The Economic Case for Industrial Application of Low-Rank Coal Technology

By:

W. Irwin
International Coal Preparation Consultants Limited
Calgary, Alberta, Canada

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INTRODUCTION

Public attention is today firmly focused on the impact all industrial activity has on the environment, and the "greenhouse effect" attributable by environmentalists to the burning of fossil fuels is a topic of worldwide interest. Coal is singled out from other fossil fuels as being the product of a tired, old, out-dated and inefficient smokestack industry. This is a distorted view which does not reflect the advances made in new clean coal technologies, and improved methods of combustion.

Despite coal's environmental problems, it is unrealistic to suggest that this fossil fuel should not be a primary energy source. Coal remains the world's favoured choice of energy and to argue against the use of coal, is flying in the face of reality. Coal already generates 47% of the world's electricity, a rapidly expanding coal market.

The World Coal Institute estimates coal should overtake oil as the world's largest source of primary energy by the turn of the century. Current world coal production of 3.6 billion tonnes in 1990 is predicted to rise to 4 billion tonnes by the year 2000.

It is conceded that a major environmental problem with burning coal is the so-called "greenhouse effect". The question is how do you use the new technologies that have been developed which now allow coal to be burned with minimum damage to the environment.

Despite their technical merits, acceptance of these new technologies is slow because they appear uncompetitive when compared with historic energy costs. Unless economic comparisons include some form of environmental evaluation, this issue will continue to be a barrier to progress. To avoid stagnation and provide the necessary incentive for implementing badly needed change, structural changes in energy economics need to be made which take into account the environmental cost element of these emerging new technologies.

TRADE

Because low-rank coals were not considered a vaible proposition in distant markets, their utilization has until recently been mainly confined to generating electricity at the mine mouth. That situation is beginning to change and when viewed against the background of universal trends in coal markets, the long-term trading prospects for these coals is now more promising.

In this regard, the U.S. has in recent years become a swing coal supplier as the Eastern U.S. bituminous coal producers with secure internal markets, move in and out of the export trade as prices warrant. This trend seems to be spreading Westwards as the recently developed large production base of low sulphur and very low cost sub-bituminous coal begins to be attractive for international trading. However, this flexible export situation may change within the next 2 to 3 years with the enactment of the Federal Clean Air Legislation. Internal U.S. demand for low sulphur coals may effectively remove those supplies from world markets with major implications for the international price of low sulphur coals.

International trade in steam coal which only took off following the first oil crisis in 1973, is rapidly expanding as coal replaces oil in electricity generation markets. The U.S. National Coal Association forecasts that international trade in coal will increase by an annual average rate of 2.8% between now and the year 2000, reaching 488 Mmt in that year. This increase will consist primarily of steam coal for electricity generating markets, and is in line with a series of forecasts of demand for seaborne coal, published by other sources.

World Coal Production Trends between 1973 and 1989 are shown in Table 1 and World Seaborne Coal Trade from 1973 is shown in Table 2.

TABLE 1

WORLD COAL PRODUCTION TRENDS
(million metric tonnes)

Year	1973	1980	1983	1984	1985	1986	1987	1988	1989
Tonnes	2181.5	2725.7	2827.1	2964.2	3127.4	3205.9	3287.7	3371.4	3425.8

Source: IEA Coal Information 1990

TABLE 2

WORLD SEABORNE COAL TRADE
(million metric tonnes)

Year	Annual Trade	
	Coking Coal	Steam Coal
1973	87.0	19.0
1979	104.0	53.0
1980	114.0	74.0
1981	122.0	86.0
1982	120.0	89.0
1983	112.0	88.0
1984	131.0	104.0
1985	141.0	133.0
1986	138.0	138.0
1987	142.0	141.0
1988	148.0	157.0
1989	150.0	170.0
1995*	132.0 - 155.0	209.0 - 279.0
2000*	112.0 - 163.0	263.0 - 432.0

* Forecast range from various sources (IEA Coal Information 1990).

While this marketing development is relevant to the Western U.S. low-rank coal industry, it is of little relevance to other U.S. low-rank coal-fields. For instance, it is of little relevance to Alaska which has almost half of the entire U.S. coal reserves. Mainly sub-bituminous with typical sulphur contents of 0.2%, Alaska's coal resources remain largely unexploited because that State is sparsely populated and lacks the infrastructure to economically transport such coals to distant markets. This situation highlights the need for the industrial application of new/advanced coal technologies. Unless such environmentally attractive, but remotely located coals can be commercially exploited, there is a danger that the energy supply and demand situation could become unbalanced when high sulphur coals are mandatorily excluded from the energy mix.

In terms of coal utilization, it now seems clear that in the final analysis, environmental considerations will determine the acceptability of a coal for use as a fuel. Low sulphur and excellent combustion characteristics are features of low-rank coal which are likely to become acceptable trade-offs against the higher heating value of their bituminous coal counterparts. The U.S. has enormous reserves of these low sulphur coals. From an environmental point of view it becomes a matter of accepting that improving the environment can only be achieved at a cost. When measured in these terms, maximizing their utilization makes economic sense.

QUALITY

While quality (primarily low heating values) is a major marketing problem with low-rank coal, other factors also effect its acceptance in the market place. It is important to recognize why this is so and how improvements can be achieved.

Firstly, the physical structure of low-rank coal is quite different to that of higher rank bituminous coal. This difference is sharply reflected in the behaviour of low-rank coal during its handling and storage. In general it is not as stable as bituminous coal. Its stability problems occur because its porous nature and resultant very high moisture content cause early weathering, resulting in rapid size degradation.

Secondly, all low-rank coals are highly reactive with very low fuel ratios. The latter is a parameter defined by the ratio of Fixed Carbon to Volatile Matter. This aspect when coupled with that of porosity gives rise to the risk of spontaneous heating.

The quality related problems of stability and spontaneous heating can now be overcome by new technologies developed specifically for low-rank coal. Actual quality control of low-rank coal requires a unique approach because unlike bituminous coal, beneficiation of low-rank coal essentially necessitates only the removal of moisture in order to increase its heating value. Its sulphur content is usually below compliance limits and its ash content normally within acceptable levels.

However to be effective, moisture removal must be permanent. This rules out the use of conventional evaporative drying processes since their drying temperatures are too low to cause permanent changes in the coal structure. In practical terms, the dried coal behaves like a sponge which when re-exposed to humidity or water merely re-absorbs moisture. It suffers the further disadvantage that after drying, the dried product becomes more susceptible to spontaneous heating and also size degradation.

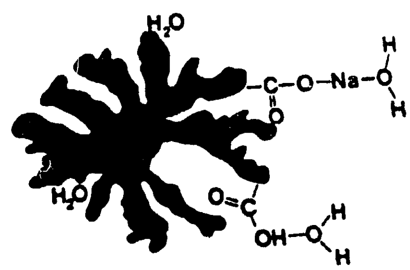
To be effective therefore, beneficiation needs to be via. a drying process which fundamentally changes the coal's structure in order to reduce or eliminate its moisture holding capacity. This is now made possible by hydrothermal treatment (hot-water-drying) as shown in Figure 1, a unique non-evaporative drying process which induces coalification in a condensed time scale of minutes rather than millions of years. The process alters the hydrophillic nature of low-rank coal by changing it into hydrophobic material that has equilibrium moisture levels

HYDROTHERMAL TREATMENT PROCESS

RAW COAL

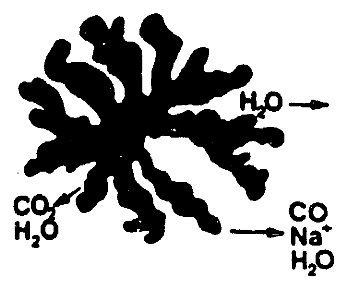
Water exists in coal as:

- Free surface water.
- Capillary water in pores.
- Chemically bound water.



HYDROTHERMAL TREATED COAL

- Water expands out of pores.
- Destruction of carboxyl groups releases carbon dioxide and associated cations, which reduces the number of hydrophillic sites.



- Tars form and migrate to the surface where they plug micropore entrance.

FIGURE 1 - HYDROTHERMAL TREATMENT PROCESS

similar to those of bituminous coal. Technical feasibility has been demonstrated in a 7.5 tpd pilot plant at the Energy & Environmental Research Center, University of North Dakota, and the process is now at the threshold of commercialization.

TECHNOLOGY

Development of clean coal technology to allow coal to be burned cleanly has been concentrated in three main areas. These are listed below, followed by a descriptive account of the influence each has on the technology.

- *Coal Preparation*
  Techniques to remove or reduce ash and sulphur levels in the coal.

- *Combustion*
  Methods to minimize the formation of free sulphur dioxide and oxides of nitrogen.

- *Flue Gas Treatment*
  Treatment of the flue gases after combustion to prevent the emission of particulate matter and SO_2.

Coal Preparation

The range of coal preparation techniques now available include deep cleaning which requires the coal to be finely ground. Unfortunately for practical reasons, the use of this technique is restricted to treatment of the natural fines, in the raw coal. It cannot be applied to run-of-mine coal because the resultant clean coal product in the form of fines cannot be handled and transported in existing dry bulk coal facilities. The technique can however be employed, if the clean coal product is handled and transported in a quasi-liquid form as a coal-water-fuel for use as a direct replacement for oil in industrial and utility boilers.

Of all alternative coal-based fuels developed to meet the future energy needs, coal-water-fuel is the most promising. In this connection, there is some evidence that Japan is abandoning its costly coal liquefaction program in favour of the much cheaper CWF technology. Having recently initiated international trade in coal-water-fuel, Japan, already the world's largest coal buyer and pioneer in their development, has now included CWF in its future energy mix, a clear sign of the importance attached to this new fuel. Figure 2 shows a commercial operation for the manufacture and utilization of CWF in Japan. A proposal for the implementation of a similar but smaller commercial scale CWF demonstration project, is currently under consideration in Alaska. The aim of the project is to establish the economic case for producing an Alaskan coal-water-fuel for the emerging Pacific Rim CWF market.

This new market for coal allows it to enjoy the economic benefits of low cost liquid storage and handling systems. The ease of handling and convenience of being able to move coal in a quasi-liquid form, greatly enhances its competitiveness, particularly when it is produced from low-cost, low-sulphur, highly reactive low-rank coal. Until the development of hot-water-drying, the high moisture content of low-rank coal was a constraint to its use as CWF feedstock. As a consequence, transportation options for remotely located deposits of low-rank coal, now include long distance pipelines which offer the potential for their exploitation and utilization in distant markets.

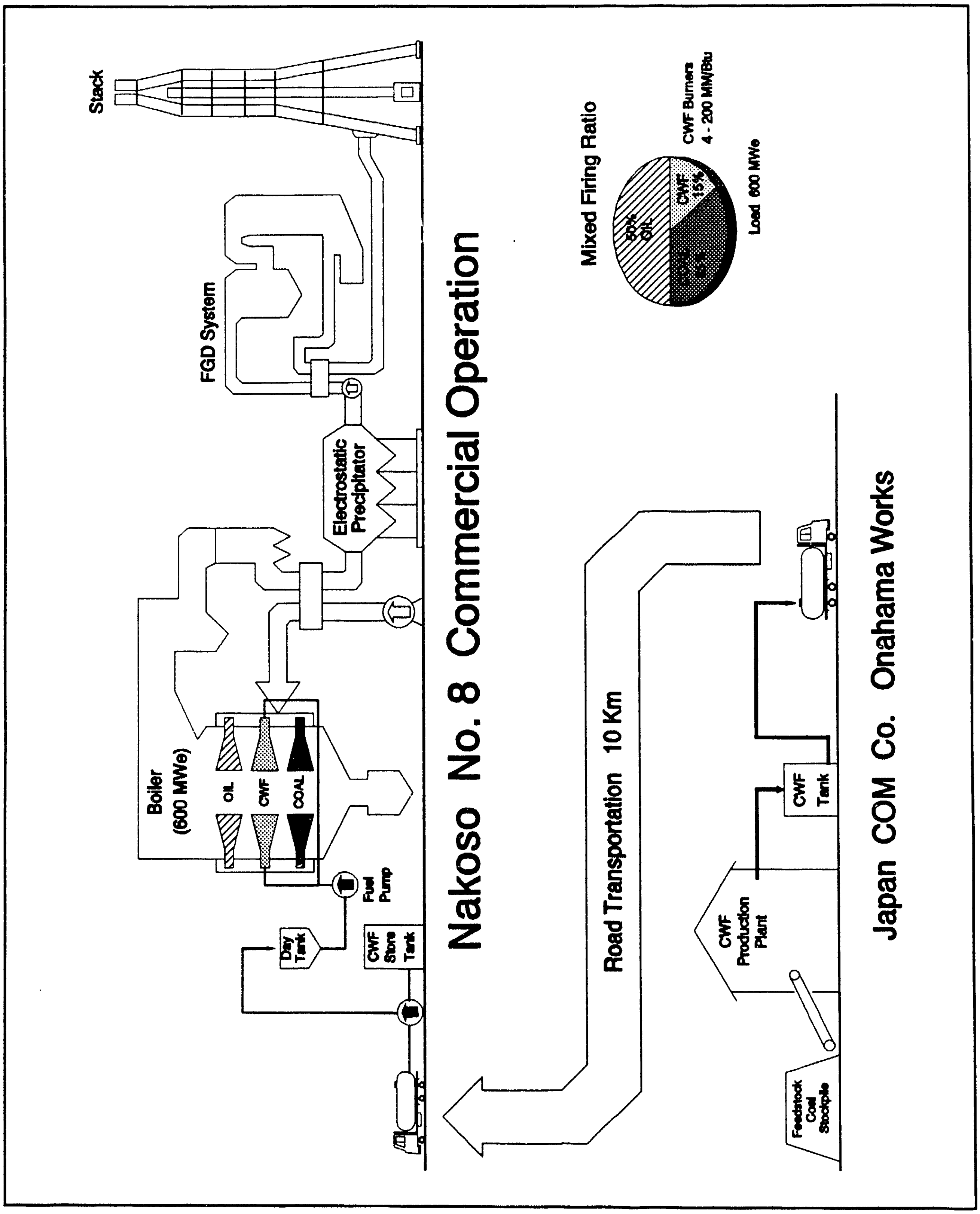


FIGURE 2 - MANUFACTURE & UTILIZATION OF COAL-WATER-FUEL

It is worth noting that hot-water-drying, which enables the range of CWF feedstock to be extended to include low-rank coals, is an exclusive U.S. developed technology.

Combustion

Perhaps the greatest progress in burning coal cleanly is being derived from advanced combustion technologies developed for that purpose. In this connection, combustion characteristics on a coal specific basis, are now receiving priority consideration (previously they were secondary to quality) and should be viewed as being a key factor.

Low-rank coal is particularly environmentally attractive because it possesses most of the characteristics that are a pre-requisite for trouble-free burning at the boiler front. It ignites more easily, burns faster, and is usually much lower in sulphur than bituminous coal. Because of its fuel ratio, it is highly reactive and good combustion efficiency is achieved with maximum carbon burn-out. From a combustion point of view it has been established that smaller particles of coal burn significantly cleaner and more efficiently than larger particles. In general this principle is followed in most of the new combustion technologies and these conditions are also ideally suited for the utilization of coal-water-fuel.

Flue Gas Treatment

The treatment of flue gases after combustion virtually ensures all particulate matter is removed. This is also the major method for preventing a high proportion of sulphur reaching the atmosphere as SO_2. Flue gas desulphurization (FGD) is established technology now in successful operation at large coal-fired power stations in many countries. In the case of low-rank coal, their combustion efficiency (which results in high carbon burn-out) and their low sulphur content, are environmental attractions in their favour because the need for installation of costly FGD facilities, is avoided.

ECONOMICS

Due to the relatively tighter supply conditions which have characterized coal markets since late 1987, international steam coal prices are on a rising trend. This situation reflects the higher demand from electric utilities as well as a constrained supply position. As a consequence of these circumstances, international trade in steam coal is rapidly expanding, a trend which energy planners forecast will continue through the turn of the century. Although the U.S. is a swing supplier in this market, hardly any of its coal mines are dedicated to export. U.S. coal producers with a secure domestic market have moved in and out of international trade according to the demand and price of coal. However, the U.S. internal supply and demand situation will in future be significantly affected by environmental legislation as the increased demand for low sulphur coal gains momentum. This will require changes in the present pattern of coal production which continues to be heavily based on mining a large proportion of high sulphur coal. While clean coal technologies may allow some of these high sulphur coals to continue being utilized under the new legislation, they are not a universal solution.

In contrast to its dearth of low sulphur bituminous steam coal, the U.S. has substantial reserves of low sulphur sub-bituminous coal. These sub-bituminous coals can not only meet environmental needs, they will also become more economically attractive as their market value increases.

Replacement of high sulphur bituminous coal with low sulphur sub-bituminous coal in the domestic utility market, will create supply and demand changes which in turn is likely to cause a steeper rise in the international price of low sulphur steam coal. Since low-rank coals are currently at the bottom of the price range, any price increase should compensate for the cost of applying new beneficiation techniques such as hot-water-drying. This is a luxury previously denied these coals which until now have been sold, untreated.

It is suggested that the environmental needs alone, is sufficient justification for the industrial application of these new low-rank coal technologies. Enactment of clean air legislation carries a cost penalty which can only be absorbed by a structural change in energy economics in order to reflect the environmental cost element. While evaluation and assessment of this element may be complex, future energy cost comparisons must take this penalty into account. Indeed under a changed coal regime, a premium for the price of low sulphur coal makes economic sense.