COAL

Issues and options in a carbon-constrained world

ROGER WICKS

Coal remains the world's most abundant, affordable and secure fuel source. With the help of technology, it is also becoming a cleaner fuel...

DURING THE PAST TWO YEARS, the use of coal has grown at a faster rate than for any other fuel[1]. In 2003, coal consumption grew by almost 7%. Demand in China grew by 15%, in Russia by 7%, in Japan by 5%, in the USA by 2.6%[2] and 2004 is expected to be similar. This will doubtless be regarded as 'bad news' by coal's detractors – those keen to see the demise of fossil fuels and desirous of an alternative and wholly sustainable energy future.

Coal can play a role in building towards a more sustainable energy future. Improved environmental performance will be driven initially through increased generating efficiencies. Continued social and economic contributions will remain important, especially in the developing countries where coal is used extensively. Coal use should not be seen as being anti renewables. In many cases coal use is complementary to that of renewables – coal can provide convenient, cheap base-load power while inherently more erratic renewables can be used to meet peak needs. In other instances coal can be co-fired with renewable materials. The advent of carbon capture and storage as a real technological alternative opens up new pathways to a near-zero emissions environment and in time will be a building block in efforts to move towards a hydrogen-based economy.

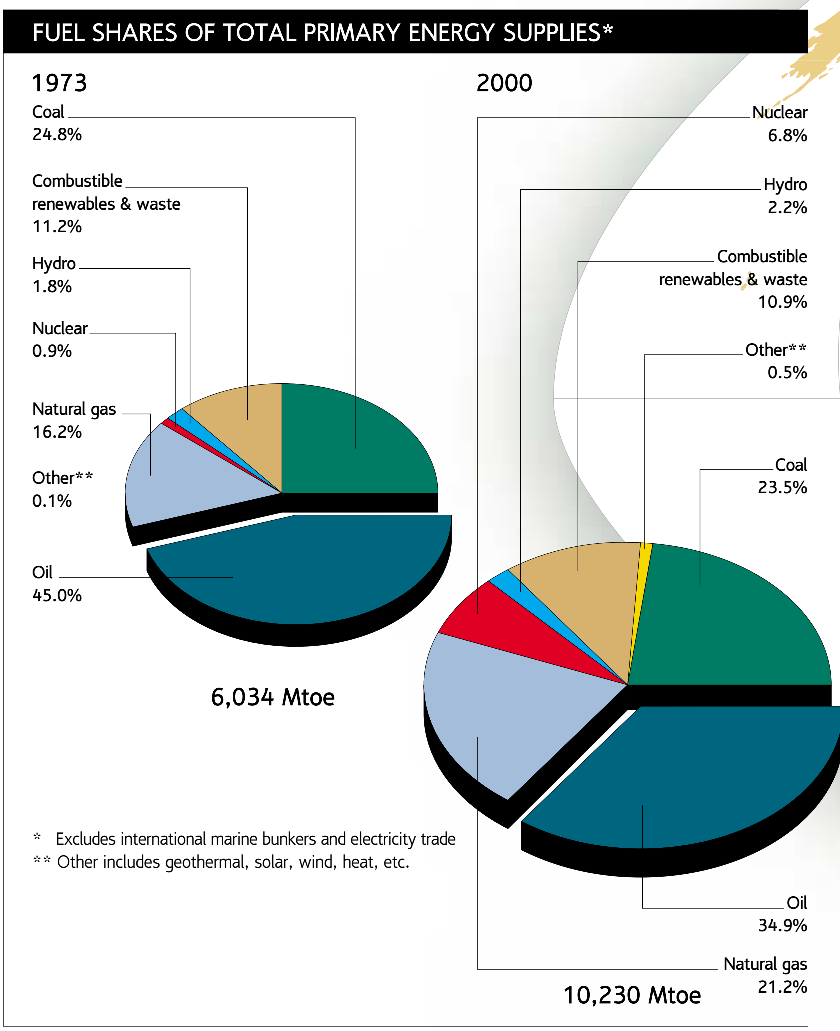
NEARLY 40% *of the world's electricity is currently produced using coal*

GALLO IMAGES

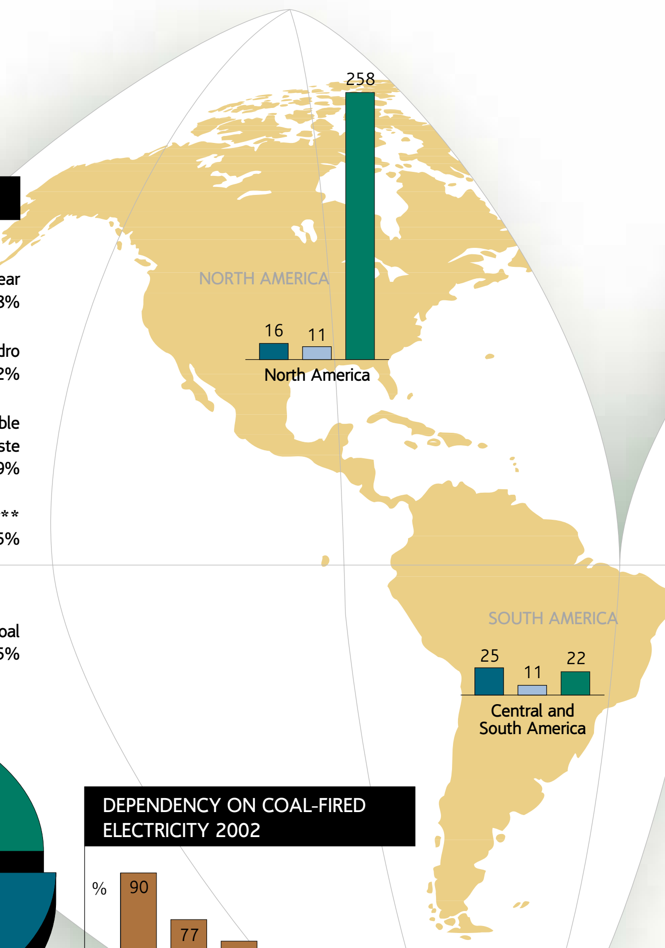
Energy-sector development – coal's significant growth

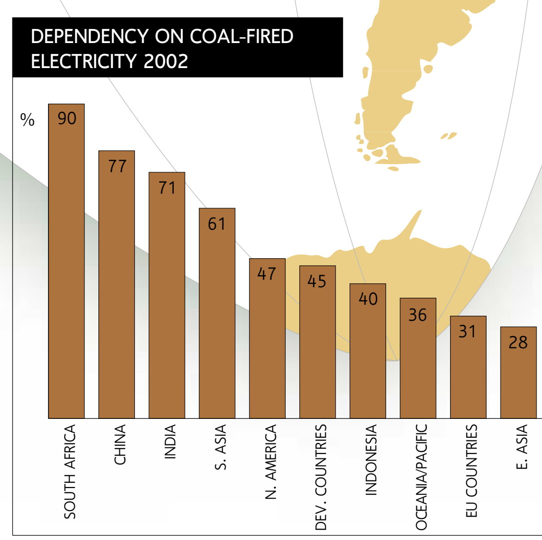
Over the past 30 years the world's supply of primary energy[3] has grown from some 6 billion tonnes of oil equivalent to 10 billion tonnes of oil equivalent[4]. That represents a compound annual growth rate of over 1.8% per year.

Although over the past three decades coal's percentage share of primary energy has reduced by just over 1%, coal production has more than doubled from some 2 billion tonnes per year to some 5 billion tonnes – a compound annual increase of 3%. The percentage share produced by the developed regions of the world has reduced significantly. The Organisation for Economic Cooperation and Development's (OECD)[5] share of hard coal production dropped from 50% in 1973 to 35% in 2003. Taken together with the fact that over 80% of the world's coal production is used in the country in which it is produced –



Source: IEA: World Energy Outlook 2004





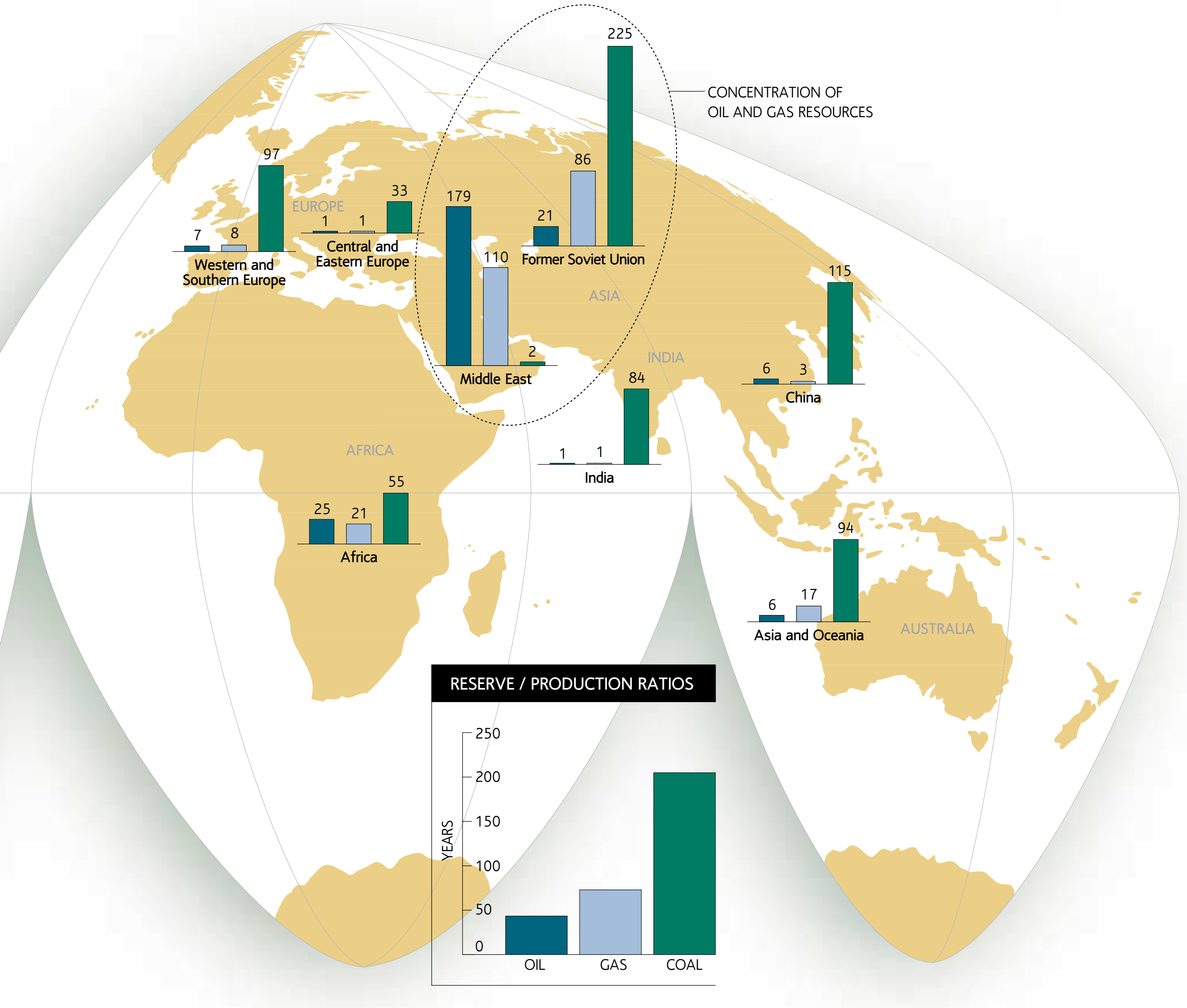
IEA, World Coal Institute, Anglo Coal

the balance is traded internationally – it is clear there has been a significant shift to an increasingly important role for coal as a source of energy in the developing countries.

Nearly 40% of the world's electricity is currently produced using coal and this level of dependency increases markedly when analysing the developing countries. China is 77% dependent on coal-fired generation, India some 75%, South Africa over 90%[6]. Key countries in the developed world such as the USA, Australia and Germany also rely on coal as their primary fuel for power generation, as do many of the transition economies that now form part of an enlarged European Union.

Coal is also a key raw material in the production of steel, with some 70% of world steel production being reliant on coal. It is widely used as both a raw material and a source of energy in the cement industry. In some parts of the world, it remains the cheapest option for domestic heating and cooking.

LOCATION OF THE WORLD'S MAIN FOSSIL FUEL RESERVES (Gigatons of coal equivalent)



Source: BP Statistical Review of World Energy
Rocky Mountain Institute – Private Client Research

Security of energy supply

Coal reserves are significantly more abundant than other fossil fuels. BP's annual analysis[6], which is premised on current consumption levels being maintained, suggests a reserve life for coal of some 200 years, compared with a gas-reserve life of 60 years and an oil-reserve life of 40 years.

For a world anxious to meet growing energy demand, the location of those coal reserves will be at least as important as coal's abundance relative to the other fossil fuels. Coal reserves are dispersed more widely and more evenly than is the case for other fossil fuel sources. Oil and gas reserves are much more tightly concentrated in the Middle East and FSU[7]. As world concern about all forms of security has increased, so too has concern about the security of energy sources. Vulnerability to supply disruption, whether in the form of blackouts which in recent years have occurred in countries previously considered immune to such events, or as a result of geopolitical instability or conflict, are now high on the political agenda. As the length and complexity of supply lines increase, for example for long-term gas supply to the European mainland, so the prospect of growing dependence on imported sources of energy is increasingly coming under scrutiny. Policy tensions and risk-management strategies that arise are key issues affecting the future of the coal industry.

Energy and economic growth – how to meet the needs of the poor

The provision of energy is a key driver of economic growth, poverty alleviation and improved health prospects. Mindful of the bleak prospects faced by the world's poor, accessibility to reasonably priced sources of energy was seen by the World Summit on Sustainable Development (WSSD), held in Johannesburg in 2002, as a fundamental building block for a sustainable future.

The contrast between those with access to power and those without is particularly stark. Work presented by the International Energy Agency (IEA) and others at the WSSD confirmed that, in a world population of more than 6 billion, there are 1.6 billion who have no access to electricity and a further 2.4 billion who rely on primitive and erratic sources of energy, primarily biomass. Fast forward to 2030 and the world population is forecast to be approaching 7.5 billion, but unless something different is done, 1.4 billion will remain without access to electricity and some 2.6 billion will still rely on primitive and erratic sources of energy.

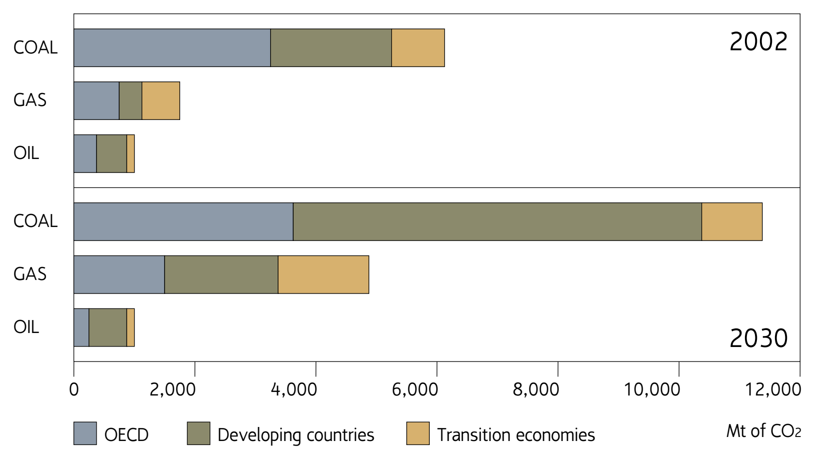
If sensible choices are to be made in the long-term interests of society, a new approach is required. The conventional fossil fuels, and especially coal for power generation, must be consumed in a manner which utilises the location and extent of reserves to best advantage whilst minimising the environmental impact. Without doubt this is the biggest current challenge facing the coal industry.

Growth in energy demand and what this means for CO_2 emissions

The latest views of the IEA as set out in its 2004 World Energy Outlook Reference Scenario – effectively a business-as-usual case premised on all policies in place by mid-2004, whether currently fully implemented or not – provide a helpful starting point against which to consider a number of critical policy issues.

POWER-SECTOR CO_2 EMISSIONS

COAL, OIL AND GAS-FIRED POWER STATIONS



Source: IEA: World Energy Outlook 2004

World primary energy demand is projected to expand by 60% over the next 30 years[8]. Two-thirds of that increase is expected to occur in developing countries. Fossil fuels are forecast to account for 85% of the increase in world primary energy demand and their share of total demand will increase slightly to more than 80%. Within this picture, coal's share of primary energy demand drops from 23% to 22%, but increases in absolute terms by more than 50%. China and India will account for more than two-thirds of the increase in global coal use.

Not surprisingly, this outlook carries with it a heavy CO_2 burden. Although energy-related CO_2 emissions have grown less rapidly than primary energy demand, this trend is expected to reverse over the next 30 years. In 2002, coal accounted for some 38% of world energy related CO_2 emissions. The increase in CO_2 over the next 30 years mirrors the primary-energy demand increase – around 60%. By 2010, just five years hence, overall energy-related CO_2 emissions are expected to be 40% higher than 1990 levels – the baseline year against which the Kyoto Protocol has established its emission-reduction targets.

Coal alone is not responsible for this outcome. Of the forecast increase in total CO_2 emissions, oil accounts for 37%, coal for 33% and natural gas for 30%.

Developing countries are expected to account for 70% of the increase in global CO_2 emissions and will overtake the OECD countries as a source of CO_2 emissions – developing-country emissions today are two-thirds of OECD emissions, whereas by 2030 they will be 15% higher. China alone is expected to account for over 25% of the world's emissions of CO_2 by 2030.

This is all very discouraging, but the extent of the dilemma is worth further reflection. In China, over the past 20 years, electricity has been provided for some 700 million people, to the point where China today is estimated to have a

GUY STUBBS

"... IN A WORLD POPULATION *of more than 6 billion, there are 1.6 billion who have no access to electricity and a further 2.4 billion who rely on primitive and erratic sources of energy, primarily biomass."*

99% electrification rate – serviced by a generating industry 77% dependent on coal. In South Africa, the electrification rate has been doubled in a decade – serviced by a generating industry 90% dependent on coal.

The scale of the climate-change problem in relation to CO_2

Over the last 100 years, atmospheric concentrations of CO_2 have risen from some 280 parts per million by volume (ppmv) to some 370 ppmv[9]. At the same time, there has been an increase in average global temperature of nearly 1°C. It is the unrestrained progression of this trend and the implications for disruptive climate change that lie at the root of scientific, public and political concern.

The scientific consensus is that climate stabilisation requires total CO_2 emissions to be limited to somewhere in the range of 450-550 ppmv. If one targets, optimistically perhaps, the lower limit of 450 ppmv, it follows that we have a remaining notional reservoir of some 80 ppmv (450 – 370 = 80). This means that in another 50 years, given CO_2 emissions growth of some 1.5 ppmv per year, the carbon-absorption reservoir will have been 'exhausted'[10].

Even applying the best technology available in the year 2000, related research[11] has shown that by 2090 the world will have emitted 480 Gigatons ($Gt = 10^9$) of carbon more than is consistent with a stabilised (1990) level of CO_2 concentration in the atmosphere.

The required scale of the solution

The scale of the CO_2 issue is only now beginning to be understood. To secure a reduction of 1 Gt of carbon emissions would, as an example, require 700 x 1,000 megawatt (MW) coal-fired power stations (twice the total current generating capacity of China) to have their entire CO_2 emissions captured and stored[12].

If renewables are contemplated, then in the case of wind generation, 1 Gt less of carbon emissions would require 300,000 x 5 MW wind turbines covering a land area the size of Portugal. Alternatively, there is nuclear-based generation and 700,000 MW of nuclear generation would also reduce carbon emissions by 1 Gt – but will a sceptical public willingly allow their governments to adopt nuclear generation at this scale?

Policy preferences vs practice constraints

Whilst the scientific community's proposed carbon concentration limit is expected to be reached in about 50 years' time, the IEA Reference Scenario predicts continuing high levels of dependence on fossil fuels – including coal. Add the widespread dependence of key developed and developing nations on coal and one begins to appreciate how difficult it is for both industry and policy-makers to find a path that is acceptable to the diverse interests involved.

In its alternative scenario, which reflects the implementation of carbon-constraining policies currently in place or likely to come into force, the IEA suggests that energy-related CO_2 emissions could be 16% lower than in the Reference Scenario. Premised on an overall reduction in energy consumption of 10%, coal demand could fall by 25% below currently forecast levels by 2030, but still grow in absolute terms – with the biggest reduction coming in power generation. To secure this alternative outcome would require a mixture of improved efficiency measures and fuel-switching arrangements, including a significant contribution from renewable energy sources and nuclear generation. All these alternatives carry cost, acceptability and deployment barriers that cannot simply be wished away, but it is clear that contributions to the reduction of CO_2 emissions are required from all energy sources.

The policy response so far and how this might develop

The most wide-ranging policy response internationally is the Kyoto Protocol. There are regional emissions-trading schemes such as that which comes into force in the EU this year. Nationally, there have been schemes operating in the lead-up to the EU scheme and there has been an increase in taxes on fossil fuels, such as those now in force in Japan, though coal used for power generation is now exempt.

The Kyoto Protocol was entered into in 1997 and addresses six gases[13], five of which are rated significantly more harmful than CO_2 in terms of their global-warming potential. Much of the world's attention is however currently focused on CO_2. Adherents to the Protocol have committed to securing a 5% cut below the 1990 CO_2 emission levels for the Annex 1 (mainly the developed) countries. The Protocol has also provided for the use of supplementary measures designed to assist the generation of emissions credits, known respectively as the Clean Development Mechanism (CDM), which covers relationships between developed and developing countries, and Joint Implementation (JI), which covers relationships between developed countries. These mechanisms enable projects to be undertaken in locations remote from the point of emission and the credits generated to be applied in the country that is the source of the emissions.

Now that Russia has ratified its participation in the Protocol, the critical qualification thresholds will be reached and the full Protocol will enter into force on 16 February 2005, with the EU in the forefront of implementing measures to support the Protocol's objectives. National emission-allocation plans (NAPs) will formalise the apportionment of available allowances between industry sectors and major emitters and must be agreed between the EU and member states. The EU emission-trading scheme will commence with 21 of the 25 EU states ready[14].

Will the Kyoto Protocol make a difference?
The Protocol's impact will inevitably be limited simply because it focuses on the developed world, but without the USA and Australia being signatories. In so doing, it selectively applies constraints and fails to adequately address the true scale of the long-term problem. It has been suggested that improving the efficiency of the world's coal-fired generating stations to the current German coal-fired generating levels of efficiency would reduce emissions further than will be achieved by the Kyoto Protocol[15]. This is before registering any benefit from tackling the emissions from transport or other fossil fuel sources.

WILL A SCEPTICAL PUBLIC SUPPORT *large-scale expansion of nuclear power generation such as that found at Koeberg, South Africa?*

DAVID GOLDBLATT/SOUTH

Importantly, the Protocol has acted as a pathfinding mechanism in an immensely complex arena, made much more difficult by the inevitable overlay of international, regional, national, economic and other sectoral interests. An increasing amount of work is already under way to consider how future developments both within and beyond the Kyoto framework might emerge. Central to this debate is how a revised or post-Kyoto regime could, on an inclusive basis, embrace all major emitting countries in both the developed and developing world.

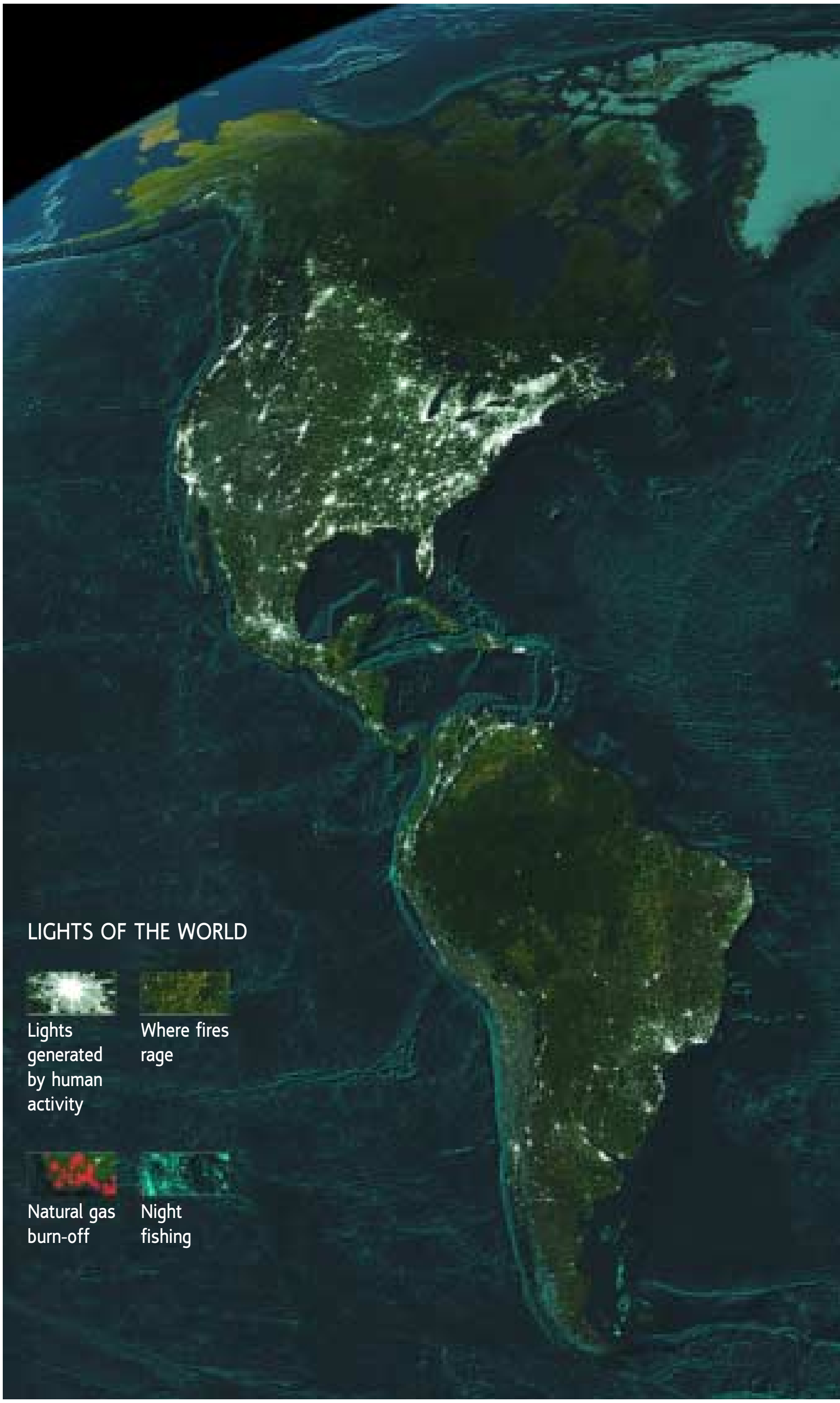
It is increasingly clear that simply abandoning traditional fossil fuel energy sources is not a viable option. Significant contributions to CO_2 reduction from all components of the fuel mix – including coal, oil and gas, renewables and nuclear, energy-demand reduction, improved energy efficiency, changes to forms of road transportation, and building design, carbon capture and storage – will be necessary if improvements at a scale that makes a difference are to be achieved.

Who is responsible – producers or consumers? The need for joint stewardship

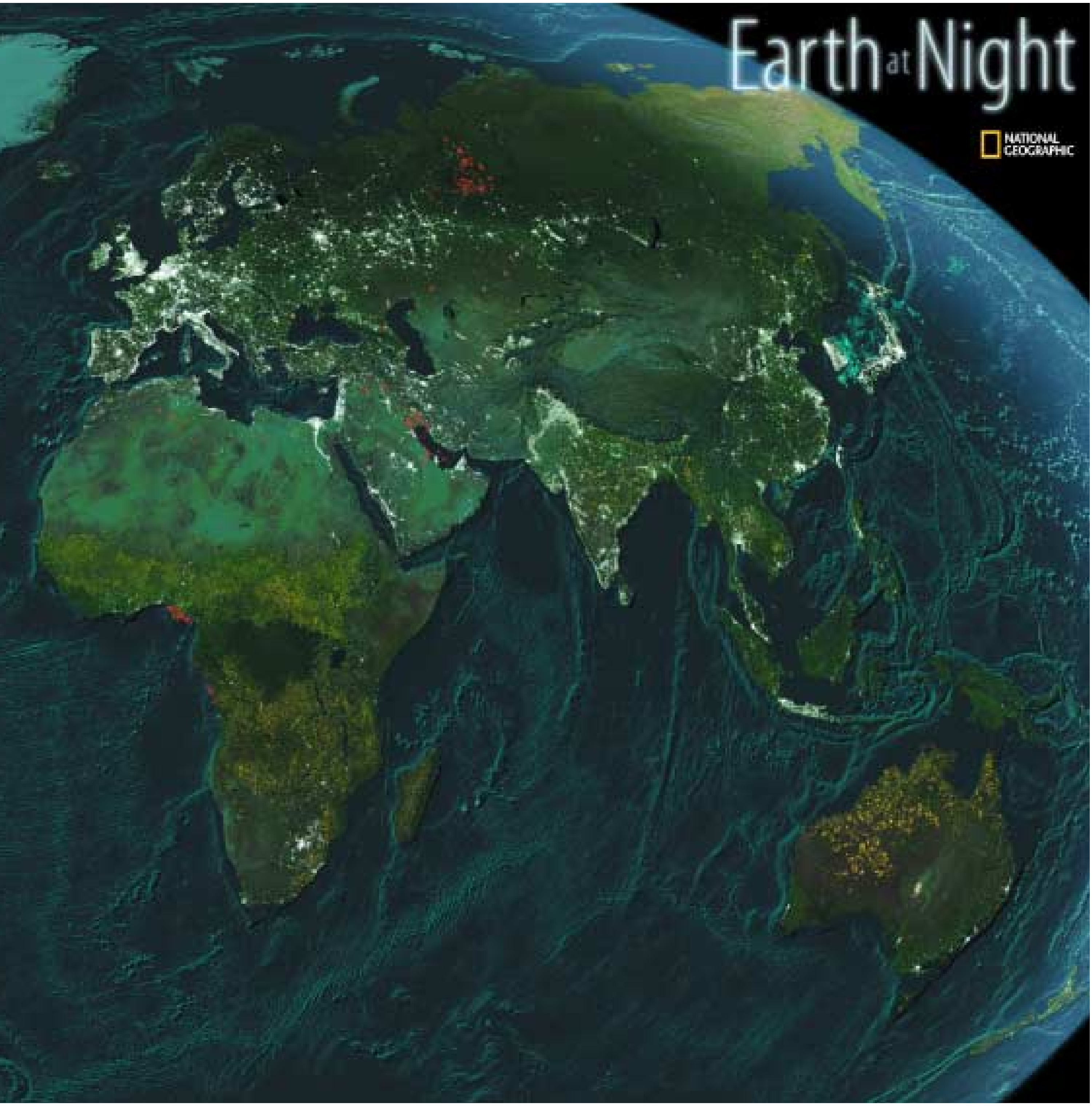
At the heart of any coal industry response to these issues lies a conundrum. With few exceptions, the coal industry produces a fuel that is consumed somewhere else by other industries.

The sustainable development agenda has brought new focus to what happens in the operations of coal-producing companies, to monitoring and reducing internally-generated carbon emissions and a host of other safety, health, environmental and community issues. But it is at the point of consumption – where coal combustion takes place – that world environmental attention is most sharply focused. It could be argued that, over and above their concerns about what their customers consume, coal producers should adopt a more holistic approach, embrace the concept of product stewardship, understand the environment faced by their customers and jointly determine how to respond.

This is not, however, an approach that coal producers can pursue in isolation. Clearly, for the



A composite of satellite images from cloud-free nights gathered over a one-year period. One look reveals the obvious: rich, developed regions like the United States, Europe and Japan glow brightly, using energy disproportionate to their populations. Yet India, with more than 1 billion people, seems dimmer than Italy, with fewer than 60 million.


Earth at Night
NATIONAL GEOGRAPHIC

concept of product stewardship to be successful, customers must be prepared to work with producers in responding to external imperatives like carbon management. Mutual survival depends on it because cost-of-carbon considerations will soon have a direct impact on hitherto narrowly defined commercial relationships.

It may well take the advent of a more transparent, more active and more liquid market in CO_2 credits to kick-start alliances between customers and producers, but companies ought not simply to be waiting for that to happen.

It is clear that without a defined price for carbon, investment in energy infrastructure in countries supporting the Kyoto Protocol is being delayed. To meet the IEA energy demand forecasts referred to earlier, it is estimated that some US$16 trillion[16] will be required – split 50/50 on replacement of existing generating capacity and new generating capacity. Ways have to be found to make the necessary investment, to do so timeously, in a way that enables the world to utilise available coal resources and in a manner that deploys the best available combustion technology in an environmentally acceptable manner.

The push towards clean-coal technologies

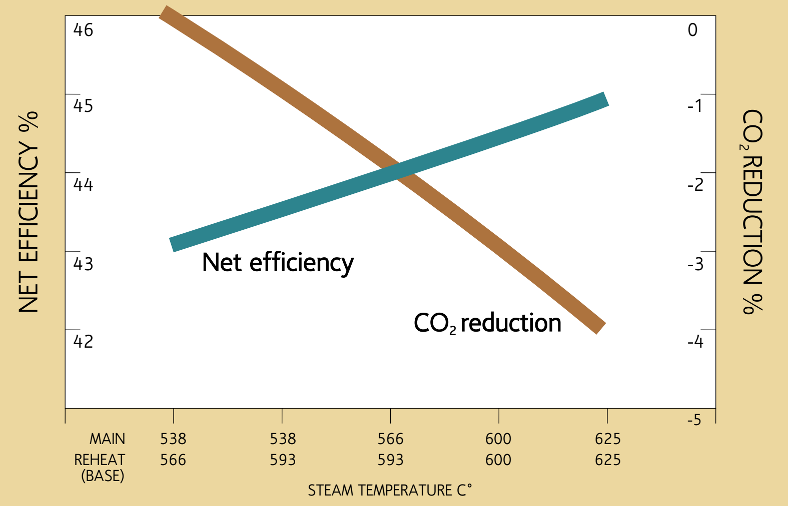
Environmental challenges to the coal industry embrace waste material in the coal, particulate emissions, trace element emissions, oxides of nitrogen and sulphur, methane and carbon dioxide emissions[17].

Significant advances have been made in areas such as waste-removal, methane extraction and capture, particulate emission removal technology, trace element reduction and the reduction of nitrous oxide – so-called 'NOx' – and sulphur dioxide – so-called 'SOx' – emissions (see box on page 56). As these technologies have developed, costs as an impediment to implementation have diminished considerably.

Increasing thermal efficiency and the use of less fuel correlate directly with reduced CO_2 emissions. In China, the average thermal efficiency of all its installed coal-fired capacity is some 27%, though newer stations with significantly improved efficiencies are increasingly being installed. This compares with a world average of about 30% and an average for the OECD of about 38%.

Advanced technologies which allow even higher efficiencies of up to 45%, and the consequent lower emissions, include Pressurised Fluidised Bed Combustion (PFBC) plants which operate at supercritical boiler temperatures and pressures. There are operational examples of these plants in the USA, Europe and Japan where, for example, the Karita PFBC coal-fired plant has demonstrated some significant gains[18]. At Karita the new plant replaced an old oil-fired unit. Simply doing that accounted for an 11% efficiency gain and the related emission reduction. The addition of in-furnace

EFFICIENCY AND CO_2 EMISSIONS REDUCTION



Source: World Coal Institute

SYNERGY WITH RENEWABLES

Renewables' weaknesses

- Inflexibility, intermittency; unpredictability

Coal's strengths

- Flexibility – easy to store, transport and supply

Examples

- Dual-fuel plant at Belle Vue, Mauritius. Enables bagasse (by-product of sugar production) to be used effectively
- Co-firing biomass (e.g. woodchips) and coal in UK, Belgium
- Coal for base-load generation supported by solar thermal

Source: World Coal Institute

WORLD COAL INSTITUTE

THE KARITA PLANT
in Japan

desulphurisation using limestone secured a 54% reduction in SOx emissions; selective catalytic reduction reduced NOx emissions by 70% and the addition of cyclones and electrostatic precipitators reduced particulate emissions by 50%. In Germany, the Niederhaussen lignite-fired plant using advanced combustion technology commissioned in 2002 has achieved a 43% efficiency level and, in so doing, when compared with average European efficiencies for similar plant, has saved 3 million tonnes (Mt) of CO_2 per annum.

More than 400 supercritical plants are currently operating worldwide, including nine such plants in China, with 16 under construction and a further eight planned[19].

Coal-fired Integrated Gasification Combined Cycle (IGCC) plants utilise oxygen and steam in a reaction with coal to produce a gas made up mainly of hydrogen and carbon monoxide. This gas is cleaned and then burned in a gas turbine to generate electricity and to produce steam for a steam cycle. This technology offers efficiencies currently in the 45% range, with developments planned to take this to the 50% level. IGCC plants operate in the USA, Spain and Japan – and there are around 160 in total – but the technology needs to prove its reliability on a large scale. However, IGCC does hold additional promise given its likely association with carbon capture and storage projects.

The application of these technologies is, however, less prevalent in the developing countries, and it is in here that the challenge of much greater deployment of available technologies lies.

Coal and renewables

Rather than simply considering coal and renewables as mutually exclusive and competing options, there is increasing evidence to suggest the two are complementary. Separate coal-fired generation can be used to support more erratic, renewable-based sources of electricity such as wind-based generation. Another option, as in the case of the Toom power station in Thailand, is co-firing coal and locally available biomass such as eucalyptus bark and rice husks. Biomass in the form known as bagasse – sugar cane plant residues – is being co-fired with coal on a seasonal basis in other plants and, in Europe, biomass is being imported where not locally available for use in co-firing applications with coal.

The move to secure a near-zero emissions environment

The next generation of clean-coal technologies is aimed at the development of zero or near-zero emissions to the environment. The key to success in this area is the capture and storage, or sequestration, of CO_2. Technologies which extract CO_2 from the emissions stream are known and are in use. Pre-combustion capture, oxyfuel combustion and chemical-looping combustion offer alternatives for the capture of CO_2 but require to be proven in large-scale applications. Long-term permanent storage options for the captured CO_2 include geological, chemical, ocean-based and biological sequestration. Current estimates indicate that the capital costs of a pulverised coal-fired plant, including CO_2 capture, would increase by some 80% and for a coal-fired integrated combined cycle plant, including CO_2 capture, by 50%[20].

Current efforts are focused on geological sequestration in formations such as depleted oil and gas reservoirs, such as the Sleipner project in Norway, unmineable coal beds and saline aquifers.

Work in this arena is being co-ordinated by the Carbon Sequestration Leadership Forum (CSLF), a 17-nation coalition dedicated to the development and deployment of carbon-sequestration technologies as a key step in the move to zero emissions.

The potential for CO_2 storage is considerable. Latest estimates reflected in the Technology Roadmap reviewed by the CSLF in September 2004[21] indicate that depleted oilfields have a total capacity of some 126 Gt of CO_2. As a result of enhanced oil production associated with CO_2 storage, some 120 Gt could be stored at a net cost saving. This is premised on an oil price of US$10 per barrel compared with a current price of US$40-50 per barrel, and the economics improve as the oil price rises.

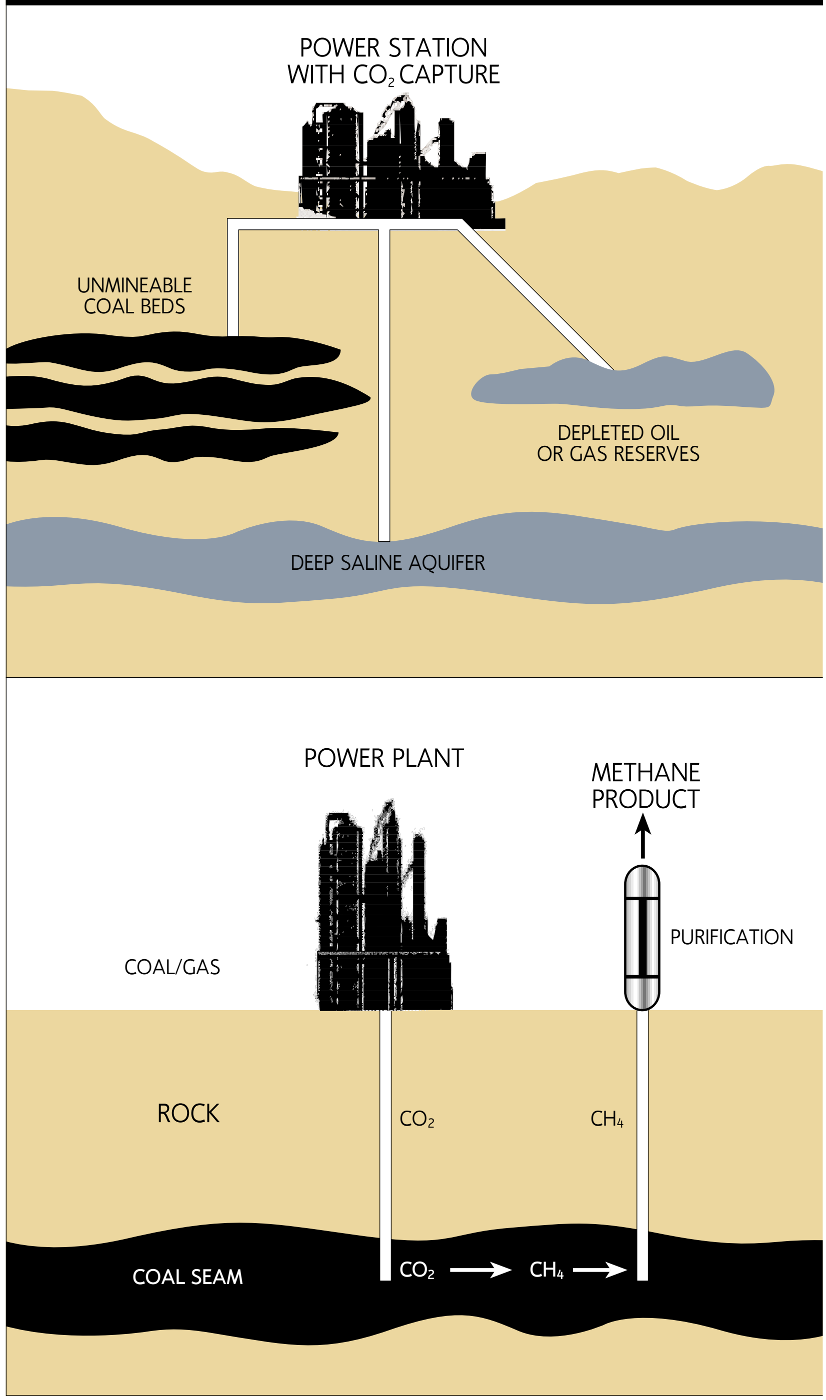
Depleted natural-gas reservoirs have a considerably larger storage capacity of some 800 Gt of CO_2 and it is estimated that in the absence of significantly enhanced gas production, a modest cost would be incurred for injection. Some 105 Gt of CO_2 can be stored at a net cost of less than US$7 per tonne of CO_2, with a further 575 Gt of CO_2 able to be stored at a cost of US$10-17 per tonne of CO_2.

Unmineable coal beds are estimated to have a storage capacity of some 150 Gt of CO_2. In the most favourable coal basins, it is estimated that 15 Gt of CO_2 could be sequestered in a manner that would generate a surplus of US$20 per tonne of CO_2 (not including the cost of capture) based on a natural gas price of US$2/gigajoule (Gj).

Firm estimates of the CO_2 storage capacity in deep saline formations have not yet been fully developed, though estimates made in the early 1990s identified a range between 400 and 10,000 Gt of CO_2. Storage costs in this type of formation are expected to be in the range of US$5-17 per tonne of CO_2.

Whilst cost estimates are currently high and distance from source of CO_2 generation to storage site is a key issue, technological improvements and large-scale application are expected to result in significant cost decreases. The capital costs of an analogous technical development, that of flue gas desulphurisation plants at power stations, have decreased by some 75% over 30 years.

GEOLOGICAL STORAGE OPTIONS

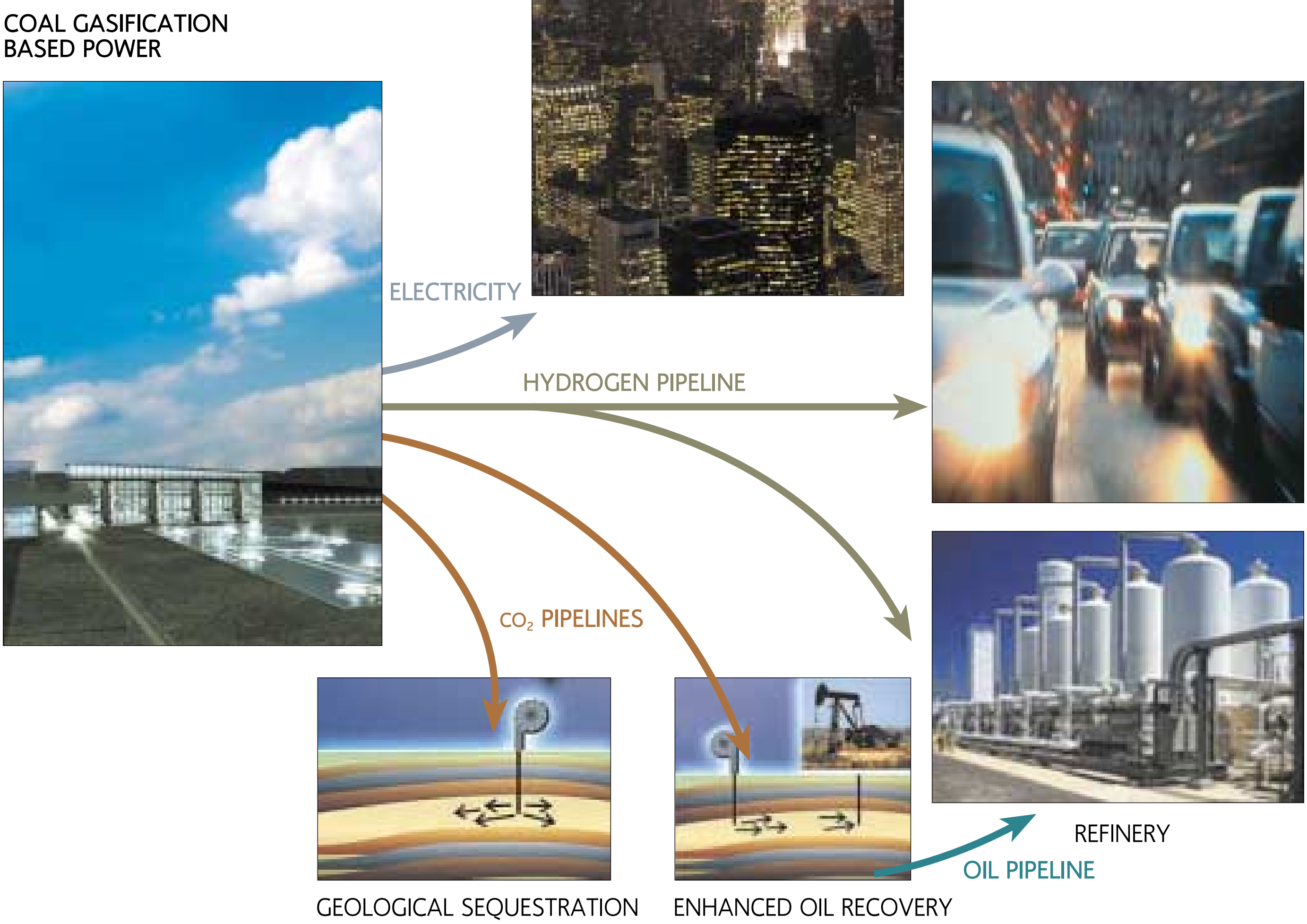


Source: World Coal Institute: Clean Coal: Building a Future Through Technology

However, the speed with which new technologies can be widely applied depends on many factors, not the least of which are size and lifetime of the equipment or infrastructure, cost and regional priorities[22]. Political will, the active provision of incentives, e.g. in the area of taxes and research promotion, which go beyond simply putting a price

FUTUREGEN

Coal-based zero emissions electricity and hydrogen plant



Source: World Coal Institute and US Department of Energy

on carbon emissions, and real commitment to the necessary research, together with public pressure, will be necessary to deliver solutions at a scale the world requires.

Ten projects in various parts of the world have been recognised by the CSLF and a variety of capture and storage-technology options are being pursued. More will follow. There are several other projects under way, the most high profile of which is the Futuregen project in the USA. This is a US$1 billion public-private venture, heavily reliant on continued government funding, which aims to have a 275 MW coal-fired plant operating by 2010, with 90% of the CO_2 emissions captured, and by 2020 an electricity price at no more than a 10% premium to conventionally generated electricity. The plant being developed under the Futuregen programme will also produce a hydrogen stream. Additional work on security of storage, monitoring and verification of CO_2 currently being stored underground, the effects of leakage, technology development in all aspects of capture, transmission and storage and the costs of each element are also being pursued by CSLF projects along with individual country-based research to identify and confirm the best sites for storage.

Coal as a source of hydrogen – the long-term future

The long-term vision, say, 50 years hence, of a hydrogen-based economy using coal's abundant reserves as the feedstock is premised on a process that would produce hydrogen gas or hydrogen-rich liquids from raw-synthesis gas derived from the gasification of coal[23]. Until recently, the energy-intensive nature of the processes involved, the prohibitive costs and the CO_2 by-products made the development of this technology unlikely. However, major advances in gas separation, catalyst, physical and chemical sorbent technologies, coupled with carbon sequestration, have opened up renewed prospects for environmentally acceptable large-volume production of hydrogen. New technologies are also being explored to address the delivery and storage difficulties associated with hydrogen – which is a low energy density gas.

Coal, given its vast reserves, is very well positioned to provide, post-gasification, the quantities of hydrogen needed to underpin a shift to a new and different energy economy. Europe, Japan the USA and New Zealand all have active hydrogen programmes and are considering coal as an option

RELATED TECHNOLOGICAL DEVELOPMENTS SUPPORTING THE USE OF COAL

Coal is often used immediately it has been mined, without any form of waste removal. Coal exported over long distances requires as little waste material as possible and the maximum heat value available in order to bear the often high transportation costs. Simply by washing coal and, in so doing, removing waste material, can yield up to a 5% reduction in CO_2 emissions for the same ton of coal.

Methane emissions from coal-mining activity can be substantial in volume and methane has a ranking some 23 times more than CO_2 in terms of global-warming potential. Rather than simply venting fugitive methane into the atmosphere, it can be captured and used. An example is Anglo Coal's Moura colliery in Queensland, Australia, where methane-rich coal seams are being pre-drained ahead of mining activity, not least for safety reasons. Rather than simply flaring the gas, it is now being sold into the local gas-distribution grid. This is earning credits as a direct result of the emissions reduction derived from the alternative approach. A related activity involves the extraction of methane from unmineable coal seams for similar applications.

Particulate emission removal technology is readily available in the form of electrostatic precipitators and fabric filters. These have efficiencies of over 99.5% and are widely applied in both developed and developing countries. At the Lethabo power station in South Africa, a 3,600 MW generating plant which burns low-grade coal, large electrostatic precipitators remove 99.8% of the fly ash, which is then sold to the cement sector as a raw-material contributor. Work at Lethabo and other stations operated by Eskom in South Africa has resulted in total particulate emissions being reduced by 85% in the period from 1988 to 2003[1].

Trace element emissions are being significantly reduced by particulate control devices, fluidised bed combustion, desulphurisation and other equipment.

Emissions of nitrous oxide – so-called 'NOx' emissions – can be cut by more than 90% by the use of low NOx burners, advanced combustion technologies and different approaches to catalytic reduction which treat the flue gas.

Emissions of sulphur dioxide – so-called 'SOx' emissions – can be reduced by between 90%-95% using flue gas desulphurisation and advanced combustion technologies. In the USA, since 1980, coal consumption has increased by 70%, but SOx and NOx emissions have been reduced by 60%. In Germany, NOx and particulate emissions have been reduced by 80% during a similar period[2].

References

1 Clean Coal – Building a Future through Technology – World Coal Institute 2004
2 The Role of Coal as an Energy Source – World Coal Institute 2003

to produce hydrogen. Large-scale production of hydrogen from coal requires suitably scaled CO_2 capture and storage; so research in support of CO_2 sequestration is a critical forerunner to the long-term realisation of a hydrogen-based economy.

Hydrogen can be used in a number of applications, the most promising of which is fuel cells. A fuel cell uses electrochemical reactions between hydrogen and oxygen, instead of a combustion process, to produce electricity.

Hydrogen-powered fuel cell vehicles are projected to be 2-3 times more efficient than the internal combustion engine per kilometre travelled. Using a different type of fuel cell which is more suited to distributed generation and central power station applications is estimated to double the efficiencies of these applications. A number of additional applications, varying from adaptations of current automotive engines to batteries, are also in prospect.

Conclusion

In a world still faced with a rapidly growing population, accompanied by ambitious development aspirations and poverty-alleviation objectives, energy demand looks set to increase significantly. Coal, the primary fuel at the beginning of the 20th century, although supplemented and in some instances overtaken by oil and gas, remains a mainstay of the world's power generation and steel-making processes. Currently it carries an unacceptably high environmental burden. In response to environmental pressure, technological solutions are being developed which will enable coal to continue to contribute to meeting society's energy demands in a manner that is far more environmentally acceptable. Beyond the short- to medium-term technological developments, such as efficiency improvements, the longer-term drive towards a hydrogen economy is set to intensify.

Abundant and geographically diverse reserves, the achievement of greater combustion efficiencies, the application of carbon-sequestration technologies and its role as primary feedstock in the production of hydrogen – given the depletion of other fossil fuel reserves – will position coal as the fuel of the future.

As policy-makers and regulators evaluate their energy options in a carbon-constrained world, great care must be taken not to prejudice important long-term options by imposing ill-considered shorter-term penalties or focusing solely and prematurely on single-sector solutions such as renewables. Doing so might damage the very industry on which a world-scale clean-energy future could ultimately depend.

REFERENCES

1 BP Statistical Review of World Energy, June 2004
2 International Energy Agency (IEA) World Energy Outlook 2004
3 Primary Energy: A combination of indigenous production of energy plus energy imports, less energy exports and adjusted for marine bunker supplies and stock changes
4 IEA Key World Energy Statistics 2004
5 OECD – Organisation for Economic Cooperation and Development, comprising Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, USA, Canada, Mexico, Japan, South Korea, Australia, New Zealand
6 BP Statistical Review of World Energy, June 2004
7 FSU – Former Soviet Union
8 World Energy Outlook 2004 – IEA
9 World Business Council for Sustainable Development: Facts and Trends to 2050 – Energy and Climate Change 2004: Hadley Centre and CDIAC
10 Rocky Mountain Institute (RMI) Private Client research
11 Battelle 2003: Presentation to Carbon Sequestration Leadership Forum Preparatory Meeting
12 World Business Council for Sustainable Development: Facts and Trends to 2050 Energy and Climate Change 2004
13 Carbon dioxide, Methane, Nitrous oxide, Hydrofluorocarbons, Perfluorocarbons and Sulphur hexafluoride
14 Planet Ark, 14 December 2004: Statement by EU Environment Commissioner
15 World Coal Institute: The Role of Coal as an Energy Source 2003
16 World Energy Investment Outlook – IEA 2003
17 Clean Coal – Building a Future Through Technology – World Coal Institute 2004
18 IEA Clean Coal Centre Case Study
19 Clean Coal – Building a Future through Technology – World Coal Institute 2004
20 IEA Working Party on Fossil Fuel: CO_2 Capture at Power Stations and other Point Sources, 2003
21 CSLF-T-2004-10: 3 August 2004 Draft Technology Roadmap – as reviewed at the 2nd Ministerial Meeting of the CSLF, Melbourne, Australia 13-15 September 2004
22 World Business Council for Sustainable Development: Facts and Trends to 2050 – Energy and Climate Change 2004
23 US Department of Energy – Office of Fossil Energy (2003): Hydrogen from Coal

THE AUTHOR

Roger Wicks is chairman of the World Coal Institute, head of energy for Anglo American and until recently was executive vice president: global strategy, marketing and sustainable development at Anglo Coal