Keynote Adress: Coal competitiveness and energy alternatives

by G. Broadbent*

It is an honour to be invited as a speaker to this ICCR conference and a pleasure to be with you here in South Africa. I have been asked to talk about the competitiveness of coal versus other energy alternatives.

Coal supplies nearly one-quarter of the global primary energy. Its most direct competitors are gas, nuclear and renewables. Oil is predominantly for transport fuels. Fuel oil is competitive with coal when crude is below its long-run average price and has some niche opportunities. But I will confine my comments to nuclear, renewables and particularly natural gas as the most potent current competitive threat to coal.

Competitiveness is more than just cost and price; there is environmental acceptability, security or reliability and increasingly image. These factors are more of a spectrum than discrete issues. Dollars and cents remain the key issue for competitiveness but one must recognize the impact of politics in sustainable development and energy security.

Let us look at the competitors to steam coal for electricity generation starting with nuclear power. This bar chart of the U.S. Energy Information Administration summarizes conventional wisdom. It shows a declining share of the world's power. Plant retirements are expected to produce net reductions in nuclear capacity in most industrialized countries. With few exceptions like France, public opposition to nuclear power is strong. In addition liberalized markets have raised the investment risk and the progress down the cost curve will be slow without a strong demand for new capacity and a competitive nuclear construction business.

Nuclear power is nevertheless a strong competitor to coal. For example in USA in 1999 nuclear power was up 8% and achieved a record of nearly 20% of U.S. power generation. Utilization was at an all-time high of over 85%. The high original capital is a sunk cost whether the capital is already amortized or whether the operation has effectively gone broke and been restructured without the original debt. We should not be surprised by the view heard from Electricité de France that existing nuclear plant will have a safe life of 50 to 80 years. One can envisage a higher maintenance budget replacing nearly everything in rotation. But for some like Vattenfall's Ringhals plant, the power prices are now too low to justify a major modernization.

For the medium term we cannot rule out nuclear competition with its low cash costs and for the longer term nuclear power has potential as a CO_2-free alternative to fossil fuels. The environmental acceptability and image are poor today, but nuclear still scores well on cash cost and security of supply.

I found it difficult to separate realistic forecasts from political targets for renewable power. Whilst fossil fuel prices remain low renewables will have a difficult time competing. Even with the programmes which mandate a share for renewables the EIA's forecast to 2020 shows a static (8%) share of total energy consumption. In industrialized countries hydro power is reaching its natural limits and some dams are even being dismantled for environmental reasons. In newly industrializing countries most notably China there are major and controversial projects like the 18 gigawatt Three Gorges Dam on the Yangze River. Even if this project stays within its \$24 bn budget it will not be cheap power. In other areas like Latin America low rainfall and an excessive dependence on hydro power has led to a policy switch to fossil fuels. Where coal is available like in southern Brazil, coal has an important advantage in balancing hydro power supply in that it has no foreign exchange consideration or the take-or-pay provisions associated with an international gas pipeline.

The more important renewables besides hydro are wind, biomass and municipal solid wastes. The driving force is normally policy and costs are still only made competitive by artificial means. A reserved market share is a decisive competitive advantage and their importance in the greenhouse gas issue make renewables a competitor to be feared despite indifferent economics and environmental credentials.

In recent years the most successful competitor for a share of the global energy markets has been natural gas and it is against gas that we need to consider coal's competitiveness most attentively. Conventional wisdom says that gas consumption will double in the next 20 years and its share of the power sector will grow from about 20% to over 30% at the expense of coal and nuclear. Gas reserves have doubled over the last 20 years and are expected to continue to grow with the stimulus of technology improvements and higher prices. Is this rosy picture in the conventional wisdom for natural gas really valid and should the coal industry fold its tent and retire? Perhaps not! Let me explain why I think the competitive case for gas is overstated.

Let us look at the geographic distribution of reserves of oil, gas and coal. The growing dominance of the Middle East in the reserves of oil is widely appreciated but it is not so widely recognized that half the world's gas reserves are in two countries Russia and Iran whose major players Gazprom and the National Iranian Oil Company have a cooperation

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agreement between them. Coal in contrast is more widely distributed with a much higher incidence in consuming countries.

Gas is to be found mainly in locations distant from consuming markets. Siberia and the Caspian region of the Central Asia are the two most prolific areas for natural gas reserves. For western Europe (and probably China and East Asia in the future) it is not a question of whether there will be a sufficient supply to meet the projected demand for imports; it is a question of who—if anyone will invest the $100–200 billion on the supply infrastructure in this decade mainly from Russia but also from Central Asia, Iran and Algeria. The gas experts say no one will without higher prices and secure off-take agreements. Putin's Russia may be a more friendly investment climate than Yeltsin's, but it is still hard to see such an investment can be made in time to meet demand.

North America is slightly different but it is still a question of the level of investment in production and infrastructure. For North America there is also the question of potential reserves and the price of gas for sustainable supply at a much enhanced level. To take one important example, Alberta has supplied about half the growth in the U.S. consumption for the past ten years and during the past five years Alberta's proven reserves have fallen 20%.

For much of the rest of the world pipeline gas is not available and the other option is liquified natural gas. LNG projects abound Indonesia, North West Shelf, Nigeria, Qatar, Trinidad to name but a few, but they all have in common a high cost of landed regassed LNG.

Gas supply will be more expensive or less secure and possibly both.

If we look at the major energy import region of western Europe it is not the cost of local supply or the average cost of supply that determines the gas price, it is the cost of the marginal supply. As import demand rises the supply comes from a more distant/more expensive source that is provided someone has made the investment in pipelines and supply in good time!

Gas supply is a classic example of a long lead time capital intensive commodity with an inelastic supply. With premature investment experienced in the mid-1990s the marginal cost was exaggeratedly low, but if demand increases in a tight market the price rise will also be exaggerated.

For any commodity it has always been difficult to generate shareholder value from the investment in new greenfield capacity unless there is unique competitive advantage. This can be from existing infrastructure, location, natural resources, subsidies but often derives from a technology breakthrough. There has just been one of those unique breakthroughs-the technology for combined cycle gas turbines and the fierce competition that has reduced the cost of this technology. There is a rush to invest until the return equals the cost of capital; this occurs when the demand for gas turbines drives up to cost of turbines and the demand for gas drives up the price of gas. It remains to be seen how far the higher prices stimulate supply.

The deregulation of the power industry in many countries has been a further stimulus to investment in CCGT. The risks in building new power capacity have risen, so there is a strong incentive to go for CCGT as the least capital intensive option and the shortest build time. Gas is capital intensive up-stream, but this is not of direct concern to a power company. Coal and nuclear are capital intensive at the generation stage, but not for the fuel. Ironically the other side of this coin is that in a deregulated gas market it is much more difficult to justify major upstream capital projects for gas supply without take or pay contracts or other structural incentives.

To return to my price elasticity we seem to near the point where the price goes rapidly from the bottom of the chart to the top.

I have talked about the competition, let me now put coal in the context of its rivals.

Firstly the coal business is predominantly made up of local regional markets. International trade of 524 million tons only represents about 14% of the total hard coal consumption. International trade in gas is about 20%. Although this coal trade is limited it is sufficient to create a consistent global price structure. The main coal deficit areas of Europe and east Asia are supplied predominantly by seven countries.

These seven coal exporting countries supply nearly 90% of the 334 million tons of steam coal trade. In practice the coal buyer's choice of supply may not be much greater than his colleague buying gas.

Some of the indigenous sources of supply are in long-term decline. W. Europe, Russia, eastern Europe or Japan, Taiwan and Korea have weak economics propped up with state subsidies.

The evidence is that as local supply declines the vacant market share is picked up partly by imports and partly by other fuels. This decline in local supply of coal in some regions has undermined the powerful competitive advantage from the security of local supply. Japan with its policy of a balanced fuel mix with about 15% from coal has stood against this trend.

The price of coal in local markets is set by the marginal supply, which is usually by import availability. Thus it is the productivity in the main export countries which dictates the price. The trend in output per man over the past two decades is encouraging. The recent evidence suggests that the rate of productivity improvement is accelerating. Market pressures, innovative developments and concentration on bigger operations are all playing a part.

Our recent study of coal export costs shows that the decline in the U.S. dollar cost of coal does not come from mine labour productivity alone; inland freight, loading and ocean freight costs have all contributed. For some sources the fall in the value of the local currency against the U.S. dollar has also had a powerful influence.

The favourable cost developments are not confined to operating costs. The mine investment costs show a healthy decline; on this analysis the average in real 1997 US $. At about $50/ton/year of capacity it shows coal mining is not a capital intensive industry. It is interesting to note that if you include the fuel capital cost including long-distance pipelines for gas you find the capital cost per kw for a combined cycle gas turbine power plant is about the same as for a pulverized coal plant. It is just that the capital is up-stream for gas and down-stream for coal. The capital productivity gains for coal are encouraging, but they probably do not match the capital productivity gains over the past ten years for oil and gas with gains of 50% or more.

Coal has a competitive advantage from its lower capital intensity. It has a greater flexibility of supply. Output can be increased more cheaply and quickly and the penalty for idle capacity is lower. In the short run it is more easily stored. The result is an entirely different price elasticity of supply than gas. Notwithstanding the low prices experienced recently, coal enjoys very stable pricing compared with many commodities. That stability may have looked like a disadvantage when gas was at the bottom of its range but the prospects for coal look good if the gas industry falls behind in its gas supply programme.

I have talked about the gains in competitiveness for coal supply but just as important are the improvements being achieved in coal's use. I show here the improvements in power plant efficiencies for China because it is the most important growth area for steam coal use. But the same trend is to be found elsewhere; more mature economies are further up the learning curve.

New technologies for coal combustion are at the commercial or demonstration stage with high efficiencies. Efficiencies of over 50% are envisaged in programmes in hand in USA, Japan and Europe. The challenge will be to bring the cost per kw into line with the competition.

The technologies for air pollution control SO_X, NO_X, and particulates are already well developed and falling rapidly in cost.

The high CO_2 potential of coal is a threat to its license to operate. However, there are several options for reducing CO_2 emissions compared with a typical power plant (net efficiency 36% LHV). Reductions of 20% are already being achieved using supercritical steam. Combined heat and power or co-firing with biomass could reduce CO_2 emissions by 30% to 50%.

Coal has a price advantage over gas and I expect this to grow in the future. Bur are these factors enough to make coal competitive? I offer you some actual costs at which generating capacity has been built or sold. The value of a power station is reflected by the price at which existing power stations change owners; for example a coal-fired power station in the UK, with FGD and low NO_X burners is 'worth' around US$ 600/kW. In the USA, current emphasis is in life extension or low-cost capacity expansion of existing units but the 'value' of a coal-fired capacity appears to be similar to that in the UK. The higher cost for Millmerran in Queensland includes a 3.6 Mt/y coal mine, but I understand the power plant expansion at Callide will cost only about US$ 550 per kW.

Exploring the competitiveness question further: let me draw on an analysis that is currently in progress at the IEA Clean Coal Centre looking at whether tomorrow's coal-fired power technologies can be competitive. The cost of electricity from a new power station is heavily dependent on the capital cost of the power station. The capital cost of a coal plant that competes with a new CCGT versus the gas-to-coal price ratio. The effect of a carbon tax that taxes CO_2 emissions at $10/tonne. For CCGT a 56% LHV efficiency is assumed with a capital cost of $ 563/Kwe. This is compared with coal at 40% LHV efficiency.

With a gas-to-coal price ratio of 2:1 it shows a competitive capital cost for coal at around US$ 680/kW. This is in reasonable agreement with the data. There are many locations where the gas/coal ratio is higher than 2:1 and coal-fired generation is correspondingly more competitive. However, the competition is not standing still. The next generation of combustion turbines will give a combined cycle efficiency close to 60% LHV. In order to maintain their competitive position, the efficiency of new coal-fired power stations will need to have increased to around 45% LHV with little or no increase in capital cost. For a new coal-fired power station this would require a full project price of below US$ 700/kW at a 2:1 gas/coal price ratio.

Coal is competitive on existing plant but it needs to accelerate technology developments faster than the competition to sustain its future; coal can address its environmental acceptability and coal has an advantage on security/reliability. But coal's image is a more serious problem.

Coal still has a bright future but only with superior technology and improved advocacy. ◆

Another SABS design institute award for the design team of UP*

A design team of the Department of Mechanical and Aeronautical Engineering and LGI won two prizes in the annual SABS Design Institute competition. This is the fifth consecutive year that this design team wins this award, and UP is the only university in the country that has been honored in this way.

The first award was made for their Hip Simulator, a simulator for testing and evaluating hip prostheses.

A second award went to the team for their overwind and underwind protection mechanism. Underwinds and overwinds during hoisting operations in mines have in the past led to serious accidents in which many people have died. Although electronic safety devices exist and are employed routinely, the very aggressive conditions under which they have to operate could lead to failure.

This project set out to find a mechanical underwind and overwind protection mechanism, that would not be subject to invisible deterioration in the aggressive atmosphere in shafts. The designs were tested in a one tenth scaled hoisting simulation, and deceleration forces were found to be within safe limits of 2,5 g for underwinding and 1 g for overwinding.

The design team consists of Danie Burger, At von Wielligh, Rudolf Ottermann, Flip de Wet, Theuns Blom, Willie Vos and Frans Windell. ◆

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