## Coal: The Abundant and Competitive Fuel for the 21st Century

*by Robin J. Bennett**

As economists and businessmen, I know you will fully appreciate that the evaluation of the supply prospects for anything as important as a source of primary energy must take into account not only the short and medium term unit price, but considerations of *long-term* availability, reliability, flexibility and security of supply as well as total costs of production and utilization. Today, environmental factors must also be examined.

I hope to demonstrate that coal is abundant, secure in supply, cost competitive, flexible in its applications and freely available to all parts of the world; and that this *traditional* energy source, so long associated in Europe and elsewhere with the first Industrial Revolution and with grime and pollution, is now and will become even more the *fuel of choice* in the next century.

**The Current Position of Coal in the World**

In 1993 – the latest year for which the figures are available – primary energy demand in the world was around 8000 million tons of oil equivalent, (Mtoe), of which solid fuels – predominantly coal – accounted for 2300 Mtoe, or 29 percent.

*Production:* Total world production of *hard coal* in 1995 was around 3590 million tons, an increase of around 1 percent over the previous year.

The biggest producers are:

| | Mil. tons Per Annum |
|---|---|
| China | 1292 |
| USA | 849 |
| India | 233 |
| South Africa | 197 |
| Australia | 196 |
| Russian Federation | 156 |

Other major producers include Poland, Kazakhstan, Ukraine, Germany, the U.K. and Canada. More importantly, there are new, rapidly growing producers such as Indonesia, Colombia and Venezuela.

*Trade:* At present, more than 85 percent of the world's coal production is consumed in the country of origin, but world trade in coal has been growing rapidly over the last 20 years. In 1995 it increased by 8.9 percent to 446 million tons.

The trade in thermal coal has been growing at an average annual rate of 7 percent over the past 15 years to reach its present level of 265 million tons, and in the future will continue to grow at the same rate, or faster. Coking coal trade has by contrast remained fairly static for several years at close to its current level of 182 Mt.

The big three exporters are Australia, South Africa and the USA, with a number of other countries rapidly expanding their share of the growing market. The ranking order of exporters is different according to whether steam or coking coal is considered.

**Forecasts for Future Production and Trade**

By the year 2010, coal production and use are forecast to rise by 47 percent to about 5300 million tons, and by the same year, world trade in coal will have nearly doubled – to 850 million tons. In East Asia alone, excluding Japan, additional imports of around 150 million tons will be required.

**The Abundance of Coal Supplies**

If we look at the picture of world coal reserves, it is easy to see how the expansion predicted above is possible and, more importantly, sustainable well into the next century. The proven reserves of hard coal are between 3 and 4 times as much as the reserves of oil and gas put together. These comparisons are based on proven and *economically recoverable* reserves, using existing technologies and without taking into account developments which could increase the recovery ratio and/or can enable inferior quality coals to be used efficiently in the future.

These figures ignore brown coal and lignite, of which the reserves are equally massive. These fuels are not normally traded over any appreciable distance because of their low calorific value per ton, but new mining techniques leading to extremely low costs of extraction – under $4 a ton in some cases – may make exports viable or may justify the generation of electricity on the mine site and its subsequent long distance transmission.

**Security and Flexibility of Supply**

The above figures clearly demonstrate the abundance of coal, but of equal importance are the security and flexibility of supply that coal offers.

*Distribution:* Unlike oil and gas, coal is produced in around 50 different countries, spread over all 6 continents. The reserves also are distributed widely in all major regions of the world. The comparison with natural gas in particular is stark.

Seventy percent of all natural gas reserves are located in the Middle East or in the former Soviet Union, where they mostly lie more than 4000km from their major domestic and export markets. The reserves of coal are widely distributed around the world and the major exporting countries have well established and politically stable governments.

*Transportation* is also secure. Ninety-five percent of internationally traded coal is shipped directly through international waters from the exporting country to the consuming country. Long distance gas pipelines, by contrast, may have to cross several other states lying between the exporter and the consumer. Moreover, if a single coal-carrying vessel sinks, it might cause a temporary problem for one consumer, but if a pipeline is fractured or closed for any reason, it could be a disaster for the whole market.

*Competition:* Security of supply is further enhanced by the intense competition which characterizes the international coal market. If one coal supplier experiences production or even financial difficulties, many others in the same or in other regions can replace the lost tonnage.

The coal industry has no equivalent to OPEC – prices are freely determined in the market place, which has ensured price stability for 30 years.

*Flexibility:* Modern coal production techniques enable producers to increase or temporarily decrease production at

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short notice without major difficulties. Unlike the traditional deep mine production in western Europe and parts of North America, where extraction takes place below the water table, and mines must be either kept open or totally abandoned, it is quite feasible to cease production for months or years at the modern, open-cast mines in other continents, without damaging the capital equipment or jeopardizing the accessibility of the reserves. This ability to adjust capacity to changes in the market, together with the ability to stock-pile coal at the mines, ports or consumers' site, facilitates flexible supply contracts.

There is no such thing as a 'take or pay' contract in the coal industry. In this way consumers can adjust their demands according to their needs and their finances, both in the short and medium term. The disequilibrium which arises from time to time in the gas supply industry is not a problem for today's coal industry.

**Coal is Competitive**

I hope that by this point I have demonstrated to your satisfaction that coal is an abundant, secure, reliable and flexible source of primary energy. But for economists, I realize that this is not enough! You will want to hear that the final cost of the coal – both the purchase price and the capital costs of the equipment to burn it – will not be uncompetitive now, or unstable in the future.

*Mining Costs:* Coal mining is capital intensive and, relative to oil and gas, is also labor intensive. However, market pressures and technical innovation have enabled the industry to reduce the cost of coal in real terms over the last twenty years. This has been achieved at existing as well as in new mines.

First, labor productivity has increased steadily in all major coal-exporting countries, particularly since 1980. These improvements have been made both in countries with high wage costs – Canada, USA and Australia, and with much lower wage costs – Colombia and South Africa. The labor cost per ton of output increased somewhat up to 1990, but is now trending downwards again as the rate of productivity growth exceeds wage inflation – this is particularly noticeable in Australia and the USA.

Of course, the development of new mines and new coal measures has been the key contributor to the improvements in labor productivity and the reduction in the total costs of coal. In the oil and gas industries, new reserves tend to be found further from the markets, and/or deeper under the ocean, and so require major capital investment on equipment and pipelines. Frequently extraction costs are higher. By contrast most of the recently established and fast developing coal fields in places such as Colombia, Indonesia and Australia enjoy extremely favourable geological conditions. Normally, extraction costs, even including infrastructure costs, are lower than in existing coal fields.

Much of modern coal mining is more like an earth removal operation than a traditional underground mine. Not only is the coal easily accessible, with relatively small amounts of overburden – a low strip ratio – and, therefore, high yields of saleable coal, but the seams themselves are extremely thick.

*Transportation costs:* While the capital and current production costs and hence ex-mine prices of coal may be expected to continue to fall in both real and money terms, it is more difficult to secure economies in transportation costs, particularly where rail transportation is used to bring the coal from the mines to the ports.

*Ocean freight costs*, while fluctuating considerably with market changes in the short-term, have tended to decrease or at least remain stable over the last 20 years. This is due partly to the excess shipping capacity available and partly to economies of scale from the increase in size of bulk carriers and the terminals at which they are loaded and discharged. Similarly, the handling costs of coal at these terminals has been brought down by revised work practices and massive investment in new equipment.

Nonetheless, transportation and handling costs together account for more than 50 percent of the total CIF value of coal and an even higher proportion of the final works delivered price, depending on where the end-user is located relative to the port. For example, coal loaded into rail cars at a mine in Australia for $20 a ton, faces a total of $10 for rail and loading costs and $14 ocean freight to Europe, so that 55 percent of the CIF price of $44 per ton is transportation. For some American producers the situation is even worse – an ex-mine price of $16/ton may result in a CIF Rotterdam price of $43, of which 62 percent is transport.

Some new coal fields are close to export ports which are, of course, built to the highest standards and enjoy the lowest costs, but transportation will remain a significant constraint on the ability of the coal industry to reduce its prices to the consumer in the long run.

*Average Prices:* The delivered prices of imported steam coal in the major markets of Europe and the Far East have not changed significantly since 1980. In Italy, for example, the delivered price to power stations averaged around $60 per Ton of Coal Equivalent (7000 kCal/kg), roughly equivalent to oil at $85 per ton, or $12 per barrel. During the period the price fluctuations were seldom more than $10 per Tce. At the same time natural gas prices to Italian power stations ranged from a high of some $160 per Tce to a low of about $60 but in only one year (1988) did it fall below the coal price and was on average some $20 or 33 percent higher.

The current downward trend in gas prices, based on a temporary surplus of gas, may tempt some power utilities to move to gas for new and replacement power stations, especially as capital costs are less. The long-term cost trends are likely to point in the opposite direction.

**Coal Demand - the Electricity and Steel Industries**

*Electricity:* Nearly 60 percent of all coal mined in the world is used for electricity generation. This proportion is predicted to remain stable or to increase in the world as a whole over the next fifteen years, despite the major inroads into coal's share of the electricity market made by natural gas, particularly in Europe.

Looking further ahead, we may see the share of coal going either way. If major developments of renewable energy sources become available at a sensible cost towards the middle of the next century, the share of all fossil fuels, perhaps coal in particular, in the electricity generation market will tend to decline, the more so if the theory of global warming is widely accepted and pressure to reduce greenhouse gas emissions becomes part of government policies world-wide.

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An alternative possibility is a rebirth of nuclear power on a much lower cost base than hitherto, and with the problems of waste disposal and public acceptability solved.

However, by that time, the total amount of coal used for electricity generation will have increased in line with the total demand for power. Coal production will have increased to more than 50 percent above current levels, and coal trade more than doubled.

*Iron and steel:* Although only about 13 percent of coal is currently used in the world steel industry, 70 percent of steel production is dependent on coal, mostly after its transformation to metallurgical coke. The death of the blast furnace/coke oven route for iron and steel making has been predicted ever since I joined that industry in the early 1960s, but the much vaunted new technologies for the direct reduction of iron ore have so far made only a negligible dent in the steel industry's requirements for coal. There has been a considerable reduction in the amount of coal used to produce a ton of iron, but this has been achieved largely by the introduction of Pulverised Coal Injection (PCI), which uses a cheaper steam coal to replace some coking coal. Overall, every ton of steel produced from iron ore rather than from scrap requires about 630 kg of coal of one sort or another. The dramatic sight of coke being discharged from the ovens will still be a feature of the steel industry for many years to come.

**Environmental Factors**

Coal suffers unjustly from a very bad image - the environmental effects of coal mining and particularly of coal use were extremely damaging in the past, but most of the effects are now in the past.

*Mining:* The results of mining were all too often despoliation of the landscape by waste heaps and, in the case of open-cast mining, the ruination of areas of countryside and the displacement of local people. Except in one or two isolated cases, this is no longer a problem. Although most of the major new mining developments in recent years have occurred in areas of low population density, virtually all governments now require full rehabilitation of mine sites, which begins even before mining is completed.

Coal companies work closely with governments and with local communities to ensure minimal impact on the environment to avoid not only the visual effects but also the emission of dust or fumes.

*Transportation:* Coal transportation by rail or by road, is now managed in such a way as to eliminate spillage of dust. The same applies to the loading and discharge of coal vessels. Coal shipments on the open seas constitute no environmental hazard and are completely safe. If a coal ship were to sink, the environmental damage is minimal - unlike the enormous problems that result from oil tanker disasters and consequent pollution of the sea and shoreline.

There are also no recorded instances of serious explosions or fires caused by the handling or transportation of coal. Coal is thus a safe and clean material to produce and to transport.

*Coal Utilization:* Most of the environmental arguments against coal focus on its use. There is no doubt that the direct burning of coal by households was responsible for much of the grime on European and American cities, the infamous smog, and for various diseases and other health problems this caused. This use of coal is declining very fast in Europe and has virtually disappeared in most other regions. The emissions from power stations, cement works and other large industrial plants are now the principal environmental concern but much of this concern is now unjustified. Over the last 20 years, the emission of particulates in the form of black smoke has been almost entirely eliminated - the white plumes seen at the tops of power station chimneys and cooling towers are merely water vapor which disperses harmlessly and quickly.

The other, less visible, problems are emissions of sulphur dioxide ($SO_2$),and oxides of nitrogen ($NO_x$), which are believed to cause acid rain.

These emissions are now being reduced everywhere by the use of lower sulphur coals, flue gas desulphurisation (FGD) and the installation of low-$NO_x$ burners, all of which can reduce $SO_2$ emissions by up to 90 percent and $NO_x$ emissions by more than 50 percent. Selective catalytic treatment can reduce $NO_x$ emissions by 80-90 percent. New power stations currently being built and commissioned utilize new clean coal technologies, such as various forms of fluidised bed combustion (FBC), or gasification systems like the Integrated Coal Gasification Combined Cycle (IGCC) which emit negligible amounts of $NO_x$ and collect virtually all the sulphur in a useable solid form.

These and other advanced combustion technologies also increase the thermal efficiency of power stations, hence improving economic performance and emitting less $CO_2$ per unit of electricity sent out. This is important if $CO_2$ reduction becomes a priority due to fears of global warming in the future. In fact, the average efficiency of coal-fired plants has increased immeasurably in this century, from below 5 percent at the beginning of this century to 35 percent now. This figure is likely to exceed 45 percent within 10 - 15 years, which will result in 23 percent less carbon dioxide entering the atmosphere for each Kwh generated. Whether or not the global warming theory proves to be correct, these improvements will reduce the cost of generation and help to conserve fossil fuel reserves.

**Conclusions**

Due to the high growth rates forecast for primary energy demand, there is room in the world market for greater volumes of both gas and coal.

In the longer term, coal offers greater security of supply, both physically and commercially, at stable prices.

Fuel costs account for 60 percent of total generating costs at gas-fired plants, as against 40 percent at coal plants.

The longer the period of power station operation, the lower is the capital cost advantage of gas - historically and currently, the life of coal-fired plants is more than 30 years.

The world economy cannot grow without energy - without coal, the energy requirements of the developing countries cannot be met.

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