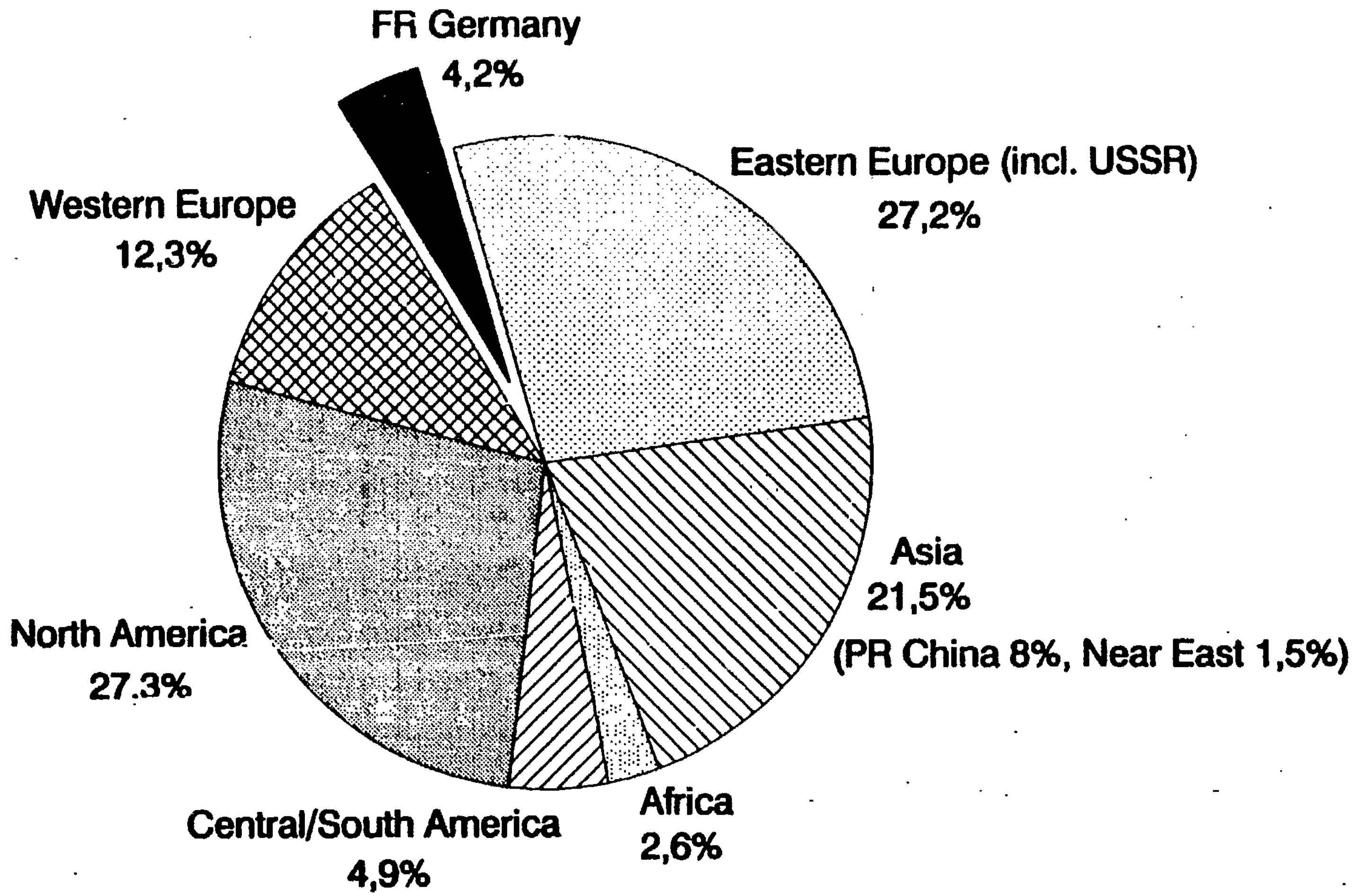


Fig. 1: World energy utilization 1986

(total $272\cdot10^6$ GJ $\hat{=}$ $9{,}3\cdot10^6$ TCE)

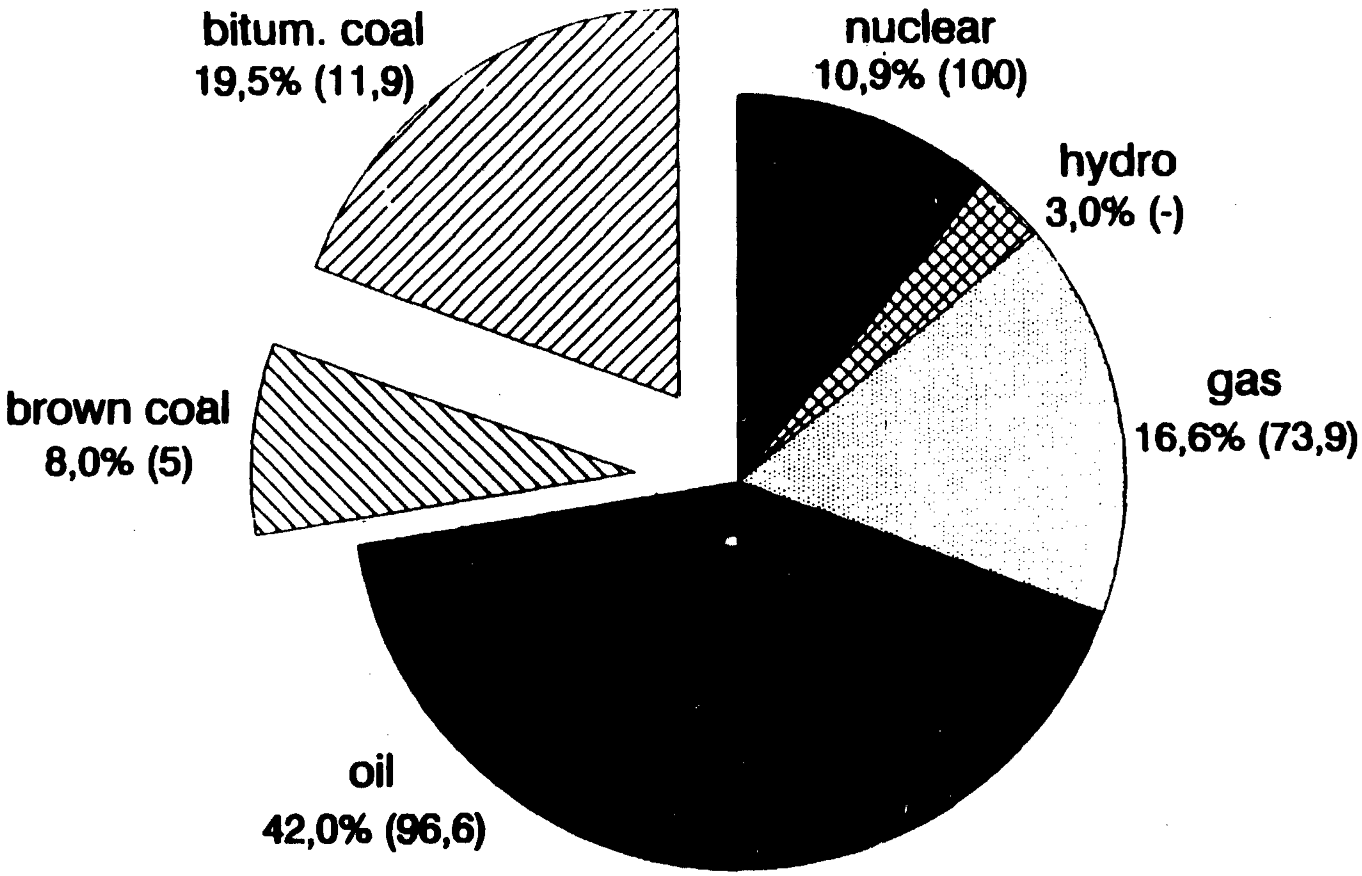


Fig. 2: Primary energy utilization; FRG 1987

(total $11{,}4 \cdot 10^6$ GJ $\triangleq 0{,}39 \cdot 10^6$ TCE; in brackets: % imported)

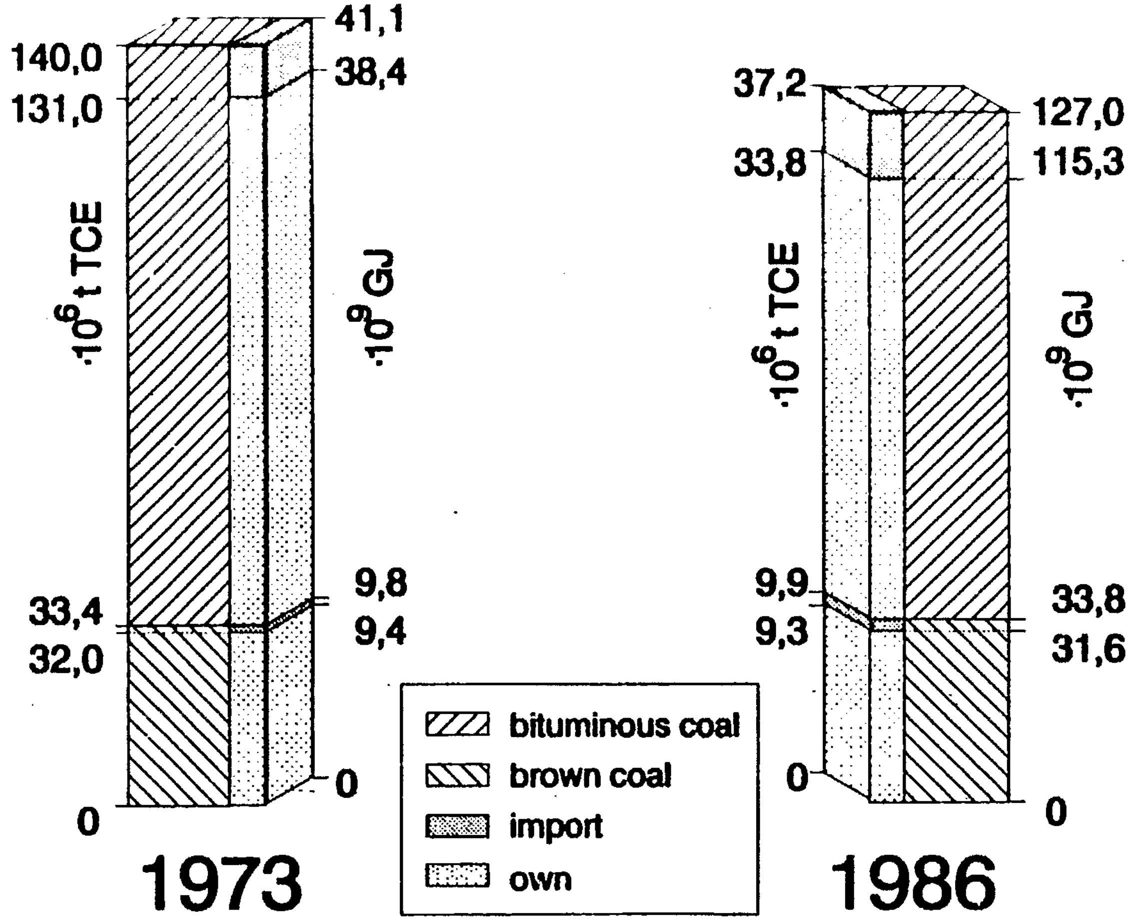


Fig. 3: Development of coal production (FRG)

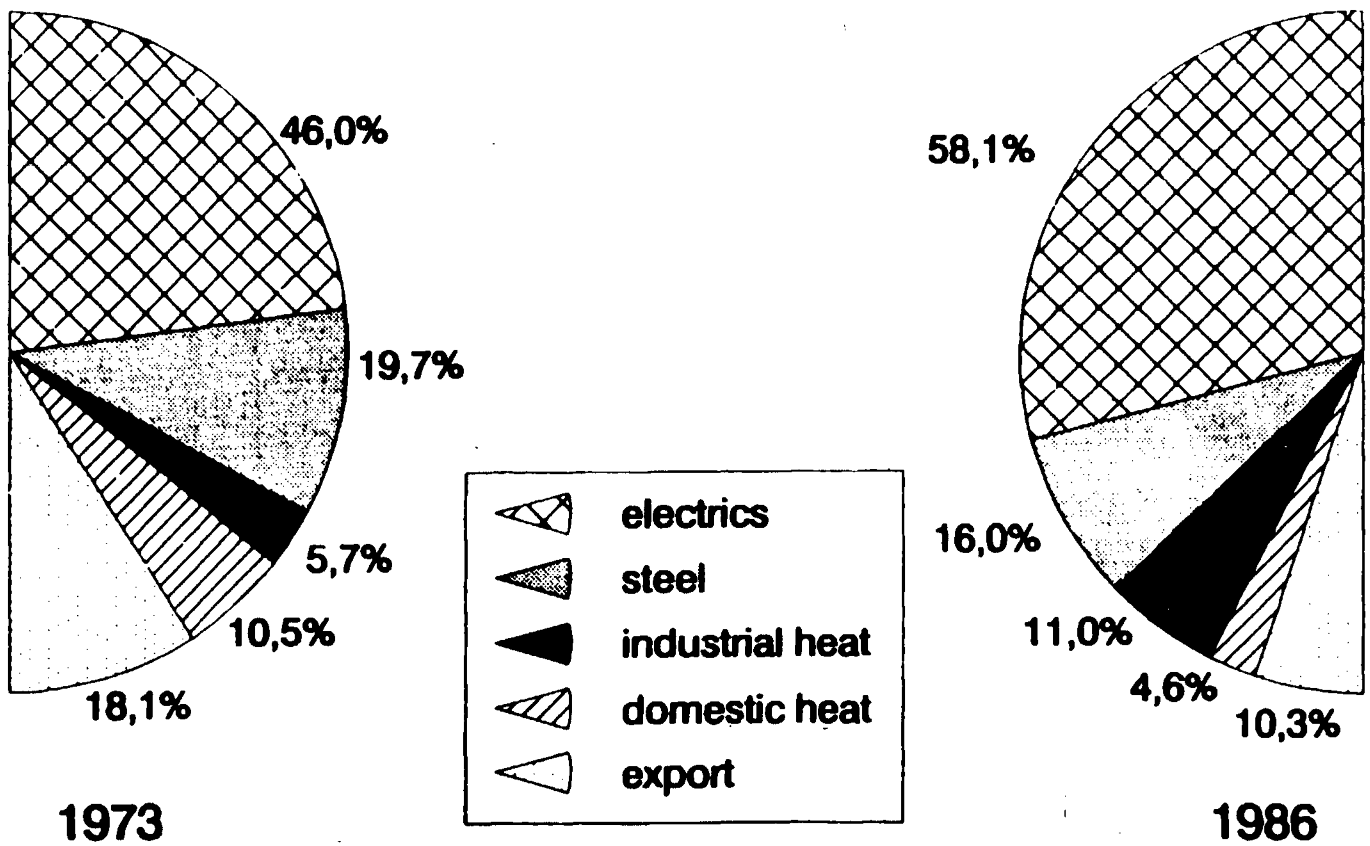


Fig. 4: Development of coal utilization (FRG)

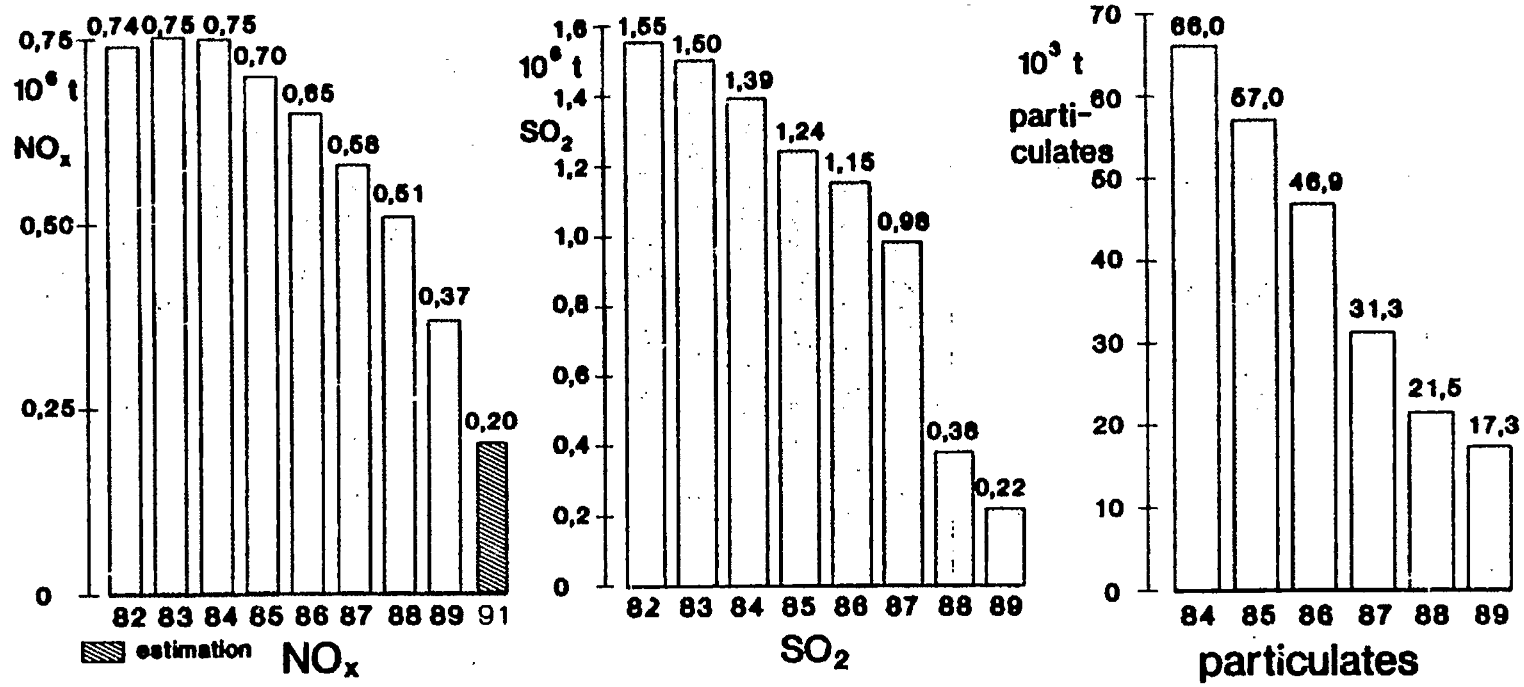


Fig. 5: Development of annual emissions from power stations

Federal Republic of Germany

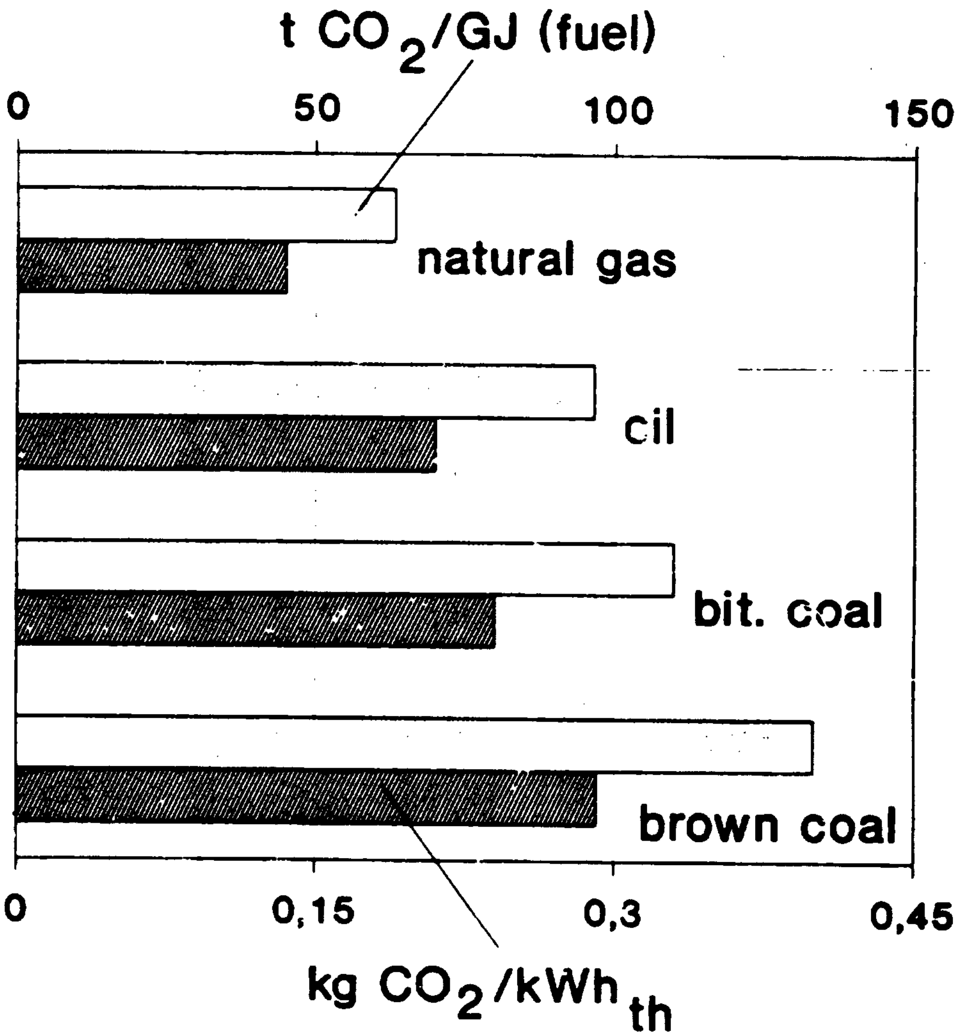


Fig. 6: Specific CO_2-emissions from fossil fuels

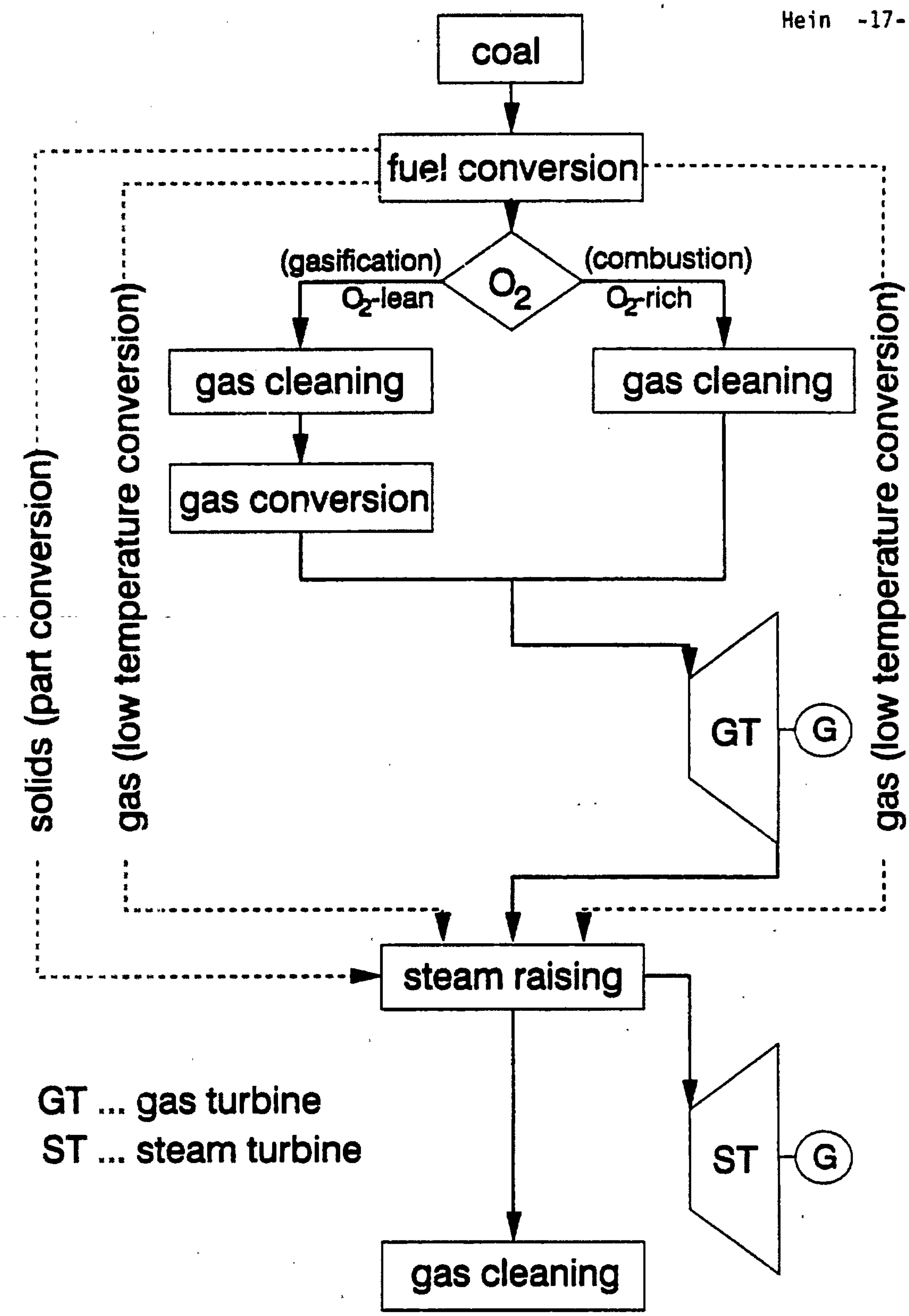
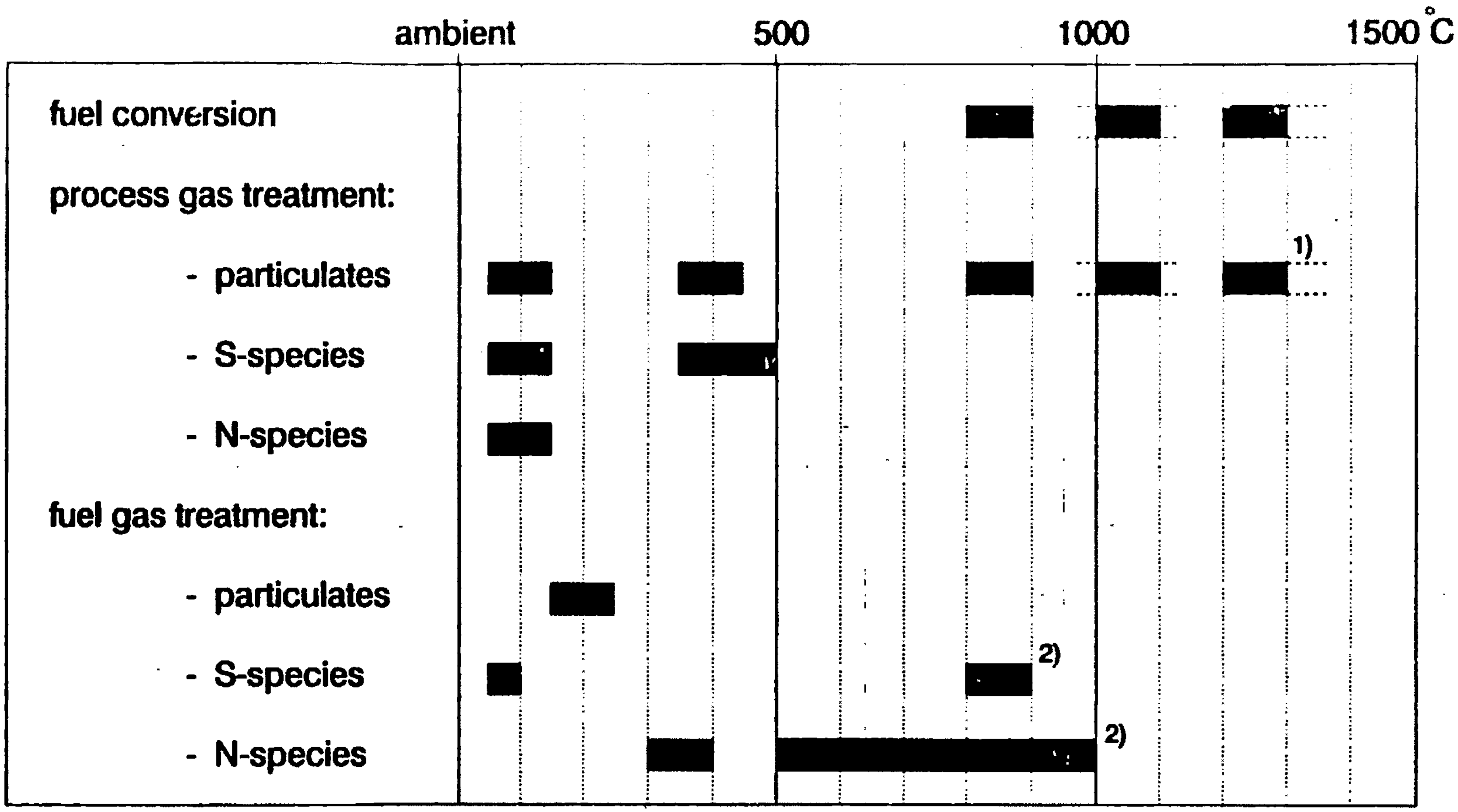


Fig. 7: Gas/steam combined cycles for electricity generation

Conversion principles:	gasification	combustion	
Process mode:	fixed bed	fluidized bed	entrained flow
Reaction partner :	oxygen	air	
First step of fuel utilisation :	full conversion	part conversion	

Fig. 8: Coal conversion processes;
various alternatives for process steps



1) liquid phase removal
2) reduction during conversion process in case of combustion available

Fig. 9:Coal conversion processes;
temperature ranges of major process steps

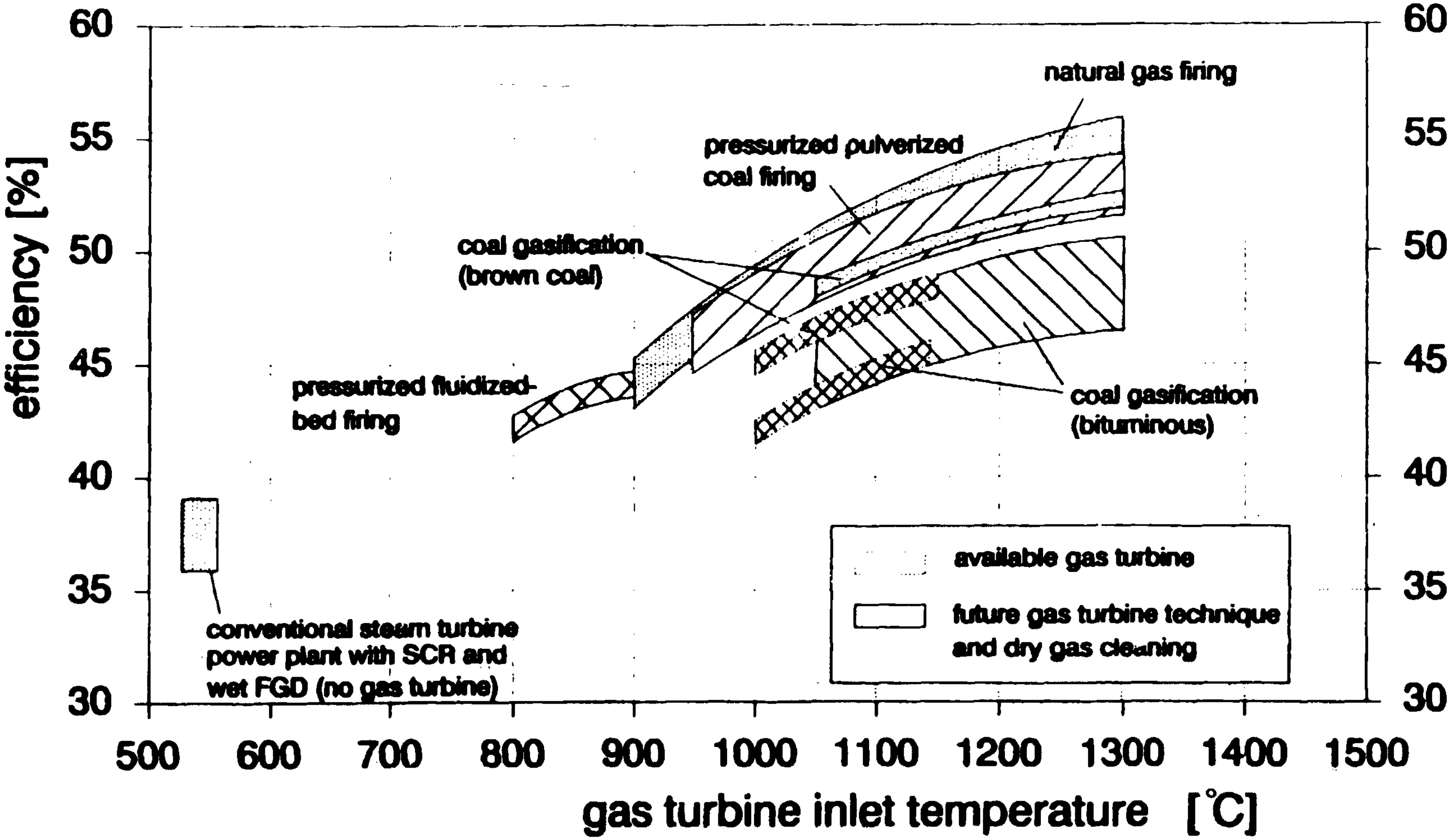


Fig. 10: Combined cycle plants; Comparison of efficiencies

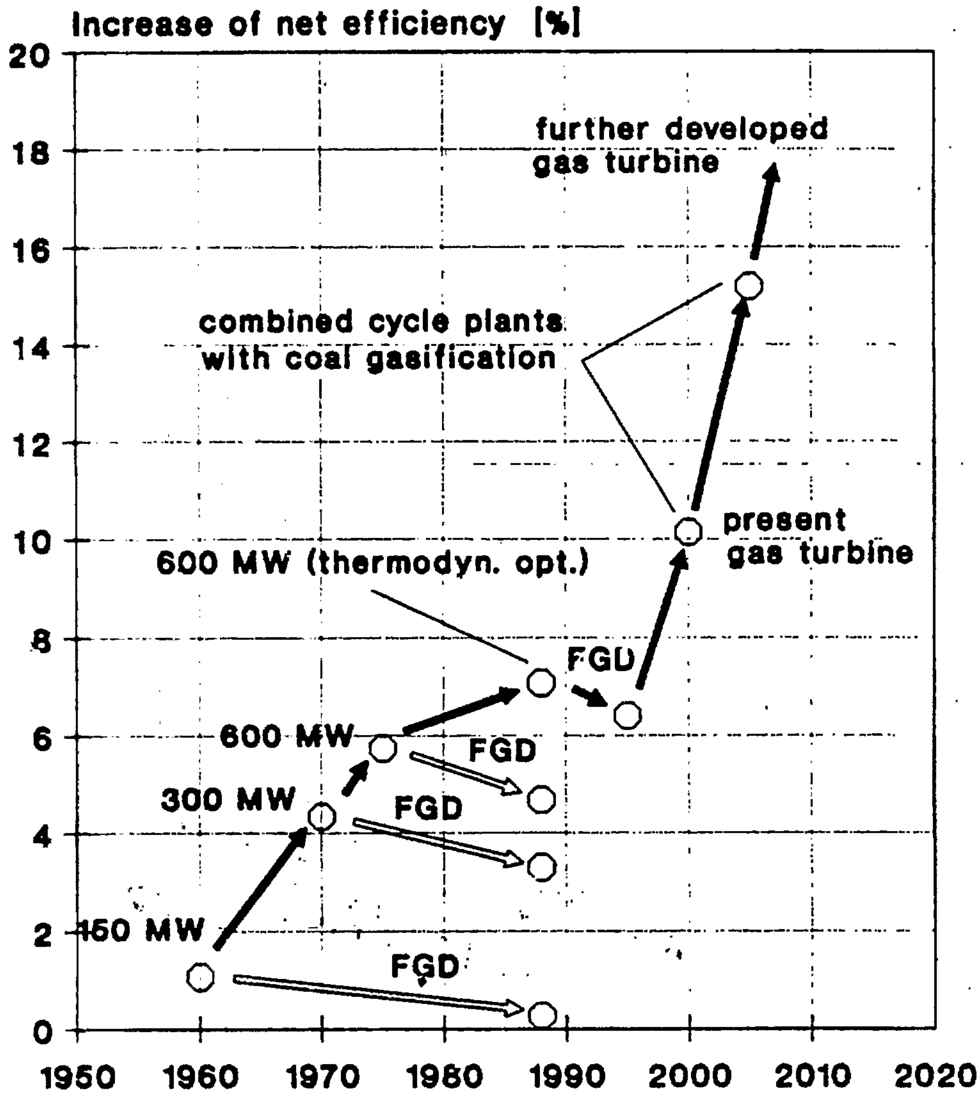


Fig. 11: Development of efficieny for brown coal based electricity generation

"THE OUTLOOK FOR COAL IN KOREA"

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THE OUTLOOK FOR COAL IN KOREA

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ABSTRACT

In Korea, not only a significant increase in total energy consumption, but also structural changes in energy consumption pattern has been changed during last 3 decades. Since Korea does not have sufficient energy resources, more than 80% of energy need to be imported. Due to the government policy to reduce the dependency of oil, coal will be a major energy source second to oil. It is projected that the demand for coking coal and for power generation will be increased at a rate of 6.7% per year up to 2010. 71.6 million tons of bituminous coal need to be imported in 2010.

INTRODUCTION

Since the launching of the First Five-Year Economic Development Plan in 1962, the most important implication for the energy sector is not only a significant increase in total energy consumption, but also structural changes in energy consumption pattern.

Table 1 shows major energy economic indicators in Korea. Total consumption of the primary energy in Korea has increased more than seven times over the last three decades from 9.7 million tons of oil equivalent (TOE) in 1961 to 81.2 million TOE in 1989, at an increase rate of 7.8% per year. Energy consumption in Korea increased at a growth rate of 8.4% per year in the 1970s while it fall slightly to 5.0% per year in the first half of the 1980s as a result of the second oil shock. Since 1986, however, the growth rate has soared up to 10.4% per year, as the Korean economy has grown at a rate of about 12% per year and energy price has fallen.

Per capita energy consumption has also increased from 0.38 TOE in 1961 to 1.92 TOE in 1989. Meanwhile, the energy/GDP ratio (TOE/million Won at 1980 constant price) has declined from 1.27 in 1961 to 0.99 in 1988, which implies the improvement of efficiency in energy use, due possibly to the energy conservation efforts and to the reorganization of industrial structure.

Korea's domestic energy resources are limited to anthracite, firewood and hydropower. However, these domestic energy sources appeared to be not sufficient enough for fuelling the continuous industrialization of the economy, particularly with emphasis on the expansion of the energy intensive industries, so that all incremental needs of other energy sources, such as oil, bituminous coal and natural gas, have to be totally imported from overseas. Consequently, dependency ratio of Korea's energy consumption on overseas supply is very high. The ratio has steadily incrsased from 8.6% in 1961 to 83.1% in 1988, with nuclear energy included, and seems likely to continue to increase regardless of the future energy environment.

<u>Structural Changes in Energy Consumption Pattern by Source</u>

As shown in Table 2, the structural change in energy consumption pattern by energy source has significantly occurred in Korea over the last three decades. Until 1961, more than 90% of the nation's total energy consumption was met by the indigenous resources, such as anthracite, firewood and hydropower. In 1962, firewood and anthracite accounted for 51.7% and 35.7% of the total primary energy demand, respectively. However, the share of firewood has significantly declined to 1.3% in 1989, and the share of anthracite has also declined to 16.6% in 1989.

On the other hand, oil consumption continued to increase and became the principal energy source from 1968. Along with the rapid industrialization of economy, oil consumption significantly increased over the 1960s and 1970s, at an average growth rate of 27.9% per year in the 1960s and 11.2% in the 1970. The share of oil demand in total energy demand increased from 9.8% in 1962 and reached its peak

<u>TABLE 1</u>

MAJOR ENERGY ECONOMIC INDICATORS IN KOREA

	1961	1966	1971	1976	1981	1986	1987	1988	1989
Primary Energy Consumption (million TOE)	9.7	13.1	20.9	30.2	45.7	61.1	67.4	75.4	81.2
Per Capita Energy Consumption(TOE)	0.38	0.44	0.63	0.84	1.18	1.47	1.60	1.80	1.92
Energy/GDP Ratio (TOE/Million Won)	1.27	1.16	1.13	1.02	1.12	1.00	0.99	0.99	
Elasticity (Energy/GDP)	-	0.77	0.93	0.78	1.31	0.70	0.85	0.98	
Overseas Dependence Rate (incld.nuclear)	8.6	17.1	50.8	62.1	75.0	78.1	79.9	83.1	

TABLE 2

COMPOSITION OF PRIMARY ENERGY DEMAND BY SOURCE IN KOREA

(Unit ; %)

	1962	1970	1980	1985	1988	1989	Change rate			
							71-80	81-85	86-88	89
Coal	36.8	29.6	30.1	38.8	33.4	30.0	8.5	10.5	4.5	
Anthracite	35.7	29.4	22.5	21.5	16.5	13.4	5.5	4.0	0.3	-12.0
Bituminous	1.2	0.3	7.6	17.3	16.9	16.6	51.3	23.9	9.5	6.2
Petroleum	9.8	47.2	61.1	48.5	47.0	49.5	11.2	0.2	9.2	13.9
LNG	-	-	-	-	3.6	3.2	-	-	-	-3.2
Hydro	1.7	1.6	1.1	1.6	1.2	1.4	5.0	13.0	-0.8	27.8
Nuclear	-	-	2.0	7.5	13.3	14.6	-	36.9	33.8	18.1
Firewood	51.7	21.6	5.7	3.6	1.5	1.3	-5.1	-4.2	-16.9	-11.3
(Million TOE)	(10.3)	(19.7)	(43.9)	(56.0)	(75.4)	(81.2)	8.4	5.0	10.4	7.8

level of 63.3% in 1978. But after the second oil shock, new energy sources such as bituminous coal, nuclear energy, and LNG have been introduced into the energy matrix and contributed greatly to the reduction of oil dependence to 49.5% in 1989. Nuclear energy, of which consumption greatly increased after 1983, accounted for 14.6% of the total energy demand in 1989, and bituminous coal and LNG accounted for 16.6% and 3.2% respectively.

Coal Supply and Demand

As a result of sharply increased oil prices in the 1970's, the role of coal in the Korean economy has increased. However, Korea's domestic coal reserves are limited and of poor quality, and therefore additional coal requirements have to be filled with imports.

Anthracite, which is the only indigenous fossil fuel in Korea, has been the principal energy source in the residential and commercial sector in the form of briquette. The other sectors, such as power generation, industrial and public, consume only about 10% of total anthracite coal as shown in Table 3. Anthracite consumption in the residential and commercial sector has increased as a rate of 4.6% per year over the period of 1976 to 1987. Such a slow but steady increase in anthracite consumption is due mainly to the fact that the anthracite, as the unique domestic produced fossil fuel in Korea, had to be inevitably responsible for satisfying the residential and commercial energy demand. Moreover, two oil crises in the 1970's highlighted the danger derived from the Korea's high overseas over-dependence in

TABLE 3

SUPPLY AND DEMAND OF ANTHRACITE COAL

(Unit; 1,000M/T)

Year	Supply			Demand				
	Total	Production	Import	Total	Industry	Res. & Comm.	Electric Utilities	Public & Others
1978	18,699	18,054	645	17,953	684	16,526	518	225
1979	20,225	18,208	2,017	18,820	640	16,942	1,064	174
1980	21,315	18,624	2,691	20,830	708	18,037	1,865	220
1981	24,128	18,865	4,263	21,413	787	18,543	1,878	206
1982	22,438	20,116	2,322	20,865	492	17,887	2,326	160
1983	20,674	19,861	813	21,670	518	18,960	2,074	118
1984	22,174	21,370	804	24,154	436	21,316	2,251	151
1985	24,876	22,543	2,333	25,339	353	23,100	2,778	108
1986	28,167	24,253	3,914	26,928	277	24,250	2,285	116
1987	27,056	24,274	2,782	26,327	206	23,587	2,444	90
1988	25,950	24,294	1,656	25,641	209	22,926	2,407	99
1989	22,538	20,785	1,753					

energy consumption, and thus the use of domestic anthracite was highly emphasized. On the other hand, a considerable substitution of anthracite for firewood has occurred, due mainly to a change in the consumer's preference for convenient heating fuel as well as to the government's policy to protect the forest. The annual growth rate of anthracite consumption during the period of oil crisis jumped up to 23.8% in 1973 alone and also rose sharply to 6.5% in 1980, which is higher figure than that of 4.5% in the period of 1974-1979. However, recently, anthracite consumption in residential and commercial sector has begun to significantly decline since 1987 owing to its weakened price competitiveness in the heating fuel market. The rapid increase in consumption of other energy sources, such as oil, bituminous coal and LNG, has relatively lowered the share of anthracite coal in total energy consumption from 40% in the 1960s to 13.4% in 1989.

Demand for bituminous coal which is totally imported from overseas has significantly grown in Korea, as it has been used as oil substitute in industry and power generation. Therefore, the consumption of bituminous coal has significantly increased from 0.8 million ton in 1975 to 20.5 million tons in 1989 at an average growth rate of 27.9% per year as shown in Table 4, and its share in total energy consumption has increased from 1.9% in 1975 to 16.6% in 1989 as shown in Table 2,

TABLE 4

SUPPLY AND DEMAND OF BITUMINOUS COAL

(Unit; 1,000M/T)

Year	Import			Demand			
	Total	Coking Coal	Steam Coal	Total	Steel	Utilities	Cement & Others
1973	612	-	612	649	424	-	225
1974	773	-	773	839	839	-	-
1975	672	-	672	786	786	-	-
1976	1,494	1,394	100	1,586	1,506	-	80
1977	2,007	1,984	23	2,100	1,795	-	305
1978	2,067	1,995	72	2,169	2,009	-	160
1979	4,217	4,190	27	4,349	3,676	-	673
1980	4,911	4,429	482	5,032	3,987	-	1,045
1981	7,245	5,825	1,421	7,434	5,941	-	1,493
1982	9,039	6,439	2,600	8,504	6,033	-	2,470
1983	10,151	6,394	3,757	9,633	6,199	546	2,889
1984	12,194	6,321	5,873	12,745	6,888	3,342	2,514
1985	17,131	8,125	9,006	14,697	6,959	5,140	2,598
1986	16,437	6,575	9,862	15,290	6,995	5,363	2,932
1987	17,834	9,247	8,587	16,218	8,348	4,442	3,428
1988	21,913	11,237	10,676	19,274	9,722	5,579	3,973
1989	23,500	11,651	11,849	20,500	11,200	5,200	4,100

gradually substituting oil. In 1989, 55% of bituminous coal was used in steel industry, 25% of them was used in power generation and the remainder 20% was used in other industries such as cement industry.

Share of bituminous coal in total energy consumption in the industrial sector has increased 5.8% in 1975 to 32.0% in 1988. In particular, since the operation of the Pohang Steel Company (POSCO) in 1973, consumption of coking coal has significantly increased 0.4 million ton in 1973 to 11.2 million tons in 1989. With the completion of the Kwangyang Steel Works of POSCO in 1987, use of coking coal noticeably increased by 19.3% in 1987 and 16.5% in 1988.

TABLE 5

COMPOSITION OF FUEL CONSUMPTION FOR POWER GENERATION

(Unit;%)

	1962	1970	1980	1985	1988	1989
Anthracite Coal	47.4	11.2	7.6	5.6	4.4	4.0
Bituminous Coal	5.3	-	-	24.4	18.2	15.0
Oil	19.7	76.6	77.3	33.1	13.0	14.8
LNG	-	-	-	-	11.0	9.5
Nuclear	-	-	9.6	30.3	48.4	51.7
Hydro	27.5	12.2	5.5	6.6	4.2	5.0
(1,000 TOE)	(-)	(2,500)	(2,035)	(13,828)	(20,701)	(22,915)

On the other hand, consumption of steam coal in the industrial sector had been limited to the cement industry. The initial growth in steam coal consumption was in 1979/80, due to the conversion of the cement industry from oil to coal-firing systems. Steam coal consumption in other industries has just started in Korea. A small number of boilers has recently converted to coal-firing with the assistance of government loans. During the period of 1979-1988, consumption of steam coal in the industrial sector has increased about six times, from 6.7 million tons in 1979 to 4.0 million tons in 1988. Average annual increase rate over the period is 21.8%.

Until 1962, the major fuels for power generation in Korea were anthracite and hydropower, accounting for 74.9% of total fuel consumption for power generation as shown in Table 8. Oil consumption steadily increased and its share reached 88.3% in 1977, while shares of anthracite and hydropower decreased to 6.2% and 5.2%, respectively. After the second oil shock, the oil consumption for power generation

TABLE 6

OUTLOOK FOR GENERAL INDICES OF ENERGY PROSPECTS

	1990	1995	2000	2010	Change rate(%)
Total Energy Demand(1,000 TOE)	86,853	113,382	138,764	180,119	4.4
Final Energy Demand(1,000 TOE)	70,135	90,857	109,382	135,207	4.0
Energy Input Ratio to GNP	1.007	0.933	0.828	0.612	-2.2
Energy Consumption per capita(TOE)	2.03	2.53	2.97	3.53	3.5
Electricity Consumption per capita(KWH)	2,057	2,694	3,344	4,798	5.1

TABLE 7

PROJECTION OF PRIMARY ENERGY CONSUMPTION IN KOREA

(Unit; 1,000TOE)

	1990	1995	2000	2010	Change rate(%)
Oil	43,267 (49.8)	57,413 (50.4)	66,471 (47.9)	77,669 (43.1)	4.3
Bituminous Coal	14,484 (16.7)	23,799 (21.0)	31,548 (22.7)	47,243 (26.2)	6.7
Anthracite	10,795 (12.4)	9,300 (8.2)	7,903 (5.7)	4,579 (2.5)	-4.3
New & Renewable	1,643 (1.9)	2,169 (1.9)	2,794 (2.0)	5,551 (3.1)	6.4
LNG	2,838 (3.3)	5,517 (4.9)	8,234 (5.9)	13,543 (7.5)	8.4
Nuclear	12,993 (15.0)	14,533 (12.8)	20,892 (15.1)	30,612 (17.0)	5.1
Hydro	833 (1.0)	922 (0.8)	922 (0.7)	922 (0.5)	-1.6
Total	86,823	113,382	138,764	180,119	4.4

( ) : Share in %

significantly declined and its share fell to 14.8% in 1989. With the completion of coal-fired power plant in 1983, consumption of steam coal for power generation began to grow as shown in Table 4, and its share in total fuel consumption for power generation reached 15.0% in 1989.

OUTLOOK FOR ENERGY DEMAND IN KOREA

Major future energy indices are shown in Table 6. Total energy consumption in Korea is excepted to increase by 4.4% per year during the period of 1990 to 2010 to 138.8 million TOE by the year 2000 and to 180.1 million TOE by 2010. The energy intensity of the Korean economy (expressed in TOE/Million won) is projected to decline by about 2.2% per year from 1.017 in 1987 to 0.612 in 2010. On the other hand, per capita energy consumption is expected to increase 1.60 TOE in 1987 to 3.53 TOE in 2010. Electricity consumption per capita will also increase from 1,525 KWH in 1987 to 4,798 KWH in 2010.

Projection of primary energy consumption is shown in Table 7. Oil consumption is projected to grow at only 4.3% during the period of projection. Consequently, the

TABLE 8

COAL DEMAND PROSPECT

(Unit ; 1,000 M/T)

	1990	1995	2000	2010	Change rate(%)
Anthracite	24,266	20,971	17,866	10,398	-4.0
Resi. & Comm.	21,540	18,132	15,083	8,386	-4.4
Others	2,726	2,839	2,783	2,012	-1.3
Bituminous Coal	21,946	36,105	47,800	71,580	6.7
Industry	15,534	21,688	27,757	33,068	4.6
Power Generation	6,412	14,417	20,043	38,518	9.8

share of oil in total primary energy consumption is projected to slightly decline from 49.5% in 1989 to 43.1% in 2010. While the share of bituminous coal in total energy consumption is projected to increase from 16.6% in 1989 to 26.2% in 2010, of which the growth rate will be 6.7% per year. So bituminous coal will be a major energy source second to oil. However, the share of anthracite is expected to significantly decline from 13.4% in 1987 to 2.5% in 2010.

Demand for anthracite in Korea is predicted to decrease at a rate of 4.0% per year during the period of 1988 to 2010 as shown in Table 8. This gradual reduction of demand for anthracite will be due to the increasing production cost and unfavorable marketability as well as to consumer's taste change to the high quality fuel, such as electricity and gas, following the improvement of living standard and also due to the increasing concerns on environmental problem. Anthracite currently accounts for 61.4% in total residential and commercial energy consumption. However, the share is expected to decline to 12.9% in 2010.

The demand for bituminous coal will show more or less high growth rate of 6.8% per year during the period of 1988-2000. so its share of total energy demand in the industry will be 34.7%. Thereafter, however, the demand for bituminous coal is expected to slightly increase at a rate of 1.8% per year. The demand for bituminous coal in the industry sector is expected to increase by 4.6% per year to 21.8 million TOE (33.1 million ton) in 2010 due to increases in use of the industrial boilers and in consumption in the cement industry.

Demand for coking coal in the steel industry is expected to increase at a rate of 6.4% per year by 2000 in proportion to the increase in production of pig iron. The production of pig iron, which is the highest energy intensive product within the industry, will be greatly increased by the early 1990's, due to the expansion of production capacity, and thereafter the growth in the production will be slackened along with the process of industrial maturation. However, as the production growth of the steel industry will slow down during the period of 2000 to 2010, the demand for coking coal is expected to show a slight increase rate of 1.6% per year.

Electricity demand in the residential and commercial sector is expected to show a high increase by 7.8% per year, due to the expansive use of electrical appliances in the residential sector. On the other hand, in the industrial sector, the increase rate will remain at 5.1% due to the development of technology intensive industries. Table 9 shows the power plant construction plan based on the current long-term power development plan. The composition of fuel for power generation in 2001 will be nuclear 36.1%, bituminous coal 29.1%, oil 11.3%, LNG 10.7%, hydro 10.5%, and anthracite 2.3%. Nuclear and coal power plants will supply most of the base load, while gas and oil power plants will be operated for meeting peak load demand. The completion of 14 additional bituminous power plant will cause more increase in bituminous coal demand greatly. So that total demand for bituminous coal is expected to increase to 71.6 million tons in 2010 at an average increase rate of 6.7% per year as shown in Table 8.

COAL POLICY

During the period of the second oil shock, the Korean economy appeared to be highly vulnerable to overseas energy situation, and bitterly suffered from the recession, high level of inflation, increased deficit in the balance of trade, and so on. Consequently, energy security has become one of the most challenging policy objectives for Korea. The second oil shock in late 1970, although it seriously affected the Korean economy, provided the motive for Korean energy policy to enforce all-out energy conservation measures and oil substitution policy through diversification of energy sources.

TABLE 9

POWER PLANT CONSTRUCTION PLAN

1,000 KW x Unit

	'90-'92	'93-'95	'96-'98	'99-2001
Anthracite		200 x 2		
Bituminous Coal		500 x 7	500 x 4	500 x 1 900 x 2
LNG	400 x 2		400 x 2	
Nuclear		1,000 x 1	1,000 x 2 700 x 1	1,000 x 1
Hydro	190 x 2	300 x 2	250 x 2	

In order to complement the structural weakness and to cope with the possible disruption caused by entire reliance on import, Korean government is now strongly stressing the direct overseas investment development particularly in the field of energy resources and encouraging private sector through various financial and tax incentives. The ambitious goal is set-up to self-supply 30% domestic coal demand by the year 2001.

As mining level is deepened and labor cost rises, domestic anthracite price always has upward pressure. But anthracite demand continues to decrease because consumers preference to the clean fuel. These situations lead the government to change coal policy from the promotion of production to its rationalization. The Korean government decided in 1988 to help close small unproductive mines under the condition that the agreement for the closure be concluded between labor and management. On the other hand, measures are undertaken to stabilize domestic coal production in the long run through improving competitive power of coal mines and government support system as well as ensuring the demand of anthracite coal produced.

In contrast, bituminous coal usage will be promoted in power plants and industry. The demand for imported bituminous coal is expected to increase to over 50 million tons by the year 2001, becoming a major energy source second only to oil.

However, the use of coal can not be promoted without solving the environmental issue. From the middle of 80's, public awareness for the environment has been increased as the improvement of living standard. Government will balance the economic development and the environment protection.

For the effective dissemination of new & renewable technology and to diversify the energy sources, "New & Renewable Sources of Energy (NRSE) Development Promotion Law" was enacted in 1987 and a long-term R&D plan was formulated. For New & Renewable Energy to supply 3% of total energy by 2001, policy efforts will be focused on building up a technical foundation for NRSE utilization by directing systematic R&D efforts among government, academia and industries concerned. About $70 million will be invested in R&D from 1989 to 1991.

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"COAL OPPORTUNITIES IN EASTERN EUROPE"

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COAL OPPORTUNITIES IN EASTERN EUROPE
Domestic Energy Development Instead of Imported Energy

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ABSTRACT

The question of using energy more efficiently is basically one of technology, economics, and social change. That is to say, we can have access to new technological developments, understand how to benefit by the use of alternative sources of energy, and understand the processes involved in using energy more efficiently; but without recognizing the complexity of those changes, efficient energy use may never become a permanent part of our lifestyle. In this paper an up-to-date review of the status and prospects of coal, with the emphasis on Coal Water Mixtures (CWMs), in Eastern Europe is given, although it is much easier to comment on present status than on the prospects.

INTRODUCTION

Energy represents politics in its highest form. More than any other commodity, energy is tied to nationalism and executive (bureaucratic) power, and political and other confrontations over its control are very common. It has an influence on our way of life, it gives us light, it runs our factories, and gives us the freedom to move. On the other hand, we are expending our world resources, and we are polluting our environment. The basic challenge lies in reliable and efficient energy supply, without pollutants, and at moderate expense; to that goal, we have to devote our work not only in Eastern Europe, but all around the world as well.

Events since 1973 have changed the position of oil in the overall energy equation. Even today nearly 20 years later, the coefficients of safe energy assessment in this equation have not been unambiguously defined in any of the East European countries. To talk about uncertainty is not an escape mechanism, but rather a way of coping with reality. The identification and understanding of key problem unknowns are of crucial importance when taking decisive and practical steps.

In past decades the incapacity to control energy has cost most of the east European countries a significant part of their potential growth -- in some cases, more than half.

Problems in the area of energy supply are reflected in uncertainties of energy consumption growth, primary electricity supply, and motor vehicle fuels. All these facts point to a lack of improvement in efficient energy

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consumption. The growing dependence on imported fuel by many countries escalates this tendency. This has contributed to high unemployment and/or serious constraints on credibility and finance in the international domain.

At the moment, the energy policy of East European countries are not clear. Indeed, an understanding of the basis of future policy barely exists. Consequently, there is a need for open debate to shape the energy structure and define the interaction between energy policy, economic growth and environmental protection. But problems can not be solved by simply bringing situations out in the open. Many individual decisions must be made in the chain from energy producer, to consumer to insure that the required energy is available when needed. Delays at any point affect the entire chain. This points up the need for prompt and related action by consumers, producers, governments, and other public agencies. Today, the energy base in Eastern Europe is much firmer than in the period before the first oil embargo in 1973; given similar conditions, this situation could exist for the next two decades. This stable period is a chance for Eastern Europe to improve its energy producers position with the knowledge that situations can change quickly.

In addition, it is apparent that the world is acknowledging that unless all people end wasteful practices and discover new sources of energy, a global shortage of energy will eventually occur.

This presentation of the energy situation is not generally characteristic of all the countries in Eastern Europe. Each is on a different level of development, and some of them are exporting energy and/or technology. It is clear that the benefit of lower prices, which positively affect the financial balance, belongs to nations that import energy.

The influence oil has had on international policy is considerably weakened, to the point where on today's market, the threat that oil might be restricted affects the exporter more than the importer. The fact is, however, that only countries exporting technology show an intense interest in adjustment, with energy and environmental equilibrium considered as strategy options. The developing countries are confronted with an historical chance to recognize and accept wise energy policies as a universal behavior model, and avoid many of the complex problems which are today characteristic of the industrialized world.

The people of Eastern Europe, therefore, must realize that we are becoming more and more "energy dependent" and must act now to make the most efficient use of energy, as we shift our emphasis to sources such as coal, in forms that are economic and practical.

<u>The Present Status</u>

The current situation in Yugoslav coal mines, as an example, is marked by an everyday struggle to survive. Based on the expectations from the 1970-ies, it was predicted that coal consumption would increase. This did not happen, mainly due to adverse economic conditions. Without the assistance of the free market economy and with restrictions that followed as a result of unpaid foreign debts, all investments have been frozen for the last four years. It follows that conditions in the mines are exceedingly difficult. Of primary interest should be the reconstruction and modernization necessary to increase productivity and improve harsh working conditions to a tolerable level. These, among other factors, raise the question of whether there is any sense in performing such a difficult and unappreciated task.

Organizationally, status of advanced coal technologies in Eastern Europe is very much the same as in North America and in other parts of the industrialized world. The reason for this is, of course, the intense crossfertilization that has taken place between East and West in the past few years. The companies and organizations in western countries working in the front line of the development, demonstration, and commercialization have had a tendency to spread their activities not only to Eastern Europe, but also to other parts of the world. The result of all this is that access to technclogy is easily within reach of interested parties everywhere.

Another factor which underlines the global similarity is the fact that a really convincing, large-scale commercial breakthrough has not yet occurred anywhere, although several appear to be in the works. It seems that the probability of a breakthrough in the very near future is rather high, almost equally in West and East. In most of the Eastern countries, particularly in the Soviet Union and Yugoslavia, it is assumed that most of the elements of the Coal Water Mixture technology have been convincingly demonstrated, including its degree of economical attractiveness under most conditions. Coal oil mixtures are clearly a thing of the past, primarily because they cannot compete economically with Coal Water Mixtures. Mixtures of coal with other liquids are still at the early devleopment stage. For certain uses though, they may be quite practical.

In Yugoslavia, two attempts at using advanced coal technology have been made. First, a gasification plant in Kosovo has been operating for several years, although without any significant conclusions. It is not clear whether the unstable political situation in this region, technical and economical reasons, or simply bad judgment, contributed to this.

A good example of a broadening of established technology is the dredge mining trial designed for the "Kovin" open pit mine. The current activity, lignite dredging from the bed of the Danube within the "Kovin" deposit, has already attracted great interest. The equipment required for the dredging programme is specified, and the testing is scheduled for the beginning of the next year. This trial will allow complete data to be gathered, which will enable the full scale mine to be designed.

As presented to the SynOps conference two years ago, potentially, the most attractive way to utilize these reserves for power generation would be to combine the hydraulic mining technique with hydrothermal processing commonly known as hot water drying, solid concentration, and coal/water fuel combustion.

The Russion CWM programs, both basic and applied, have been in operation for more than 20 years and have involved combuston tests of several different types of coal fueled boilers and furnaces. During the early seventies, the Russians acquired a wide range of combustion experience with CWMs. Particular emphasis was put on the utilization of waste materials from coal beneficiation plants and coke plants. For example, the energy recovered from burning fine coal slurry can be used to run the driers in conventional coal preparation plants.

The main driving force behind the Russian effort has been the lack of accessibility of the vast Russian coal reserves to major population centers. The USSR is believed to possess more than half of the world's total reserves of coal. The high cost of exploiting these reserves and transporting them to distant energy markets has rendered coal an uneconomical fuel for industrial utilization. A great deal of this coal is of low quality, located in thin or steep seams in an Arctic environment, and must be transported over vast distances on unreliable rail systems. Millions of tons of coals are lost in transit every year. If the USSR could remove these logistical bottlenecks and increase its domestic utilization of coal, particularly in the area of power generation, it would free Russian oil and gas production to earn desperately needed currency in world fuel export markets.

This need has stimulated a considerable interest in converting coal into a more readily transportable and conventionally usable liquid fuel. Slurry pipelining of coal is presently regarded by most of Eastern countries, as an extremely promising form of transport. However, the construction of commercial-scale long distance slurry pipelines represents a high capital and technology intensive venture.

The USSR is the first country where an integrated system for the production, transportation by pipeline, direct combustion of CWM in a thermal power station without dewatering, before combustion will be implemented. The location of the project is in southwestern Siberia. The slurry production plant will be built near the city of Bolovo, in center of coal fields of the Kuzbass region. The CWM (3 million metric tons/year of dry coal) will be transported through the 20 in. diameter, 256 km long pipeline to a power station at Novosibirsk.

In the area of CWMs combustion, the Russians have made several notable accomplishments. Experimental research and theoretical modeling work on the mechanism of combustion has characterized the burning process as explosive in character. Coal devolatilization and water evaporation take place simultaneously, and the presence of water tends to accelerate the combustion process. An increase in the particle reaction surface and its activation occur during the initiation stage, and steam-carbon reaction becomes significant during the combustion stage.

Wet grinding using a ball mill has been successfully applied by the Russians in preparing CWMs. They have been able to prepare, transport, and burn 50% CWMs without additives. Mixtures consisting of 66% coal and 34% water have been successfully burned by properly blending coarse coal and fine coal. The Russians also determined that the ash from CWMs combustion is much more friable and benign in character than the fly-ash obtained from combustion of the original coal. This leads to the conclusion that the use of CWMs may mitigate ash fouling, erosion, and slagging of heat transfer surfaces for certain coals.

One way to describe the status of the CWM field is to point out the fact that anyone wanting to use the technology, as a fuel customer or as a fuel producer, can pick and choose between a number of commercial companies for either the whole system or for singular elements. In this respect, the technology in Eastern Europe is considered already commercial. For most of the competing companies the field is, unfortunately, not profitable, hampering further development.

Finally, to summarize the status in Eastern Europe as well as in the other regions: commercial breakthroughs are now imminent. When the breakthrough occurs, many customers now sitting on the fence wanting to avoid the high cost of pioneering, will follow. We believe the CWM technology has clearly passed its "credibility crisis."

<u>The Prospects</u>

Although the situation in the East European countries is more or less the same, prospects seem to vary. There are many reasons for this:

1. In some East European countries coal has always played an important role in energy production. In other countries coal has never been used or ceased to be used when cheap oil flooded the world after the second World War. These countries might be referred to as "new coal countries."

2. The new coal countries are today in an interesting situation. In their technical considerations they are not bound by conventional coal utilization, or by investments made or established by coal consumption habits and constraints. They have the possibility of choosing among a number of new and promising coal technologies. They will, of course, see this as an opportunity to do something better and different than what takes place in those countries using coal in the traditional manner. Initially these new coal countries will probably advance the state-of-the-art of coal utilization.

3. The East European countries have different industrial traditions, and this will, to some extent, determine their preferences in choosing their own particular new technologies.

4. Many East European countries differ drastically in how they require their primary energy. This leads to quite different energy transmission and consumption infrastructures, which in turn determines to what extent the demand for coal fuels comes from large or small facilities, which fuels have to co-exist and be switched in particular plant, and to what extent coal using plants and situated in urban areas. The characteristics of the infractructure are quite important for the prospects of Coal Water Mixtures.

5. Dependance on imported oil and gas is a major predicament for some countries in Eastern Europe, but certainly not for all. Those countries that share the predicament of import dependence have different strategies for developing new primary energy sources. Some countries see coal as their logical first choice; others see it as a last resort. The first group has introduced government incentives to stimulate and speed up the introduction of new coal technologies and increase the use of coal. Other countries have increased the taxes on coal to slow down the introduction of coal use that would otherwise inevitably occur.

6. Energy production in Eastern Europe has changed. Oil consumption has been stimulated, gas is becoming much more important energy source, and use of nuclear power and coal generation of electricity has been increased. The influence of these changes, as well as more efficient energy consumption, are still being felt. The energy sector in Eastern Europe is in a transitional phase, but most energy sources today come with advantages and disadvantages. The Nuclear energy is associated with radiation, oil with price volatility, coal and gas with carbon-dioxide and other pollutant emissions.

7. The difference in price between coal and oil is perhaps the single most important factor in the commercialization of CWMs. The differential varies geographically and with time, and seems to be due to regulation of prices for oil and natural gas, sulphur emission standards and fuel import factors. The price differential determines the investment pay-off time for conversion of an oil fired facility. Price differences lead to variations in the pay-off time from less than a year to more than five years. In reality, this means the difference between an investment attractive enough to offset the considerable technical risk, and an investment which is not feasible.

8. To all this has to be added the immense influence of the mass media and their impact on the energy markets. Today most market information is accessible to all interested parties in the world almost immediately. This means that reaction time is far shorter, and that the various energy markets are interconnected and directly influence one another.

The Market

The CWMs market is not one but several markets. A breakthrough in one area will not necessarily have positive consequences in another, and some markets may never be penetrated.

The first large-scale commercial applications will probably be CWMs applications in industrial boilers where energy cost is crucial for the competitiveness of the product, and where emission problems or processing restraints may not be so acute. Cement furnaces and glass furnaces are examples of this category. Another market of early interst will be steam generation in the chemical industry.

The electric power industry obviously represents the most significant market. European studies continue to show nuclear energy as more competitive, with cost difference varying between countries. Coal's advantage may lie in less easily quantified problem areas in the nuclear industry such as the lower output ratings, arising from faulty operation reported in some East European stations; the economic concern about wholesale plant shutdown if serious problems are discovered; uncertainty over fuel costs; reprocessing and disposal of spent fuel; and plant decommissioning. Basic decisions about nuclear power expansion, which currently are stalemated, will be made in the next decade by a number of East European countries and this will clearly affect coal's prospects.

The high requirements in reliability and long-term performance that traditionally apply in this field slows the introduction of CWMs in