FOREWORD

As the most abundant non-renewable energy source available, coal has traditionally played a major role in ensuring energy security. With reserves geographically diversified across the globe, major exporters in every continent of the world, and a healthy, transparent, highly competitive and expanding international market, international coal prices have had a strong track record of stability, especially in comparison with other fossil fuels.

The importance of coal as part of a strategy of energy diversification was clearly recognised by the IEA with the creation of the Coal Industry Advisory Board (CIAB) in July 1979. This provided for "individuals of a high standing in coal-related enterprises to provide advice and suggestions on coal production, trade and utilisation".

However, future coal use now faces major challenges. The liberalisation of the electricity generating sector, the major customer of coal, and the gas market, coal's main competitor as an input fuel for power generation, is introducing new uncertainties into the coal market. At the same time, the environmental commitments of governments are increasing significantly, especially with the signature of the Kyoto Protocol. The mechanisms to be adopted to meet these environmental objectives are still being elaborated, but it is inevitable that coal, with its relatively high carbon content, faces an increasingly uncertain future.

In this context, the "Future Role of Coal" was chosen as the topic for debate at the 1998 Plenary meeting of the CIAB. In an effort to ensure that the personal market experiences and views of the industry executives were fully aired, CIAB Members were invited to prepare papers to serve as the basis for the Plenary discussion. These papers, together with the debate which followed at the Plenary, raise a number of issues which the IEA believes deserve consideration by a wider audience. The individual insights which they contain are pertinent to the larger debate of how to ensure energy security whilst addressing the important issues of energy market reform and how to internalise in energy prices the real costs of environmental externalities. This collection of papers is published on my responsibility as the Executive Director of the International Energy Agency and does not necessarily reflect the views or positions of the IEA, its Member countries or the CIAB as a collective body.

Robert Priddle

FOREWORD
by the CIAB Chairman
Leigh Clifford

World demand for coal continues to grow steadily, with coal providing fuel for 37% of the world's electricity generation. Coal is a secure energy source, widely available from politically stable sources. The economies of the Asia-Pacific region, especially, are looking to increased use of coal to sustain their growth. This growth, temporarily undermined by the financial crisis in 1998, must resume strongly in order to meet societal expectations. Coal use elsewhere is also growing strongly, for example in North America. While coal trade forms only a relatively small part (around 12%) of total coal use, that proportion is increasing. Coal exports are significant components of trade in several countries, especially in Australia, South Africa and Indonesia.

Nevertheless, coal is under strong attack. One reason is its contribution to increasing atmospheric concentrations of carbon dioxide, argued to be a cause of potentially adverse climate change. (In supplying 37% of the world's electricity, coal contributes about 10% to the enhanced greenhouse effect). The UN Framework Convention on Climate Change, and most recently the Kyoto Protocol, poses threats to fossil fuel use by placing limitations on carbon dioxide emissions.

Coal use is seen to pose local and regional environmental threats. These threats come not from the use of coal itself, but in the failure to employ modern combustion and emission control technologies, now widely adopted in developed countries. Competing fuels, especially the increasing use of natural gas in rapidly liberalising energy markets, pose parallel challenges to coal use. Nuclear power and renewable energy sources, which have their own environmental impacts, are promoted as energy sources without the drawbacks of carbon dioxide emissions.

The Coal Industry Advisory Board is not complacent in the face of these challenges. In its advice to the IEA Executive Director and, through the IEA, its member countries, the CIAB has sought to promote the adoption of modern coal technologies. It has argued for striking a balance between the imperatives of environmental protection and economic advance.

Following the renewed composition of the CIAB in 1998, the CIAB Members were invited to set out their own individual perspectives on the issues shaping the future role of coal. Subsequently these papers were circulated and used as the basis of a stimulating discussion at the CIAB Plenary meeting in October 1998. That discussion was not intended to lead to agreed conclusions or in itself to form CIAB advice to the IEA.

The papers are individual views of CIAB members, not resolved by CIAB discussion and debate and certainly not any kind of agreed CIAB view. The points discussed do however indicate priority topics, which can be taken into account in forming the CIAB's future work program.

Our task in the CIAB is to ensure that policy decisions about the future of coal are taken on the basis of the widest and best information available from industry. In making these papers and discussion available to a wider audience, I trust that consciousness of coal issues is raised, and that the solutions to be adopted and the balances which need to be struck, will come more into focus.

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CIAB ISSUE PAPERS AND DISCUSSION

INTRODUCTION

In 1997 the Coal Industry Advisory Board decided to reconsider the "Future Role of Coal". In order to identify key issues, CIAB members were invited by the then CIAB chairman, Irl Engelhardt, to prepare papers setting out their own views on key issues affecting coal markets, supply and transport, and where possible, giving their opinions how conflicts (for example, between energy supply and environmental protection) might be reconciled. A guiding list of suggested topics was supplemented by a paper from the IEA Secretariat. CIAB members then chose their own subjects and set out their own views.

First drafts of these "Issue Papers" were made available in July 1998, and it became apparent that, for discussion purposes, they might be divided into two broad groups:

1. Papers which largely discuss changes affecting coal markets and supply, which are occurring irrespective of whether governments ratify the Kyoto Protocol limiting future carbon emissions. For example, such changes may arise from the increasingly liberalised structure of energy markets (especially in electricity and gas), changes in coal trading mechanisms, and competitive challenges from other fuels such as natural gas, nuclear power and renewables.

2. Papers which are more especially concerned with the challenge to future coal use arising from the climate change debate and in particular from the Kyoto Protocol. Issues here include both the resulting challenges to, and potential constrictions on, coal use, and industry's potential response.

The papers were therefore discussed in two debating sessions held at the 1998 CIAB Plenary on 2nd October 1998 at the IEA Offices, Paris. Each of the two sessions was introduced by a moderator who sought to give his perspective, both on the issues and to the ideas contained in individual papers for that session. The moderator's introduction was then followed by a time for clarification from authors of the papers and then by general debate among CIAB members and the IEA Secretariat.

The moderators' introductions, the Issue Papers (in a few cases with changes supplied after the meeting) and summaries of discussion are assembled in this report. The two sessions as conducted at the Plenary meeting are separated in the text. For each session the material begins with the Moderator's introduction and a short summary of points contained in the subsequent discussion. This is then followed by an index of the Issue Papers for that session and the Issue Papers themselves,

Deliberately, no attempt has been made to draw "CIAB conclusions" from the discussions, and ***the Issue Papers themselves remain what they were always intended to be, individual viewpoints, and not necessarily accepted by the CIAB collectively nor by the IEA.*** However the papers and the discussions are seen as a valuable guide to CIAB priorities, and as such will influence CIAB work over the next few years.

SESSION 1

COAL MARKETS AND SUPPLY IN A CHANGING WORLD

Moderator:

Mr Jim Gardiner

President and CEO, Fording Coal Limited

INTRODUCTORY REMARKS BY THE SESSION MODERATOR

Jim Gardiner
President and CEO, Fording Coal Limited

Good morning ladies and gentlemen.

In this session, I will moderate a discussion of issues crucial to the future role of coal in providing energy security to modern societies which depend increasingly on electricity to provide for the health and economic well-being of their citizens. These issues relate to the ever-changing nature of coal markets, the supply base of coal, and competition with other primary energy sources. This session will provide a lead-in to the next session which will consider the acute issue of possible carbon constraints and its potential to affect future coal markets.

Before I begin, however, I would first like to thank and commend the authors who contributed such excellent discussion papers for this session. I would also like to thank Irl Engelhardt and CIAB committee members for creating and designing this meeting format which I believe will prove to be an excellent one for CIAB members and the IEA secretariat as a method of encouraging a wholesome exchange of ideas.

My role as moderator is to get us started in our discussions. Each of you received the full set of papers early in September, and have had a chance to carefully consider the various views presented. Rather than trying to summarise the messages contained in the nineteen session papers, I've decided instead to focus on the messages, conclusions and questions which stood out for me after reading the papers. With this approach, I hope to stimulate discussions on the key issues which need further study and debate within the CIAB.

These papers made me stop and think about our purpose here as set out in 1979 with the *Principles For IEA Action On Coal.*

The CIAB was created in response to a crisis that occurred when our world became overdependent on cheap and plentiful oil. IEA countries paid heavy consequences when political actions beyond their control drove up energy costs and put a stranglehold on the world's economy.

As a result, IEA governments made an objective to establish coal as a major energy source for their countries to ensure secure energy supplies for the future.

As members of the CIAB, we are here to provide advice on coal and energy security. This has never been more important as governments ponder their energy future in the wake of the Kyoto agreement.

In the nearly 20 years that have elapsed since 1979, the world has increasingly benefited from a strong, growing competitive coal industry with the infrastructure, technology and proven track record of providing economic and environmentally acceptable energy for global markets. Almost all of the papers touch on the accomplishments of the coal industry as well as the ever present challenges we must meet if our industry is to hold its own in the future.

In reading and thinking through these papers, I noticed certain key points were consistently repeated. First and foremost is the conclusion that economically and environmentally sensible energy is the foundation for the continued health and economic well-being of the earth's people. And electricity is the most essential form of energy for human welfare.

Several papers also point out that all known energy sources will be needed in the future to meet increasing world energy demands.

Coal contributes significantly to global energy needs, especially for electricity generation and essential base industries such as steel and cement production. The global dimension of coal is in no small part due to the foresight of IEA governments encouraging the development of the world's immense coal resources.

Coal, because of its' reserves, qualities, economics, and a well-developed infrastructure for trade, can be counted on to continue playing a strong and growing role in meeting the world's increasing energy demands. In fact, many of the papers conclude that there is no other practical alternative to coal that will meet the world's energy needs.

Many of the papers discuss the variety of market factors which continue to provide short-term challenges for coal, but none of these are expected to impede coal's long-term prospects. But what many papers do identify as a significant impediment to coal are market interventions by governments to address the current climate change issue.

This takes us back to the mandate of the IEA and the CIAB regarding energy security and the long-term role for coal. Achieving energy security first requires understanding the many forms of energy, where they can be obtained, how much is available … and at what cost.

As many of the papers point out, coal is plentiful with large, established and diverse reserves that are attractive using today's economics. Since 1979, natural gas has entered onto the world energy scene in a significant way. As highlighted in some of the session papers, it is sometimes portrayed as having the clear potential to replace coal in coal's traditional market of electricity generation. Indeed, this seems to be the basic justification for governments to intervene in markets and discourage the use of coal.

Returning to our energy security mandate, governments need sound advice on the strategic value of coal versus gas, or said another way, coal as well as gas. More importantly, this must be based on a careful analysis and comparison of reserve bases of coal and gas, the cost required to produce and deliver them, and the geopolitical risks of supply interruptions that are associated with each of these energy sources. Several of the papers conclude that this is a job that has yet to be done. It is clear from the papers presented that this area represents a most important task for consideration by the IEA and the CIAB.

"History has a habit of repeating itself!"

I was struck by this quote from Nick Baldwin's paper as it captures the circumstance we find ourselves in today. For example, we can be sure, based on known historical facts regarding the past several thousands of years on earth, that the climate will change in the future, and potentially at a very rapid pace. History also tells us that human capacity to cope with things like climate change depends on technology and abundant energy. Let us be sure that climate and other things will change. Let us not be unsure about our ability to cope with what the future holds for us.

Our political leaders from the past who created the IEA and adopted the principles for action on coal understood from bitter experience the economic dangers of placing an over-reliance on a relatively scarce, geopolitically risky energy source. Today's politicians have not had such a painful experience, and may not recognise that energy security remains as important today as it was in the 1970s.

And surely that is the challenge before us; to communicate to our governments the critical importance of energy security in all its forms, and all its costs. I believe Friedrich Esser perhaps summed it up best when he states in his paper:

"To cover the future world energy demand, all available energies need to contribute. Discriminating against coal among the complementary energy sources would be fatal, simply on the grounds of development policy."

Ladies and gentlemen, these are powerful, thought-provoking words, and I believe an excellent starting point from which to initiate discussion from the floor.

SUMMARY OF POINTS RAISED AT CIAB PLENARY DISCUSSION
2 October 1998

SESSION 1: MARKETS AND SUPPLY IN A CHANGING WORLD

Points which came up in discussion included:

1) The continuing importance of coal in underpinning energy security, including:

a) the advantages of coal over other fossil fuels owing to its geographical diversity, the abundance of coal resources world-wide, the diverse global ownership of the resources, and the large number of players in the coal market

b) the importance of keeping the coal option open, in face of competitive and climate change pressures from natural gas-fired power generation

c) potential security issues, in some regions, from an over reliance on natural gas fired power generation, because of the longer term sources of gas supply being in more politically difficult regions (than for coal supply)

d) in some instances, the technology of CCGT plants may be less reliable than steam cycle plant, both for high load factor operation and in coping with variable load demands

e) a recognition that governments will nevertheless not support coal solely on grounds that it has historically been a guarantor of secure energy. Coal and associated industries will have to fight commercial and other challenges through attractive pricing and an improved, cleaner image. Hitherto the industry has done a poor job of image presentation.

2) The uncertainties resulting from increasingly deregulated and restructured electricity markets, where coal use is challenged by:

a) the long time for "true deregulation" to occur

b) unforeseen and potentially market-distorting impacts which can occur during the transition to effective competition (the "regulatory lag" effect)

c) doubt whether governments do really deregulate, but instead regulate afresh in different ways. In some countries the effect is argued to be greater regulation coupled with greater volatility in energy supply and prices

d) the market for electricity not being a true commodity market.

3) The consequent uncertainty over the outcome of deregulation and structure:

a) may well create an "unlevel playing field" for coal against other sources (e.g. nuclear, gas)

b) feeds through to increased investor uncertainty and is likely to cause delay in financing new power stations, new transport infrastructure and new coal mines

c) may encourage new types of unstable ownership patterns: for example financial collapse of highly leveraged utilities increases the chances of business failures, with potentially serious knock-on effects to coal suppliers and customers. This enhances the risk of insecurity of power supply, with longer term risks

d) inhibits co-ordination of electricity supply, where generators, for example, must compete rather than co-operate with each other

e) has led to power “brown-outs” in some places (e.g. parts of Australia).

4) Continuing coal use in developed countries is threatened by tightening environmental regulations on SOx and NOx emissions, and foreseen regulations of greenhouse gas emissions. There is a need to ensure that developing countries which certainly will use massive amounts more of coal do so with sound technology.

5) A recognition that there is a need to create greater public awareness about:

a) the vital role of coal in providing energy for societal development

b) the lack of realism in those who advocated quick changes in energy mixes

c) the emerging conflict between consumer desire for secure electricity supplies at reducing real prices and the effects of rising levels of environmental regulations and taxes.

LIST OF ISSUE PAPERS AND AUTHORS

SESSION 1: COAL MARKETS AND SUPPLY IN A CHANGING WORLD

WHAT COULD SHAPE-UP AS THE BIGGEST SURPRISE TO INFLUENCE THE FUTURE DEMAND FOR COAL?

Dr. Peter Rohde

(1) The demand for coal is determined by the future developments of coal users as well as by the competitive position of coal versus other energies. Therefore, in looking for a possible surprise to influence the future demand for coal three questions have to be answered:

- Which will be the future users of coal?
- What is the future of these coal users?
- What are the major factors influencing the competitive position of coal?

(2) Today, coal is needed by a variety of end users of which two groups play a predominant role:

- Power plants.
  Power plants represent by far the largest group of coal end users. They consume 60 % of the total world coal production to produce heat and generate electricity.
- Industrial users.
  Among the industrial users two are of major importance: steel plants and cement works. Steel plants use about 15 % of the total world coal production by using coke made from coal to produce pig iron and by injecting coal into blast furnaces. Cement works consume about 5 % of the total world coal production to produce clinker, the basic component of cement.

All other coal users like residential users account for 20 % of the total world coal production, most of it in China and in some parts of Eastern Europe.

Today, the use of coal concentrates on those applications for which coal has a competitive edge or for which coal cannot be replaced due to the applied technological process. Given the presently existing demand of the various energy sources, I do not expect new coal end users of any major importance to show up in addition to the presently existing coal end users. Therefore, it would be a big surprise if the presently existing structure of coal end users consisting in particular of power plants and industrial users would change substantially.

(3) The future of electricity generation is determined by the fact that electricity is a fundamental element to ensure economic growth and human welfare. Therefore, the growth rate of the world's electricity production exceeded the increase of the world population in the past. There is no reason to assume that the dynamic growth of electricity production will not continue in the future. Consequently, it would be a big surprise if the growth rate of electricity would differ far from the 3 % p. a. growth rate as forecast by the IEA.

Given such a growth of electricity production, all energy sources available are needed to cover the demand for fuels required to generate heat and electric power. As of today, no new energy - like fusion energy - is to be added to the existing fuel portfolio; the existing energy sources will have to cover the energy needs of the power plants. How much of each of these energy sources will be needed, will depend on the competitive position of each fuel at a given time in a given location of the world. Coal has proved to be available in sufficient amounts and desired qualities and at competitive prices. Consequently, IEA forecasts indicate that the share of coal amongst the fuels for generating electric power will remain at today's level of almost 40 % in the future. It would be a big surprise if the world's coal demand for power plants would differ widely from 2600 million tce in 2010 as assumed by the IEA.

With respect to the steel industry, history has demonstrated the difficulties to forecast the world's steel production as well as the various methods of how to produce steel. However, there is no denying the fact that steel remains as a base material used in modern economies inspite of technological changes. Thus, the world steel consumption is estimated to remain at today's 120 kg per capita over the next 15 years.

Given the present state of pig iron and steel making, there is no reason to assume that the fundamental direction of developments will change in the near future. Consequently, the coal demand of the world steel industry will remain about where it is today: A possible higher demand for coking coal will be off-set by pulverized coal injection; in addition, an increase of the steel production of the developing countries will be compensated by a lower steel production of the OCED countries and by more steel from electric arc furnaces.

It would be a big surprise if the future demand of coal by the steel industry - as estimated by the IEA for 2010 - would differ very much from today's level of 600 million tce.

The future of the world cement consumption depends on the growth of the world population as well as on the cement and concrete needs created by a growing world economy. These factors have led the world cement production - i. e. the world cement consumption - to grow at a rate of about 3 % p. a. over the last ten years.

Given the outlook for the economic development of the various regions of the world, Asia will - however influenced by the present slow down - continue her dynamic development over the next fifteen years; Eastern Europe and Russia will need more cement to develop housing and infrastructures. On the other hand, no substantial increases of cement consumption are to be expected in the other parts of the world. All in all, the growth of the world cement production should be in the order of 1 - 2 % p.a. over the next fifteen years.

Cement works have succeeded to use a whole variety of primary energy sources like coal, oil or gas and of secondary energy sources like rubber tires and high-calorific waste. Which fuel is used, depends on the competitive position of the respective fuel. Given all circumstances, it is fair to assume that the coal demand by the world cement works will increase to some 200 million tce in 2010.

(4) During the past, coal has proved to be a highly competitive fuel for those end users using coal for their energy needs. The competitiveness of coal is based in particular on the following aspects:

- There are ample resources of coal all over the world. New resources are developed according to new needs.
- In general, coal resources are located in conflict-free areas. Coal as a fuel is being accepted world-wide.
- A highly developed mining technology is available through out the world.
- The international coal logistics-chain has proved to be highly efficient and to enable the world sea-borne coal trade to grow according to international needs.

In a world market which is characterized by increased globalization and liberalization, the above mentioned assets of coal will gain even more importance. They will continue to widely outweigh the CO_2 emission-problem which is sometimes raised in connection with the use of coal.

(5) Considering the above, history has demonstrated the competitiveness and the security of supply of coal in widely diversified world energy markets. To the best interest of coal users, coal has been available in sufficient quantities, desired qualities, and at competitive prices. Therefore, the biggest surprise which could shape-up for the future demand of coal would be if the world-wide competitiveness of coal would cease to exist.

THE EFFECT OF ELECTRICITY DEREGULATION ON THE COAL INDUSTRY

Nick Baldwin,
Executive Director, UK Operations, PowerGen plc.

INTRODUCTION

In this paper I discuss the deregulation of the electricity industry in England and Wales, examining the effect of that deregulation on the indigenous coal industry and drawing lessons for the coal industry worldwide both now and into the future.

BACKGROUND

The UK electricity industry was privatised in 1990, following the sell-off of a number of other nationalised industries including gas and telecommunications. Deregulation went alongside this privatisation: the Government aimed to improve efficiencies and cut costs in the industry by exposing it to market forces rather than by policy intervention.

The bulk of the UK coal industry remained in Government hands until December 1994, when the majority of English mines were sold to one private company, RJB Mining.

E&W ELECTRICITY INDUSTRY STRUCTURE BEFORE PRIVATISATION

Prior to privatisation, E&W's electricity was generated and transmitted by the Central Electricity Generating Board and was distributed and supplied to customers by twelve regional Area Boards. In this industry structure, power station capacity and fuel use were centrally planned. The majority of generation was coal fired, with some nuclear, hydro and oil. There was no gas fired generation; indeed the use of gas for electricity generation was precluded by European law. As a nationalised industry, there was no significant pressure to cut costs: the main driver was a statutory duty to 'keep the lights on'.

PRIVATISATION PROCESS

The initial privatisation plan was to split the CEGB into two vertically integrated Scottish electricity companies and three E&W companies - a transmission system company (National Grid) and two generators (National Power and PowerGen). National Power, the larger generator, was to take on all the nuclear stations and absorb the associated costs. With the exception of the nuclear plant, this plan was implemented in 1990, when the twelve Area Boards also became 12 regional distribution and supply companies (Regional Electricity Companies).

During 1989 it had become clear that the liabilities of the nuclear plant represented too great a risk for potential investors and the nuclear stations were pulled out of the programme. Nuclear Electric (E&W) and Scottish Nuclear were formed as nuclear generating companies, which remained in government hands. Subsequently, the nuclear stations were allocated to two new companies; the Sizewell PWR and the more modern AGR stations in England, Wales & Scotland to British Energy, which was privatised in 1996, and the older Magnox stations to Magnox Electric, which was later merged with British Nuclear Fuels Ltd. and remains in Government ownership.

A market - the Electricity Pool - was set up in 1990 to trade electricity. Generation was bid into the Pool on a half-hourly basis and despatched least bid price first subject to system constraints. The bid price of the last required generating unit set the price paid to all generation units running in that half hour. Electricity purchasers such as the RECs and some large industrial and commercial customers hedged the Pool price uncertainty through direct financial “contracts for differences” (CfDs) with the generators.

At privatisation, the majority of Britain’s electricity was generated from coal purchased under long term coal purchase contracts between British Coal and the new electricity generating companies. These contracts were initially for three years and were re-negotiated in 1993 for a further five years to provide some stability during the coal industry privatisation.

Following withdrawal of the nuclear plant from the privatisation process, timescales prevented the creation of a greater number of generating companies. If nuclear plant had been taken out of the equation before the privatisation process began and a larger number of companies created, this would have encouraged greater electricity market competition at the outset and faster deregulation. As it was, the market was initially quite heavily regulated pending the further development of competition via the entry of new generating companies.

CHANGES SINCE PRIVATISATION

Privatisation exposed the electricity companies to market forces for the first time. Whilst the lights still had to be kept on, there were now shareholders expecting returns on their investment and customers who would strike deals with the generating company offering the best prices. Meanwhile, the RECs sought to diversify their options for purchasing electricity.

As the electricity market was becoming increasingly deregulated, environmental regulations were getting more stringent. Limits on the emissions of SO_2, NO_x and particulates were being progressively tightened and there were proposals to tax ash disposal. Increasing concerns about global warming led to countries pledging at the 1992 Rio Summit to reduce emissions of ‘greenhouse gases’, principally CO_2.

Equally significantly, EC Directive 75/404/EEC restricting the use of natural gas in electricity generation was repealed in March 1991.

These three factors led to a re-examination of the options available for electricity generation, which in turn resulted in the most significant change in the electricity industry - the rapid and largely uncontrolled increase in the use of gas for electricity generation. New Combined Cycle Gas Turbine technology was relatively cheap and plant could be constructed quickly. Moreover, gas is plentiful in the seas around Britain and is a cleaner fuel: when generating an equivalent amount of electricity, a CCGT plant emits half the CO_2 of a coal plant, around a quarter of the NO_x, and negligible amounts of SO_2 and particulates. Also, burning gas does not produce any ash.

Consequently, gas became the preferred fuel for electricity generation. PowerGen, National Power and, most significantly, new independent electricity generators built new CCGT plant which resulted in a much more rapid rise in gas fired electricity generation than anyone had anticipated in 1990.

Many new companies have joined this ‘dash for gas’, building new CCGT plant largely backed by long term gas supply and electricity sales contracts which is bid into the Electricity Pool to run at baseload. The remaining coal fired plant now runs at much lower load factors. There are now around 25 generators bidding into the Pool, compared with 10 in 1990. By 1997/98, gas fired generation accounted for 31% of Pool generation and the coal-fired market share had fallen to 34% from its 1989/90 level of 72%.

Shareholder expectations, and pressures to reduce costs and emissions, have also led to a change in the behaviour of those generators who are still running coal plant. Since privatisation an increasing proportion of the coal burned at E&W power stations has come from UK opencast sources and the world market, which are cheaper and have lower sulphur contents than UK deep-mined coal.

RESPONSE TO THE DECLINE IN COAL USE

When the coal contracts with the generators were transferred to British Coal’s successors, they still had three years to run. The new mining companies were therefore not immediately exposed to the market forces which would have increased the need to cut costs.

The rapid erosion of the electricity generation market for coal and the uncertainty about its future potential size made the electricity generators reluctant to renew long term contracts for UK coal at anything like earlier prices and volumes. Competitive supply arrangements were needed if coal was to retain a position in electricity generation alongside gas. Debate became steadily more active, eventually involving the rest of the energy industry and the Government in a review of national energy policy.

The conclusions of the Review of Energy Sources for Power Generation were published by the DTI in October 1998. Of relevance to the use of coal for electricity generation, it was found that distortions in the wholesale electricity market had affected competition between different fuels and between existing and new generating plant.

In response, Government policies were outlined which would discourage CCGT plant development while reforms to the structure of the wholesale electricity market were being put in place. These measures were designed to slow the decline of coal use for electricity generation, in support of the Government’s fuel security and diversity aims. To support the sustainability of coal in the longer term, Government would maintain a research programme on clean coal technologies.

It is clear that Government’s ability to intervene directly in support of coal is restricted by the nature of the de-regulated electricity market. Although electricity market structural distortions can be addressed, the UK coal industry will remain exposed to the competitive market drivers which influence the behaviour of the electricity generating companies.

LESSONS FROM THE E&W EXPERIENCE

To summarise, as the E&W electricity market has become deregulated we have seen:

- significant entry of new gas fired electricity capacity;
- a rapid increase in gas fired generation with an equivalent reduction in coal use; and
- diversification of coal supply sources.

These developments have resulted from commercial drivers on the deregulated electricity industry, which are in turn heavily influenced by short term shareholder expectations. Further reinforcement of the growth in gas generation has come from tightening environmental regulation.

E&W now has a well-balanced electricity generation portfolio: around a third gas, a third coal and a third nuclear and renewables. However, the dominance of gas seems set to increase, resulting in further decline in UK coal production despite the industry being lower cost than most of the European competition. Clearly, the short term competitive drivers on the E&W electricity industry sit unhappily with the longer term market security required to support continued investment in a deep mined coal industry.

WILL THIS EXPERIENCE BE REPEATED WORLD-WIDE?

Electricity deregulation in England & Wales has resulted in the rapid growth of gas use for power generation, despite the availability of existing coal fired generation capacity sufficient to support much higher coal use. While this has been facilitated by easy access to gas supplies, which may not be universally applicable, there are nevertheless some important lessons for the world-wide coal industry:

1. Developments in the electricity generation market will have profound affects on the coal industry.

2. Environmental regulation pressures reinforce the need to find ways of burning coal cleanly. Advanced coal fired generation technologies offer the best prospect although they are more costly than conventional technology and require further operational demonstration.

3. Electricity market deregulation exposes the coal industry to short term commercial pressures that may be in conflict with the longer time horizon of coal mining investment.

4. In the search by deregulated electricity companies for fuel diversity, only competitive coal production capacity will survive.

5. The varying pace of electricity deregulation in individual countries world-wide could result in sub-optimal management of coal production capacity.

History has a habit of repeating itself!

WILL THERE BE A CONTINUED DESIRE OF MANY GOVERNMENTS FOR A DIVERSITY OF SUPPLY, PARTICULARLY IN THE FACE OF ANY INCREASING SHARE OF FUTURE ENERGY IMPORTS? IF SO HOW WILL THIS AFFECT COAL USE?

Richard Budge
Chief Executive RJB Mining, United Kingdom

INTRODUCTION

The demise of coal production and burn in the UK has been well documented, a consequence of the structure of the electricity market liberalisation programme and availability of gas for power generation. Following representations from the UK coal producers and other parties, the new UK Government announced in December 1997 that they would undertake a review of energy sources for power generation as a part of their evolving energy policy based upon the principles of diversity, security and sustainability at a competitive price. The interim conclusions of that review were announced in June 1998. The review highlights that by 2020 gas could account for 60% of total UK primary energy supply and over 75% of UK electricity generation with imports of gas accounting for between 55% and 90% of requirements. UK Government is rightly concerned about ongoing fuel security of supply.

UK POSITION

UK oil and gas fields are mature with many fields discovered in the 1960s and developed in the 1970s and 1980s. Whilst there is some further gas to be discovered and improved recovery techniques are leading to a recalculation of reserves, it is clear that the life of existing reserves are not keeping pace with the increased demand for gas, particularly gas for power generation. Taking the ratio of proven plus probable reserves to production as a measure of life then the remaining life has fallen from 23 years in 1991 to 15 years in 1997. When account is taken of CCGT stations already committed but not yet commissioned, then 1997 reserves amount to only a 13 year life. Such figures highlight the concern that accelerating the use of gas in power generation is not in the UK's national strategic interest.

Over recent years gas prices have fluctuated wildly as the gas industry has gone through fundamental restructuring and opening of markets. The ex-state owned British Gas historically procured all gas on a field depletion basis but has, over recent years, been required to concede significant market share to new gas suppliers and traders. In 1993 prices for new long term interruptible gas contracts peaked at 25p/therm with spot gas available at less than 10p/therm in 1996. The distortions associated with the introduction of competition in the gas and electricity markets contributed to the dash for gas which lead to economic coal fired stations being displaced by more expensive gas stations.

There are additional gas supplies in the other parts of the North Sea, particularly the Norwegian sector and the Netherlands. However, European gas prices are significantly higher than UK prices and UK's exports of gas earn only 12p/therm whilst current imports from Norway are at 21p/therm. In the longer term, imports into Europe will come from FSU, Middle East and North Africa and the prices for such imports, as identified by IEA in its 1995 Natural Gas Security Study, will be at least 3$/Mbtu or 18p/therm at the EU frontiers to meet a modest increase in European gas demand. Further transport costs would significantly increase prices for UK delivery.

There has been a dawning realisation in the UK that longer term security of supply could be in jeopardy. Consultants to Government have advised that the UK could be importing between 55% and 90% of its gas demand by 2020, a frightening thought for a country that has been largely self sufficient in recent years.

It has become apparent to Government that the dependency on imported gas raises a number of concerns - industrial competitiveness, sustainability and security of supply. Representations by the coal industry have highlighted the diversity of coal reserves around the world and the rich wealth of reserves in the UK. These compare very favourable with the geographical disposition of gas reserves with over 50% of the world's gas reserves are vested in just two gas companies, Gazprom of Russia and the Iranian National Gas Company.

A number of associated issues have been raised in the UK debate that impact on the security of the electricity market. In particular the peaks of demand on the electricity and gas network coincide at times of severe cold weather when gas supplies under interruptible contracts may be suspended. It is important to acknowledge that at times of disruption electricity networks fail safe and gas networks fail unsafe with significant delays in reconnecting customers when gas supplies are re-established. Therefore the priority in gas supplies will be to domestic/industrial users, not to power stations. Furthermore insufficient value has been ascribed to the ability to stockpile coal at power stations to isolate generators from supply chain disruption. Gas station may be dependent upon pipelines and events 1000s of kilometres away and are currently not mitigated by local stockholding of gas oil. Coal is flexible, not dependent upon pipelines and can be stockpiled to meet peak demands.

Government has weighed up the evidence and concluded that there is strategic value in retaining the coal component in the electricity sector.

CONCLUSION

The UK coal industry and others have successfully persuaded UK Government of the risks associated with overdependence on gas. With opening of European electricity markets in 1999 the pressures to build further gas stations on mainland Europe to displace coal capacity will be immense. Unless European governments are appraised of the risks of overdependence upon imported gas it is likely that economic European coal production will unnecessarily close and opportunities for imported coal into Europe will also reduce.

WILL THERE BE CONTINUING DESIRE OF MANY GOVERNMENTS FOR A DIVERSITY OF SUPPLY, PARTICULARLY IN THE FACE OF ANY INCREASING SHARE OF FUTURE ENERGY IMPORTS? IF SO, HOW WILL THIS AFFECT COAL USE?

N.G. Ketting[1]

In several countries governmental policies concerning diversification of fuels for security reasons are known. The key point however is whether and how such policies can be implemented.

Present trends are liberalisation and demonopolisation of energy markets, including those of electricity and gas; restrictions on the use of gas have generally been cancelled. These trends conflict with governmental regulation of fuels supply and diversification.

In liberalized markets lowest costs determine use of fuels. Earning back periods and control of risks are basic factors for decisions on investments e.g. in power generation.

For environmental and/or budget reasons governments sometimes introduce taxes/levies which may vary per kind of fuel. Such trend may influence the use of different fuels. In theory governments could use levies to enhance diversification of fuels, in practice however no examples are known. To the contrary most import duties primarily exist to protect domestic energy production and therefore prevent diversification.

Assuming a continuing trend towards free and open energy/electricity markets, coal for power generation will have to compete with natural gas in regions where gas and sufficient infrastructure are available.

Moreover hydro- or nuclear power or imported electricity may compete with coal fired power. In such competition coal may easily lose position in the face of investments, risks and environmental constraints, even if the price of coal per caloric unit is more attractive than the price of gas.

It seems very unlikely that governments will or can prevent such developments even if they have strong desire for diversification of fuels.

Diversification of fuels may have different angles: stability of costs, security of fuels supply, interfuel competition (e.g. in dual fired power plants) and, increasingly likely, “green electricity” requiring CO_2 neutral/renewable fuels. It will be the market players however who will determine the application of fuel diversification strategies, e.g. large electricity generators in view of their supply commitments, using coal for its price stability and storage possibilities. Small generators and new entrants into opened power generation markets will rather focus on one fuel, which is unlikely to be coal when alternatives are available.

Coal will have to put maximum effort into developing concepts and technology to cope with such threat.

1. With the assistance of M. Bloemendal, Associate.

IS COAL MERELY A 'NECESSARY EVIL' FOR THE SHORT-TERM, OR IS IT A RESOURCE WHICH MUST BE NURTURED FOR LONG TERM USE?

Friedrich H. Esser

1. THE ENERGY ECONOMY FRAMEWORK

A joint feature of all scenarios concerning the future of energy supplies is the expectation of strongly increasing world energy demand far into the next century. "Business-as-usual" scenarios until 2050 indicate at least a doubling if not tripling of the world energy demand. In this context "Business-as-usual" means that the efforts aimed at improving the energy efficiencies will be continued. Even "ecologically driven" scenarios, which assume an unprecedented level of international cooperation and understanding concerning the necessities of environmental and climate protection and which therefore require extremely high costs for restructuring the energy industry, expect growth rates of around 50 per cent.

The reason for the large increase in energy demand is obvious. In the industrialized countries a stable supply of energy is the basic prerequisite for production and services. It secures jobs, prosperity and quality of the business location. In many industrialized countries efficient and energy-saving technologies are already available or are being introduced. In "threshold" countries (i.e. those on the threshold of industrialization) the growing supply of energy fuels the economic catching-up process. In developing countries energy is a prerequisite to overcome poverty. There the dissemination of advanced energy technologies is a major task for the future.

In brief: growing energy demand reflects the aspirations of an ever larger part of the world population for economic and social prosperity. Energy is thus a strategic key element and indispensable for the sustainable development of every economy.

2. THE ROLE OF COAL IN WORLD ENERGY SUPPLIES

Accounting for some 25 per cent of world energy supplies and about 40 per cent of world electricity generation, coal is a decisive pillar of the energy industry today. In almost all scenarios coal continues to be an essential component of future energy supplies, with a constant share in relative and an increasing amount in absolute terms. Even the boldest scenarios assuming a developed solar power industry by 2050 require coal, although with a lower market share than today. The dynamics of coal demand is largely supported by the growing requirement for coal-based electricity generation in developing and "threshold" countries. Here coal is a basic prerequisite for economic growth and prosperity.

Coal as an energy source has a number of advantages which point the way ahead. As a result of its wide resource base coal has the potential to contribute to the supply of energy to the world population for more than 200 years. Therefore it is a legacy which we can pass on to future generations.

What is more, coal is a relatively conflict-free energy source compared with oil and gas, on grounds of the quite different distributions of the various resources. This gives an additional value to be attached to coal as a raw material. And after all, given highly developed mining technology, coal can be produced at favourable cost in large parts of the world. Thus hard coal is well positioned, as a low-cost energy source in its main field of application, the electricity industry, for the increasingly liberalized electricity market.

Today, decisions are often taken in favour of the construction of gas-fired power stations with low fixed costs, i.e. to give short repayment times. In this micro-economic calculation potential long-term gas prices and the increasing risks of natural gas purchases from unstable regions are not taken into account. Gas reserves are not only relatively scarce but also concentrated in politically and economically unstable crisis regions of the world (OPEC, former USSR). Before long, these two regions will determine international gas supplies. The policy of diversifying the supply sources for gas increasingly encounters geopolitical limits.

Moreover, growing demand for gas would rapidly result in higher gas prices. Eventually gas deposits would be exhausted sooner than calculated. I dare to forecast that given the pursuance of a forced natural gas offensive our minds will very soon start to turn back to coal again. In the current world coal market trends towards higher prices are not foreseeable, unless coal prices are to be driven up by higher oil and gas prices. This, at least in the longer term, cannot be excluded given the high geopolitical concentration of the oil and gas reserves.

3. COAL IN THE ENVIRONMENTAL DISCUSSION

The fact that the role of coal in future world energy supplies is disputed at all can be explained by a single term: “CO_2”. The context of this gas has triggered a discussion on coal, which would otherwise hardly have occurred given its previously mentioned advantages. But is this discussion really appropriate?

To cover the future world energy demand all available energies need to contribute. Discriminating against coal among the complementary energy sources would be fatal, simply on grounds of development policy.

In the electricity generation sector, arguments in favour of natural gas as a low-CO_2 fuel are advanced on grounds of alleged climate protection. The balanced energy mix in electricity generation, which can ensure at the same time security of supplies, favourable prices and environmental compatibility, would be jeopardized by a natural gas offensive. Relatively scarce gas should be preserved as long as possible for high quality applications where it has major advantages compared with the other energy forms, rather than in the electricity generation sector. Also advocates of nuclear power develop the CO_2 argument, but where, with the exception of a few countries, can nuclear power count on the support of the population? Finally, renewable energy forms are still far from being introduced economically into the market. So what energy source can be in a position to replace coal?

What is more, coal has faced ecological challenges for a long time. A major prerequisite for a resource-conserving, environmentally and climatically adequate utilization of coal is the continuous improvement of the conversion efficiencies when using coal for electricity generation. Also the “end of the pipe” technology of flue gas scrubbing makes a decisive contribution to the coal’s environmental compatibility.

Using energy sources as economically and efficiently as possible is the only suitable approach to meet economic, ecological and social requirements, globally as well as regionally. To this end coal can make a decisive contribution or, more accurately, the coal users can. The industrialized countries are responsible for bringing energy technologies to the global market-place, and also for making them available to the developing and "threshold" countries with growing energy demands. Against the background of dynamically growing global coal use in electricity generation, this point applies in particular to the further development and dissemination of advanced coal-fired power station technologies.

Combining realistic energy policy with reasonable environmental policies means not "demonizing" coal, but instead supporting projects to improving the efficiency of coal utilization and disseminating such technologies worldwide. Here the term "double dividend" would be justified. E.g. the average conversion efficiency in German coal-fired power stations is around 40 per cent, with an upward trend. In China and India by contrast it reaches only around 29 to 31 per cent. Climate protection measures should be concentrated only on no-regret measures, which have both economically and ecologically positive effects, against the background of scientific understanding which is still unclear. In particular measures should include the intensified transfer of efficient environmentally compatible coal technologies.

Therefore we should welcome the principle agreed upon at the 3rd Conference of the Parties on the Climate Framework Convention in Kyoto to introduce trans-boundary forms of co-operation to reduce greenhouse gases by means of joint implementation and clean development mechanisms. These instruments seem suitable to meet climate targets much more cost efficiently. Moreover they offer the opportunity for more rapid dissemination of efficient and climatically acceptable technologies particularly in developing and "threshold" countries. Here new possibilities also open up for the implementation of suitable coal technologies.

On this basis particularly Germany as a coal-producing country has good prerequisites to contribute to the strengthening of the coal's position worldwide. Today hard coal-fired power stations to be planned reach already efficiencies of 46 per cent in Germany. These figures alone indicate the large environmental protection potential of the coal worldwide provided that coal technologies are continuously developed further. This is possible e.g. in Germany because here a coal market at a high level, some 70 mtce of hard coal and around 50 mtce of lignite, can be expected in the long term. Thus the largest West European coal market has the opportunity to demonstrate that the future of coal can be shaped by environmentally friendly coal technologies in a responsible way and also in a global perspective.

TRENDS IN COAL CONTRACTING AND PRICING, AND LIKELY CONSEQUENCES FOR COAL PRICE VOLATILITY, COAL USE AND COAL SUPPLY

Dick Austen AO

INTRODUCTION

One of the coal trade issues identified by the CIAB as being important in the context of the future role of coal is the question:

> *will the recent move away from long term contracts to more spot pricing be continued and, to the extent it is, might it induce greater volatility in coal prices and might this carry adverse consequences for coal supply and coal customers?*

This paper confines itself to steam coal markets.

Over the last few years there has been a general move by steam coal buyers away from term contracts to spot purchases and tenders. In Europe there has been a continuing swing away from term contracts to spot purchases, and this has been brought about as much by the general oversupply position and the widening choice of producers and producer countries, as by the increasing range of coals that generators are prepared to burn through technical innovation driven by competitive forces. This move to spot purchases has also been widely experienced in many importing countries in Asia. However possibly the one major development in coal contracting and pricing which has inspired the above question is the change in the coal purchasing practices of the Japanese power utilities from 1996, when new electricity legislation signalled the beginning of a deregulated and more competitive market for electricity in Japan.

The Japanese Government introduced its *Program for Reform and Creation on Economic Structure* in December 1996 and followed this up with its *Action Program* in May 1997. These measures are designed to accelerate structural reform in the industry, including by facilitating the introduction of Independent Power Producers, all with a view to reducing electricity costs in the medium to long term to levels comparable with other industrial countries.

In 1996, the Japanese utilities began procuring some of their annual steam coal requirement on the spot market. While this was something of a watershed in policy for Japan, the tonnages retained under traditional term contracts continued to be much larger, as a proportion of total requirements, than has been customary in Europe and in certain other Asian markets where security of coal supply has been a lesser concern than price.

Last year, the IEA published an excellent report, *International Coal Trade, the Evolution of a Global Market*. It contains a perceptive account of the international coal market and insight into the price formation process, and a compelling prognosis of how world coal markets will evolve into the future. The report noted that the proportion of spot sales in Europe-Atlantic steam coal markets has long been higher than in the Asia-Pacific; prices in the European market have effectively been capped by the price at which US coal is induced to enter the market (a price related to marginal costs); and low European prices are transmitted into the Asia-Pacific region via South African producers who are reasonably proximate to both market areas. This analysis is no less accurate now than when it was prepared and, indeed, some of the developments then foreseen have since been realised.

DISTINGUISHING 'SPOT' AND 'TERM' CONTRACTS

The IEA report observed that the spot market for coal is not strictly defined. It can be distinguished from the market transacted under 'long term' contracts which normally, in the Asia-Pacific market, have been linked to the 'benchmark' price and have involved annual price reviews whilst in Europe "long term" supplies have in recent years been no more than annual contracts with an unwritten "expectation" of renewal each year, subject to price agreement. Spot contracts, by contrast, are for single cargoes, part cargoes or a series of cargoes and, characteristically, do not define any ongoing relationship between buyer and seller. Tenders, for example, may seek to preclude such relationships deliberately. Because of the subjectivity involved in this kind of distinction — and the diversity of actual commercial relationships — it is not possible to be definitive about the 'spot' and 'term contract' shares of the total coal market in any region.

Term contracts have been useful to investors in both power stations and coal mines as instruments assuring, respectively, fuel supply continuity at defined cost, and a guaranteed revenue stream adequate to service debt and equity finance. Because there is a general lack of 'fungibility' in the commodity coal — which is sometimes perceived of as a lack of maturity in the coal market — these contracts have facilitated developments which would otherwise have not proceeded. The world-wide trend towards spot purchasing for installed power generation may well affect the coal industry as existing mines exhaust their reserves. In these circumstances new mines are required to come on stream without the backing of term contracts; however there is also a contrasting position arising in the guise of IPPs which are likely to form a significant element of newly installed generating capacity.

In this case, the requirement by the IPP financiers for security of coal supply is providing the necessary coal supply contracts for coal producers to develop greenfield sites.

The shift to greater reliance on spot markets emanates principally from the established power utilities. Those in Denmark, Holland, Hong Kong and Chinese Taipei, amongst others, have generally maintained thermal coal supplies while relying largely on spot purchases — in conjunction with large stockpiles, and interconnection with neighbouring countries in Denmark's case. And spot prices, as with most commodities, have been substantially lower, routinely, than negotiated term contract prices. Reflecting more than anything the ongoing reduction in coal prices in real terms. Taipower (from Chinese Taipei), and many other utilities in Asia and Europe, have also purchased much of their requirement in tender processes.

Now the Japanese and other utilities seem bound to follow suit, at least to some extent. As the IEA report noted, the practice of spot purchasing is increasing among many major utilities due to the greater number of supply alternatives and reduced concern over security of supply — a perception which, other things equal, augers well for an enhanced role for coal in world energy markets.

One aspect that may in the longer term assist both coal users and producers is evolving in the USA where generators are moving towards trading in coal futures, options and swaps alongside gas and oil as part of their energy portfolio, in order to compete effectively in the deregulated electricity market. These concepts may be further expanded to link coal sales prices with electricity pool prices. It is likely that this will also develop in Europe as the European grid expands and the full force of competition is experienced.

DEVELOPMENTS IN JAPANESE STEAM COAL MARKETS

The decision of the established Japanese electric power companies to begin procuring wholesale power using a tender system was motivated by the reforms of 1996 and 1997 mentioned above. The tender system, and the emergence of IPPs to participate in it, is beginning to transform the Japanese electricity supply industry. Some 3050 MW are to be procured from IPPs to be commissioned between JFY1999 and JFY2002, plus 2855 MW for the period JFY2001 to JFY2004. Japanese power utilities have confirmed they are planning to continue to make use of the power tender system into the future.

Increasing competition in the Japanese industry has heightened attention on reducing operating costs, including, of course, fuel costs — and coal and LNG, which are regarded as supplementary sources of base load power in Japan to nuclear, are seen as foremost targets for cost reduction. This view may have been reinforced by MITI's recently announced plan, in response to the Kyoto Protocol emissions reduction commitment, to contain the share of coal-fired generation in Japan to its 1996 level of about 14% (cf a level of 20% in the utilities' 1997 *Long-Term Electric Power Facilities Development Plan* for 2006).

In their quest to balance cost reduction imperatives on the one hand, and stability (assurance) of supply on the other, the Japanese power producers have sought additional "flexibility" in their fuel purchasing strategy.

This was manifest late in 1996 when two utilities bought 0.5mt spot tonnage — both at a discount of about 17% from the benchmark price and there was also some resort by others to exercising options for additional cargoes at renegotiated prices. That year, some 5% of the Japanese power companies' total coal purchases were made at spot prices, whereas previously all of the utilities' base coal requirement and options were exercised at the benchmark price, the latter were used to manage unexpected levels of demand.

ATTITUDES OF COAL SUPPLIERS

Australian suppliers, at least, have made clear that they are not averse to their Japanese utility customers participating in the spot market. Long term contracts negotiated with the Japanese utilities and other north Asian utilities underpin Australian coal production, and if surplus coal is available for sale at a discounted price contract customers should be first to be offered the opportunity to purchase it. Australian suppliers' stated position is that, only in the event that contract customers are unable to avail themselves of the opportunity, should this additional coal be offered to other buyers.

The supplier/customer relationship is valued by coal mining companies and will be rewarded in this way when possible.

THE PRICE – SUPPLY SECURITY TRADE-OFF

Nothing in this world routinely comes cheaper than something of the same quality. And quality — in one or other of its guises — has been the economic rationale for benchmark pricing for term contracts. The Japanese benchmark system provided incentive to suppliers to afford priority attention, in production, delivery and coal specification to the Japanese power company buyers (and others adopting the Japanese benchmark). Apart from rare occasions, this was the best price on offer and it warranted maximum effort to ensure contracts were won and renewed. This assured the best possible service to benchmark buyers and guaranteed access to the best quality, and consistent quality, coals.

What this means is that there is a trade-off between supply stability (and quality) and average procurement cost. If expected average coal procurement costs are reduced by buyers increasing their spot market exposure, there must be ramifications on the supply side — just as there are if coal price levels on average decline.

SPOT PURCHASING FOR COST MANAGEMENT IN EUROPE

Increasing competition in electricity markets, and the concomitant imperative of reducing costs, inspired changes in the coal purchasing policies of European utilities earlier in the 1990s. The case of the Dutch utility GKE, reported in *International Coal Trade*, is a good example. GKE coined “battle coals” to express the program of procuring a wider range of lower cost coal types and developing the capability in Dutch power stations to use these coals acceptably. Flexibility is key to this strategy and it is facilitated by large stockpiling and blending capacity and, as necessary, resort to last minute coal purchasing.

As the IEA report observes, this strategy does involve risk-taking — and GKE itself accepts that stocks may run low and problems may be encountered with the quality of the blend. Coal purchasing by the Danish utilities has been somewhat less adventurous, but spot purchases are an important component — about 40% of supply in Denmark’s case — and an important source of “price flexibility”.

In Europe the role of coal is under threat not only from price competition from other fuels, most importantly gas, but also from environmental legislation on emission levels. The latter has driven many generators towards gas which is in abundance in most European countries either directly or through the European gas pipeline structure and has considerable emission benefits over coal. In these circumstances the reduction in coal prices from the increased use of the spot market has helped coal to keep its level of usage higher than might otherwise have been the case.

SPOT MARKETS AND PRICE VOLATILITY

It is an interesting question as to whether greater resort to spot markets (and lesser “cover” from term contracts) will have consequences for price volatility which might, in turn, affect the economics of coal production. Market models do not usually indicate a relationship between average prices paid for a commodity and the ratio of spot sales in total sales. While spot markets, for obvious reasons, are more volatile than contract markets, the larger they are in the total market the less volatile they are likely to be. With a larger spot market, term contract prices might be expected to display more cyclical movement than has been customary on coal markets to date.

Market demand for coal can change rapidly: small variations in economic growth are accentuated in coal demand and, while there are sometimes offsetting factors — like favourable rainfall, for example — as often as not they compound the variation. Markets can be relied upon to manage these circumstances; however, it is as well to be aware that price is the instrument of this management. And the price signal has two functions: one is to facilitate efficient allocation of available supply in the short term; the other is to induce appropriate levels of investment. Greater resort to spot markets, tenders, spot market-related options and so forth will not prejudice short term allocation. Those buyers willing to pay the highest price will get their coal. However, short term price “spikes” are unlikely to induce new investment in long term coal supply and, if the “new” coal procurement strategy achieves its purpose and reduces average returns to coal producers, a lower rate of investment is inevitable.

In other words, average prices (and price expectations) are the key — not price volatility. Term contracts at benchmark prices in Japan, and at closely referenced prices in other Asian markets — notably Korea and Chinese Taipei — have provided security of supply to buyers and, importantly, security of revenues for coal miners. These contracted revenues have been at above average prices. What has been emerging, and what is envisaged for the future, is a smaller proportion of these contracts in total sales, and hence somewhat lower average prices.

IMPLICATIONS FOR COAL MINING INVESTMENT AND OPERATIONS

The implications of this development are fairly clear. Greenfields coal mining projects, and major extensions to existing mines and infrastructure, attract equity capital and debt in line with the security of future revenue. A project whose projected sales are largely secured by term contracts will be financed before, and in preference to, a project more reliant on spot sales. Unless the latter project can secure its long term revenue with hedging instruments (not usual in coal) it will be assessed by the bankers to be riskier, and they will demand an interest premium reflecting that risk. At the margin, this will inhibit new investment and market prices could, as a consequence, be somewhat higher than otherwise. This extra cost will be borne by all participants in the market, including traditional spot market buyers.

In ordinary circumstances, this outcome is a good one for the contract (and benchmark price) buyers whose need for supply security has, in effect, underwritten marginal capacity used to satisfy spot market demands. Benchmark buyers have subsidised those who have chosen to rely on the spot market. In the world of less contracts, that voluntary cross subsidy will be curtailed.

In circumstances when supply is tight, however, or when supply is disrupted, customers dependent on continuous supply, and tightly specified coals, can expect interruptions or, at best, to pay high prices to obtain the coals they need. But this cost/risk trade-off is one they must evaluate for themselves, but it is worth noting that as electricity privatisation world-wide forces generators to reduce costs to compete, so they look to their plants to take a wider (and cheaper) range of coals, and so the risk of supply disruption is reduced.

The IEA's *International Coal Trade* report suggested three likely consequences of the development of a larger Asian spot market:

- possibly increased uncertainty for investors in new mine capacity dedicated to exports;
- "certainly," a weakened link between producers and consumers (which "contributed to the growth of the Asia-Pacific coal market"); and
- the breakdown of any "national" approach to coal marketing as individual companies compete for market share.

None of these are necessarily negative — and indeed one corollary may be that new investment in supply capacity which, since the early 1980s, has tended to be unduly optimistic or premature, will be more subdued and more closely aligned to current and immediate demand.

Access to spot markets is not an advantage enjoyed exclusively by coal purchasers. For coal producers, a certain proportion of spot sales provides the flexibility to match deliveries and production most efficiently. But while average costs might be minimised with a certain balance of spot and firm sales, an excess reliance on spot sales (and on options as opposed to firm sales) can destabilise mining operations and create inefficiencies. Mine development and planning is not optimal when management is required to be overly responsive to short-term demands.

Current levels of spot trading in Asia are, however, well within manageable limits. It is possible that recent trends in purchasing practices, if continued, could begin to test some of these limits — and coal buyers will need to be conscious of the implications for supply continuity and costs.

WILL THERE BE A RESURGENCE OF NEW COAL-FIRED PLANTS OUTSIDE THE PACIFIC RIM ?

Poul Sachmann
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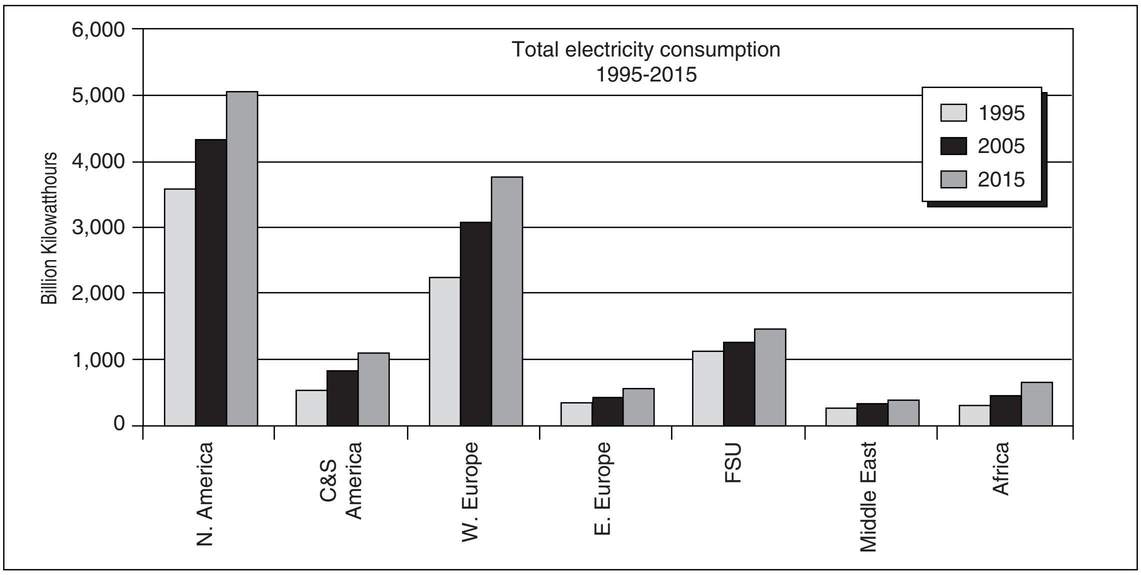
1. HOW WILL THE DEMAND FOR ELECTRICITY DEVELOP?

Forecasting is inevitably a difficult matter, and needless to say, encumbered, with a great deal of uncertainty. In this paper the forecasting period is limited to a twenty-year period ending in the year 2015. The data used to predict future development is mainly taken from "World Energy Projection System 1997" published by the U.S Energy Information administration /1,2,3/. Assumptions used in the forecasting can be found in ref. /1/.

This paper deals with electricity consumption in countries outside the Pacific Rim, i.e. Japan, China, India, Australasia (Australia, New Zealand and U.S. Territories) and other Asian countries are excluded. "World Energy Projection System 1997" operates with three scenarios: the reference case, a high growth case and a low growth case.

In the reference case total world demand for electricity is forecast to increase by 75% from 1995 to the year 2015. The greatest growth is in the Pacific region, 140%, whereas the rest of the world (mainly USA, Western Europe and Former Soviet Union "FSU") is only expected to increase electricity consumption by 55%. In the non-Pacific region the largest growth in electricity consumption is around 100% and is found in Central & South America and Africa. The Former Soviet Union exhibits the lowest growth rate: 30%. See figure 1.

Figure 1
Growth in electricity consumption in the period 1995 to the year 2015.
Based on ref. /1/, reference case.



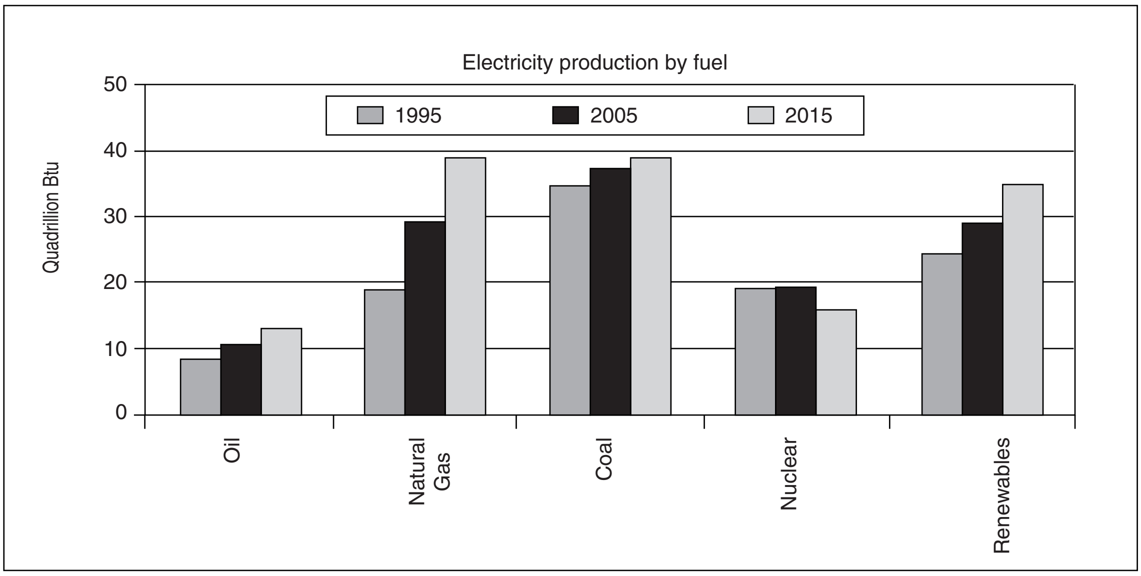
The low growth and high growth cases predict an increase in electricity consumption at 36% and 73% respectively in the period 1995 to the year 2015, compared to 55% in the reference case. In absolute terms electricity consumption in non-Pacific regions is thus predicted to increase 4600 billion kWh in the period 1995-2015 in the reference case. The lowest and highest increase is 3100 and 6300 billion kWh respectively.

Although Asia is generally regarded as a region with very high growth, it should be remembered that, in absolute terms, however, electricity consumption growth in non-Pacific rim countries is larger (4600 billion kWh) than in Pacific Rim countries (4000 billion kWh) in the period 1995 to the year 2015.

2. THE ROLE OF COAL IN THE FUTURE ELECTRICITY PRODUCTION

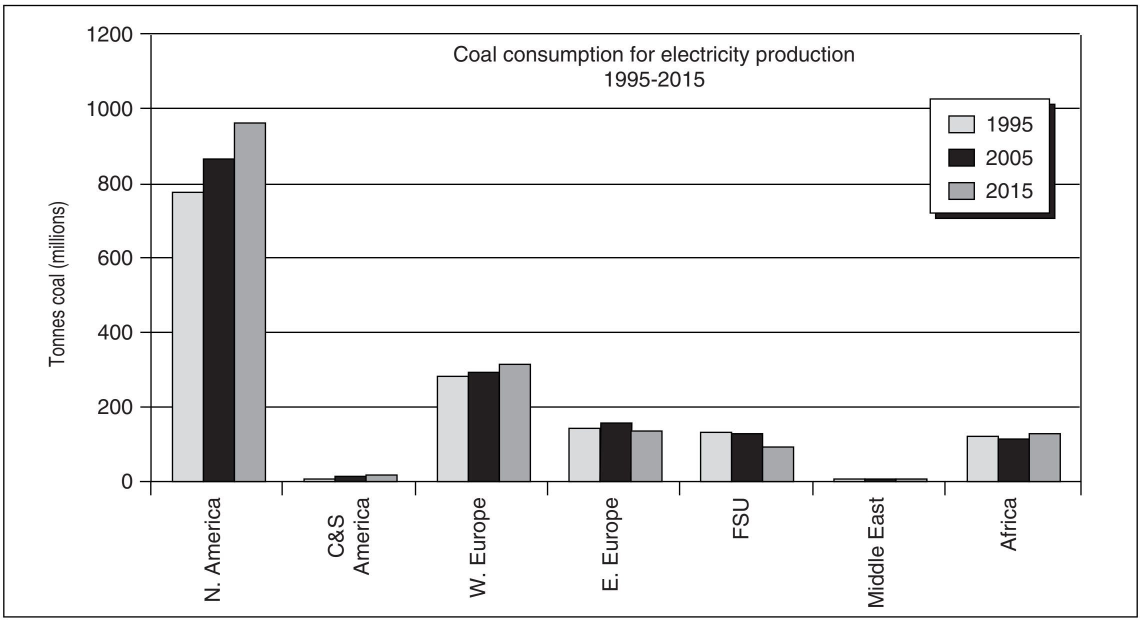
In 1995 coal accounted for 33% of the electricity production in the whole non-Pacific region. There are, however, considerable differences in the role of coal in the various parts of the world. In North America, Eastern Europe and Africa approximately half of the electricity is produced with coal as the fuel. In contrast, only approximately 5% of the electricity in Central & South America and the Middle East are based on coal. For all regions **the percentage of electricity that is produced from coal decreases in the period from 1995 to the year 2015**. This is most notable in the Former Soviet Union (45% reduction). In contrast only a modest decrease of 7% is expected in Northern America. In Europe a reduction of 18% is expected.

Figure 2
Development of fuel usage for electricity production in the non-Pacific regions 1995-2015. Based on ref. /1/, reference case.



Taking an overall look at the non-Pacific region, figure 2, it can be seen that in absolute terms, however, the increase in electricity production by the year 2015 outweighs the decrease in the percentage of electricity produced from coal. **The result is an increase from 35 to 39.3 quadrillion Btu (equivalent to 12%) in coal consumption from 1995 to the year 2015** in the reference case. In the low and high growth case the increase in coal usage for power production is 4% and 27% respectively. Natural gas and renewables (hydro, wind, wave, bio-mass etc) take up the majority of the growth in electricity demand.

Figure 3
Coal consumption for electricity production 1995-2015.
Based on ref. /1/, reference case



The total amount of coal used in different regions of the world for electricity production is shown in figure 3 (the recalculation from Btu's to tonnes coal has been made using a "standard" calorific value of 6000 kcal/kg=25,12 MJ/kg=10800Btu/lb). **The only regions where significant increases in coal burn for electricity production can be identified, in the period from 1995 to the year 2015, are North America and, to a lesser extent, Western Europe.** In North America the forecast predicts an increase in annual coal burn of 185 million tonnes or 24% (low and high growth cases predict growth of 18% and 37% respectively). The increase in coal burn for Western Europe is 34 million tonnes per year or 12% (low and high growth values are 6% and 12%). With respect to Europe a UNIPEDE forecast (ref. /5/) is less optimistic: a 0% growth from 1995 to the year 2010. Even more pessimistic is a prediction by the EC: a reduction in annual coal burn of 29 million tonnes of coal is forecast from 1995 to 2015 for Europe (ref. /6/).

3. REQUIREMENTS FOR NEW COAL FIRED CAPACITY

As shown above North America and maybe Western Europe are the only regions where significant increases in annual coal consumption for electricity production are predicted in the coming 20-year period. With respect to electricity production from coal, North America is essentially equal to USA. In the following, the discussion of future capacity increases will be focused on USA and Western Europe.

3.1 Factors influencing the need for new capacity

Both USA and Western Europe are in a highly competitive electricity market, and there is a strong incentive to keep production cost at a minimum. This involves lifetime extension of existing power plants. At the same time there is a great incentive to increase the utilisation of existing plants.

3.2 USA

Of the 185 million tonnes growth in coal consumption predicted for North America, the majority, 155 million tonnes, will take place in USA. If this growth should be accomplished only from new units, it would require a total of 250 new 300 MW units to be build before the year 2015 (assuming a plant efficiency of 40%, 6000 hours of operation per year and a coal calorific value of 25MJ/kg). Add to this figure a number of plants to replace existing capacity.

However, the “Annual Energy Outlook 1998”, ref. /4/, only predicts **49 GW of new coal fired units to come on line in USA between 1996 and the year 2020.** This corresponds to 160 new 300 MW units, of which 60 are expected to be built before the 2010 and the remaining 100 in the period 2010 to the year 2020.

Thus, lifetime extension and better utilisation of existing plants can be calculated to compensate for scrapped units and furthermore to account for an increased coal burn of approximately 50 million tonnes by the year 2015-2020. The rest, 105 million tonnes of coal, is burnt in new plants. Using these figures the number of new units built in the low growth case and the high growth case can be estimated to be in the range 95 to 310.

3.3 Western Europe

For Western Europe as a whole the coal fired generating capacity is expected to decrease 2% to 141000 MW over the period 1995 to the year 2010. The decrease mainly takes place in France, UK, Germany and Denmark, but capacity increases are expected in Spain and Italy (ref. /5/).

Besides those plant already under construction, **a total of 9 coal fired plants with a capacity of 4700 MW are planned to be built in Europe in the period 2000 to 2010** (ref. /5/). Most of these units will be built in Germany to replace old capacity. This is in line with ref. /6/, which states “it is not envisaged, that any significant amount of new conventional coal-fired plant is built”.

3.4 The influence of Kyoto

The above estimates are given using existing national policies. The aims for reducing CO_2-emission set up at the Kyoto conference may in the future severely restrict the use of fossil fuels and especially coal. Power production from coal will be cut to approximately 50% of the figures given above if the CO_2-reduction targets shall be met (ref. /6/). Greater use of non-fossil fuels and electricity savings are the means to fulfil the Kyoto-agreement. With these prospects the need for new coal fired capacity will be very limited.

4. CONCLUSION

Assuming “business-as-usual” electricity demand in the non-Pacific region is expected to increase 55% from 1995 to the year 2020. Although the percentage of electricity produced from coal decreases in the period, coal consumption for power generation increases 12%. The growth in coal consumption takes place almost exclusively in USA and Western Europe. In USA 49 GW of new coal fired capacity is expected to come online before the year 2020. In Western Europe 4.7 GW coal fired capacity is expected to be built before the year 2010; mainly in Germany. No other major markets for new coal fired capacity have been identified. If the Kyoto-targets for CO_2-reductions are pursued, the use of coal for power production will fall dramatically. In this case the need for new coal fired capacity in the non-Pacific region may be close to non-existent.

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WILL THERE BE A RESURGENCE OF NEW COAL-FIRED PLANTS IN COUNTRIES OUTSIDE THE PACIFIC-RIM?

Angel L. Vivar[1]

INTRODUCTION

Coal has always been the main source of primary energy in the production of electricity. Widespread throughout over the world, coal was accessible by most countries, especially the developed ones. Nevertheless, during this century, coal has been threatened by other methods of producing electricity.

During the sixties, nuclear appeared to be the best solution to produce large amounts of electricity in accordance with the big increase in demand at that time. The complexity of the technology involved and especially the potential risk associated with the improper use or construction of nuclear plants brought such high initial costs and social opposition that, in many countries, the nuclear option had to be abandoned.

The second threat came from oil. Cheap at that time, easy to transport and use, it appeared to be the best solution for the generation of electricity. Problems arose because of its perceived scarcity and the geographic concentration of the resources. The producers realised that, at the rate of increase in demand that existed during the sixties/seventies, the deposits would soon be depleted. As a response, they started to increase prices to limit the demand. The price of oil went so high that it could no longer compete with coal in the production of electricity.

The problem then arose that many countries had closed their coal mines and not all countries had enough coal to satisfy their needs. This was the origin of the international steam coal trade in the eighties.

The nineties have brought a variety of circumstances that propitiated certain changes in some areas of the world that will be analysed later. Whilst they have not generated the same feeling of crisis in the coal industry that nuclear or oil did in previous years, coal is again threatened by a new way of generating electricity: natural gas used in combined cycle plants.

CURRENT SITUATION

To define a realistic scenario for coal over the next twenty/twenty-five years, it is necessary to analyse the current situation and then to project it into the future.

At the end of the twentieth century, the countries of the world can be categorised as follows:

Developed countries: this would include: Western Europe, USA, Canada, Australia, New Zealand and Japan.

Emerging Areas: Including the Pacific Rim, most of South America, some countries in Eastern Europe, the Near East and Northern Africa.

Undeveloped world: Most of Africa and Asia.

1. With the assistance of Antonio Canseco, Associate.

Specific cases: There are countries in the world that because of their size, political regime or large social, ethnic or economic imbalances should be considered aside. These include: Russia, China and India.

When trying to evaluate which could be the areas that could experience a reasonable growth of construction of coal fired power plants, and therefore in coal demand, the following general statements should apply:

In the **Developed Countries**, the weight of political decisions is stronger than purely economic considerations. Therefore environmental concerns, social satisfaction, cleanliness, safety and security are concepts that are increasingly important.

The **Emerging Areas** are experiencing very large rates of growth and, because of this, there is a considerable increase in the construction of electricity generation facilities. The types of fuels used in each case depends upon the cheapest one available that each particular region.

The **Undeveloped World** requires very small quantities of electricity to cover its basic needs. In any case, it could be said that these parts of the world do not have the capacity to access the international energy market and therefore their generating plants will be based on local energy sources.

Russia, China or India tend to be self-sufficient and, although these countries have always been present in the international coal market, the quantities involved have been marginal and have not had a significant influence on the normal evolution of the market.

LIKELY EVOLUTION (→ 2025)

The Kyoto Protocol, which still has to be ratified, has introduced severe commitments in relation to the emissions of certain gas in a defined list of industrialised countries. As a consequence, there are or there will be specific policies designed that will encourage the development of renewable energy sources, the establishment of incentives for constructing more environmentally-acceptable electricity generating plant and perhaps taxes that will penalise those plants that emit higher quantities of certain gases.

The introduction of deregulation and liberalisation into the electricity sector has introduced new players into this business. They are generally smaller than the traditional utilities, they require less risk and smaller plants for their investments. For these, the modular combined cycle plant is the best solution.

New clean coal technologies are still perceived as expensive, not fully operational in many cases and a high risk compared to other options.

As gas liberalisation goes ahead, competition in this sector will encourage lower gas prices that will make life still more difficult for coal. This will be especially true in those areas where gas is accessible by pipeline (the USA and Canada, Europe, South America and northern Africa).

Developed Countries

Western Europe will have low rates of growth in electricity demand. The natural gas industry will be deregulated and the availability of natural gas will increase with new sources coming from Russia (Yamal fields), the North Sea (the Interconnector to continental Europe) and northern Africa (the extension of Algerian gas pipelines). The environmental commitments made by countries will encourage policies favouring the construction of low CO_2 plants (natural gas - combined cycle) and an increased use of renewable energies (wind, waste, solar, hydro etc.).

The replacement of indigenous coal production with imported coal will allow a moderate increase in trade, although the total percentage of coal used in electricity generation will decrease. South Africa and Colombia/Venezuela will be the main suppliers (and, in the future, the sole suppliers of Europe).

The USA and Canada will follow a similar trend as Western Europe, especially in relation to the massive use of natural gas to cover the increase in electricity demand. However, due to the large coal reserves in these countries, the use of this fuel will maintain its share although, with the increasing environmental restrictions, the replacement of high sulphur coal with PRB coals will continue.

Large amounts of imported coal are not expected in the future. Only ad hoc imports by coastal plants in the Gulf of Mexico and the Eastern coast could continue.

Japan, due to the absence of natural gas in the area and the high cost of LNG in comparison with coal, will maintain its programme of power plants using imported coal. The involvement of this country in the development of the coal industry of Australia, Indonesia and, to a certain extent, in China will support the continuation of this policy.

Emerging Areas

The four large emerging areas of the world: Pacific Rim, Central and South America, Eastern Europe and Northern Africa will require large amounts of energy to develop. However, not all will follow the same route.

The Pacific Rim will base its development on the use of coal for electricity generation. Natural gas, with no pipeline infrastructure, will have to be used as LNG, with the inherent economic and strategic limitations on its use to generate electricity.

South America will clearly move towards an increased use of natural gas and of the large hydroelectric resources, with some limited exceptions. No new coal power plants are expected to be built in this region, and the important coal reserves of Colombia and Venezuela will be used for export to other regions of the world.

Eastern Europe will use both coal and gas, although local coal production will shortly disappear to the benefit of natural gas.

North Africa has three natural gas producers: Algeria, Libya and Egypt. Within the region, Algeria exports to Morocco and Tunisia, while Egypt may, in the future, export gas to such countries as Jordan and perhaps Israel.

Undeveloped world

During the next twenty five years most countries in central Africa and Asia will cover their minimal electricity requirements with plants based on local primary energy resources that will have no impact on the international coal market.

Special cases

It is difficult to analyse briefly the long term future of countries such as Russia, China and India. However, at the risk of falling into over-simplifications and generalities, the following statements could be made.

The three countries are amongst the largest coal producers in the world and have largely based their future expectations of growth on this fuel.

The three countries do have an impact on the international coal market; Russia and China (mainly as exporters) and India (as an importer). However, the lack of infrastructure both in overland transportation and in port facilities mitigate against these countries making a major impact on the international coal market in the future.

On the other hand, if the globalisation of the economy moves ahead strongly in these countries and foreign financial investment contribute to developing the indigenous coal resources, then the potential effects of these countries on the world coal market could be very important. This would not happen overnight but the market player should be attentive in order to avoid any undesirable effects.

CONCLUSIONS

The growth in the demand for coal for power generation will take place in the Pacific Rim.

The international coal market will replace, partially, the reduction in the domestic coal production in Europe. Natural gas should cover most of this demand if it is available at a reasonable price, which should in principle be the case.

In some areas of eastern Europe still some coal plants will continue to be built.

There is a great deal of uncertainty existing over the future development of the coal import/export capacity of countries as Russia, China and India.

DISTRIBUTED GENERATION – ITS FUTURE AND DOES COAL HAVE A ROLE TO PLAY?

M Deats and D Murray[1]

1. INTRODUCTION

The challenges posed by modern energy, development and environmental issues mandate a changing paradigm in the approach to energy supply, transport and use. As a contribution to the debate around coal based paradigms, the Coal Industry Advisory Board of the International Energy Agency has undertaken an exercise to define the future role of coal. This short note is a contribution to that exercise. It should be noted that these are merely ideas which attempt to stimulate debate and innovation in addressing the development imperatives of poor nations around the world, whilst at the same time putting the energy sector on the path to Sustainable Development. This essay does not attempt to find a role for coal in this picture, it rather discusses the challenges and presents possible mechanisms to address them. The potential role of coal is presented in this context.

It is widely recognised that electricity is the premium energy source when it comes to social upliftment and the progress of modern society. Electricity becomes the source of high quality lighting, communications and refrigeration which fundamentally enhance the quality of life of those who have never had access to it. The long term social and environmental benefits of electrification programmes have been demonstrated around the world. It should be stressed that this electricity may be sourced from any primary energy form, including coal, nuclear, hydro etc – the benefits of electrification in improving quality of life, as well as the attendant long term environmental benefits, far outweigh any negative impacts of the primary energy source used for power generation. This will not be covered further in this note, rather the most challenging aspect of any electrification programme will be discussed, namely how to get electricity to poor rural communities in the face of high costs and weak rural infrastructures.

2. THE ENERGISATION CHALLENGE

Energy starvation has increasingly become a harsh reality of life for millions of people in developing nations around the world. This is particularly true for African rural communities where drought, overgrazing and population concentrations have resulted in depletion of the natural resources most commonly used for energy – namely fuel wood. The search for energy becomes a major factor in the lives of such communities – on a par with the need to grow sufficient food to survive. This in particular takes up the major portion of women and children's time and effort. The challenge is not only to look at mechanisms to meet the energy needs of such communities, but also to give them access to the form of energy which plays such a major role in social upliftment – namely electricity. Access to electricity in remote rural areas enhances communications, creates job opportunities and improves education levels.

This challenge is poised to become one of the greatest development focuses of the developing world. The question is how may it be achieved economically viably? It is felt that one of the main techniques used will be distributed generation coupled with energisation programmes.

1. With the assistance of Dr S J Lennon, Associate.

3. DISTRIBUTED GENERATION/ENERGISATION

The concept of distributed generation is widely understood, however the full potential is often not appreciated. In this sense distributed generation is seen to have application in:

- Creating small, stand alone, community owned networks which service that community only
- Creating local networks – essentially a distributed utility, which may meet the needs of a few communities
- Combining the excess capacity of numerous home systems e.g. solar home systems, into a community network for common supply e.g. for water pumping
- Reinforcement of the local grid where lines may be undercapacity or underdesigned.

The supply side component of distributed generation systems are extremely flexible and can be conventional technologies such as diesel generators, or renewable technologies such as solar photovoltaic, mini hydro, wind, or a combination of all of the above. It should however be noted that, in most cases, these sources would not be adequate to meet all of the community's energy needs. As such the energisation concept needs to be implemented. Energisation entails the combination of electricity with other energy sources to ensure that an integrated energy package is supplied to the community. Therefore a relatively low capacity electricity supply could meet a community's lighting, cooling and communications needs, and other energy sources, such as wood, LPG, coal, kerosene or biogas, could be used to meet their heating and cooking needs.

The integration of these concepts, and, in particular their financing in such a way as to ensure sustainability, are the major challenges posed to those engaged in rural development programmes. It is however felt that the use of utility type financing, coupled with opportunities being created out of the United Nations Framework Convention on Climate Change and the recent Kyoto Protocol, brings the possibility of global electrification and sustainable energy supplies to rural communities a lot closer. It is clear that the role of coal in this regard is limited. Coal does have potential to be the "energisation partner" in certain very specific instances where availability dictates it as the low cost fuel of first choice. This does however result in a high degree of local and indoor pollution. The transformation of coal into smokeless fuels would be a priority in such cases. If the coal industry wishes to play a role in this energisation drive, then the development of low cost and easy to use smokeless fuels as well as the associated appliances presents significant opportunities. These opportunities are however tempered by low energy consumption and affordability levels. As such an investment in this area is inevitably a long term one! Clearly other opportunities such as coal gasification for powering small scale gas turbines, or eventually even local fuel cells, could present longer term opportunities. However these technologies are unlikely to enter the energy mainstream, especially in developing nations, within the next 20 years at least.

THE FUTURE ROLE OF COAL
A SOUTH AFRICAN PERSPECTIVE

D Murray[1]

1. INTRODUCTION

The challenges posed by modern energy, development and environmental issues mandate a changing paradigm in the approach to energy supply, transport and use. As a contribution to the debate around coal based paradigms, the Coal Industry Advisory Board of the International Energy Agency has undertaken an exercise to define the future role of coal. This short note is a contribution to that exercise in providing a perspective of coal's future from a South African viewpoint. Five specific focus areas have been selected for commentary.

2. IMPACT OF DEREGULATION

Electricity deregulation is creating an environment of greatly increased competition, resulting in both a shorter term focus for generators, and greater concentration on input costs. Whilst the electricity sector in South Africa is currently in a regulated mode, the enhanced coal requirements of local generators is having a similar effect. Pressure on pricing and shorter term settlements have resulted. In particular greater use is made of the spot market with more flexibility being required of coal suppliers and generators alike.

3. BASE LOAD GENERATORS AND CONTRACT PURCHASES

There is a limit to the amount by which a base load generator can reduce contract purchases. Especially in an oversupplied market, however, flexibility and shorter term pricing, with the potential use of risk management tools such as futures trading, can be significantly increased against any basic tonnage commitment.

4. SOUTH AFRICAN FOSSIL FUEL RESERVES

Reserve base calculations show that coal is (in relative terms) plentiful, with known economically extractable reserves available for longer periods than those for any other fossil fuel. As such it is widely recognised that coal will continue to play a major role in South and southern African energy supply for the foreseeable future. South Africa has coal reserves of some 121 billion tonnes – with some 55 billion tonnes being economically recoverable. The draft energy policy of South Africa specifically mentions coal discards as a potential resource in stating: - "The production of discard coal during 1996 has reached about 53 million tonnes, mainly as a waste product of coal beneficiation. It is estimated that 550 million tonnes of discard coal are stockpiled above ground, which can be regarded as a future reserve of low grade coal."

1. With the assistance of S J Lennon, Associate.

5. SOUTH AFRICAN ENERGY POLICY APPROACH TO COAL

The draft energy policy of South Africa states: - “The [coal] industry will remain deregulated and its performance will be monitored. Whilst coal will probably remain the major source of energy for the foreseeable future, significant scope exists to reduce the environmental impacts of coal with clean coal technologies.” National energy policy for coal is to “maintain a successful and competitive coal market, ensure the efficient utilisation of coal resources and to reduce the environmental impacts associated with coal usage.” In addition the policy covers the collection and availability of coal information, the potential for coal bed methane and the promotion of clean coal technologies.

6. COAL PRODUCTION IN DEVELOPING NATIONS

In spite of constraints imposed by developments around the UN Framework Convention on Climate Change and the Kyoto protocol, it is considered that coal production in developing nations will continue to grow – at least for the next 20 years – where the resource is available. In particular production is likely to increase in China, India, Colombia, Indonesia and Venezuela. This growth will be driven largely by increased demand for coal in developing nations, coupled with the increasing scarcity of large scale economically viable resources, in particular in Europe.

WHAT IS THE FUTURE FOR NUCLEAR ENERGY ?

Roland LOOSES[1]

1. TODAY'S SITUATION FOR NUCLEAR IN THE WORLD

The nuclear share in the world's energy "mix" is currently 17 % (distributed between 22% for industrialized countries and 3% for developing countries), including 35% for Western Europe and Japan, 20% for North America, and 10 % for the ex-Soviet Union and Eastern Europe.

After a fast growth raising the share from 3% in 1970 to 17% by 1990, and then a decade of stagnation, nuclear energy is today in regression : the number of reactors currently in service has been stable for three years, at a level of 424 reactors and an installed power of 347 GWe.

Currently two to three new reactors are being constructed each year, mainly in countries of Eastern Asia, in Japan, in southern Korea and in China. The closing down rate of electricity plants in North America and Europe could soon exceed that of new reactors construction throughout the world. In Canada and in the United States, about ten reactors are being decommissioned, and the deregulation of the electricity market is going to increase failed investments. In any case, the number of reactors in service would not increase a lot in the years to come, so as to probably reduce in a short term the share of nuclear in the world energy "mix".

2. ADVANTAGES AND DRAWBACKS OF NUCLEAR ENERGY

Nuclear power has advantages and complies with most environmental requirements:

- It does not produce emissions of carbon dioxide, neither other pollutants in the atmosphere;
- Potential reserves of uranium through the world are considerable and hardly started;
- Nuclear reactors are very compact and fill a tiny place as compared to the quantity of electricity they produce;
- There is no big need of logistics for the transportation and storage of fuels and wastes, since the volume of fuels used in the whole world is only in the order of 10,000 tons per year.

In spite of globally good results in the field of the protection of the environment, public opinion shows a strong opposition against nuclear power, drawbacks of which are:

- The treatment of strongly radioactive nuclear wastes hasn't been solved so far;
- Nuclear reactors require an important security area, where the density of population is weak;
- The transportation of nuclear fuels also requires very severe safety measures;
- In some countries, there is a risk of nuclear proliferation.

1. Roland Looses acknowledges the contribution of his associate Pierre BERTE in the preparation of his paper.
He also thankful to EDF for the supply of various data and information.

It is important to know that the new reactor French - German EPR (European Pressurized Reactor) doesn't meet the reproaches mentioned above, particularly in the field of safety: reduction of serious accident risks and improvement of the safety in operation.

3. THE ECONOMIC COMPETITIVENESS OF NUCLEAR ENERGY

The diversification of supply sources and energy autonomy have been key factors, originally, in the nuclear program development of countries such as Japan or France. Today worries linked to the security of supplies are reduced and economic competitiveness is required as an essential criterion in energy policy development. But more and more awareness about environment means taking into account environmental costs that were not considered previously in the framework of economic analyses.

The current situation is marked by the low price of fossil fuels, the increased role of the private sector and the growing severity of environmental and health protection rules. Since 1985, the cost of electricity from nuclear is more or less stable in constant currency, while decreasing for coal and collapsing for gas.

The particular cost structure of nuclear plants (65% of the cost of the production of electricity is dedicated to investments) entails a stability of the cost of electricity production but implies long payback time of capital investment. This does not match the objectives of private producers of electricity, who prefer gas plants which require lower capital investment.

The uncertainty of the cost of dismantling nuclear plant does not favor these private investments any more.

4. THE ENVIRONMENTAL ASPECT

It is difficult to anticipate to what extent worries linked to the environment will affect medium and long-term energy policies.

Great doubts remain so as for the impact of greenhouse gas emissions on the environment and particularly on the risk of world climate change.

However, it is probable that sources of energy producing lower emissions will be retained whenever the choice is technically possible and economically valid.

Finally, the attribution of a value to emissions of carbon, in order to tackle problems raised by the threat of a climate change, would increase the cost of electricity produced from coal or gas, while the cost of nuclear production would remain unchanged (a 20 dollars value per ton of carbon would increase by 18 % the cost of coal-based electricity).

5. EVOLUTION AND PROSPECTS

Nuclear production capacity is today virtually settled at 364 GWe for the year 2000.

Delays for a nuclear plant construction (from 6 to 12 years according local regulation and political conditions) and the relative geographical concentration of the production (United States, France and Japan represent 60% of world capacity) allow the evaluation of prospects until the year 2010 with practically no doubt.

According to the C.E.A (Commissariat à l'Energie Atomique, France), world capacities should reach 413 GWe in 2010, showing an increase superior to the previous decade (13,4% against 5,5%), but this will be mainly thanks to Japan, Russia to some extent, and newcomers to nuclear production.

On the other hand, traditional producers will either decrease their capacities (United States), confirming the trend of the nineties, or will maintain it at a stable level (Germany, United Kingdom or France).

By 2020, prospects are more difficult to evaluate because factors of uncertainty are numerous and often opposed (economical and environmental aspects).

There is a serious uncertainty about the adoption of a voluntarist policy for environment protection and greenhouse emissions reduction, which would imply a development of nuclear energy. Without considering such environmental policies, the share of nuclear energy would decrease or be stable.

The falling trend in nuclear electricity production, beginning in 1990, is currently continuing among the different studies carried out on the period 2010-2020.

World capacities, according to recent works from the D.O.E and the I.E.A, would range between 302 and 420 GWe for the year 2020, according to the world growth level.

Let us note that the upper limit (420 GWe) of this range for the year 2020 is practically at the same level as the C.E.A in France chose for the year 2010 (413 GWe).

Around 2015-2020, nuclear programs will be able to begin a recovery provided that we bring solutions to concerns relating to the safety of reactors, the transportation and the elimination of radioactive wastes or the nuclear fuels proliferation.

The challenge in Europe and in North America, for the manufacturers of nuclear plants as for governments, is to find a way for nuclear to remain an energy supply possibility in a long term, despite a probable stagnation of nuclear programs up to 2010-2015.

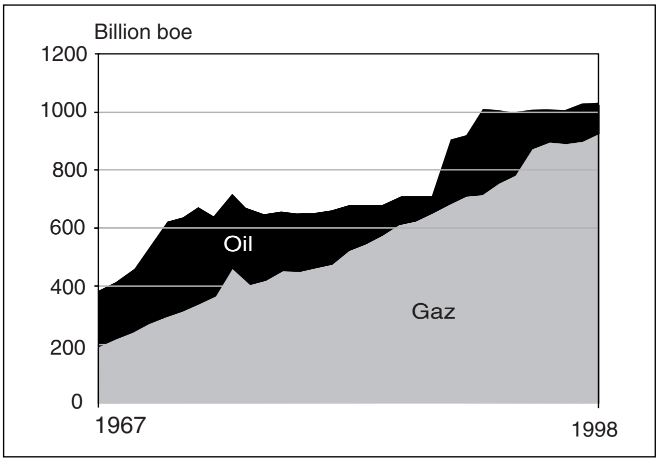
WILL NATURAL GAS REMAIN A FORMIDABLE COMPETITOR FOR 20 YEARS OR MORE?

Walter van de Vijver
Chairman of Shell Coal Pty Ltd, Brisbane [1]

Fossil fuels supply around 85 per cent of the world's commercial primary energy needs with the contribution made by natural gas being over 25 per cent and growing. Of the 2310 Gm^3* (equivalent to 2900 Mtce) marketed gas production in 1997, 520 Gm^3 (23%) was traded internationally including 110 Gm^3 in the form of LNG (Liquified Natural Gas). The equivalent data for coal is production of 3280 Mtce and international trade of around 13%.

Natural gas is the youngest of the commercial fossil fuel energies (following coal and oil) and it did not feature significant as a primary energy until the 1930's. Its early development was constrained by the long distance technology required for transportation from field to customer and the majority of its use was for the indigenous markets, particularly in the US and Russia. The advent of major pipelines and the development of LNG plants with the associated transport and storage systems, together with the discovery of large gas reserves in the Netherlands and the North Sea in the 1960's and 70's, resulted in the opening up of international trade. Total gas demand has grown by 2.7% per annum over the last 15 years, a rate of growth which is projected to continue into the future. This growth will come from established markets in Europe and in the Asia/Pacific region, as well as those markets in developing counties where industrialisation and raising living standards of the population will require additional supplies of energy.

Evolution of Proven World Oil and Gas Reserves (1/1/98)



Natural gas reserves are currently estimated at 152,000 Gm^3, resulting in a reserve / production ratio of 65 years compared to 41 years for oil and over 200 years for coal. Of the gas reserves, 37% are located in

1. Paper prepared by Associate R. N. McBride
* Gas volumes are expressed in terms of $10^9 m^3$ also referred to as Gm^3, Bcm (Billion cubic metres) or milliards. The later two units are those generally used in the gas industry.

the Former Soviet Union and 33% in the Middle East. The remaining 30% are distributed around the world. Gas reserves have steadily increased with respect to oil over the last 30 years and new gas fields of significance continue to be discovered in many parts of the world.

The current driver for increasing demand for natural gas is as a fuel for power generation, a use which is projected to account for half of future demand growth. The advent of high-efficiency, coupled with low-emission, combined-cycle generating plant has given gas attractiveness a significant boost. In this post-Kyoto world, electricity can be generated from gas plants at half the carbon dioxide emission per unit output compared to coal plants, along with zero sulphur oxides and low nitrogen oxides. Given that the capital costs of gas stations are considerably less than those of coal plants and the far shorter construction time scale, the advantages that gas holds for newly built plants are considerable. However on a marginal fuel cost basis, gas remains more expensive than coal. It is the power generation sector that forms the main gas/coal competition interface.

The major challenge for the gas industry is not the availability of resource but the ability to deliver it economically over increasing distances. Developments continue to be made which reduce the cost of conveying gas either by pipeline or by LNG from field to customer. These developments will enable longer-distance gas trade to become increasingly economic at lower energy costs. In the case of cross-border pipelines, the political complexities that arise have to be overcome.

Gas-to-gas competition in some markets, notable in North America and the UK, is currently putting prices under pressure to the benefit of consumers. This competition starts at the production source where there is generally a potential excess of gas supply over demand and continues down the distribution chain. Growing demand could change the supply/demand balance but, at present, this is in favour of the buyer resulting in the increased competitiveness of gas.

To summarise, gas is plentiful, the economics of delivery are being tackled, combustion emissions are low, power generation economics are in its favour in many regions of the world, it is a clean versatile fuel readily used in the domestic, commercial and industrial consumer sectors - in short, natural gas will remain a formidable competitor to coal for the next 20 plus years.

TRENDS IN UTILISATION OF RENEWABLE ENERGY SOURCES AND THEIR EFFECT ON CONSUMPTION OF COAL IN THE EU AND IN FINLAND

Ilkka Pirvola [1]

1. WHAT ARE RENEWABLE ENERGY SOURCES

The following is a brief presentation of the principal renewable energy sources:

Biomass

In addition to firewood, the forest industry's wood-based waste, and plants grown specifically for energy use, biomass includes waste from agriculture and from the food industry, dung and organic solid community waste, sorted household waste and waste sludge. Biomass can be utilised in a variety of ways – to produce electricity, heat or fuel, as needed.

Hydropower

Hydropower technology is highly advanced, and hydropower has been competitive with other energy sources for a long time. Within the EU, the technical and economic capacity of major hydropower plants is already utilised, or their more extensive utilisation is not possible for environmental reasons. However, many more small-scale hydropower plants (under 10 MW) can still be constructed.

Wind power

Wind power is exploited in electricity generation by means of wind turbines. Wind power technology is currently under rapid development. The size of wind turbines has increased considerably in the last few years. In some EU Member States, wind power is now the fastest growing energy source for electricity generation.

Solar power

The sun's thermal energy can be utilised for heating, and nearly optimum technology has already been reached in this field. When compared to heating of water by means of electricity, a heating system based on solar heat is economically competitive, especially in the southern regions of Europe.

Exploitation of the sun's luminous energy for generating electricity is among the latest and most advanced technologies for utilising renewable energy sources. Even though the costs of this technology have come down rapidly (25% during the last five years), they are still considerably higher than the costs of electricity generated by means of conventional fuels. At the present price level, solar electricity is competitive only at sites that are not linked to the general power network.

Geothermal energy and heat pumps

Geothermal energy accounts for a very small percentage of the energy generation that utilises renewable energy sources within the EU. The heat extracted by heat pumps from the soil and from water should also be considered a renewable energy source.

1. With the assistance of Lars Horn

2. USE OF RENEWABLE ENERGY SOURCES IN THE EU

The table below shows the gross consumption of renewable energy sources (million tonnes of oil equivalent) and their share of total energy in 1995 and a forecast for 2010.

	Consumption 1995		Consumption forecast 2010	
ENERGY TYPE	Mtoe	%	Mtoe	%
1. Wind power	0.35	0.02	6.9	0.44
2. Hydropower	26.4	1.90	30.6	1.90
3. Solar electricity	0.002	0.006	0.26	0.02
4. Biomass	44.8	3.30	135.0	8.50
5. Geothermal energy	2.5	0.20	5.2	0.33
6. Solar heat	0.26	0.02	4.0	0.25
Renewable, total	**74.3**	**5.40**	**182**	**11.50**
EU gross consumption	**1,366**	**100**	**1,583**	**100**

3. THE EFFECT OF RENEWABLE SOURCES ON USE OF COAL

Although the use of renewable energy sources will rise steeply from 1995 to 2010, and the share of other energy sources will fall from 94.6% to 88.5%, the absolute consumption of other energy sources will increase by 8% (from 1,292 Mtoe to 1,401 Mtoe).

From the above it follows that the more intensive utilisation of renewable energy sources within the EU will not directly reduce the potential for coal use. The trend in coal use depends much more on changes in fuel prices and in the taxes levied on fuels, as well as on laws and other regulations set forth by the authorities in order to steer energy consumption and production.

4. CASE FINLAND

Being based on the exploitation of many different energy sources, the Finnish energy production system is highly varied. Renewable energy sources already cover a higher percentage of the need for primary energy (22%, excluding peat) than the EU target for 2010 (12%). In addition, Finland has long experience of co-generation of power and heat and of district heating, which are highly efficient ways of utilising energy.

The table below shows the consumption of primary energy in Finland in 1995 (million tonnes of oil equivalent) and a forecast of the gross consumption of renewable energy sources (including peat) in 2010.

	Consumption 1995		Consumption forecast 2010	
ENERGY TYPE	Mtoe	%	Mtoe	%
1. Oils	8.5	29		
2. Coal	4.1	14		
3. Natural gas	2.9	10		
4. Nuclear power	4.9	17		
5. Net imports of electricity	0.6	2		
6. Peat	1.8	6	1.5	4
7. Waste liquors of industry	3.4	11	4.5	13
8. Wood fuel	2.0	7	2.4	7
9. Hydropower	1.1	4	1.2	3.5
10. Wind, sun, biogas, etc.	0.0	0	0.08	0.02
Gross consumption	**29.3**	**100**	**34**	**100**

Since the proportion of renewable energy sources is already fairly high in Finland, no major increase in their use is possible. In consequence, the more extensive utilisation of renewable energy sources will not reduce the use of other energy sources in future. In the same way as elsewhere in the EU, the future of coal consumption in Finland will depend on other factors much more than on the higher utilisation rate of renewable energy sources.

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COAL SUPPLY
A VIEW FROM 2015

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Placing ourselves in the year 2015 and looking back over the last 15 years, we see a world in which environmental restrictions have been tightened; technology has improved; mines have grown larger; coal transportation has become lower cost; and markets for all forms of energy have become more efficient. Freely operating energy markets have imposed changes on all industries in search of lower costs — and the coal industry has been no exception.

We also see that the location of coal consumption growth continued to play a significant role in determining where coal is being produced. There always has been dynamism in the coal industry based upon the location of coal reserves, transportation options and the location of coal demand. Prior to the 1970s, steel plants were located where access to high quality coal was economical. Similarly, power plants were located adjacent to reserves and designed to burn local coals to serve local electricity markets. In the 1980s and 1990s with the growth of coal consumption in Asia, development of coal production in the Pacific Rim was increased — a trend that has continued through 2015.

Market pressures, however, have pushed world coal production away from higher cost reserves that were being mined for "qualities" other than low cost heat content in steam coal and the ability to coke in metallurgical coals. Quality "concerns" that have become less important since the 1990s include the sulfur, ash, and moisture of a coal product. Additionally, we have seen that reserves accessible from the infrastructure of existing operations have supplied a great deal more of the world's coal production than was commonly anticipated in the 1990s.

TRANSFORMING THE MARKET: THE DRIVE FROM HIGH QUALITY TO LOW COST

Common sense tells us that industry will always mine the "low cost reserves" first, resulting in a long-term trend of mining progressively higher cost reserves. In the coal industry, however, **factors such as improving technology, competition, and falling transportation costs have changed the definition of what constitutes a "low cost reserve."** For example, in the 1970s, what were once poor metallurgical coal reserves in the eastern U.S. became premium steam coal reserves. What were once low quality and remote steam coal reserves in the western U.S., in the 1990s became recognized for low cost heat content and low sulfur.

The terms high and low quality are used guardedly, precisely because the definitions have changed since the 1990s. In steam coal markets, consumers now want heat content, and everything else is along for the ride. As technology continued to improve, consumers of coal found ways to circumvent quality considerations that once stood in the way of lower cost coals. Continued improvements in the technological solutions to sulfur removal in steam coals, for example, allowed the increased use of higher sulfur coal in areas where there were significant delivered cost advantages. Sulfur content, in other words, was marginalized as a quality consideration.

On the production side, the constraints that stood in the way of using low cost coal reserves — infrastructure, labor, and political considerations — loomed large at the turn of the century. These constraints, however, were only fingers in the dike that failed to withstand the unrelenting pressure of deregulated energy markets. Entering the new century, increased competition continued to force the coal industry to go where the mining conditions were optimum, and the market found a way to make it all work. As we moved beyond short-term constraints, the potential for low cost coal reserves, wherever they were located, prevailed. Ultimately, high cost coal reserves were abandoned.

Clearly, the toughest task back in the 1990s was to look to the future to assess how long "short term" constraints would remain. It is notable, however, that we entered an era where market pressures were unleashed like never before. This shortened the life cycles of constraints to low cost coal production throughout the world. As transportation costs declined, both for coal and for the electricity generated by coal, market access to optimal mining sites improved.

In the U.S., continued focus on lowering the cost of delivered Btus pushed consumers to find ways to economically use the low cost but remote coal in the Powder River Basin and the low cost but higher sulfur coals of Appalachia and the Illinois Basin. Higher cost reserves, traditionally protected by low transportation costs or "higher" quality, were caught in a squeeze.

Internationally, Australian underground mines gradually resolved labor problems and achieved productivities approaching those in the U.S. Economic reserves in China are now being exploited far more efficiently than they were in the 1990s.

INCREMENTAL PRODUCTION - ECONOMIES OF SCALE

The traditional coal industry structure – typified in the eastern U.S. and Europe in the 20th century — was one of many small mines, often serving very local markets. The world coal industry structure of the year 2015 is one where a relatively few number of very large mines, such as those found in the Powder River Basin in the U.S. at the turn of the century, provide a large percentage of the world's coal supply. Production has come from those areas of the world with the reserves capable of supporting such large, capital intensive mines.

The easiest and least costly way to end up with a large mine is to start with a mine that already exists. **Looking back the past 15 years, a surprising amount of the world's increased coal production has come from fewer larger, more productive mines using infrastructure that was largely in place in the late 1990s.** The name of the game has been squeezing more out of what we had rather than making new capital investments. The less-developed coal fields in Indonesia, Colombia and Venezuela offered more opportunities for greenfield development, but even those regions found incremental production to be a significant contributor.

As we look back to the late 1990s, the world coal industry was on the threshold of an era very much like what the U.S. experienced in the 1980s and 1990s. Old sites, distant reserves, thinner seams, different seams, different qualities — any reserve with an infrastructure advantage over greenfield reserves became a candidate for production improvement.

. . . .

The coal industry in 2015 continues to provide clean and economic energy, having overcome the fears and uncertainties that plagued the industry in the late 1990s.

THE ABUNDANCE OF COAL AS A PHYSICAL AND ECONOMIC RESOURCE

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Viewed from the perspective of an American coal producer, the question of whether world coal resources are scarce or plentiful when measured both in physical and economic terms seems almost fanciful. In the American economy, the price of coal has fallen in real terms over approximately 15 years. Except for some agricultural commodities, no other product in the United States has a record of such stability in price. Moreover, price trends in the international coal trade suggest that the same economic phenomena has occurred world wide. Instead of relying exclusively on prices, however, to answer the question, it is useful to re-examine some basic data about coal resources and to recall how free markets translate physical resources into economic resources.

Three primary physical facts determine whether coal may be profitably extracted: the thickness of the seam, its quality characteristics, and the depth of its location. All other physical conditions - the features of the supervening and intervening geological strata, the presence of water and gas, and surface topography and development - either add to or detract from these fundamental physical characteristics. Considered together, they determine whether a coal reserve can be exploited as a physical matter.

Viewed strictly in physical terms, coal is abundant. As many contributors to papers for the CIAB Plenary have noted, among coal's most attractive features as a fuel resource is its diversity of location. It is found on every continent. Even a cursory review of standard sources quickly verifies this fact.

In South Africa, recoverable reserves of 55,000 million metric tonnes (Mt) have been estimated, with 95% of this reserve occurring at depths of less than 200 meters (m). Australia has estimated recoverable reserves in excess of 60,000 Mt in its principal geological basins in Queensland and New South Wales. Its recoverable coal reserves at its surface mines are customarily less than 60 m deep and are 1.5 m in thickness. In Colombia, the Cerrejon-Norte deposit alone contains 3,000 Mt of which one third of the reserve is less than 100 m from the surface. Reserves in the Peoples' Republic of China, although difficult to quantify are known to exist at depths of less than 600 m.[1]

Coal reserves in the United States are so diverse across regions that it difficult to grasp their abundance. The Powder River Basin of Montana and Wyoming have surface minable reserves alone of more that 54,000 Mt. The Illinois Basin coal filed has identified reserves in excess of 230,000 Mt. All reserves across the Appalachian Basin exceed 200,000 Mt. Profitable underground mines in Utah are mining at depths greater than 300 m. The San Juan Basin in New Mexico has surface minable reserves of 6,900 Mt in multiple seams which range in thickness of 1 to 4.5 m and billions of tons more at depths of less than 600 m. The San Juan Basin is relatively undeveloped among the major coal mining regions in the United States.[2] Much of this coal, especially in the Western United States, can be recovered using existing technology.

1. Coal Information, 1993, pp. 139-143
2. Coal Information, 1993, pp. 144-145.

In a world in which the annual coal production is currently less than 3,800 Mt,[3] the physical quantity of coal available in regions currently in production using transportation infrastructure in place would satisfy any foreseeable demand for the product. Coal that is physically abundant, however, may have only a nominal economic value because of lack of market, limitations in technology, another product which can substitute for it, or restrictions imposed by government regulation. Historical experience in the United States illustrates how each of these factors can create either economic abundance or scarcity.

The first commercially developed coal field in the United States occurred in three counties in Eastern Pennsylvania in the 1830's. The anthracite coal mined there was accessible to a growing market in Philadelphia and eventually New York because of the presence of a railroad system that developed during the same period. The far larger and more economically significant bituminous coal field in Western Pennsylvania did not develop for another 30 years because of the lack of transportation from that region and until a new market - steel manufactured using blast furnace technology - emerged. Similarly, the Powder River Basin coal region remained largely undeveloped until the last 25 years because no market for the product existed until utilities became convinced that subbituminous coal could be accommodated in boilers designed for higher quality coals.

Technology also has the effect of creating economic value in coal resources that may be perceived as insubstantial. Current large scale surface mining in Central Appalachia reflects this development. Across much of the region, relatively thin seams of coal less that 1 m in thickness were ignored during the first mining that occurred in the first half of the century. Although later selectively augured, this coal was not significantly recovered until large scale mines utilizing draglines, shovels and trucks were deployed in the 1970's. This use of existing technology in new applications has had the effect of enlarging the reserve base of coal in this region.

Substitutability of products can effect the economic value of a product. This happened in the United States in the 1950's as natural gas virtually eliminated coal in household use over the decade. A similar phenomena may be occurring in the United Kingdom and elsewhere in Europe today as electricity producers move increasingly from coal to natural gas as their principal fuel source. As has been frequently observed, however, the reasons for this shift may not be entirely economic in origin.

Finally, government regulation can have the effect of diminishing the economic value of a coal reserve. In the United States, laws regulating the social and environmental effects of coal utilization have been justified fundamentally by the policy of internalizing these social costs into the price that must be charged for the product. As an economic matter, it is difficult to disagree that external costs imposed on society broadly should not be internalized to the product. What has been observed, however, is that in a variety of contexts, such as the debate over acid rain regulation in the 1980's, the attempt to reduce emissions of pollutants below what Congress has already mandated, and more recently in the debate over carbon dioxide, the determination of externality costs is subjective, frequently political, and inadequately grounded in scientific fact. One casualty has been the Illinois coal Basin which, because of its sulfur characteristics, is unlikely to see substantial new development for another generation.

The worldwide physical abundance of coal is an irrefutable fact. The economic factors briefly considered can alter the significance of this fact only marginally. As verified by the price signals that are observed in the international coal trade, and in the fuel prices paid by major coal consuming economies, one cannot conclude that economic scarcity of coal will occur in the foreseeable future.

3. Coal Information, 1996, p. III-11.

COAL PRODUCTION IN THE EUROPEAN UNION

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In today's European Union, with 15 countries, only 4 of them are really producing coal i.e. Great Britain, Germany, Spain and France, and the first two ones produced 100 MT in 1997 which represents roughly 80% of the European production. As a consequence, and in order to compensate, these countries have imported 63 MT i.e. 43% of the E.U. importation.

Furthermore, this situation is a painful one for social reasons. Restructuring the coal mining industry has meant and still means important reductions of workers. The total is now less than 90 000 miners (48 000 in Germany, 22 000 in Spain, 10 000 in Great Britain and 5 000 in France).

The logical result of this restructuring is that the average production has increased to 755 Kg per man/hour.

GREAT BRITAIN

In 1997, Great Britain produced 47,6 MT which represents a decrease of 2% compared with 1996 (which already showed a decrease of 4,5% versus the precedent year). When British Coal was privatised at the end of 1994, there was a certain euphoria, but one can only observe that the British mines still working are only following the tendency of other European mines which show a steady decrease in production.

Production is mainly underground (32,2 MT in 1997, which means - 2,7% compared to 1996). The part of open cast mining has also diminished to 15,4 MT.

This is why Great Britain is now the second biggest coal importer (behind Germany) with 19 MT of coal from abroad, (6,5 MT from the USA - 4,4 MT from Australia - 3,3 MT from Colombia - 1,6 MT from Canada - 1 MT from South Africa and 0,6 MT from Poland). But we must notice that steam coal (10,3 MT) is now the most important import.

This increase in imports has compensated the loss of domestic production, and the total coal consumption is about 71 MT, out of which 50 MT are for electricity generation. In Great Britain 45% of electricity is produced by coal.

The balance of imports (roughly 9 MT) is for the steel industry and for coking plants.

GERMANY

With 52 MT, Germany is the first coal producing country in the European Union. However this production shows a decrease of 2,2% from 1996 to 1997, and there again this loss is more than compensated by a strong increase in imports (+ 9,2%) which means a total of 19,9 MT.

Restructuring is today the key-word of the German Coal Industry. Production is diminishing in many sites. For example Aachen Basin only produced 200 000 MT in 1997. This means of course a reduction of the number of miners. In 1994 they were 72 000 and only 47 500 in 1997.

This tendency will go on, for it has been decided in 1996 to limit the production to 30 MT in 2005. Such evolution means obviously an important coal subsidy policy and for example the Brussels Commission has authorised in mid-June of this year a subsidy of D.M. 10,4 billions for 1997. In fact one estimates that the subsidies could reach more than D.M. 50 billions between 1996 and 2005.

Restructuring also means the fusion of the three coal corporations (Ruhköhle Bergbau, Saarbergwerke and Preussag Anthrazit) into one called Deutsche Steinkohle.

As far as coal consumption is concerned Germany is about at the same level as Great Britain with a figure around 71 MT.

However Germany has become the main European coal importer, most of it being steam coal (coking coal only represents 2,5 MT in 1997).

Main suppliers are South Africa (7,2 MT), Poland (4 MT), Colombia (3,8 MT), USA and the Czech Republic.

One estimate even states that coal imports could reach 40 MT in 2005, 30 MT of which being steam coal. However we must not forget that Germany is the main lignite producer with 175 MT in 1997.

SPAIN

Since the beginning of the nineties there has been an evolution in the Spanish coal policy. Production still exists at the level of 17,5 MT, but the number of miners has to be decreased (1 200 last year) and if today there are still 22 500 people, it is estimated that at least 4 000 people will have to quit in the next years. Furthermore the productivity compared with the other European countries is fairly low (314 kg per man/hour e.g. 40% of the European one). The State Company HUNOSA has lost 260 million dollars in 1997.

Again, as a reminder, Spain is a lignite producer (9,5 MT) and this production is stable.

There again coal is mainly used for electricity generation (24 MT in 1997) and the steel industry is far behind with 3,5 MT.

Of course, Spain, is an important country for coal imports (9 MT in 1997) mainly from the USA and from South Africa (and it is interesting to mention that Spain for some years has been an importer of Wyoming coal).

The European steel industry is on the way to privatisation and after some fights between European steel mills, it is the Luxembourg Steel Manufacturer ARBED which won. The name is now ACERALIA.

FRANCE

Coal production in France is also decreasing from 8,1 MT in 1996 to 6,8 MT in 1997 (-16%).

There are 2 main sites of production :

- Lorraine (in the east of France) which is decreasing every year (6,1 MT in 1996 and 4,7 MT in 1997). This decline is mainly due to very difficult geological conditions.

- Centre-Midi in Provence (Gardanne near Marseille) with a production around 2 MT (1,95 MT in 1996 and 2,05 MT in 1997).

There is also a small activity due to the recovery of slag-heaps in the North of France, producing 0,5 MT in 1997 of high-ash products which are used for electricity generation.

The domestic coal production is no longer used for the steel industry, but only for electricity and industry, and by 2005, France is planned not to produce any more coal.

This is why coal importing into France is important (15,8 MT in 1997), which can be divided into 9,5 MT for steel purposes (including coke, coke breeze, coking coal, coal for injection and coal for sintering), 3 MT for electricity, 2 MT for the Group Charbonnages de France and 1 MT for industry.

The importation is small for electricity in comparison with other European countries, France having 78,2% nuclear generation in 1997.

Two interesting technologies should be noticed :

- In Provence there exists the world's most important fluidised circulating bed combustion power plant (250 MW).

- The development of power plants working half with sugar cane leaves and half with coal, according to the season. This technique is used in some overseas French departments (Reunion Island and Guadeloupe Island).

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So in conclusion we can see that through restructuring and rationalising of the coal industry, each year European coal production is declining (-3% between 1996 and 1997) and it is estimated that such production will scarcely reach 110 MT in 1998.

HOW COAL IS POSITIONED IN THE ENERGY MIX IN ASIA

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1. DEPENDENCY ON AND DEMAND FOR THERMAL COAL IN ASIA

The dependency on coal among all energy sources, on a power-generating capacity basis, in the 10 major Asian countries of China, Korea, Taiwan, Indonesia, Thailand, Malaysia, Philippines, India and Pakistan is about 40% on average, and it is therefore apparent that coal is currently the most important energy source in the region. In South-east Asian countries, which heavily depend upon oil and gas, coal is positioned as one of the core energy sources for replacing oil and gas.

Dependency on Each Energy Source in 10 Major Asian Countries
(on a power-generating capacity basis as of 1997)

	Coal	Oil	Natural Gas	LNG	Hydro	Nuclear	Geothermal
Average	***40%***	15%	4%	10%	21%	10%	under 1%
(Japan)	***(10%)***	(23%)	-	(25%)	(20%)	(21%)	(under 1%)

Asia is the largest market for coal exporters. The total demand for thermal coal import in Asia is currently about 140 million tons p.a., which accounts for a little more than 50% of the total world trade in thermal coal. Therefore, the coal market has been heavily affected by the recent Asian currency crisis and resultant economic turmoil in the region.

Thermal Coal Demand and Supply (1997 Estimate)

Total (mil t)	Demand		Supply				
	Asia	Others	Australia	Indonesia	China	USA	Others
272	***141***	131	74	32	26	28	112

2. IMPACT OF ASIAN ECONOMIC CRISIS ON COAL

In Indonesia, out of a total of 26 IPP projects, for which Power Purchase Agreements (PPAs) were made prior to the currency crisis, only 7 projects have started operation or construction, and the development schedules of the rest are uncertain. Those projects include as many as 8 coal-fired power stations. Also in Thailand, "Phase II" coal-fired IPP projects, which have passed the PPA stage and would have created an additional thermal coal demand of 7 million tons p.a. during 2001-2003, have since been delayed. Coal-fired IPP projects in China and Taiwan also are currently in a great deal of uncertainty.

The Asian crisis has sustained the recession in the coal market in the Asia-Pacific region in the short term. As a result, thermal coal suppliers, especially Australians, are facing a great deal of difficulty, and it is rumored that about half of the total production capacity in Australia has been or is potentially for sale due to poor profitability.

There is, of course, another reason for the recent depressed coal market, namely on the supplier's side. Since Australian suppliers responded to a future boost in thermal coal demand in Asia with too much and too early expansion of their supply capacity, the spot price of Australian thermal coal has been continuously falling since last year and now reached a level (low US$20's) that is more than US$10 less than the 1998 price applicable to long-term contracts (about US$34). Such decline in the price of Australian coal is also supported by the depreciation of the Australian dollar, which is partly because of the Asian currency crisis. The recession in the coal market in the Asia-Pacific region is being accelerated by significant improvement of the price competitiveness of Indonesian coal in US dollar terms, backed by the weak rupiah, and also by China's policy of encouraging coal export.

3. ADVANTAGE OF COAL IN ENERGY MIX IN ASIA

There is no doubt that the major restraining factor on an increase in coal demand is the global warming issue. In the host country of "COP 3" last year, Japan, coal as an energy source is under strong pressure, while the use of LNG, which has the lowest carbon dioxide emission characteristics among all fossil fuels, and nuclear power is encouraged by Government policy.

In this regard, it is expected that the future growth of coal demand will be not as much as originally estimated, not only in Japan but also in the whole Asian region. However, coal is not necessarily in a weak position, because the political energy mix is subject to economic factors, and coal is in an advantageous position in that respect compared with other energy sources.

There are immense coal reserves, and the main producing and/or exporting countries of coal, especially of thermal coal, are broadly spread all over the world. Compared with other energy industries, coal has lower hurdles for market entry by newcomers, with less technical expertise and less initial capital investment required for resource development. This encourages competition in the industry, and supply sources are therefore diversified even in any single country. Such a large number of "players" in the industry makes it possible to achieve both targets of stable supply and price competitiveness, which are otherwise deemed to be contradictory to each other.

On the other hand, in case of coal-fired power generation, initial capital investment shares a relatively large portion of total generating cost, with the fuel cost accounting for as little as 30%, which is the lowest percentage among all fossil fuels. In other words, coal requires lower operating costs including fuel cost. Therefore, the maximization and equalization of the load factor at existing coal-fired power plants and the development of new base-load coal-fired power stations continue to be economically attractive.

Pipeline natural gas is being focused on as an energy source competing with coal and is expected to increase its share in Asia. However, the demand for another competing source, LNG, in Asia is not expected to continue the current rate of growth, as consuming countries are now limited to Japan, Korea and Taiwan in the region, and it costs any new consumer a huge capital expenditure for infrastructure development.

Weak currencies have depreciated the US dollar value of electricity rates in Asian countries. This means more severe price competitiveness is required for fuels purchased from overseas. In IPP projects, where PPAs had been made on a US dollar basis, there has emerged the problem of the domestic currency value of the IPP price exceeding the electricity rates in the country.

Also, it might be difficult for the governments in Asian countries, which are afraid of the potential for riots during the period required for overcoming the economic crisis, to increase the price of any public service, including electricity rates, in the future. This will result in greater focus on the economics of energy sources.

Provided the possible devaluation of the Chinese RMB happens in the near future, concern about which has been growing since the recent devaluation of the Russian ruble, a stronger export drive for Chinese coal would accelerate fierce competition in the Asian coal market. Also in Indonesia, coal producers will remain encouraged to export their products, aiming at better profitability than domestic sales in rupiah terms.

In the largest coal exporter to the region, Australia, many existing mines are facing restructuring and reduced production, and the development of most green-field or brown-field projects is being delayed, under the current market circumstances. However, no big downward adjustment of excess supply capacity in the near future is expected, considering some mines, which were recently closed because of poor profitability, are finally going to resume operations by the new owners.

Under such circumstances in major exporting countries, it is expected that the market price of thermal coal in the Asia-Pacific region will, after short-term ups and downs, stabilize at a low level in the longer term. This means the economic advantage of coal over other energy sources will be maintained in the future.

It is, of course, essential for all the parties in the industry to endeavor to further improve thermal efficiency in coal-fired power generation, and to materialize large-scale commercial operation of clean coal technology and international cooperation in providing and exchanging such technology, so that the energy mix wherein coal plays an important role can be the “best mix”.

THE COST OF COAL: CRITICAL FACTORS AFFECTING FUTURE TRENDS

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INTRODUCTION

Coal is found throughout the world in a wide variety of locations. It provides a vital, economic source of energy and is used in numerous ways. There are a broad range of markets for coal based on the many different types of demands, and these create a variety of competitive pressures on coal prices which, in turn, affect the cost of producing coal.

This paper reviews the main factors which have the potential to influence coal production costs and either raise or lower them over the long term – 10 to 25 years into the future. The cost of coal is an important issue since the prices paid for coal are closely tied to production and delivery costs. This distinguishes coal from the other major hydrocarbon energy sources for which markets have historically provided a significant premium over costs.

Coal is a diverse, complex commodity sold into markets characterised by significant competition between various coal products and other fuel sources, especially oil and natural gas. The strong linkage between coal prices and production costs makes production costs a critical issue in maintaining coal's competitive position in its major markets as a primary energy source for electricity generation and steel-making.

MAJOR FACTORS AFFECTING COAL PRODUCTION COSTS

The five major factors which have the potential to affect coal production costs include: geology, coal supply chain, infrastructure, politics and markets. Each of these factors has numerous aspects important to coal which are identified and assessed as summarised in Table 1. Given the long-term time frame for considering the potential importance and effect of these factors and aspects, the discussion necessarily examines importance on a relative and subjective basis.

GEOLOGY

The world contains vast reserves of coal which are very much larger than other hydrocarbon energy sources. Current reserve ratios for coal are sufficient to last at least 250 years as compared to oil at 45 years and natural gas at 70 years. The dominance of coal as a secure fuel source is underscored by the example of North America, where about 90 percent of the hydrocarbon reserves are coal. North America contains over 24 percent of global coal reserves whereas it only contains 7.3 percent of global oil reserves and 5.8 percent of global natural gas reserves.

Table 1

Relative contribution of factors to near-term changes in coal costs for world coal industry

FACTOR	ASPECT		CONTRIBUTES TO COST INCREASES	CONTRIBUTES TO COST DECREASES
Geology	Global distribution of coal resources			++
	New coal resource supply opportunities			++
	Existing operations			+
Coal Supply Chain	Minesite productivity	Mining technology		+++
		Processing technology		++
	Transportation and handling	Rail technology		++
		Port technology		++
		Ocean transport		+
	Input costs	Energy		+
		Labour	+	
Infrastructure	Rail capacity	Exporters	+	
		Importers	+	
	Port capacity	Exporters	+	
		Importers	+	
Political	Coal production subsidies		+++	
	Taxation / regulation		+++	
	De-regulation	Energy costs		+
		Transportation		++
		Customers		+++
	Employment laws		++	
	Infrastructure		+	
	Resource access		++	
	Environmental		+++	
Markets	Coal quality	Environmental	+++	
		Product specifications	+	
	Buyer influence over markets			++
	Producer competition			+++
	Inter-fuel competition			+++
	Customer efficiency gains			++
	Demand growth			+

Rating scale for contributions:

+ low effect
++ medium effect
+++ high effect

Gardiner: The Cost of Coal: Critical Factors

Coal resources are well known in most parts of the world and there are no strong incentives to undertake exploration to "discover" new fields. Most developed coal fields contain significant new resource opportunities that are geologically equivalent to resources currently being extracted. At existing mine operations, mining areas generally face equivalent or slightly lower stripping/development costs as the operations mature, and this will tend to decrease operating costs, other factors remaining equal.

COAL SUPPLY CHAIN

Minesite productivity for the coal industry has continued to show improvements over time which have provided significant operating cost reductions. Technological changes in mining and processing have been a major contributor to productivity gains, as have improved management practices. Technological advancements in mining and processing equipment are expected to continue strongly in the future, augmented by new information management opportunities such as Global Positioning Systems (GPS) and computerised automatic control systems.

Transportation and handling of coal from minesite to markets represents a substantial proportion of the final delivered cost of coal. Improved technologies have contributed to lower costs in rail, port and shipping, and there are important opportunities for further cost reductions in these areas.

Energy is an important input to coal mining, and recent trends toward declining real energy costs have generally contributed to lower coal production costs. Labour costs have tended to increase over time but have been offset by productivity improvements. These existing trends for energy and labour should continue for the foreseeable future.

INFRASTRUCTURE

The continued expansion of world coal production, particularly the component involved in sea-borne trade, will ultimately lead to pressures for additional infrastructure for rail and port facilities. Both exporters and importers will be faced with considerable investment decisions, and, to the degree that the cost of new capital must be carried by incremental coal volumes, new investments in infrastructure could add substantially to the delivered cost of new coal supplies.

POLITICAL

As with all markets, especially those involving competitive trade between countries, political trends can create significant changes. Coal subsidies, especially in OECD nations, continue to keep global average coal costs higher than they would be in fully competitive markets. The support of uncompetitive coal production diminishes the markets available to competitive coal suppliers, such that important opportunities to achieve higher efficiencies through economies of scale are lost. Taxation policies and regulations can drive up production costs within producer countries, as well as increase the cost of products which use coal as an important input (e.g. steel, electricity).

The de-regulation of the critical components of modern economies is expected to provide long-term benefits to consumers. Lowered energy costs, competitive transportation services and the introduction of competition between regulated coal consumers will all tend to contribute towards cost decreases for coal production. Employment laws, public investment in infrastructure, access to public resources and environmental rules and regulations have tended to increase costs for coal producers. This trend is likely to continue in the future.

MARKETS

Coal quality will continue to grow in importance in coal markets, and may potentially increase costs for producers to meet the increasingly sophisticated needs of customers. Customer needs will be driven by continued changes in coal utilisation processes, as well as changes in environmental rules and standards.

At present, coal markets are heavily influenced by large volume buyers who use their market dominance to enhance supply options above what normal competitive markets would support. This, in turn, increases producer competition, which would be robust in any event, because of the continuing over-capacity of producers to meet market needs.

Coal's traditional markets in steel-making and electricity generation have been eroded because of increased competition from other fuels and different quality coals. These trends are likely to continue indefinitely.

The demand for coal will continue to increase over the long-term, which will tend to encourage additional supply capacity whenever prices experience short-term increases. This continuing feature of coal markets will tend to reinforce long-term cost decreases by sustaining robust competition over time.

DISCUSSION

Coal will maintain its position as the lowest cost fuel in the world energy mix. The factors described above, when considered in aggregate, favour a continuation of the decreasing real cost of coal.

There are, however, key vulnerabilities which could disrupt this cost trend such as:

- Regulations which create non-market barriers to the use of coal;
- Public attitudes that malign/reduce coal's acceptability;
- Loss of cost advantages to competing fuels by factors other than the marketplace;
- Diminished customer confidence in coal as a stable, acceptable fuel.

The greatest risks for coal are associated with factors that will lead to cost increases which, in turn, will make competing energy sources more attractive. The factors which need the most urgent attention by the coal industry are those which have the potential to most strongly contribute to cost increases (i.e., coal subsidies, taxation/regulation and environmental politics).

THE FUTURE OF COAL: MINING COSTS & PRODUCTIVITY

Robert D. Humphris,
Peabody Resources Ltd, Australia[1]

1. COST AND PRODUCTIVITY TRENDS

Trends in key cost and productivity indicators for the period 1987-88 to 1996-97 are as follows:

		% pa
Inflation (CPI - Australia)		+ 3.8
Coal Mining material energy costs (Australia)		
	- Open cut	+ 2.1
	- U/ground	+ 2.9
Average weekly earnings (NSW)		+ 6.2
Saleable output per employee per year (NSW)		+ 7.5
Labour cost per tonne (NSW)		
	- Current prices	- 1.3
	- Real	- 5.1

These cost reductions have been achieved by the introduction of new technology, new capital and increasing economies of scale through development of larger mines. They are also supported by a gradual change to open cut and longwall mining from underground bord and pillar methods, changed work practices allowing more flexibility for employees, fewer employees and moving away from high cost weekend penalties.

2. NEW DEVELOPMENTS

New mine developments over the next 20 years will see a continued increase in longwall mines, large open cut mines and an increase in coal production in Queensland.

The following table summarises the current and forecast future mine size profiles in both NSW and Queensland. Appendix 1 lists major new greenfields mines which are expected to add to the industry's capacity over the next decade.

A significant reduction in the number of mines in the under 2.5 Mtpa category is expected, with rises in the 2.5 to 5.0 and over 5.0 categories. There will also be expansions at existing open cut and underground mines, with consequent efficiency gains. Appendix 2 provides examples of these expansions.

Most of the new large scale open cuts have stripping ratios lower than many existing smaller high cost mines. Mt Arthur North for example has a stripping ratio of about 4.5:1 BCM/romt compared to Bayswater No.3 at about 7:1, Mt Pleasant 4.3:1, Coppabella 3:1 and Bengalla 3.0. Most of the new longwall mines in Queensland will have extraction thicknesses greater than 4.5 metres compared to Hunter Valley mines of less than 2.8 metres.

1. Prepared with the assistance of Barlow Jonker Pty Ltd and Denis Porter of the NSW Minerals Council

Table 1
Mine Demographics & Total Capacity

State	Total No. of Mines	Mines less than 2.5Mtpa product	Mines greater than or equal to 2.5Mtpa product	Mines greater than or equal to 5Mtpa product	Total product capacity (Mt)
1998					
NSW	71	57	11	3	117
Queensland	41	22	12	7	119
TOTAL	**112**	**79**	**23**	**10**	**236**
2008					
NSW	64	38	19	7	155
Queensland	45	12	22	11	163
TOTAL	**109**	**50**	**41**	**18**	**318**
2018					
NSW	51	27	14	10	136
Queensland	49	9	28	12	186
TOTAL	**100**	**36**	**42**	**22**	**322**

3. NEW TECHNOLOGY

Productivity improvements and cost reductions are expected to continue over the 20 year period. These improvements will come from new capital, new technology, new and flexible work practices and an increase in lower cost large scale open cut mines. Although inflation is now low and is forecast to remain low in the foreseeable future, mining costs are expected to fall. As with all commodities this is an historical trend that is matched by traditionally falling commodity prices.

New technology driven by R&D in a variety of areas (mining, processing, maintenance, handling and transport) will be a key factor in improving productivity and lowering costs. Examples of recent and developing new technologies are listed in Appendix 3.

The new mines in Queensland like Crinum are now producing at a productivity of 15,000 romt tonnes per man per year. This benchmark is forecast to increase with Oaky North planning to produce at 20,000 rom tonnes per man per year with a high capacity shearer, thick seams and panel widths of 270 metres. Bulga in NSW already has achieved this level of productivity in 1997.

Improved productivity in truck and shovel operations are now achieving consistent rates of 20,000 rom tonnes per man per year at Camberwell, Liddell, Mt Owen and Burton Downs. Dragline operations have also lifted productivity with Blair Athol now achieving over 40,000. and Bengalla expected to achieve above 30,000 romt per man per year.

In Australia, key institutional arrangements are expected to continue to contribute to technology development (including the Australian Coal Association Research Program, the Black Coal Co-operative Research Centre and the Centre for Mining Technology and Equipment).

4. MINING METHODS & WORK PRACTICES

Improved coal recoveries have resulted from a change in open cut mining practices through coal standoff, dozer assist and highwall mining methods. Increased standoff in dragline operations provides an increase in dragline productivity and reduced coal loss. Highwall mining provides the ability to economically extend coal extraction beyond conventional open cut mining methods. This has led to new options in highwall mining including the longwall punchmine at Oaky Creek now under operation. This should provide new options for extending mining limits at many other open cut mines. Dozer assist and in pit dragline operations with cast blasting techniques have revolutionised dragline productivity. It is expected that further advances in this area will lead to increases in dozer size and productivity and more widespread use of the method. Blasting technology will continue to improve with larger benches over 65 metres in height being blasted in single stages, reducing blasting costs and improving cast blasting ability. New GPS technology is leading to changes in mine operation with automated truck dispatch systems and driverless trucks. This technology has the potential to further reduce labour costs in open cut mines.

Underground opportunities for longwall mining of thick coal seams in excess of 4.5 metres will provide increased productivity and match extraction requirements of the thick seam, high quality Bowen Basin deposits. As the larger open cut coking coal mines of Peak Downs and Goonyella reach economic limits further refinements in longwall technology will provide economic extraction solutions to these thick seam down dip reserves. Improved horizon control and face automation combined with high capacity coal removal systems will provide ongoing productivity improvements and reduced labour costs for longwall mines.

Increased automation in coal preparation plants and the continued use of tradesman operators has seen some larger modern plants like Mt Owen and Dartbrook operating with only 3 employees per shift. This trend is expected to continue at other mines with retrofitting existing systems and at new greenfield projects.

Other forecast changes in mining operation include increased flexibility through the use of contractors, new enterprise agreements and individual employee contract arrangements. Contractors provide the opportunity for small niche mines to open and effectively operate with reduced levels of capital, e.g. through modular wash plants and contractors supplying their own mining equipment. Another benefit of contractors at larger mines is the outsourcing of non core activities that require specialist capital equipment and additional labour. These services are more readily available through an increasing number of service contractors who can amortise equipment over several mining operations and maintain a pool of specialist technical staff.

5. CONCLUSION

Mining costs will continue to reduce in real terms. This has been demonstrated in the past and is expected to continue over the next 20 year period. The cost reductions have been achieved by many contributing factors including changing mining methods, new technology and more flexible work practices.

The general trend is to larger open cut and longwall mines at both existing and greenfield deposits. New developments are forecast in both New South Wales and Queensland but the bulk of these will be in Queensland. The new underground mines will generally be in excess of 3 Mtpa saleable product for longwall operations which will mostly be thick seam and have panel widths in excess of 250 metres. The new open cut mines will mostly be greater than 4 Mtpa product but there will be the opportunity for small niche mines, with small reserves operated by contractors.

In both open cut and underground mines there will be an increase in the use of contractors for outsourcing non core activities. In the shorter term there will also be an increased use of contractors for change management strategies, as at Collinsville, to introduce flexible enterprise agreements at existing operations with existing structured award based clauses including seniority and overtime constraints.

Overall costs will continue to decrease through a need to improve competitiveness in domestic and export markets. Competition in domestic markets will be driven by other states and generating regions in the National Electricity Market. Competition in export markets will be driven by other emerging countries like Indonesia, Colombian and Venezuelan producers and the increasingly competitive Canadian and United States producers.

APPENDIX 1

Current & Forecast
Future Mine Size Profiles

In NSW

Bengalla Open Cut Mine	ultimate capacity 6 Mtpa
Maules Creek Open Cut Mine	ultimate capacity 7 Mtpa
Mt Arthur North Open Cut Mine	ultimate capacity 6 Mtpa
Mt Pleasant Open Cut Mine	ultimate capacity 7.6 Mtpa
Wyong Underground Mine (Longwall)	ultimate capacity 3.5 Mtpa

In Queensland

Coppabella Open Cut Mine	ultimate capacity 3 Mtpa
Dawson Open Cut Mine	ultimate capacity 4 Mtpa
Daunia Open Cut Mine	ultimate capacity 4 Mtpa
German Creek Grasstrees Underground (Longwall)	ultimate capacity 3.6 Mtpa
Hail Creek Open Cut Mine	ultimate capacity 5.5 Mtpa
Moranbah North Underground (Longwall)	ultimate capacity 3.3 Mtpa
Moranbah South Underground (Longwall)	ultimate capacity 3.3 Mtpa
Newlands Underground (Longwall)	ultimate capacity 3.4 Mtpa
Peak Downs East Underground (Longwall)	ultimate capacity 3 Mtpa
Theodore Open Cut Mine	ultimate capacity 5 Mtpa
Togara North Underground (Longwall)	ultimate capacity 5 Mtpa
Wards Well Underground (Longwall)	ultimate capacity 3 Mtpa

APPENDIX 2

Expansions at Existing
Open Cut & Underground Mines

There will also be expansions at existing open cut and underground mines to increase size and achieve improved economies of scale. Examples of these mines are:

Burton Downs	with a fleet expansion
Cooranbong Extension	with a new longwall
Newlands Open Cut	introducing a new longwall
Newstan Underground	with a new longwall
Oaky Creek	with a new longwall
Ulan Underground	with a second longwall
United Underground	introducing a longwall
Warkworth Expansion	with a new dragline

APPENDIX 3

Recent & Developing New Technologies
Underground Mining

- Improved communications and control of longwall chock movement and stress monitoring
- Geophysical imaging to map areas of high stress ahead of the advancing longwall shearer
- Innovative ground support systems
- Laser guidance systems and longwall horizon control systems
- Continuous haulage systems

Open Cut Mining

- Dragline automation
- New truck technology to increase payload capacity
- GPS and communication systems for surveying, machine guidance, maintenance download in real time and truck dispatch
- Hydraulic shovel advances
- Improved tyre technology for larger trucks
- New highwall mining techniques including arch conveyors, longwall punchmines and Moura steep dip highwall miner

TRANSPORTATION ISSUES FACING INTERNATIONAL COAL TRADE

David R. Goode
Chairman, President, and Chief Executive Officer
Norfolk Southern Corporation

The transportation sector will be significantly impacted by the future trends in coal movement. The impact will differ by market segment as is discussed below.

The movement of coking coal will not fluctuate greatly under either the business as usual or diminished demand scenarios. Demand for coking coal will be determined by the demand for integrated steel production and the technology of making both coke and steel. The same can be said for the demand for coal for PCI or GCI processes. Changes in environmental standards and electric arc furnaces will play a role in metallurgical coal demand but it is hard to foresee how these factors will be advanced any more rapidly than is currently the case. Coke ovens will close and be built according to their own economic rhythms.

The movement of steam coal will fluctuate dramatically and in diametric opposition under the two scenarios. Under the business as usual scenario transportation will flourish. Under the diminished demand scenario transportation, as an industry, will languish or decline.

The primary issue in both scenarios is capacity. Prior to the global climate change scare the forecast for seaborne coal trade was for unprecedented growth. The expected increase in coal for power generation in Asia alone was enough to severely constrain the existing transportation capacity of railroads, ports and vessels. The question was where to invest in needed assets.

If the business is allowed to develop without artificial constraints, these will still be the key questions to answer. We can already see port bottlenecks in South America and South Africa. It is safe to say that if the ports could handle the demand the rail infrastructure in the same regions of the world would be unable to keep up. Australia is headed for the same problems.

There should also be concern about the world's vessel quality and supply if the growth that comes with business as usual should occur. The over supply of bottoms that led to the current depressed freight market should not give us comfort. The age and condition of a significant portion of that fleet will cause a shortage when the inevitable retirements come at a higher than normal rate.

The capacity issues can be addressed. Railroads, ports and vessel owners can invest in the assets necessary to handle volume increases. The problem is one of uncertainty. The kind of assets needed to handle the potential tonnages have very long useful economic lives. No company can invest in a 30-year piece of equipment without some reasonable expectation of a return. The companies involved in coal transportation have the means to invest in the future. The companies just don't know if they have a future.

That thought leads to the second scenario – that of significantly diminished demand due to competition from alternative fuels or energy sources or environmental/carbon constraints. The impact is exactly the reverse of the business as usual case. Instead of the need to add capacity, the transportation sector will be working to dispose of capacity.

A substantial decline in demand will produce idle assets among railroads, ports and vessel companies. The only credible solution will be to rationalize those assets in the best way possible via sale, scrap or write down of investment. This strategy can't help but weaken the companies forced to employ it as a solution. Further, the coal trade represents a material portion of the revenues of transportation companies. Since you can't transport natural gas, solar power or environmental regulations as a substitute for coal, those revenues will be lost. The impact of that decline won't be limited to coal. The transportation companies will have fewer dollars with which to operate their business in other commodities as well. It would not be hard to imagine the closing of port capacity, the sale or scrapping of rail equipment and vessels and a general deterioration of transportation services around the world.

The effect of a major decline in coal demand can be minimized by planning. Companies can cancel plans for major capital expansions in fleet and facilities and scale back on maintenance of those assets expected to become idle over time. The key is the reduction of uncertainty. If the demand trends are clear the transporters can work to spread the revenue declines over time. Then rationalization can be undertaken gradually and capital deployed in other assets or other businesses. That development would have an effect on current business as transporters become more discriminating about the business they accept and the realizations they require.

Ultimately, the capital and investment markets demand a degree of confidence in order to support investments needed in transportation infrastructure – rail and ship. A significant diminution of coal trade will produce a significant and negative result for the transportation industry. Further, uncertainties produce difficulty in making the needed investments to insure transportation supply to support the demand.

SESSION 2

A CARBON-CONSTRAINED FUTURE

Moderator:

Mr R Leigh Clifford
Chief Executive, Rio Tinto Energy

INTRODUCTORY REMARKS BY THE SESSION MODERATOR

Leigh Clifford
Chief Executive, Rio Tinto Energy

In this session I am seeking your input on the future role of coal under a “carbon-constrained future”. To more fully set the stage for our discussions, I would propose to you a set of conditions upon which we base our discussions. First, the conditions anticipated with markets and supply in a changing world as we discussed in the first session are still in place. Second, a major constraint will have been placed on the emission of greenhouse gases from developed countries.

Although it remains uncertain whether the Kyoto Protocol will gain the necessary support for it to enter into force, for this discussion let assume that the carbon constraint incorporates the major provisions of the Kyoto Protocol. This assumption has some validity, because, at the present time, all of the OECD member countries have signed the Protocol except the United States. The Protocol will not enter into force until it is ratified by 55 countries which accounted for 55% of the carbon dioxide emitted in 1990 by the Annex I Parties to the Framework Convention on Climate Change.

To begin our discussions I would like to review briefly with you some of the issues that have been raised in the issue papers that relate to this carbon constrained future. The issues that I will review are taken from the papers that were prepared under the topic of environmental issues. After my remarks, I would invite any author of a paper to add, expand or correct any points that I have raised or any points from any paper that I may not have raised.

Following your response to my remarks, I would like to pose to you a number of key questions that have been identified by the issues papers and the IEA Secretariat. As in the first session, I invite the members and the IEA Secretariat to use this opportunity to raise question or provide opinions on the topics at hand.

CLEAN COAL TECHNOLOGY

In a carbon-constrained future, fossil fuel combustion will need to be made more efficient to reduce the amount of emissions per unit of energy produced. The development, demonstration and commercial deployment of clean coal technologies will be an important component in the future role of coal. Key points concerning clean coal technology are as follows:

1. In a carbon-constrained future, CCT’s will be required and will result in increased thermal efficiency and lower carbon emissions.

2. The trend of improving coal-fired plant efficiency will continue.

3. In a carbon-constrained future coal demand in Japan will be reduced. The impact in Japan might not be mitigated by the deployment of CCT’s because supercritical technology is already commercial and IGCC, on which Japanese coal-related R&D is focussed, will take longer than previously expected to commercialize. In developing 94 countries, aggressive policies and measures by governments are required to expand the adoption of CCT’s. The CIAB and IEA should closely monitor each individual action taken in a carbon-constrained future and make quantitative analyses of its likely effect on coal.

4. The CIAB should continue to promote the transfer of CCT’s through maximum reliance on free market systems, transparency of transactions and the private sector.

5. Improvement in base transport and generation operations through improved maintenance, planning, coal washing, etc. will improve efficiency and environmental performance.

6. Political incentives should be used to encourage technological development for reducing carbon dioxide and methane emissions. Further work on coal bed methane recovery should be supported.

7. Policies that promote the substitution of natural gas for coal will be ineffective in reducing the atmospheric concentration of carbon dioxide and most likely will delay the development of CCT's.

FLEXIBILITY MECHANISMS

The Kyoto Protocol recognises that flexible market mechanisms may offer ways to reduce the cost of any emission reduction commitment, when compared to a command and control approach. Even so, the cost of achieving a significant reduction in carbon dioxide emissions would still be significant.

Development of these flexibility mechanisms on an international basis faces many challenges. Some key points concerning the flexibility mechanisms are as follows:

1. In a carbon-constrained world, joint implementation (JI), and emission reduction projects implemented under a Clean Development Mechanism (CDM) may be preferable to carbon taxes.

2. Emission trading requires caps on emissions to operate and is similar to a carbon tax; it should be handled carefully or it could reduce flexibility, not increase it. Also, as an economic instrument its use would have financial and investment consequences.

3. If the carbon constraints were adopted, flexibility mechanisms should create the least distortion to markets. Arbitrarily limiting the extent to which flexibility mechanisms can be used to meet reduction commitments is economically sub-optimal and serves no environmental purpose. CDM may provide a real spur to emissions abatement in developing countries.

4. Operation of flexibility mechanisms would be complex and create a large administrative burden. International emission trading may be a more attractive alternative than domestic action, but could entail significant wealth transfers between countries.

5. The CIAB should focus on principles used to guide the design and implementation of flexibility mechanisms rather than endorse a specific approach. Also, it should help develop the understanding of coal-using sectors, principally the electricity generating and iron and steel industries.

BALANCING ENERGY AND ENVIRONMENTAL NEEDS

Increasing the standard of living of all nations and people inevitably results in competition between societal goals. The competition between the goal of energy development and environmental protection is paramount to the Future role of coal. The key issues raised in this area are:

1. In the developing world, electrification using coal is a clean energy source because it replaces less desirable fuels. CDM will enhance efforts for electrification. Coal-refuse combustion is a major source of energy.

2. Alternatives to coal are limited; coal must be used to avoid a major reduction in living standards unless an alternative such as nuclear power can be revived. However, nuclear is not an option for all regions. Reliance on renewables to any great extent would require excessive amounts of land.

3. Enhanced use of natural gas is not necessarily a useful measure to extend the time until atmospheric concentrations of carbon dioxide reach a critical level.

4. Coal is necessary to deliver the affluence of the developed nations to the developing nations. CCT's are required.

5. Electricity costs are declining, but this trend is threatened under carbon constraints.

6. Consideration of the life cycle analysis of fuels from an environmental perspective improves coal's credentials as a viable fuel source in relation to other fuels and process uses. This message is not being well communicated.

7. Supply, security, economics and environmental objectives need to be treated in a balanced fashion, i.e. there is a "best-mix" combination of fossil fuels nuclear and renewable sources based on a county's circumstances. The role of nuclear power needs to be reassessed.

CONCLUSION AND INVITATION

That concludes my summary remarks. You can see that these issues are critical to the future role of coal. Now I would like to invite any author of a paper – either which I have mentioned, to add to, expand or correct any point in my presentation. I also invite any author who perhaps I should have cited, but did not, to make any extra point.

Now, I want to lead us into a discussion of several questions that seem pertinent, I shall briefly pose some questions. However, if CIAB members or members of the IEA Secretariat wish to raise other questions thought to be more relevant, then please do so.

QUESTIONS FOR DISCUSSION:

1. *What if any, should be the role of governments in advancing the development and commercial deployment of CCT's?*

2. *Should the CIAB develop a position on the role of flexibility mechanisms and if so, how can the CIAB contribute to the design of the most effective flexibility mechanisms, e.g. advise the IEA, develop and publish a recommendation, etc.?*

3. *IEA and other energy forecasts project that coal must be utilized to meet the worlds energy needs for the foreseeable future. How can the industry most effectively encourage the most efficient use of coal?*

4. *How, if at all, is the coal industry reacting "on the ground" to the Kyoto Protocol? For example, is Kyoto just increasing investment uncertainty or are precautionary measures being taken?*

SUMMARY OF POINTS RAISED AT CIAB PLENARY DISCUSSION
2 October 1998

SESSION 2: THE ROLE OF COAL IN A CARBON CONSTRAINED WORLD

Points which came up in discussion included:

1) Reactions to the Kyoto Protocol:

a) major countries, especially the United States, may well not ratify the Kyoto Protocol

b) however with the surrounding publicity for the protocol, with or without ultimate ratification, coal demand in developed countries is likely to be less than hitherto predicted

c) some consumers in some countries are showing willingness to pay extra for “green electricity”.

2) Clean coal technologies:

a) there is a continuing importance in accelerating the use of “clean coal technology”, both in:

  i) the construction of clean high efficiency power stations, especially in developing countries where most of power station construction is taking place

  ii) the upgrading of existing facilities right along the “coal chain”

b) a problem with the introduction of advanced coal fired technology is that payback times for existing projects tend to exceed 10 years, and are longer than those of projects to convert to natural gas burning

c) investment in clean coal technologies in developing countries is not going to occur without government involvement, and in developed countries also, existing projects for advanced technologies are unlikely to proceed without some government support, for example by underwriting markets rather than by direct subsidy

d) in some countries (e.g. Japan) governments have promoted advanced clean coal technologies by subsidy in the past, and this was likely to continue

e) India and China are already engaged in financially promoting the upgrading of coal-fired plants. The Chinese approach was particularly sophisticated and advocated the need to look after the needs of investors as well as consumers – “or else there is no investment”

f) there is a continuing CIAB role to provide greater input to governments and investors about the cost-effectiveness of new coal-based technologies

g) attempts to substitute coal by natural gas-fired power generation will simply delay the time when specific concentrations of CO_2 occur – and offer no permanent solution, especially as the natural gas resource is more limited than coal

h) in developing countries, electrification itself is locally and regionally a clean coal technology: nevertheless the costs of electricity infrastructure may be prohibitive in remoter areas, and there is a need to consider local power generation options.

3) Flexibility mechanisms:

a) there was considerable disagreement about flexible mechanisms to implement commitments which may arise from the possible ratification of the Kyoto Protocol

b) there was concern from some CIAB members that such mechanisms might be a "Trojan horse" for potential attack on the coal industry, and should therefore be shunned

c) but other CIAB members thought it was essential to get involved in the debate, because the debate would inevitably go ahead, with or without industry participation, and the chance to influence the outcome would be lost

d) governments in some countries were projecting major new investments in capital intensive energy forms such as nuclear power. Such plans were unlikely to command great public support or be realised. Industry would prefer to advocate flexible mechanisms such as CDM as an alternative approach

e) if flexibility mechanisms are to be studied by the CIAB, it will be essential to examine: their likely costs, their likely effects on coal demand, and potential knock-on effects generally throughout the energy system

f) the IEA has already carried out work on understanding such mechanisms, and further shared work with the CIAB would be possible

g) further and more intensive study of "life cycle CO_2 emission analysis" would be welcome to see whether such a study might play a part in creating a new more friendly perception of the role of coal in comparison with alternative energy sources.

LIST OF ISSUE PAPERS AND AUTHORS

SESSION 2: THE ROLE OF COAL IN A CARBON CONSTRAINED FUTURE

GLOBAL WARMING ISSUES
THEIR INFLUENCE ON FUTURE COAL DEMAND

Hiroshi Sugiyama
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1. FUNDAMENTAL RECOGNITION

The COP 3 Kyoto Conference set forth a set of targets for the reduction of Greenhouse Gases (GHGs) applied to the developed countries in 2010, with a view to preventing global warming. However, each member country has not yet released its concrete countermeasures to meet the Protocol, and participation by developing countries is still subject to future discussion. As such, the current situation would impose uncertainty as to its implementation.

Even in the face of such uncertainty, coal usage, with highest CO_2 emissions per calorie produced among fossil fuels, will likely be much affected in this context, despite its advantages like abundant supply and cheap cost.

2. FORECAST ON COAL DEMAND IN JAPAN

Japanese MITI (Ministry of International Trade and Industries) recently released a forecast for future energy demand in Japan, which describes that the coal demand in 2010 in business-as-usual case will be 145 Mt (million tonnes), 10% increase from the level in 1996. Whereas international undertaking committed at Kyoto Conference will force it down to 124 Mt, 6% decrease from 1996 level, or annual 0.4% reduction during those years. (In this case, coal demand for power generation is estimated to show slight increase.)

3. FORECAST ON COAL DEMAND IN MAJOR ASIAN COUNTRIES

APEC forecasts that coal demand in major Asian economies (Japan, China, Korea, Taiwan, Indonesia, Malaysia, and Thailand) will increase from 788 Mtoe (million metric tons of oil equivalent) in 1995 to 1,217 Mtoe in 2010. However, its percentage share in the total primary energy demand will decrease from 47% in 1995 to 42% in 2010. Such demand increase is mainly attributed to China and some Southeast Asian countries. Measures for CO_2 emission reduction in these countries are not yet determined. However, if they were to participate in the international scheme, increase in their coal demand would be still smaller.

4. TREND IN COAL DEMAND BY POWER UTILITIES IN US AND EUROPE

CO_2 emission by power utilities in US and Europe could be reduced by enhanced use of natural gas. Optimistic outlook on physical supply limit of natural gas, together with demand for cheap power in more deregulated business environment in parallel with energy-efficient Advanced Combined Cycle Technology, is likely to boost up the use of natural gas and dampen coal demand, even in case of slower or stagnant pace of nuclear development.

5. DISSEMINATION OF CLEAN COAL TECHNOLOGIES (CCT)

The above consideration would lead us to conclude that future coal demand could sensibly be reduced in response to the need to decrease the amount of CO_2 released through the process of burning coal. However, before drawing such conclusion due attention should be paid to the impact that the development and dissemination of CCT can have for reduction of CO_2 emissions.

Some technological development is too much long-term oriented. Based on the current status of Japan's CCT Program, it appears that commercialization of Integrated Gasification Combined Cycle technologies could take place around the year 2010. Prior to that time, there seems to be little likelihood in other developed countries that IGCC technology would be introduced commercially.

Some other technological developments have already reached the commercialization stage, as is the case for Supercritical PF. In developing countries, taking into account the technological choice of Independent Power Producers, whose attitude is mainly influenced by reliability, technology cost and financing constraints, it may be difficult to expand the adoption of those technologies without aggressive Policies and Measures by the government.

6. ROLE OF IEA AND CIAB

It follows that measures for global warming will have significant impact on future coal demand. However, it is very difficult to make a quantitative evaluation of such effect, under a current situation where, as mentioned before, specifics of neither international nor national program for GHG reduction are available. What is required of IEA and CIAB now is to closely monitor responses and actions taken in this regard and to make a quantitative analyses on its effect to future coal demand.

More importantly, a road of GHG emission reduction does not end in 2010, but rather continues on beyond that. Therefore the mission of IEA and CIAB should naturally be of a long-term nature.

THE CHALLENGE OF COAL TECHNOLOGY TRANSFER

R. E. Wilhelm
Exxon Corporation

Developing countries need significant economic growth to provide the opportunity for their citizens to escape poverty, improve health care, and education. Assuring timely availability of the necessary primary and secondary energy supplies will require substantial capital investment for resource development and technology. Economic growth will require increases in energy consumption and for the foreseeable future, fossil fuels will meet virtually all this growth.

A few figures from the IEA's 1998 World Energy Outlook help support these points. World GDP is projected to grow at about 3% per year through 2020, about the same as the historical rate. In the Business As Usual case, world primary energy demand will grow at 2% /yr. Most of the energy growth is for transportation fuels and power generation, and fossil fuels will meet 95% of the growth through 2020.

Focusing on power generation, this IEA projection translates into a need for the construction of ~70 GW per year of capacity in China, India and the other developing countries. Although the investment required between now and 2020 depends on fuel mix, plant location, and equipment and labor costs, it could easily approach $1.5 trillion for these countries. Substantial additional investment would be required to produce and deliver fuel to the plants, and for transmission and distribution of the electricity. Much of this investment will have to come from developed countries and intervention from capital markets.

Although gas will command a rapidly increasing share of the world's power market (~30% in 2020), oil growth will be significant and coal will retain the largest share of the power generation market (~42% in 2020). The role of coal in China and India will be much more significant. Clearly, the technologies utilized for providing coal supplies and for generating electricity will have a major impact, not only on the level of economic growth, but also on the level of CO_2 and other emissions. State of the art conventional technologies and Clean Coal Technologies (CCT's) available in developed countries can be installed in the developing countries on a "no regrets" basis. This could significantly enhance the ability of developing countries to achieve their economic growth targets, while simultaneously slowing the growth in SO_x and NO_x emissions and CO_2.

The CIAB has placed significant focus on CCT's. However, there are a number of other vehicles by which developing country governments can more efficiently meet their fuel needs, improve power generation, transmission, and distribution efficiency, reduce urban pollution and, thus, optimize the use of available financial capacity. Improved maintenance and operating practices would improve system reliability and reduce new capacity needs. Better planning of sites for power plants and the integration of transmission systems would increase the utilization of generation capacity, reduce the redundancy of plants, and reduce transmission losses. Expanded use of coal washing could have major benefits for strained transportation systems by reducing the amount of material to be moved and the fuel needed for transport. Finally, recovery of coalbed methane has safety benefits for mining operations, provides an inexpensive fuel source for power plant operation, and reduces one of the significant Greenhouse gases. All of these factors would reduce the amount of SO_2, CO_2, and dust pollution in urban centers, and ease ash disposal problems. Developed country interest and support for these activities would also improve their credibility and facilitate the dissemination of CCT's as the technology "chain" evolves.

However, one of the significant decisions that will be faced by developing countries will be the technology selection for the 70 GW/yr. of growth capacity. Particularly significant gains in efficiency and environmental performance can be realized with the successful transfer of CCT to these countries. Exxon commented on this potential impact in the 1995 Plenary. At that time, a reasonable case which reduced the CO_2 loading of the atmosphere by 5Gt over the next 40 years was reviewed. This option provides significant improvement and confirms the need for the CIAB to continue its focus on deployment of improved coal technologies.

CCT covers a range of technologies in various stages of commercialization. First are supercritical pulverized coal units. These units have been proven and are successfully operating in Denmark, Germany, the USA, and Japan, with efficiencies in excess of 45%, versus 36 - 38% for sub-critical units. Ultra-supercritical units will be the next step of evolution, and projects utilizing this technology are currently in progress in Japan, Germany, and Denmark. It is expected that efficiencies above 50% are possible.

Atmospheric Fluidized Bed (AFB) units are commercially proven, but are limited in size and exhibit very little efficiency improvement versus sub-critical pulverized coal units (~38%). However, their environmental performance is better, they are capable of handling a wide range of coal qualities, and are excellent for industrial consumers and as retro-fits at existing power plants. Pressurized Fluidized Bed (PFBC) designs are still in the demonstration phase. Their performance should exceed that of the AFB units and larger unit sizes are possible. Integrated gasification combined cycle (IGCC) technology is still in the early stages of establishing its reliability and commercial acceptability. Although current efficiencies are in the range of 43 - 45%, expectations are that efficiencies above 50% will be possible. Emission levels will also be lower than for pulverized coal units. We do not advocate direct government involvement in the development or subsidization of these technologies, but there is room for facilitation of demonstration units. The IEA's Energy Technology Collaboration Program provides an excellent mechanism for accomplishing this objective.

Some excellent work of outlining the challenges associated with the deployment of CCT was done by the CIAB in the 1996 study series related to "Factors Affecting the Take-up of Clean Coal Technologies". One challenge identified is the concern of developing country officials, power developers, and financial institutions about system availability and reliability. A second challenge is cost. A third challenge is the fact that some of the developing countries do not have in place the legal and financial processes that are needed to attract investment by western companies. Timely transfer of CCT will not occur unless these process deficiencies are corrected.

Each of these challenges should be treated briefly:

- The earlier comments regarding the current status of the various CCT's speaks to the issue of system availability and reliability. Supercritical pulverized coal and AFB units have been used sufficiently over the past 20-30 years in a commercial environment to establish their availability and reliability. Dozens of supercritical units are in service in Japan, Germany, Denmark, and the USA. AFB units have been in use throughout the world in both primary and retrofit service for 5-7 years. Full-scale trials of PFBC's are in progress in 4 locations, with ~6 additional projects in advanced stages of implementation. PFBC should move into the "proven" technology category within the next 3-5 years. Ultra-supercritical and IGCC technologies are at an earlier stage of evolution, but do have a number of full-sized units operating in the field. However, it is not likely that these technologies will move into the "proven" category in less than 5 years.

- Although the cost of most CCT's exceeds that of sub-critical pulverized coal units, the differential is not large (3-5%). With the elimination of coal price subsidies, higher efficiencies, and improved environmental performance, they should be competitive on a "no regrets" basis. Furthermore, with additional experience, we should see their cost and competitiveness improve substantially. One obstacle to be dealt with is the desire of some countries to utilize their own technologies. This is discussed further below.

- By far the greatest challenge will be to achieve an improvement in the legal and financial requirements and processes for implementing projects in developing countries. With increased openness and transparency in transactions, well-defined processes, and adequate legal protection, private investors will sponsor viable CCT projects. Deployment of CCT is also likely to attract export credits or other international financial support.

As an alternative to direct investment in CCT units in developing countries, two other forms of technology transfer are available. One is licensing CCT to developing country manufacturers. The other is to establish co-manufacturing groups which could gain access to markets which otherwise might not be available. These approaches could result in the transfer of more of the plant construction to the developing country, thus boosting domestic employment and promoting self-sufficiency. However, they will not occur unless the royalty is fair and there is adequate intellectual property protection.

What can the CIAB do to facilitate the transfer of CCT to the developing countries? Clearly, it cannot stop with the publication of the 1996 studies. It needs to continue to provide both policy input and to facilitate other steps, including:

- Continuing to promote at the policy level, maximum use of free market systems, transparency of transactions, and reliance on the private sector. This should be the principal objective.

- Continuing to provide an objective perspective of technology availability, capability, and commercial acceptability to the IEA, to governments and to other policy makers;

- Fostering personnel exchanges at several levels. Key developing country decision-makers could visit developed countries and gain exposure to free market processes, helping boost their confidence and support for western business practices. In addition, personnel having equipment selection and operational responsibility could be seconded to developed country utilities and manufacturers to gain confidence in operating practices and technology.

The CIAB and its members need to remain proactive in communicating with host country governments, within the IEA, in public forums, with equipment suppliers, utility customers, and developing country governments to provide ideas and an objective perspective on CCT's and the role of coal in future energy markets. They should also assure that full advantage is being taken of the IEA's Energy Technology Collaboration Program.

THE FUTURE ROLE OF COAL IN THE GLOBAL ENERGY SUPPLY (In the midst of Enforcement for Environmental Regulation)

Osamu Wakai
President, Taiheiyo Coal Mining Co., Ltd.

When I consider the position of coal in energy supply and demand in 10 to 25 years, it is necessary to look back on the progress we have made during a similar period in the past. The problems we are now discussing are about future needs, though the approaches to solving them may differ. I, therefore, would like to look forward to the future by reviewing trends from the past and present, even though this approach is fairly traditional.

1. THE IMPROVEMENT OF ENVIRONMENTAL PROTECTION IN COAL PRODUCTION

In general, the coal mining industry has not made great progress in environmental protection at mine sites, compared with the technological evolution over the past 30 years in coal usage. For example, environmental protection measures such as lowering ash content in coal washing, improving the quality of water effluent from preparation plants, dust control and noise reduction have been carried out at coal mining companies including Taiheiyo. However very few coal collieries are taking measures to capture CH_4 generated during the coal mining process. CH_4, in the form of coal mine methane gas contained in coal seams, is said to have about 20 times the global warming potential of carbon dioxide.

At Kushiro Colliery of Taiheiyo Coal Mining Co. Ltd., the underground methane gas is supplied to a gas utility company which makes effective use of it. This is because:

1. The gas has also to be recovered to ensure safety in the underground mine,
2. The public use of the gas is easy in this case because of the mine location in a township of approximately 200,000 population. We cannot say that coal mine methane gas can similarly be utilized at any mine in the world, because only a few collieries have this kind of condition. I believe though that it is worth study at each coal mine how the emission of methane gas may be reduced.

Also, two model projects, in which Taiheiyo Coal Mining is involved, have been launched recently.

1) the Japan Coal Energy Center is promoting a coal mine gas recovery and utilization project at Tiefa Coal Mining Administration in Liaoning Province in China. The project is commissioned by The New Energy and Industrial Technology Development Organization, which is one of the Japanese government agencies.
2) The Center for Coal Utilization, Japan and a group of companies including NKK are constructing a bench-scale pilot plant (5 tons/day) for Dimethyl Ether or DME (CH_3OCH_3), which utilizes coal mine methane gas. DME production needs a pre-process which raises its cost. But compared to the usual use of coal at conventional coal power plant, DME is easy to handle. Existing transportation facilities such as LPG tankers and LPG tank trucks can be utilized and it is a clean fuel, which does not require FGD. In addition, DME is an ash-free fuel that can be processed near the mine site and it is also expected to be a fuel for power plants located in suburban areas, thus reducing electric transmission losses.

As and when these experiments are successful and their commercial feasibility is proved, coal mine gas, almost all of which has been emitted to the atmosphere until now, will be processed effectively at many coal producing sites. That will surely contribute to the improvement of the global environment.

The problem we have here is cost. The most costly fuels were not accepted by the market when competition in supply occurred between high cost fuels (Liquefied Coal, for example) and cheaper “coal itself”. Such competition was induced by a “counter oil crisis” that followed the “oil crisis” 23 years ago and the study of alternative fuel development stimulated by the crisis. Of course, we cannot pay “sky-high” costs to achieve a reduction in greenhouse gas emissions. Therefore, I suggest creating some kind of system which gives political incentives to technical developments in reducing emissions of CO_2 and CH_4, produced by the mining and use of coal, the reserves of which are abundant world-wide. From the perspective of the long range future, it would not be the best choice in the utilization of energy to try to consume more LNG or petroleum, which are relatively limited resources, just in order to decrease CO_2 emission.

2. THE JAPANESE COAL INDUSTRY

The Japanese Coal Industry has a history of more than 100 years. Production has decreased from its peak of 55 million tons per annum (from 662 collieries) to 3.3 million tons per annum from 2 collieries at present: this has been largely caused by the availability of inexpensive fluid fuels in the market. Continuing efforts have been made to decrease price differences by lowering the price of domestic coal, which is comparatively much more expensive than imported coal. The major cause of the high cost of domestic coal is the increasing depth and remoteness of the coal production sites underground within the mine, but we are trying to increase our productivity while ensuring safety amid difficult mining conditions. Japanese mining technology, developed in the harsh mining conditions of underground coal mines where the depth and remoteness of work places has increased, is now being transferred to developing countries such as China and Vietnam where similar coal mining conditions exist. Japanese mining technology could be utilized widely in coal producing countries around the world where the underground mining proportions rise and mining depth and remoteness increase. It would contribute to stabilization of coal production from a mine while ensuring the safety of the workforce.

No coal mine can avoid this increasing depth and remoteness as it continues in operation, which eventually leads to closure. At Sunagawa Colliery of Mitsui Coal Mining Co., which was closed in 1987, the deep shaft, which is now abandoned, continues to be utilized in other ways. To be specific:

1) by creating zero gravity conditions by dropping a capsule in the 700 meters vertical shaft
2) by observing “cloud” movement by developing artificial cloud using the 700 meters vertical shaft
3) by generating electricity during hours of peak demand and price, through using highly compressed air which is produced and stored at a tank located underground, utilizing inexpensive late night hours electricity

The experiments as above have made continuous use of the closed mine facilities, in order not to waste the capital expenditure for the mine shaft and road ways which has been incurred over a long period.

3. CONCLUSION

The coal industry is now facing a new technological challenge of controlling carbon dioxide and methane gas emissions on environmental grounds. Both producers and consumers need to deal with this challenge seriously, but “zero emission” would be impossible to realize. But, over the next 25 years I expect it will contribute to the prosperity of human beings if we keep trying both to utilize effectively methane gas produced from coal mining and to decrease the environmental burden of coal consumption by steadily lessening CO_2 emissions. I also believe that our efforts to resolve the difficulties the Japanese coal industry is now facing will give results that can contribute to the future prosperity of the world.

EFFECTS OF SUBSTITUTION OF NATURAL GAS FOR COAL ON CO_2 CONCENTRATION FORECASTS

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Idemitsu Kosan Co., ltd.

This paper summarizes an analysis to illustrate the effect on CO_2 concentration of substituting natural gas for coal in meeting the expected growth in energy demand in the decades to come.

The exact figures shown do of course depend critically on the assumptions made, and only one specific case is illustrated. We have also examined several other alternative cases, with higher energy demand, and also with higher assumed levels of gas and petroleum resources. The general conclusions remain the same.

The assumptions for the example here are:

a) Total primary energy demand to be supplied from fossil fuels increases at 1%/year on average for the foreseeable future.

b) Recoverable reserves are assumed in this case to be:
   For coal: 541 billion tons oil equivalent (billion toe)
   For petroleum: 282 billion tons
   For natural gas: 248 billion toe

c) We have examined other cases where larger reserves/resources of petroleum and natural gas are assumed.

d) In a base case, world production/consumption of each fossil fuel is allowed to grow until it reaches 150% of its 1995 production level (these were 3270 million tons/year for oil, 1917 million toe/year for gas, and 2216 million toe/year for coal), and would then decline in a smooth "decay curve".

e) In a contrasting "enhanced gas use" (EGU) case world coal production and use is assumed to be kept level at its 1995 level: i.e. increase in use in some regions would be balanced by assumed contractions in use in other regions. Natural gas, as the least CO_2 intensive fossil fuel, would be used to substitute for the extra coal use in supplying the base case increase in total energy supply. The intention of course would be to reduce the growth in CO_2 emissions compared with the base case in d) above.

f) The relationship between CO_2 emitted and atmospheric concentration in ppm is assumed to be 31ppm/100 billion tons of carbon emitted . This is a historic relation over the last 20 years or so, which allows for absorption/recycling of some CO_2 emitted.

The three figures at the end of this paper illustrate:

- World consumption of fossil fuels, which in the EGU case and under these assumptions, grows to rather over 10 billion toe around the 2025, and thereafter declines.

- The total CO_2 concentration, which can be seen under these assumptions to grow to about 500 ppm by 2025, but stabilize at around 650 ppm around the year 2200. While such a far-out projection may seem highly speculative, the underlying truth is that, with reasonable estimates of economically recoverable reserves or resources of fossil fuels, there is no reason to expect that CO_2 concentrations should grow indefinitely.

- The CO_2 concentration over a 75 year period under the two cases: the base case and the EGU case. The concentration can be seen to be lower with EGU, but not by very much. In fact substitution of natural gas simply delays reaching any level of CO_2 concentration only by a few years.

CONCLUSIONS

1. Enhanced natural gas use is not necessarily a useful measure to delay times when CO_2 concentrations reach a critical level: the few years delay is not significant in the long run.

2. Substitution among fossil fuels by distorting markets may be harmful, because discouragement of coal use in industrial countries will postpone highly efficient coal utilization technologies.

3. On the fossil fuel reserve estimates in this paper, fossil fuel supply would be inadequate to meet growth in energy needs after the year 2020.

4. Therefore there is a need to promote the adoption both of non-fossil fuel energy technologies and accelerated adoption/development of more efficient fossil fuel utilization technologies.

Figure 1
Fossil Fuel Supply
(2 x Reserves/Enhanced Gas Use)

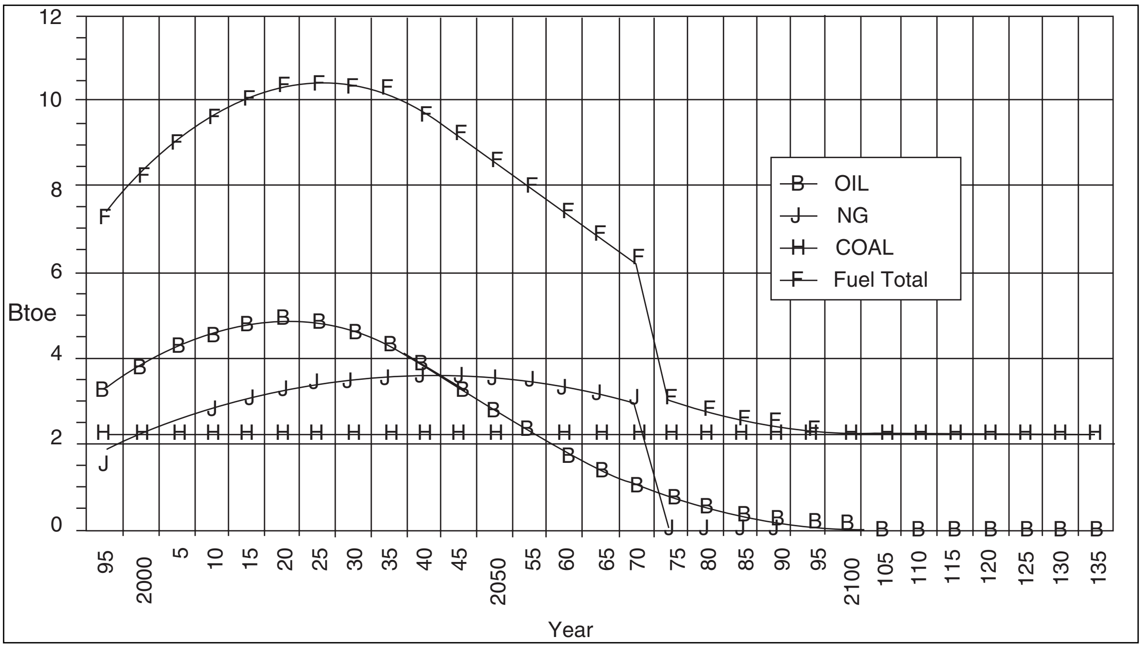


Figure 2
Atmospheric CO_2 Concentration Prediction
(2 x Reserves)

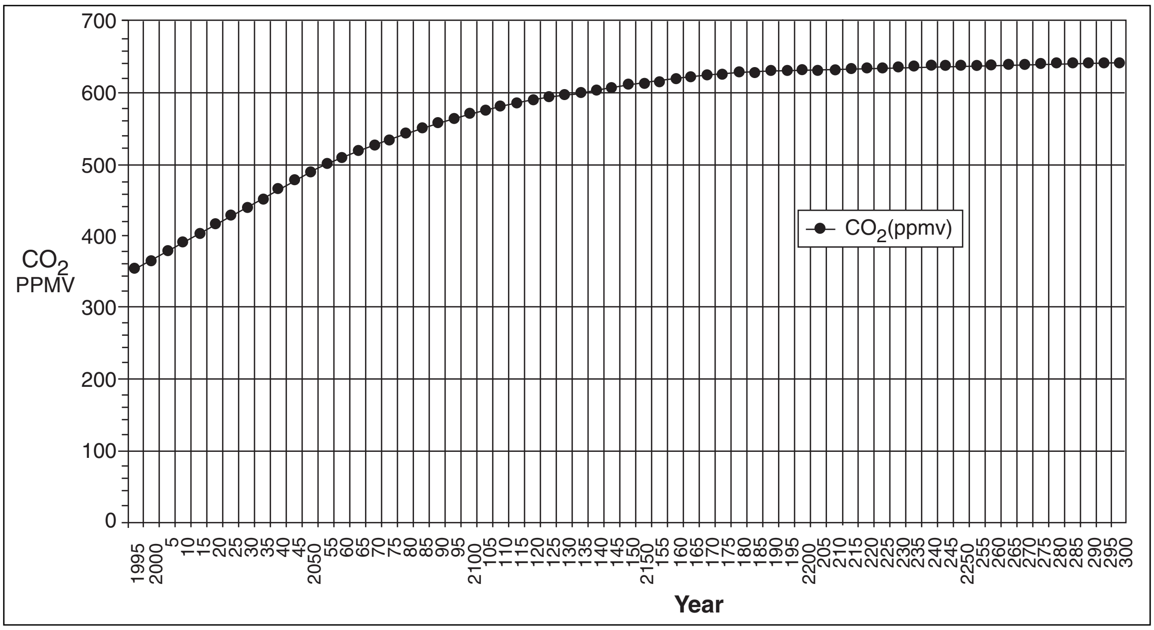
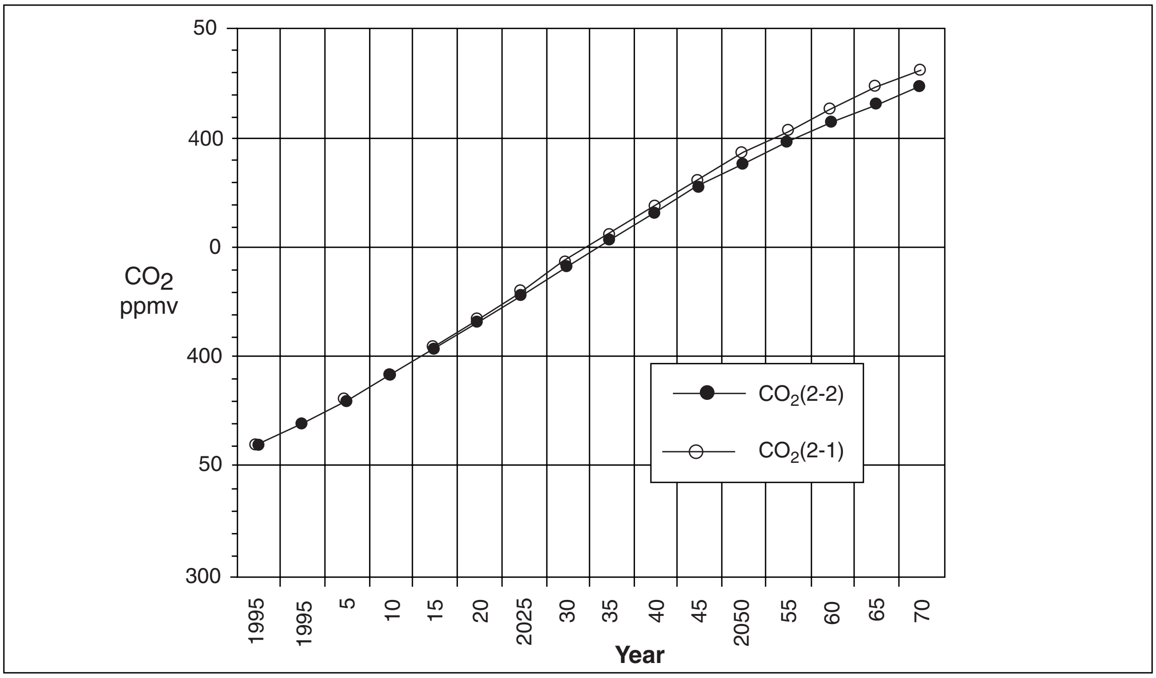


Figure 3
Atmospheric CO_2 Concentration
(2 x Reserves/Enhanced Gas Use)



THE KYOTO PROTOCOL AND THE FUTURE ROLE OF COAL FLEXIBILITY INSTRUMENTS / BASKET OF SIX GASES

Dr. Dieter Henning

Chairman of the Board of Rheinbraun AG, Germany[1]

In 1992, the States signatory to the United Nations Framework Convention on Climate Change (FCCC) have undertaken to initiate policies and measures, with the object of reducing the greenhouse gas emissions. At the third Conference of the Parties in Kyoto in 1997, 38 industrial countries have stipulated concrete emission limit values for the first commitment period of 2008 - 2012. These commitments include CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. The ratification of the Kyoto Protocol, however, will be a lengthy process, and, e.g., in the USA it can under no circumstances be expected before the next presidential elections.

Since more than 50 % of the greenhouse gas emissions occurs during the conversion of fossil fuels, the energy sector and energy-intensive industrial branches are particularly affected by the Kyoto Protocol. In this context, the greatest importance is attributed to the CO_2 emissions; but the methane emissions play a decisive role as well. Effects on the coal sales in the OECD states and deterioration of the competitiveness against oil and gas may be expected since coal is the energy source with the highest CO_2 emissions per unit of energy. The risks regarding coal's competitive position were clearly reflected in the definitions of position made by the EU and many other European countries after the Kyoto conference: The switchover from C-rich energy sources (coal) to C-poor (natural gas) and C-free energy sources (renewables, nuclear energy) is considered a major measure to attain the reduction targets. The CO_2/energy tax approach is emphasised as a suitable instrument to implement such a policy. In the future, the coal industry will have to point out the effects of such a policy and show decision-making aids or alternatives even more emphatically than it has done so far.

The Framework Convention on Climate Change also lays down that the policies and measures to be applied have to be cost-effective so that world-wide sustained development will be ensured. The Kyoto Protocol takes account of the demand for cost efficiency, inter alia, by the introduction of flexible price mechanisms as far as the emission reduction issue is concerned. The contracting countries can utilise these mechanisms to fulfil their mitigation commitments. The participation of companies in the realisation of these instruments is still to be discussed. From the coal industry's viewpoint, the flexible instruments are to be welcomed. Although the latter do not eliminate coal's disadvantage compared with competitive energy sources, opportunities, however, are opened up for the coal users which allow them to fulfil their mitigation commitments not only by a switchover in fuel use, a decrease in the energy input or new tax burdens.

FLEXIBILITY INSTRUMENTS

- In addition to the introduction of the bubble concept for communities like the EU, the Kyoto Protocol plans the following flexible instruments:

– Joint Implementation (JI) as a project-related instrument among the industrial states (Annex B states)

– Clean Development Mechanism (CDM) as a project-related instrument between Annex B states and developing countries: The modalities are still to be defined at the following Conferences of the Parties

– Emission Trading (ET) as a supplement to the measures taken in each individual state

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– Consideration of greenhouse gas sinks (e.g. reforestation).

- JI and CDM are instruments that can be introduced in a quick way and with relatively low bureaucratic expenditure and that are also applicable to companies. Considered on a long-term basis, the CDM concept, however, is only promising if the developing countries, too, assume definite commitments since only in this case concrete incentives will arise for both CDM project partners, as far as the implementation of mitigation measures is concerned. Emission reductions, which result from JI and CDM projects still before the year 2008, are to be credited already for the commitment period of 2008 to 2012 (early crediting).

- The most-discussed market instrument, which has been included in the Kyoto Protocol, is Emission Trading (ET). In the USA, ET has proved successful in the field of cost-efficient SO_2 reduction; the world-wide adoption of such a concept for the mitigation of six greenhouse gases, however, is much more complex. Many questions, e.g. about emission detection and monitoring, are still completely unsettled. The worries existing here are above all focused on inflating bureaucracy to allow fair world-wide implementation to be guaranteed. The participation of companies in ET is currently given very different assessments – primarily due to the detection and monitoring problems to be expected. The fact to be taken into account here too is that the companies' participation in trading first calls for the definition of a company-related emission reduction target. Despite all difficulties, the interest that most of the signatory states in Kyoto have shown in an adoption of the ET instrument is great; a conceivable concept, which will be discussed in Buenos Aires, could be step-by-step introduction of ET, e.g., by first testing only the trade with CO_2 emission units in specific sectors, e.g. the electricity generating sector. From the coal industry's viewpoint, the emission trading instrument is to be assessed with reservation since it could have an effect similar to that of a CO_2 tax.

- All statements about the future market price of CO_2 emission units in the case of ET introduction are speculations. The prices mentioned range between \$ 5 and 50/t CO_2. If we regard a value of \$ 15/t CO_2 as realistic, coal's competitive disadvantage compared to natural gas would total some \$ 18/tce.

- The most unreliable assessments are presently made in respect of the way the fuel gas sinks can be implemented. Almost all individual cases are different, and the knowledge gaps in this field are still very large. No feasible concepts have been detected so far.

- Several European countries, in particular Germany, have developed the concept of industries' self-commitment to reducing greenhouse gases, which is incorporated into long-term agreements between government and industry. This concept has proved to be efficient and cost-effective; the same applies to monitoring by a neutral expert. This instrument is to be considered as far as the implementation of the Kyoto commitments by the individual nations is concerned.

BASKET OF SIX GASES

- The Kyoto Protocol provides for mitigation commitments for six greenhouse gases or gas groups: CO_2, CH_4, N_2O, HFCs, PFCs and SF_6. At present, these six gas groups have approximately the following shares in world-wide greenhouse gas emissions (CO_2 equivalent):

CO_2:	80%
CH_4:	13%
N_2O:	4 - 5%
other gases:	2 - 3%.

In view of the above amounts, it is the reduction in CO_2 and CH_4 emissions that matter in respect of the preventive climate protection target.

The N_2O and SF_6 emissions primarily occur in agriculture, the production of adepin and nitric acids and the manufacture of sound-proofing windows and automobile tyres. A special feature can be attributed to the HFCs because – due to the 1987 Montreal Protocol – the latter have taken the place of the CFCs since the 90s and their output is steeply rising all over the world. The reduction commitments can only be fulfilled if this rise is offset by a considerable reduction in the other greenhouse gases (in particular CO_2 and CH_4).

- Oil, natural gas and hard coal – the fossil energy sources – make varying contributions to the greenhouse gas emissions which result from their CH_4 emissions during mining and transport. These emissions, too, are subject to the reduction commitments laid down in the Kyoto Protocol. Lignite mining, on the other hand, is almost free from methane emissions.

The reduction commitments will result in the industrial states increasingly taking measures to avoid methane emissions or making use of this gas during mining of fossil raw materials (e.g. coal-bed methane use). Against the background of competition, the extraction of fossil fuels in the industrial countries is additionally burdened by this disadvantage since the developing countries and virtually all the countries of the former East Bloc (hot air problem) as well are not faced with such a commitment. Depending upon the deposit and the mining technique, the actual commercial disadvantage can differ to a very large extent.

FLEXIBILITY MECHANISMS:

WILL THEY BE SUCCESSFUL? WITH WHAT IMPACT ON THE FUTURE ROLE OF COAL IN OECD COUNTRIES?

Leigh Clifford
Chief Executive
Rio Tinto Energy

The Kyoto Protocol establishes greenhouse reduction targets for developed countries. The Protocol also establishes three specific mechanisms which countries can choose to use to help them meet their targets. Countries will be expected to take domestic policy measures to reduce their own emissions, but they will also be able to take action abroad to gain credits towards meeting their national targets.

These mechanisms are to be welcomed. The concept behind all of them is economic efficiency. They open up routes through which emissions reductions can be achieved wherever the lowest cost options exist. These lower cost emission abatement projects are likely to be found in developing countries or in the FSU.

Whilst the three mechanisms were agreed in the Kyoto Protocol, the detailed rules are still to be developed. It will be some time before there is a clear picture of the final form, scope and utility of these concepts. Comments about their impact in the coal market place can therefore only be broadbrush at this time.

The three mechanisms are:

EMISSIONS TRADING

Under the Protocol, trading can occur between developed countries. Countries (or designated legal entities) could buy emissions permits from other countries, or could sell their own surplus.

Although potentially more economically efficient than other policies such as taxes or regulation, emissions permit trading is an economic instrument which will impose a cost on those who need to buy permits. Power generators or steel mills using coal would need to hold permits to emit associated CO_2. If they do have to buy permits (rather than have them allocated by governments, or generate them by reducing emissions in other parts of their businesses), using coal will attract a financial impost. Coal users in developed countries will be at a competitive disadvantage to users in developing countries, or to suppliers of less carbon intensive fuels.

However, having the ability to trade emissions permits is a better option than not having that ability. Trading provides flexibility for countries and for entities in responding to emissions constraints.

Trading can only be successful if there are enough participants to create a fully functioning market, and if there is adequate transparency and certification of trades. It is in the coal industry's interest to support a comprehensive trading regime because of the flexibility it offers our customers, and because it will allow emissions savings which can be more readily achieved outside energy markets (e.g. transport, commercial, forestry sectors) to be "transferred" to the energy sector (albeit at a cost).

CLEAN DEVELOPMENT MECHANISM (CDM)

Under the Protocol, the CDM will allow developed (Annex B) countries to undertake individual approved projects which reduce actual or potential greenhouse emissions in developing countries. Developed countries (or entities within those countries) undertaking projects will gain all, or a proportion of, the credits for the reductions – which can be used to meet targets or offset other emissions.

This mechanism represents a major breakthrough since it provides a real spur to emissions abatement occurring in developing countries – which have no specific emission reduction obligations under the Protocol.

Many of these countries will need to expand their use of coal as part of their energy mix to satisfy rapidly growing demand. The CDM provides one route whereby that coal can be used in a more greenhouse efficient way than would otherwise be the case.

It is expected that most CDM activity will focus on energy efficiency projects with particular emphasis on more rapid transfer of [efficient coal fired power generating] technology into developing countries.

JOINT IMPLEMENTATION (J.I.)

Like the CDM, this is a project-based mechanism, but it applies to reduction projects undertaken between developed (Annex B) countries. Credits are gained, in full or in part, by the investing Annex B country or entity.

WILL THE MECHANISMS BE SUCCESSFUL?

There is a lot of interest in the possibilities generated by each of the mechanisms.

Discussions are underway on rules, with different countries starting with markedly different approaches. Reconciling the differences through formal negotiations will be time-consuming and inefficient. Nevertheless, it is likely that agreement will be reached on enough of the core principles for these mechanisms to start to be used with increasing degrees of confidence. Investor certainly is a key to making these mechanisms work.

Since the Protocol limits two of the three mechanisms to Annex B countries only, and developing countries are excluded from emission reduction obligations, there are already in-built competitiveness distortions facing the Annex B participants. Within that constraint, the mechanisms and markets will be more successful, the deeper and wider the participation.

It is important that the emerging rules do not limit the extent to which these mechanisms can be used to meet obligations. There are political moves to constrain their use to contributing only a proportion of a national target. This has no rationale in economic or environmental efficiency. Likewise these mechanisms must include emissions abatement from all sectors, sources and sinks. Limits will only result in reduced flexibility and hence in higher costs for the energy sector.

IMPACT ON THE FUTURE ROLE OF COAL

Coal will be required to meet the energy needs of the next decade and well beyond. However the future role of coal in energy markets will change at the margin under stringent greenhouse policies, through:

- energy efficiency and technology upgrades;

- some substitution of less carbon intensive fuels; and
- accelerated uptake of renewable sources in niche applications.

The energy sector cannot and should not bear a disproportionate share of the adjustments which will be required in Annex B countries to meet their greenhouse targets. Countries should place the burden of adjustment where it is economically efficient to do so. Use of the flexibility mechanisms is one important element of this.

ATLANTIC MARKETS

Given the European Union's extensive menu of options for its energy mix, coal has been identified as one of the key targets for meeting individual member states targets. Domestic production and consumption of coal within the European Union is expected to continue to decline. However, this decline is arguably related to the relative uncompetitiveness of much of the coal currently produced under heavily subsidised and market restrictive arrangements.

It is unlikely that the European Union's use of flexibility mechanisms would postpone or mitigate these changes. Even with credits from major investments in energy sector J.I. or CDM projects, the future state of energy markets in Europe is already changing through other forces.

JAPAN

In Asia, Japan is the sole Annex B country. Japan is re-examining its future energy scenarios and policies with a view to shaving the share of coal in favour of less carbon intensive fuels. However, realistically, given its fairly limited domestic opportunities to reduce emissions, Japan will need to continue to use coal and will most probably seek to buy a significant proportion of its target and will look to each of the three flexibility options on offer. This will impose some cost burden on the nation and a competitive disadvantage against other Asian industrial competitors. If there are significant limits on the extent to which flexibility mechanisms can be used to meet targets, Japan will need to suffer a substantial negative impact on its coal consumption and its economic growth to make up the required domestic reductions.

REST OF ASIA

Developing Asia, and China in particular, is a key consumer of coal, and source of much of the recent and projected growth in the coal industry and in global emissions. It is isolated from the direct impact of the Kyoto Protocol. However, the Clean Development Mechanism offers opportunities for firms or governments to invest in projects to reduce emissions within Asia. These projects may extend to funding alternative sources of energy (for example gas), but provide a challenge and an opportunity to encourage greater uptake of cleaner coal technologies.

U.S.A.

In the United States, coal consumption underpins economic growth. Deregulation and other forces already at work will dominate energy markets over the next decade. The United States will be a primary user of the flexibility mechanisms to achieve its national target. It will also be a powerhouse of technology and funding for CDM projects in Asia and South America. Support for clean coal technologies will be important.

CONCLUSIONS AND OBSERVATIONS

- Emissions trading, joint implementation and the Clean Development Mechanism offer countries some flexibility in the way they meet their emission reduction targets.
- Use of any of the three mechanisms will impose costs on participants purchasing quota or funding projects. However, the costs on countries and on individual firms may be less than if emissions reductions were imposed in other ways.
- Arbitrarily limiting the extent to which flexibility mechanisms can be used to meet targets, is economically sub-optimal and serves no environmental purpose.
- Ensuring that the mechanisms cover all projects in all sectors, all gases, all sources and all sinks, will encourage the burden of greenhouse emission reduction to spread to all sectors where it is economically efficient to do so.
- Countries' energy sectors will offer potential for greenhouse savings and will adjust under pressure of greenhouse policies and the costs of trading and the other flexibility instruments. However, access to flexibility mechanisms will enable governments alternatives to impacting disproportionately their energy sector through inflexible and costly policies.
- Coal will be used more efficiently in developed and developing countries alike as Kyoto obligations flow through in Annex B countries, and as the CDM encourages technology transfer into developing countries. The industry and regulators must actively encourage the more efficient use of coal.

THE KYOTO PROTOCOL AND MARKET MECHANISMS

Ellen Roy
Senior Vice President
Intercontinental Group

OUTLINE OF GCC PAPER

1. EXECUTIVE SUMMARY

The importance of the Kyoto Protocol (KP) lies less in the specific targets than in the methods outlined for achieving these targets. I believe that in many countries the timetable and targets may be revisited and revised as the deadlines for compliance approaches. Certainly, in the U.S., specific actions will be dependent on how other aspects of the protocol are managed and to what degree developing nations such as China and India play a role. However, the debate about how to implement such a treaty and how to structure market mechanisms is just beginning to take shape. While numerous proposals from academic institutions and government agencies on emissions trading schemes exist, no one vision dominates the debate. Even less has been done on the Clean Development Mechanism (CDM). Rather than suggest or endorse a specific proposal or approach, I believe the most productive approach for the CIAB is to vet a set of principles that should underpin any specific scheme that is ultimately implemented. Such a set of principles could also be used to screen and rank existing models.

The KP outlines market mechanisms such as emission trading and joint implementation in the most vague and general terms. This paper suggests a set of principles that should guide the design and implementation details of these market mechanisms such as the Clean Development Mechanism. This paper also summarizes three emissions trading proposals designed for the “early action” period (1998 – 2008) by well-regarded institutions in the U.S.

Predicting the likelihood of whether such provisions will be adopted in the KP and what their impact on coal will be is a tricky question. If you believe that U.S. adoption of the treaty is an essential ingredient in any world-wide concerted action, then some form of these provisions is likely to be incorporated into the KP. There are primarily political, not technical barriers to making these provisions work.

Inevitably, the whole issue of whether the U.S. will ratify this treaty will remain unresolved for some time. However, even if the KP is delayed or abandoned by key players such as the U.S., it is still possible that individual countries will move forward independently with domestic or regional trading programs. It is prudent, therefore, to assume that the current debate about the design of market mechanisms for carbon gases is of vital interest to the coal industry. Under any scenario, coal is bound to lose market share under a global climate change regime, but the question of whether it is a manageable problem or a severe cutback will be decided in the details of agreements like the KP.

2. SET OF PRINCIPLES FOR THE CDM

The flexibility mechanisms included in the Kyoto Protocol are essential to making progress in reducing greenhouse gas concentrations in the atmosphere. I believe that the CIAB should support the following principles with regard to the development and implementation of the CDM:

Credible

- Any international effort to reduce greenhouse emissions must include sufficient technically rigorous mechanisms to ensure credibility. Therefore, the CDM must result in emission reductions that are measurable and auditable.

Flexible

- Industry must be provided reasonable flexibility to develop and implement CDM projects that result in real emission reductions.

Simple

- The CDM process must be sufficiently simple to ensure active participation by industry. A simple process will ensure that transaction costs are minimized.

Cost Effective

- Unnecessarily high costs to support inefficient and bureaucratic regional or international bodies created to manage the CDM will act as a deterrent to industry's participation in the CDM process. Likewise, if an unreasonably high proportion of the emission credits generated by a CDM project are allocated for adaptation/mitigation projects, then the economic value of such projects will be reduced and industry will fail to invest in the mechanism. Although adaptation/mitigation projects may be necessary, an unreasonable burden on the CDM will ensure that no revenue will be generated for such adaptation/mitigation projects.

Inclusive

- The CDM should include all gases, sources, sinks and technologies. Although it may be necessary or desirable to allow certain types of CDM projects to occur earlier than others due to the availability of technical information, industry should be allowed and encouraged to move forward with any project which creates real emission reductions.

Additionality

- Additionality is a legitimate concern that must be addressed up front to give project developers sufficient assurances that their investments will create real reductions. Notwithstanding, debate over additionality should not be allowed to discourage projects which promote sustainability. Industry should be allowed to present technical information to the appropriate certifying organizations, which supports the assertion that the project creates real emission reductions.

Early Experience

- Early experience with the CDM will generate practical experience with the trading of emission credits on an international basis and should create confidence in the role of flexibility mechanisms in economically reducing emissions. For this reason, every effort should be made to ensure that the CDM program is in place as soon as practicable. To facilitate this learning process, COP-4 should instruct the SBSTA and SBI to develop work-plans for addressing the technical and program implementation issues.

Banking

- Industry must be allowed to bank credits generated in the period of 2000 to 2008 for use during the first or any subsequent commitment period in accordance with domestic agreements between Annex B countries and the individual businesses and industries.

Ensuring Success

- Investment by business and industry in developing countries is the most effective mechanism for technology transfer to those countries. The CDM will only be successful if the private sector participates. As such, industry must have an active role in the development of CDM's programmatic requirements. This will help ensure the viability of the implementing programs.

3. EMISSION TRADING PROPOSALS

Emission Trading Proposals

Issues	CCAP	EDF	RFF
Allocation	* Upstream * Acts like a carbon tax * Auction w/grandfathering	* Voluntary program – open to all participants	* Upstream * Acts like a carbon tax * Auction w/grandfathering
Eligibility/Process	* 6 gases * Sinks are offsets or credits on project basis	* 6 gases	* 6 gases * Sinks are offsets or credits on project basis
Baseline	* Line decreasing from 1998 to first budget commitment * Credit below baseline	* 3 year average constant until 1st budget * Credit below baseline	* Line decreasing from 1998 to first budget commitment * Credit below baseline
Accounting	* Early credit taken from 1st budget * Limited to 5%	* Early credit taken from 1st budget	* Early credit taken from 1st budget
Timing	* Early credit program is 1998-2007	* Early credit program is 1998-2007 * Credit applied upstream	* Early credit program is 1998-2007
Verification	* By governments w/role for private sector		* By governments w/role for private sector
Compliance	* Strong financial penalties		* Penalized by reduction in subsequent quotas
Government Role	* Tracking trades, certifying and regulating brokers	* Guarantee credit	* Tracking trades, certifying and regulating brokers
Other	* 1605b credits limited to 1% of 1st budget		

CCAP – Center for Clean Air Policy
EDF – Environmental Defense Fund
RFF – Resources for the Future

CAN A COAL MINING BUSINESS SURVIVE IN A "GREEN" WORLD? AN AFRICAN PERSPECTIVE

M Deats and D Murray[1]

INTRODUCTION

The challenges posed by modern energy, development and environmental issues mandate a changing paradigm in the approach to energy supply, transport and use. As a contribution to the debate around coal based paradigms, the Coal Industry Advisory Board of the International Energy Agency has undertaken an exercise to define the future role of coal. This short note is a contribution to that exercise. It should be noted that these are merely ideas which attempt to stimulate debate and innovation in addressing the development imperatives of poor nations around the world, whilst at the same time putting the energy sector on the path to sustainability.

There is a widespread perception that coal is a dirty fuel and that it is the major culprit in processes which release greenhouse gasses. This paper recognises this perception and does not attempt to address it. It rather paints a picture of the role of coal in economies in which sustainable development is becoming a priority. It also presents some practices which could add value to the coal mining business in the long term.

1. THE REALITY OF COAL AS AN ENERGY SOURCE

In spite of the negative sentiments towards coal which have developed internationally over the last 10 years or so, coal still plays a major role in energy provision internationally – in both developed and developing nations. In many developed nations – especially the EU and the USA, natural gas has become the low cost primary energy source for new power generation capacity bearing in mind that much of the large existing coal fired capacity base is still in midlife and will continue to operate well into the 21st century. As such coal has been (and will continue to be) displaced by normal market forces. Clearly this has had advantages in that the environmental impacts of power generation have been considerably reduced. It is anticipated that, as developed nations meet targets to reduce greenhouse gas emissions and further reduce other power station emissions, this trend will accelerate.

The trend in many developing nations is however different. Many developing nations have no other energy source to rely on for electricity, industrial heating and domestic heating. As such coal consumption is likely to increase as these nations develop their economies and improve the quality of life of their citizens. This increase is likely to continue for at least the next 20 years, given the expected lifetime of current coal burning plant in operation, under construction and on the planing horizon. Whether this increase will continue until 2050 is uncertain and is strongly dependent on technological developments over the next 10 years or so. The challenge for the coal mining sector is to cater for this important development need whilst assisting these economies onto a sustainable path.

The coal mining sector may initiate such proactive activities as:

- Development of low cost, clean burning fuels and appliances for domestic consumption.

1. With the assistance of Dr S J Lennon (Associate)

- Demand Side Management of coal usage by their customers to reduce coal consumption, enhance competitiveness, reduce environmental impacts and facilitate more sustainable markets.
- Encouragement of electrification and energisation programmes aimed at reducing domestic coal combustion – the single greatest source of urban air pollution in many developing nations.

  Note: Energisation refers to the provision of integrated clean energy packages to communities. For example electricity for lighting and communications, Liquified Petroleum Gas for heating and cooking and solar water heating.
- Development of the high added value sector of the coal market. For example, coal could be a valuable chemical feedstock in 50 years – too valuable to merely burn for energy production.

2. COAL'S ROLE IN AFRICA

Africa, especially Southern Africa, is richly endowed in coal resources, with reserves adequate to sustain at least four times current consumption for at least 50 years. In addition this resource is at least matched by hydro potential and, to a lesser extent nuclear potential in Uranium reserves. Coal resources are currently widely applied for power generation (~ 40%), liquid fuels, chemical feedstock and as a primary energy resource in the industrial and domestic sectors. In the latter application it is responsible for extremely high levels of air pollution in urban areas. The majority of coal is produced and consumed in South Africa. Given that most coal fired power stations are less than 15 years old and new coal fired plant in South and Southern Africa is currently being planned, coal is likely to continue to be used for power generation for several decades. The extent of this utilisation is however uncertain. Power demand is likely to increase at between 2,5 and 4,2% per annum, due to economic growth and increased levels of electrification. Whilst the latter will displace some domestic coal combustion, this will be a relatively small impact which will only be fully realised after 15 to 20 years. At this stage the primary fuel source for power generation is still uncertain. Several options are open and these are presented below: -

- Demand Side Management – the reduction of peak loads in the region is a priority. As such DSM can play an important role over the next 10 to 15 years, as a viable alternative to the construction of more power stations. The energy efficiency component of DSM is less attractive, however if adequate funding and financing is made available from mechanisms such as the Global Environmental Facility, Joint Implementation and the Clean Development Mechanism, then significant energy savings are possible. These savings could, in some cases, be achieved in the mining sector, thereby enhancing the viability of mining operations.
- Development of southern African hydro resources – the hydro resources of southern Africa are adequate to supply the entire continent with electricity. It is even postulated that excess capacity could be sold into the European system. Feasibility studies to develop these resources have been underway for some years now. The viability of such development has however yet to be demonstrated. This, coupled with regional instability and the desire for energy security amongst most nations in the region, makes the development of the southern African powerhouse a long-term vision. The creation of the Southern African Power Pool does however create a useful enabling environment for such development.
- Pebble Bed Modular Reactor – electricity demand in most African nations, whilst increasing rapidly, is growing from a very low base. As such the demand is for small scale, flexible, stand alone power generation which can form the basis of a national grid if required. The Pebble Bed Modular Reactor creates such an opportunity. Whilst not a new technology, it is currently being developed as a low cost,

low maintenance, inherently safe nuclear power generation option, ideally suited for developing nations. This could create huge opportunities for the modular expansion of the electricity infrastructure in African nations. The first unit could be commissioned in South Africa as early as 2005.

- Discard Coal Combustion – the millions of tons of discard coal produced by mining operations (55 million tons pa in South Africa) results in significant negative environmental impacts. The combustion of this coal presents an opportunity to both remove these impacts and generate electricity at low cost. The reserves currently available could meet projected increases in South African electricity demand for the next 10 to 15 years. The feasibility of re-powering mothballed plant in South Africa is also being explored.
- Non hydro renewable energy supply – the options for power supply from renewable sources are limited and expensive. Nevertheless potential does exist in Africa, especially in the context of opportunities created under the Global Environmental Facility, Joint Implementation and the Clean Development Mechanism. It is anticipated that large-scale rural photo-voltaic electrification programmes could become a reality over the next 10 to 15 years. The feasibility of bulk solar generation (solar thermal), is being investigated in South Africa.
- Conventional and advanced pulverised fuel power generation.
- Natural Gas power generation using recently discovered gas reserves in Namibia and Mozambique.

In the context of the details provided above, coupled with drives to increase the manufacturing or beneficiation sector of the African economies, it appears that the long term use of coal in Africa will undergo significant changes. In fact the entire energy infrastructure could undergo substantial changes if the vision of the African Renaissance is realised. This could include the development of a regional gas and liquid fuel infrastructure which exploits African gas and oil reserves, as well as a strengthened regional electricity infrastructure. The continued role of coal as the dominant primary energy source is likely over the next 20 years, but uncertain thereafter.

Ultimately the economic viability of a variety of energy sources will determine which plays the dominant role for energy provision in Africa beyond 2050. It is clear that mechanisms such as the Clean Development Mechanism could play a critical role in defining that economic viability. At the same time the obstacles to the uptake of new technologies and the costs of developing a support infrastructure capable of sustaining those technologies must not be underestimated. The latter factor alone could dictate coal continuing to play its leading primary energy role far into next century.

CAN A COAL MINING BUSINESS SURVIVE IN A GREEN WORLD?

James J. Howard,
Chairman, President and CEO,
Northern States Power Company

Can coal survive in a green world?

Yes. It has to if the rising aspirations of the global economy are to be met. The world needs the low-cost energy afforded by coal to power businesses, industries, manufacturing operations and homes.

Despite the current claims of some environmental organizations, this planet cannot run without fossil fuel. It is not a post-war trend, or a 20th century "thing." It is an extension of history dating back to the Industrial Revolution. Ever since James Watt invented the steam engine in 1785, mankind has relied on coal and its more recently discovered cousins, oil and gas, to help with the work. Without these three energy sources, the global economy as it is known today could not exist. Standards of living in the Industrialized Nations would change significantly and the aspirations of the Developing Nations might never be realized. At this time there is no obvious other way to feed, transport, house and support the almost 6 billion people of planet Earth.

Fossil fuel represents 90% of the world energy consumption. And on a global basis, coal provides 40% of the electricity used by the earth's current population. Mined in over 100 countries, it provides a local energy source to much of the earth's population. Unlike oil and gas that are becoming harder to find and seem to be concentrated in politically unstable areas, coal is everywhere and has been for a long time.

Coal plays a key role not only in the energy sector, but also in the housing and infrastructure sectors of the world. Over 70% of the steel on earth is produced with coal, as is a majority of the cement. If the estimated doubling of the earth's population in the next 60+ years occurs, the steel and concrete required for these people must be factored in. If coal is no longer used to produce these materials, oil or gas must be used, or a new bio-fuel technology must be developed.

Sometimes extremists in the Government or privately funded environmental groups pressure utilities to totally get rid of coal. Those same people don't seem to want the use of hydro or nuclear power either, despite the fact that these sources have almost no emissions. One Internet website claims "nuclear has NO role in the climate change issue". The same Website also calls for phasing out of ALL coal, oil and gas over the next 30 to 40 years. The reason for this drastic measure appears to be to stabilize the climate. How the earth's population will feed itself, transport itself, house itself, and support itself is not detailed.

The one fuel source that seems to be socially acceptable today is renewables.

Unfortunately, renewables can't possibly replace all other energy sources. There isn't enough land to grow enough biomass to replace coal energy. The land requirements for coal mining operations are also significantly less than bio-crop operations. World-wide, biomass would require 22% of the earth's available cropland to equal the energy provided from coal today. If an attempt was made to achieve the environmentalist's dream of phasing out all coal, oil, gas and nuclear production, it would require more than 70% of the available crop, forest and permanent pasture on the planet.

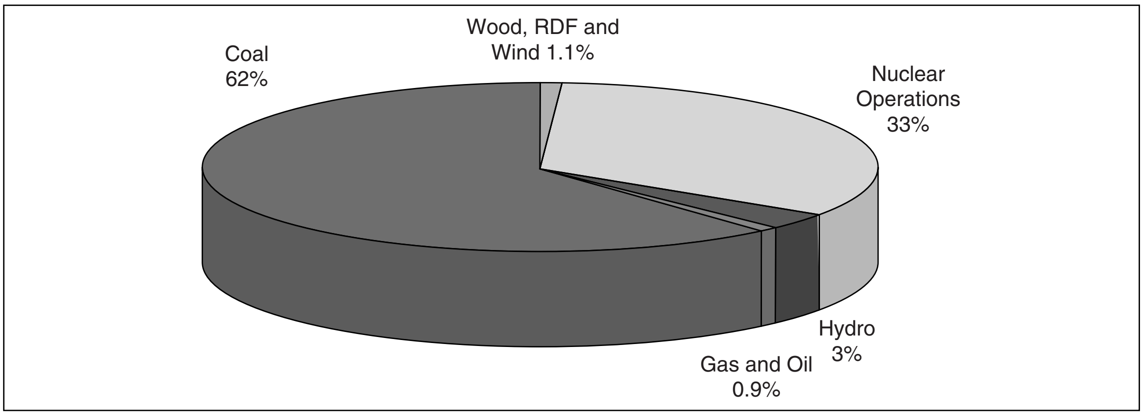
Wind energy is not the answer to the world's energy needs either. It is not as reliable as fossil fuel or nuclear power because the wind does not blow on command when power is needed. With low capacity factors in average locations, and a limited number of "really good" locations, wind does not meet the reliability requirements for the current global economy. Although Northern States Power Company (NSP) has one of the largest wind farms in the United States, with an average capacity factor of 25%, wind will never offer the reliability provided by the company's nuclear or coal plants. When, and if, a new technology for storing wind energy is developed, wind can provide a greater supplement to the conventional fuels. It cannot provide a substitute role.

Minnesota, the state where most of NSP's plants are located, is arguably one of the "greenest states" in the United States. State regulations were enacted in the 1970s that required all power producing plants to have air quality permits. NSP's plants received air quality permits from the state of Minnesota in the 1970s. The Environmental Protection Agency, as part of the Federal Clean Air Act, did not require submittal of applications for these same type of air quality permits until the mid 1990s. Many sources in the U.S. do not yet have permits.

In 1985, the state approved the Minnesota Acid Deposition Control Act which capped SO_2 emissions from utilities beginning in 1990. The Federal Clean Air Act only capped utility emissions for a few facilities in the U.S. starting in 1995 and for most facilities starting in 2000.

At NSP, it has long been believed that customers are best served economically and environmentally when electric energy is produced from a wide mix of fuels, including coal, nuclear, gas, oil and renewables. Here's a breakdown of NSP's current energy mix.

NSP's 1997 Electric Energy Mix



A mix like this helps to keep costs down, because it limits effects on the company of fuel price fluctuations or government regulation posed by reliance on a single fuel.

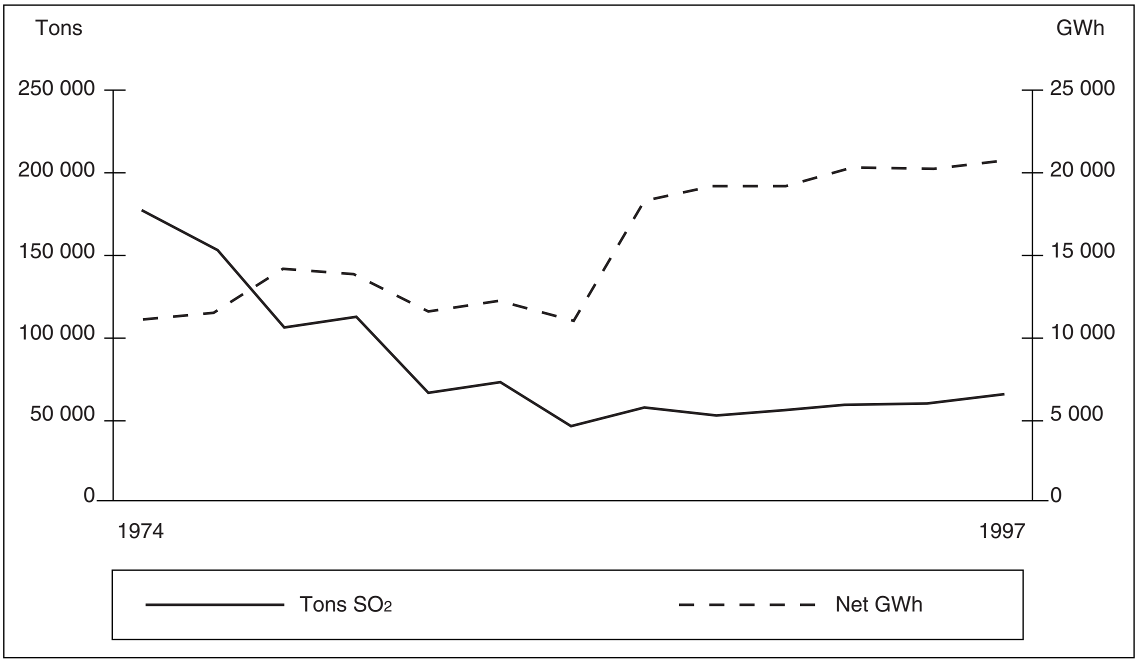
Because of its historical low cost, coal makes up a significant portion of NSP's energy mix now and is expected to continue to in the future. There are six coal plants in the NSP system which burn between 11 and 12 million tons of coal a year and have a collective generating capacity of almost 3,600 megawatts. This represents more than 60 percent of the company's generation.

Not only is coal reliable and low cost, but NSP has been able to balance that low cost with environmental protection through research and innovation that have enabled its coal plants to perform at levels well below current emissions limits, while maintaining low costs for customers.

In the late 1960s, in an effort to reduce costs, NSP decided to investigate the use of sub-bituminous coal in its generating units. All NSP coal units except the three at Sherburne County were designed to burn Eastern U.S. bituminous coal. The company gradually converted the units to burn low-sulfur sub-bituminous coal from Montana and Wyoming. By the early 1980s, a conscious decision was made to go to 100% western sub-bituminous coal to lower both costs and emissions.

Beginning in the 1970s, NSP also pioneered the use of wet scrubber technology to reduce sulfur emissions. The technology was first tested in a demonstration module at one of its older plants, and later installed on a full-scale basis at Units 1 and 2 of its Sherburne County plant (Sherco), the largest plant in the system. The same approach was instituted with dry scrubber baghouse technology, installing a demonstration unit at the Riverside plant, before using the technology on a full-scale basis in Unit 3 at Sherco.

SO_2 Emissions vs. Net Generation



In fact, over the past 27 years, with the use of sub-bituminous coal and the installation of sulfur removal equipment, NSP has reduced sulfur dioxide emissions by more than 71 percent, while simultaneously increasing the amount of generation from coal by 70 percent.

What's more, despite the relatively old age of these coal-fired facilities, the NSP system has been in compliance with the 1990 amendments to the Clean Air Act's SO_2 emission rate goal for the year 2000 since the early 1980s.

These achievements required extensive research and more than $630 million in investments in advanced pollution control equipment. But the savings in fuel costs offset those investments and prepared NSP for the more stringent environmental regulations faced today. If those same investments were made today, the cost would be far greater. Making these investments early and over a number of years has enabled NSP to operate some of the lowest cost plants in the region, while balancing environmental needs.

NSP continues to invest today in research that will balance the need for low-cost energy and increased environmental control. For example, to improve particulate emission performance at Sherco Units 1 and 2, the old wet scrubber system could have been scrapped and a dry scrubber/baghouse installed for a cost of $140 million. Instead, NSP worked with the Electric Power Research Institute to demonstrate particulate removal using a wet electrostatic precipitator, which is currently being installed at a cost of $42 million, or a capital cost savings of almost $100 million.

Obviously these investments would not have been made unless NSP believed that coal does have a place in a green world. NSP is committed to the use of coal now and in the future as a vital part of the company's generation mix. NSP has found it can balance costs and emissions in using coal as a major fuel source.

With this in mind, the coal industry faces a challenge. It needs to do a better job marketing and advertising the benefits of coal. Public opinion research has shown that from 1981 to 1993, the number of Americans who believed coal was important for future energy needs declined from 46 percent to 18 percent. Research also shows that more than one third of the public is unsure what fuel constitutes the primary source of their utilities' power. It is also not obvious that the governments of the Western Nations will ever acknowledge coal's crucial role in energy production.

Educating the public and world leaders about the facts concerning coal's role in environmentally responsible electrical generation will help keep retain coal's leading position in future energy production.

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CAN A COAL-BASED ENERGY BUSINESS SURVIVE IN A “GREEN WORLD”?

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Chief Executive Officer
AUSTA Energy

INTRODUCTION

The future of coal as an energy source will be determined by the combined abilities of coal producers, plant manufacturers and operation and maintenance (O&M) service providers to maintain the position of coal-fired generation as a long-term cost effective energy option.

The position of coal as the preferred fossil fuel for power generation is being challenged by natural gas.

The low fuel cost of coal relative to other fossil fuels remains a strong competitive edge in many parts of the world.

TREND IN CAPITAL COST OF COAL-FIRED PLANT ($/KW)

The cost of coal-fired plants varies widely depending on:

- the location
- the type of technology
- the regulatory environment

Coal-fired technologies have higher capital cost than gas-fired plants, with gas-fired plants also benefiting from shorter construction periods and higher conversion efficiency of fuel to electricity.

Unlike other fossil fuel energy types, the high cost of coal-fired plant means that new coal-fired plant will need to be base-loaded throughout its operating life to be economically viable.

The trend for capital cost of coal-fired plant has been strongly downward for a number of years and shows no immediate signs of ending.

This will improve the opportunities for new coal-fired plant and maintain competitiveness with the reducing trend in capital cost of gas-fired generation technologies.

TREND IN O&M COST OF COAL-FIRED PLANT (CENTS/KWH)

The trend for O&M cost of coal-fired plant is also strongly downward.

This has been driven by factors including:

- automation of generation plant requiring fewer operating staff

1. With the assistance of Dr Ian Rose, Austa Energy

- world-wide benchmarking of world's best practice O&M resulting in across the board improvements of performance
- mergers and acquisitions in utilities and IPP's increasing economies of scale in O&M
- improved availabilities of generators through technological advances resulting in direct savings in expenditure.

ENERGY OUTLOOK

The outlook for energy use world-wide continues to show a strong prospect of rising levels of demand over the next 20 years.

This will be led by the growing demand in the developing countries, particularly in Asia where consumption is expected to double by 2015.

Coal's share of the energy sector is projected to reduce in percentage terms.

However, because of the expanding total energy market, coal still has major growth prospects.

China and India combined are projected to account for more than 80 percent of the world's total increase in coal consumption over the next two decades.

In this "business as usual" scenario the industrialised world would increase its total carbon emissions by about one third from 1990 to 2015, while the rest of the world would almost double its carbon emissions.

CARBON EMISSION TARGETS

An alternative view emanated from Kyoto in December 1997.

The objective of the Kyoto agreement will be to reduce total carbon emissions in the developed nations from the present levels back to the 1990 levels by about 2010.

RESULTING COAL PRODUCTION OUTCOMES BASED ON GREENHOUSE TARGETS

If total CO_2 emitted is to stay constant, then the total coal burned must stay relatively constant or even decrease.

Therefore, in the current environment of global concern about Greenhouse, the market prospects for coal in traditional uses are not encouraging.

RELATIVE CO_2 EMISSIONS

The pulverised fuel technology that is presently used in Australia for black coal fired power stations provides efficiencies of about 36 percent and CO_2 emissions of some 900 kilograms per megawatt hour.

Brown coal plant has efficiencies of about 30 percent and its CO_2 emission levels are around 1250 kilograms per megawatt hour.

Integrated Gasification Combined Cycle (IGCC) plant is considerably better than conventional plant with CO_2 emissions of about 600 to 700 kilograms per megawatt hour.

Natural gas-fired combined cycle plant has a significant advantage in terms of greenhouse with CO_2 emissions of about 400 kilograms per megawatt hour.

In order to provide increased energy production levels without increasing carbon emissions, coal-fired energy production will have to become more efficient. If that trend is not pursued by all parts of the coal-based energy industry, there is a risk that coal will lose favour to fuels with relatively lower greenhouse gas emissions.

CONCLUSION

The signals for the future of coal as an energy source are mixed, with significant divisions between the views of opinion makers.

On the one hand are the pragmatists who see an increasing trend in fossil fuel usage, including coal, as a way to deliver the affluence of the developed nations progressively to the less-developed nations.

The arguments in favour of this are the abundance of coal world-wide, the ability of coal to be traded widely, and ongoing improvements in the environmental performance, cost and operation of coal-fired plant.

On the other hand are the local and global implications of emissions from combustion of fossil fuels, and the associated predictions of climatic change.

The result is likely to be increasing pressure on all facets of the coal-fired generation industry to mitigate the effects of the use of coal for energy production.

The coal-fired energy industry can therefore expect to be strongly challenged for the foreseeable future.

ENVIRONMENTAL CREDENTIALS OF COAL

R Kirkby
BHP Coal

Explanatory Note

This paper is intended as introductory paper only on some of the issues involved in considering the environmental credentials of coal. A more detailed analysis and a more detailed paper are required to fully explore the issues introduced in the paper.

INTRODUCTION

This paper discusses aspects of the environmental credentials of coal compared to other energy and reductant sources, from a life cycle perspective. The emphasis is on Greenhouse issues because of its current and future importance for coal. The purpose is to highlight misleading information for coal, and to illustrate how the environmental impact of coal can be markedly improved by optimum use of coal by-products (especially ashes, slags and process offgases) through displacement credits.

LIFE CYCLE ANALYSIS (LCA)

An LCA for coal needs to evaluate the environmental impacts from using coal for a **specific** application; e.g. to produce 1 tonne of hot metal from a blast furnace, 1 GJ of electricity from a power station, or 1 tonne of steam for heating.

The basis used for comparison is called the functional unit, and the entire production chain being considered (e.g. mining, beneficiation, transportation, utilisation, and the disposal/utilisation of wastes/by-products) is called the system.

To enable comparison, a similar analysis is required for the competing energy or reductant. This need not use the same technologies. For example, coal used in a pulverised coal (pf) fired power station could be compared with a combined cycle gas turbine using natural gas, or steel from an integrated steelworks could be compared with steel from an electric arc furnace using direct reduced iron from a natural gas based process such as Midrex or Finmet.

An LCA comprises two principal tasks;

- A life cycle inventory analysis (LCIA).
- Estimation of the environmental impacts of the inventory.

Life Cycle Inventory Analysis

LCIA involves determining the mass and energy flows into and out of the system. For power generation, the emissions to atmosphere would include all gases emitted during mining, transportation and combustion, and also include the emissions from the externalities (supporting services) such as diesel fuel production, the production and maintenance of mining equipment, and could include the power station itself. The complexity depends on the level of accuracy required and the purpose of the analysis.

Impact Assessment

Impact assessment involves determining the environmental impacts of the inputs and outputs obtained from the inventory analysis.

Because of the complexities and lack of scientific data, there is currently no universally accepted methodology for doing detailed impact assessment. The most common accepted methods are:

- Direct comparison of the material and energy flows obtained from the inventory analysis. This method is particularly useful for benchmarking processes or for comparing similar products.
- Total resource energy consumption. Although energy itself is not the polluter, nor in short supply, it is a useful proxy for environmental damage.
- Greenhouse gas emissions (GGE), which is the weighted aggregate of greenhouse gas emissions as equivalent CO_2. This is particularly important for coal, and coal based products such as steel and electricity.

A more detailed list of impacts assessed in comprehensive LCA is given below:

- Acidification
- Aquatic ecotoxicity
- Biological oxygen demand
- Depletion of biotic reserves
- Greenhouse warming potential
- Human toxicity
- Landfill volume
- Nutrification
- Ozone depletion
- Photochemical oxidant
- Resource depletion
- Terrestrial ecotoxicity

Displacement Credits

When a by-product or co-product from one process route is used to replace some other product, then the environmental impacts for the main product can be credited for the overall saving in environmental impacts. LCA can identify and quantify these credits.

CREDENTIALS OF COAL

As the environmental impacts from coal and competing energy and reductants are numerous and complex, this section gives only a sample of misleading environmental impact data, and two examples of significant displacement credits for coal.

Table 1 shows the commonly accepted GGE for several coal and competitor products. On this basis, coal based products have a significant environmental disadvantage. However, these values are incorrect and misleading.

Table 1

Example GGE for electricity several competing materials

Product	GGE equiv. t CO_2/unit
Hydro electricity	0
Natural gas electricity	155kg/GJe
Conventional pf electricity	260kg/GJe
Integrated steel	3000kg/t
DRI-EAF steel (50% scrap)	1400kg/t
Timber products	<200kg/t
Concrete products	380kg/t

Misleading Impact Data

The most common cause of misleading impact data is basing the analysis entirely on the utilisation phase; i.e. combustion in a boiler. The entire life cycle must be considered to avoid these errors.

Table 2 shows the effect of common errors or misallocation in calculating the GGE for several coal-based and competing products.

Table 2

Common errors which impact negatively on the Greenhouse effect for coal based products, showing estimates for the percentage disadvantage to coal (products)

Application	Error	Underestimate in GGE
Hydro electricity (compared to pf)	Omitting the large amounts of CO_2 and CH_4 emitted from drowned vegetation in some dams.	100 - 6000%*
Solar electricity	Omitting the energy intensive production of photovoltaic silicon wafers.	100 - 1500%**
Coal electricity	Omitting displacement credit from using fly-ash in concrete.	1 - 5%
Natural gas energy	Omitting well head stripping and distribution losses	5 - 8%
Coal energy	Omitting displacement credit from coal bed methane and mine ventilation air utilisation.	5 - 20%
Steel products	Omitting the scrap advantage in HBI/scrap-EAF steelmaking.	10 - 80%
	Omitting displacement credit for BF slag for cement.	2 - 10%
Concrete products	Omitting CO_2 emissions from calcination of limestone	20 - 50%
Timber products	Omitting forestry practices, forestry waste, timber to landfill	100 - 1000%

* Relative to coal. The GGE (kg CO_2/GJ) for hydro-electricity could be 1 - 60x greater than for equivalent coal based generation if dam emissions were considered (ref.: New Scientist, May 1996).

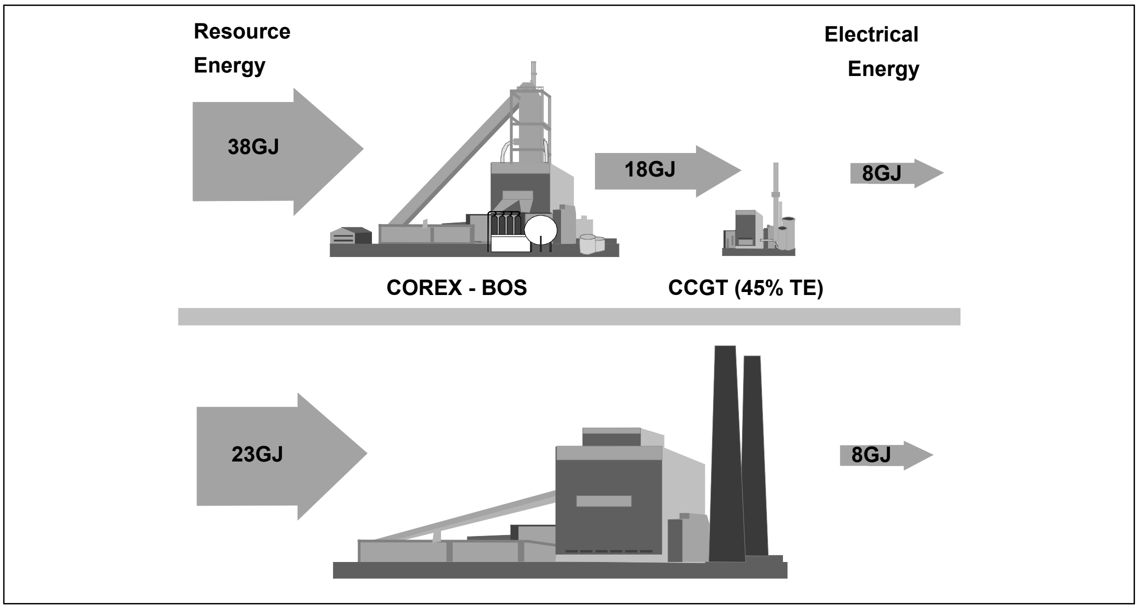
** Relative to coal. Solar energy is usually claimed as having zero emissions. Presently, the CO_2 pay back period may be up to 15 years.

Displacement Credits from Electricity

Some coal-based processes produce large quantities of process offgas which may be used to generate electricity at higher thermal efficiency (TE). The displacement credit will usually be the displacement of grid power.

For example, the CO_2 credits from coal based iron-making can decrease the GGE for the integrated process to significantly below that for a gas based process.

Displacement of 23GJ of energy results in a GGE credit up to 2000 kg CO_2/t steel



Displacement Credits from Cement

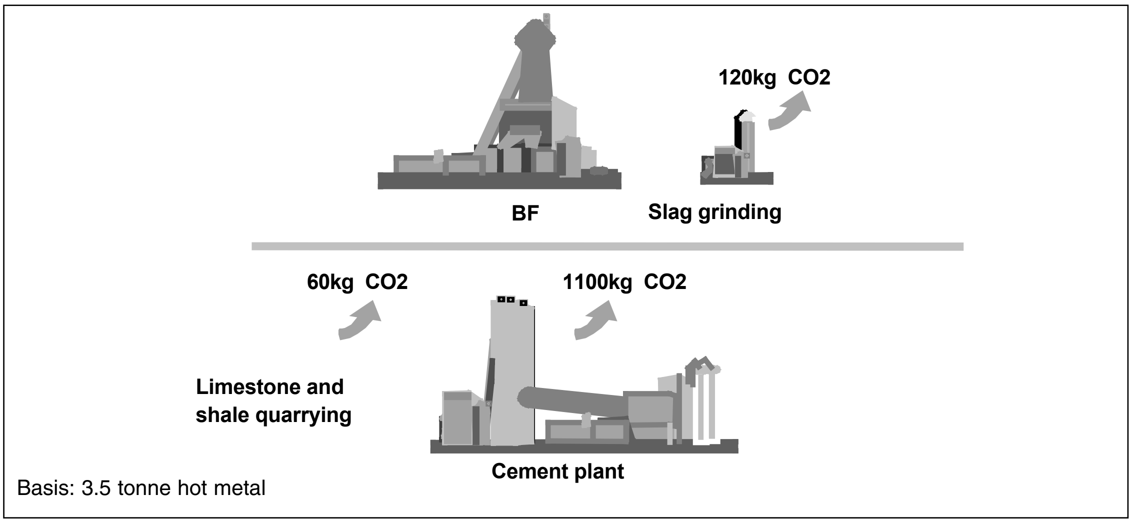
Granulated blast furnace slag (GBFS) can replace an equivalent mass of cement clinker, which are ground to make cement. GBFS replacement rates vary widely, but 35-50% is most common - when it is used.
The displacement GGE credit from converting GBFS to cement (displacement of calcining and fuel for cement production) is 900 - 1200 kg equiv. CO2/t slag. This credit can decrease the effective GGE for steel products by over 10% (although the capital required to obtain these savings by conventional technology improvements is high).
Unfortunately for most integrated steel products, the majority of BF slag is used for aggregate which gives negligible credits (with the exception of some parts of Europe, especially Holland and Germany).

In addition, the durability of BF slag cements is superior to ordinary Portland cements. World-wide only ~25% of BF slag is used for cement. This missed opportunity is entirely due to “waste” management attitudes and marketing perceptions; not technology.

Other Considerations

Although the present discussion has focused on Greenhouse issues, a detailed evaluation of coal’s environmental credentials would need to consider a much broader range of impacts, and a wider range of technologies. This should also include emerging clean coal technologies and new products from fly-ash and slags.

Displacement of 3-5GJ of energy and burning of 1000kg of limestone results in a GGE credit of ~900-1200kg CO_2/t BF slag



CONCLUSIONS

Presently accepted values for the relative environmental impact of coal significantly disadvantage coal and coal based products. Many are based on incorrect or misleading analysis.

There are opportunities to improve the environmental credentials of coal by identifying and quantifying displacement credits, and by providing more detailed information on competing energy sources.

Coal based integrated steelworks can match or exceed the GGE performance of gas-based routes by using displacement credits.

Increased product stewardship by coal suppliers is required to ensure optimum utilisation of coal, and therefore accurately promote coal's environmental credentials.

ENERGY AND ENVIRONMENT INTERFACE

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1. CHALLENGES

The United Nations forecasts that population growth is set to continue, particularly in developing countries, and by the middle of the 22nd century the global population will have doubled its present size to 12 billion people. If such estimates prove accurate, it is possible that global energy demand, much of it again originating in developing countries, will also double in size, and taking into account expected future economic growth in the developing world, the demand for energy may grow even higher. On the other hand, according to the IPCC report, it will be necessary to cut the annual emissions of greenhouse gases to 30% below 1990 levels by the year 2100, in order to avoid the grave consequences of global warming.

The recent Kyoto Conference (COP3), however, imposed no obligations on developing countries to reduce their greenhouse gas emissions, even though they are expected to figure largely in increased output in the future. What is more, although the environmental problems posed by sulfur and nitrogen oxides have already been technically surmounted, global warming due to emissions of greenhouse gases including CO_2 is an entirely different issue, and no technology has so far been developed that can adequately deal with it.

2. OVERCOMING BARRIERS AND GOVERNMENT'S ROLE

Balancing the conflicting needs of energy provision and the prevention of global warming is not easy. In order to interface between these, what specific measures should be taken jointly by government and private sector, and what role in that effort should governments play?

Efficient Use of Energy

First, energy must be used more efficiently, and more energy-saving measures incorporated at all stages, from production to consumption. And it is also necessary to pursue economic growth while minimizing growth in energy consumption. This will require greater awareness of the problems of energy and the environment on the part of every person on the planet, and modification of the sort of affluent lifestyles that tend to rely on heavy energy consumption. Governments must educate their people to better understand the need to save energy and protect the environment. Furthermore, for effective promotion of greater efficiency in both supply and demand, governments should provide more information on the energy efficiency of different types of equipment, and use market mechanisms to bring influence to bear on the private sector, by offering incentives.

Renewable Energy

On the supply side, in choosing between different resources, it is important to urge more active use of energy sources that do not generate greenhouse gases. Hydro, solar, geothermal and wind energy are all renewable, environment-friendly sources, and should be utilized to the maximum extent possible. However, current technology has yet to resolve problems of economic feasibility and low density production, and renewable resources alone will never be able to meet total energy demands.

Energy Best-Mix

Thus it is inevitable to introduce a combination of renewable sources and existing energy sources such as fossil fuels and nuclear power. In practical terms, it will be essential to balance security of supply, economic feasibility and reduction of environmental impact, by using a best mix combination of renewable, fossil-fuel and nuclear sources matched to the country's or region's energy resource profile.

Nuclear Power

In particular, from the standpoint of efficient use of limited resources, nuclear power should be appraised as an energy source that generates no CO_2 and fulfils both needs of ensuring stable supply and protecting the environment. It is quite possible for government and the private sector concerned that execute policy, to cooperate in overcoming the difficulties associated with nuclear power, and private sector suppliers have already achieved cost savings without compromising safety. In co-operating with the private sector, government should appraise nuclear power as an energy source that contributes both to easing global warming and to offering a more secure energy supply, and in step with world-wide consensus, should establish policies to further its development.

Coal

Coal has been the object of various policy measures since the oil crises, and considerable advances have been achieved in many areas: development, trade, transportation and use. Coal is currently highly rated as an economic energy source that offers stability of supply. One of its characteristics is its high unit emission of CO_2, but the situation is such that coal, together with natural gas, should be considered as leading energy sources in the medium to long term. Developing countries currently consume large quantities of coal, and so the widespread introduction of technology to make its use more clean and efficient is an urgent matter for these countries. Here, developed countries can play an important role in technology transfer. Energy demand is expected to rise steeply in developing countries, particularly those in Asia, and these regions do not currently have adequate countermeasures to even control sulfur and nitrogen oxides. Therefore, from a global standpoint, it might be appropriate to encourage them to turn to natural gas for their additional energy requirements, as it is clean to use even without the installation of special facilities, while having developed countries with the necessary funds and technical resources, utilize coal.

Developing Countries and Flexible Mechanisms

For developed countries, one can visualize how greenhouse gases might be reduced through greater efficiency in energy use and the promotion of a best mix of energy sources, including nuclear power. How such policies should be encouraged in developing countries, where the prospect of a significant rise in greenhouse gas emissions due to population growth and economic expansion, is causing much concern.

Developing countries tend to lack the necessary funds and technical expertise, so opting for environment-friendly energy sources is difficult. More to the point, they are under no obligation to reduce greenhouse gas emissions. But lessening the effects of global warming will require front-line participation from developing countries, and to resolve the issue at a global level, developed countries will need to support them through arrangements that exploit market principles. Government use of public funds for this purpose is likely to continue to play an important role. Furthermore, to involve the technology and capital of the private sector, the technology that helps control greenhouse gas emissions must be made to produce a greater value-added effect through market mechanisms. Governments should study international arrangements such as joint implementation, Clean Development Mechanism, emissions credit trading etc., for their economic rationality. These arrangements should become mechanisms to provide the private sector with incentives to transfer technology and funds to developing countries, with the guarantee of freedom to select projects.

3. CONCLUSIONS

The COP3 agreed on targets to reduce greenhouse gas emissions including CO_2 without the support of available technology that can prevent global warming while ensuring energy supply. It is undoubtedly important to make best our efforts to set high goals, but it is time now to pursue actions rather than agendas. What is required now are targets and policy formulations backed up by measures that are practical and feasible to implement.

Coal, in particular, scores highly as an economic source of energy that promises stable supply, and will be an important energy source over the long term. From a global perspective, there exists urgent necessity to consider and establish specific measures and frameworks that will make possible the more efficient and cleaner use of coal, through detailed study from both technical and policy aspects.

Developing countries need the technologies to reduce emissions of sulfur and nitrogen oxides, in order to encourage the clean and efficient use of coal, in addition to the countermeasures to CO_2 issues. The transfer of technologies developed and applied in developed countries is one of the most effective ways to accomplish this purpose. During the transfer, however, it is important to remember that the specific technology must match each recipient country's or region's particular needs and circumstances, taking into account that recipient's state of technological development and ability to bear costs. In the process of technology transfer currently implemented, the related information often flows in only one direction, from the supplier to the recipient. To give alternatives to the recipient, it should be appropriate to consider an international system through which the related information is pooled and flows in both directions, allowing recipient countries to more easily access the specific information most useful to them.

All governments must endeavor to avoid placing undue emphasis either on environmental impact or energy supply alone, and instead pursue flexible policies that interface the requirements of both, based on the country's specific energy circumstances. To this end, it is desirable to seek international policy agreements that include check and review systems of targets and mechanisms. In addition, much remains to be understood about global warming, and so further research is necessary. Governments should therefore also support further scientific clarification of the connection between the emissions of CO_2 deriving from human economic activities and global warming.

GROWING THE COAL MARKET THROUGH TECHNOLOGICAL ADVANCEMENT

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InterGen

INTRODUCTION

The signatories to the 1992 United Nations Framework Convention on Climate Change and recent Conference of the Parties in Kyoto in 1997 have demonstrated an increasing awareness of greenhouse gas emissions and a desire to take action by many countries. CO_2 emissions have received wide attention and will likely have a major impact upon the energy sector in the coming years, in terms of overall energy growth and increased attention to fuel selection.

Already, natural gas has gained significant market share from coal in the past ten years. In large part, gas has benefited from technological advances, which have dramatically increased the efficiency of gas-based generation while simultaneously lowering manufacturing and installation costs. Overall primary energy consumption has risen in the past ten years by 1.5% per annum, although coal use has declined from 30% of the total to 27%, representing an annual opportunity loss of about 390 million tonnes of coal consumption for 1997. By contrast, gas use has risen from 21% to 23% during the same period.

In the coming decades, natural gas is expected to continue to achieve an ever-increasing share of the global power generation sector. Overall, however, coal is expected to maintain the largest share of generation. According to the IEA, global GDP is expected to grow at about 3% per annum through 2020 and energy demand at around 2% per annum, with fossil fuels meeting about 95% of the increase. The IEA also forecasts a need for about 70 GW per annum of new generating capacity in developing countries. This translates into about 180 million tonnes per annum of additional coal demand for new conventional coal-fired capacity, or about 82 billion cubic meters per annum of new gas demand!

With this tremendous opportunity, what strategic direction would the coal industry like to take in the future to capitalize on the capabilities of all stakeholders and maximize the return to the industry?

THE FUTURE OF COAL

In the coming years, the competitive and regulatory framework will require pushing the technological envelop to its limit to get every kWh out of a tonne of coal at the lowest possible cost. At the same time, it will be important to ensure that the most stringent environmental regulations are met, including CO_2 emissions reduction, which will drive the search for higher efficiency conversion processes. The route to growth for coal is in promoting clean coal technologies (CCT), which can be achieved by overcoming some of the critical hurdles, such as improved value chain efficiencies, the need for increased collaborative ventures, development of new financial instruments, and innovative technology implementation strategies. This route requires support from industry, governments and international agencies, many of which already have longstanding cooperation activities underway.

TECHNOLOGICAL NEED

Conventional coal-based power generation technology has, in many of the fast-growing energy markets, had difficulty competing with advanced gas turbines in combined cycle mode. Gas prices have declined more than coal prices in the past five years, contributing further to the poor competitive position in which coal producers find themselves. Only in isolated locations, where coal is very low cost or gas supplies are expensive or unavailable, have conventional coal power generation technologies been competitive. Likewise, CCT has been unable to compete since the often lower cost of coal has not offset the substantially higher capital and lower efficiency characteristics of CCT as compared to gas-based combined cycle generation.

Where CCT have been implemented - the U.S., Europe and Japan - typically liquids rather than coal have been the preferred fuel. There is a strong tendency by clean burning generation technology licensors to consider bottom-of-the-barrel oil conversion projects, often related to their own refinery products or those of related business interests. This has been the case in a wide range of refinery/chemical-oriented projects all over the world - several refineries in the U.S. using coke; a chemical facility in Japan using coke; numerous refineries worldwide considering technologies for residue conversion; and several projects in Italy already under construction using heavy oil residues.

New CCT (including super critical boilers, advanced gasification combined cycle, advanced pressurized fluidized bed, advanced gasification fuel cells, and high performance power systems) based on coal as the primary fuel, while not quite competitive today in most markets, are likely to be competitive and gain widespread support in the coming years for five key reasons.

First, in the future, CCT will have to take advantage of continued reductions in costs and increases in efficiencies for gas-based combined cycle generation (e.g. new “G” and “H” generation gas turbines). Additional cost reductions will be achieved in the area of integration of the gasification and power blocks.

Second, crosscutting enabling technologies will have a material impact on a variety of applications to the benefit of CCT. Advances in high temperature and pressure filters, combustion turbine technology, steam cycle materials, hot sulfur clean-up and NO_x removal have all contributed greatly toward improving the viability for a range of CCT.

Third, as gas demand grows rapidly and infrastructure constraints potentially develop, coal in CCT will become more competitive. Improved competitiveness could result from: (i) stability of pricing (effectively fixed long term prices not tied to commodity markets), (ii) diversity of supply sources in accordance with such regulations as the EC diversification requirements, and (iii) an abundance of already proven reserves.

Fourth, the more recent developments associated with some CCT could allow a broader group of stakeholders – power generators, gas distribution companies, gas-based chemical manufacturers – to reap benefits and this will help improve the economics of these technologies. Furthermore, forecasts for the year 2020 predict efficiencies of Advanced Gasification Combined Cycle, Hybrid and Integrated Gasification Fuel Cell technologies reaching 55-70+ percent efficiencies.

Fifth, the environmental driver toward cleaner-burning technologies could also play an important role, especially with an increased focus on CO_2 reduction as outlined in the Kyoto Agreement. Low emissions boilers, circulating and pressurized CFB, mixed fuel cycles and novel cycles, as well as “tri-generation” options in advanced systems could all contribute toward renewed interest in CCT.

Although these five reasons alone are compelling, it will still take a coordinated effort to ensure widespread implementation of CCT. Below, four specific initiatives are suggested for the CIAB to consider promoting.

INITIATIVES FOR THE FUTURE

Focus on the Value Chain

While implementation of CCT offers the most promise to grow coal's global market share, the entire value chain must be considered to ensure superior competitiveness against other fuel options. A few areas where the value chain could be improved include:

- Increased use of coal washing, to effectively make more effective use of coal transportation systems by reducing the amount of coal needed to be moved by improving quality at the minemouth;
- Development and utilization of coal seam methane, which has significant safety benefits for mining activities and could, in certain locations such as Australia, provide a low-cost fuel source for generating power as well as reducing greenhouse gas emissions.
- Expansion of existing facilities at the minemouth, loading and receiving terminals, transportation (i.e. rail and slurry pipelines), and in power generation plants could allow more effective utilization of assets than has previously occurred. This is particularly true for developing country generation assets that could be rehabilitated to improve efficiency, expand output and reduce emissions.

The coal industry's increased participation along the entire value chain could dramatically help overcome inherent inefficiencies. Increasingly, mines as well as power generation assets are being privatized in developing countries and collaborative efforts between investors in power generation and coal producers could bring real improvements and create opportunities for implementing CCT. The CIAB should consider promoting initiatives to reduce inefficiencies and increase cooperation along the value chain.

Producer-Technology Provider- Generator Partnerships

The coal industry has actively promoted the use of CCT in an effort to grow the world coal market. However, the lack of concentration within the production side of the industry and lack of vertical integration between coal producers, equipment providers, technology licensors and consumers has, in some respects, limited the success of the industry's efforts. In the U.S., there are about 10 companies that produce 60% of domestic coal output. The remaining 40% of production is highly fragmented. Globally, the situation is even more fragmented where a large number of government and private sector coal producers operate in many countries. While there is a recent trend toward industry consolidation, deregulation and privatization, the lack of concentration historically has limited the cooperative potential of producers. As such, insufficient emphasis has been placed on engaging CCT licensors and generators in building technology-driven marketing joint ventures to grow coal's market share.

Inevitably, there will be more emphasis on CO_2 emissions in the future leading to fundamental changes in energy policies. The coal industry has an opportunity to utilize technology to emerge as the environmental and economic energy supplier of choice. The consolidation in the coal industry is occurring at a fast pace and this can generally be viewed as an enabler for forming joint ventures. The next step is for industry leaders to develop long term strategic relationships with a broad range of technology licensors and power generators that will "open widely the fuel door to the market". The CIAB can play an integral role in this cooperative effort.

Financing New Technology

Financing new technologies has never been easy. Commercial lenders are typically reluctant to take on the added risks of new technology in already complex international transactions. If the coal industry hopes to grow the market through the use of CCT without the use of additional on-balance sheet debt, an innovative financing strategy is required to prove-up technologies and jump-start implementation. The appetite for multi-lateral and export credit agency lending, while very important, is unlikely to go all the way toward meeting the requirements of the industry. Alternative financing strategies must be considered. One option is for the industry, in combination with technology manufacturers and, in some cases, governments or generators, to develop a technology-specific "credit agency" that cuts across national boundaries to the benefit of the industry as a whole. A collaborative effort composed of a cross-section of industry participants could potentially provide sufficient seed capital for facilitating the broad use of CCT. An industry-led credit facility could also provide the necessary comfort level to garner support from commercial, institutional and multilateral lenders.

Implementation Process

The largest market for power generation is in developing countries, many of which have extensive coal resources and, in some locations, lack alternative competitive fuel options. In China and India, for example, significant indigenous coal resources can be developed utilizing CCT to improve overall economics. Together, these countries will require between 20-30 GW per year of new generation during the next 10-15 years, even considering the global economic crisis, and a large portion could be coal-based. Direct investment, via independent power projects, is certainly one avenue that is being pursued in both these countries to grow the market for coal, and independently promote CCT. Other avenues, such as licensing CCT to domestic manufacturers and establishing cooperative manufacturing through joint ventures, may be more successful, especially where direct access to markets is limited or where project implementation time is very long. Cooperative arrangements with domestic manufacturers can promote technology transfer to developing countries and encouraging the usual knock-on effects in the economy (minimizing the drain on hard currency, employment growth, self-sufficiency objectives, etc). Coal producers need to be actively involved in this process to ensure a "fuel-technology" match. The CIAB can play an important role in fostering technology transfer to developing countries and encourage implementation of CCT for independent or utility power projects.

Conclusions

What will the state of the coal industry be in 2020? Will it contract as environmental regulations tighten in the post-Kyoto world and gas threatens the economic viability of coal-based generation? Or, will the industry have developed a clear strategy and have taken a leadership role in the implementation of CCT and ancillary improvements in the value chain from minemouth to busbar.

It is incumbent upon the industry to create a new "Clean Coal Strategy for the 21st Century", drawing on the extensive capabilities of a global industry. This strategy should recognize the clear benefits of supporting technological developments in CCT in the post-Kyoto environment, support producer-technology licensor-generator collaborative efforts, develop industry-led financial instruments, and promote a "home grown" approach to CCT implementation.

All countries have an economic imperative to secure low cost energy that contributes to their competitiveness in the world economy. At the same time, countries have an environmental imperative to have a non-despoiled earth for generations to come. The coal industry needs to fit within these requirements in order to gain market share and prosper as an industry. To this end, the CIAB and its members should continue to be proactive in promoting Clean Coal Technologies through the IEA, industry-sponsored groups, industrialized and developing country governments, and also through the IEA's Energy Technology Collaboration Program.

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