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CLEAN COAL

A CLEAN, SECURE AND AFFORDABLE ALTERNATIVE

Tony Lodge

With a Foreword by Richard Budge

THE AUTHOR

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ISBN No: 1 905389 51 5

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Printed by The Centre for Policy Studies, 57 Tufton Street, SW1.

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SUMMARY

- Coal still plays an important part in electricity generation, producing more than 35% of the UK's baseload electricity during an average year. In recent winters, this has risen to 50%.
- Coal has numerous advantages: it is plentiful, indigenous, relatively cheap, flexible and responsive to peaks and troughs in demand, can be stored, is not prone to outages, and is not vulnerable to geo-political risk. Only nuclear power can match these advantages.
- However, because of their substantial carbon emissions, current coal-fired power stations are considered to be environmentally unacceptable.
- New clean technologies are being developed around the world which can reduce the environmental impact of coal-fired generation. They are now proven to work. Powerfuel's new development at Hatfield in Yorkshire – backed by Friends of the Earth – is an example of how a new clean coal plant can be developed in practice.
- More energy generation is urgently needed. The UK has an installed electricity capacity of 77 gigawatts (GW); it is expected that by 2016, it will face a shortfall of 32 GW as older coal, nuclear and oil plant is closed, and as demand increases.
- Clean coal is competitive, with a generating cost estimated at between 2p/KWh and 3.5p/KWh. Wind power (excluding the extra costs of intermittent supply) costs between 3.7p/KWh and 5.5p/KWh.

- The UK has the opportunity to be at the forefront of developing clean coal technology. This would not only be beneficial to the UK, but would also be the most effective way of helping developing economies (notably China and India) to take advantage of their own coal reserves in a way which is considered as environmentally acceptable.
- Electricity generators are private companies. For them to make the substantial investment in clean coal plant depends to a large extent on changes in government policy in three respects:
  - Clear political support is required to reassure investors;
  - Planning rules for sites need to be rationalised (it took 20 years for the Asfordby coal mine to reach full production);
  - Clean coal plant should enjoy the same level of subsidy as is granted to renewable energy sources (such as windpower).
- The clear benefits of such a policy would be increased reliability of electricity supply and cheaper electricity prices for the consumer. Such a combination ought to be attractive to all policy-makers.

FOREWORD

It can be stated with confidence that the UK's dependence on fossil fuels will continue far into the future.

Coal is a key constituent of the energy portfolio: it currently produces more than 35% of electricity generation during the year. Over the last two unseasonably warm winters, this has risen to 50%.

It is true that CO_2 emissions from coal are higher than alternative fuels. However, this presents an opportunity to capture the greatest amount of CO_2 captured per unit of electricity. For today, the process of coal gasification has the ability to capture 90% of CO_2 emissions for sequestration. It can also produce a synthetic gas, known as "syngas", which is 99.5% pure hydrogen. Once fired through a conventional gas turbine, syngas emits nothing more than water vapour.

The Integrated Gas Combined Cycle (IGCC) is a near zero emissions clean coal solution for the UK. It would significantly reduce CO_2 emissions as well as providing pressurised gas for injection into the North Sea Oil fields, thereby enhancing the recovery of oil reserves known as Enhanced Oil Recovery (EOR). Powerfuel, of which I am the Chairman, is now constructing one of Britain's first IGCC clean coal power stations in Yorkshire which would use British coal from an adjacent colliery.

However, new power station development of this type will, without a change in government policy, be the exception. For current government policy is to encourage retrofitting supercritical boilers at existing coal-fired power stations or installing advanced burner development. It offers no such encouragement to IGCC plant.

While the cleaning up of existing plant is welcome, it will not have the impact that is required by those who want to reduce significantly our CO_2 emissions. Nor will it capture any CO_2 for alternative income generation.

Coal gasification is the only process that changes one form of energy, coal, into another more flexible energy source, hydrogen gas. The benefits are clear; in addition to providing a clean, reliable and local source of power, syngas would improve our negotiating position with imported gas producers and could thereby possibly cap the price of gas.

Security of supply and environmental improvement are matters for Government and not individual companies. In addition, the Treasury can expect to be a substantial financial beneficiary of EOR. It should conclude its negotiations with the oil companies so that it is in their interest to invest in the necessary infrastructure for transportation of CO_2 into the oilfields.

However, without a clear government energy policy, IGCC will not happen. For it to be viable, the new IGCC plants require the same allocation of CO_2 allowances as existing coal plant, whereas at present it would receive the allowances for a CCGT (gas fired power station).

This is therefore the political opportunity: for a simple change in policy to allow the UK to compete in the provision of a new technology which will provide a reliable and secure source of energy for the years ahead.

Richard Budge

Chief Executive Officer, Powerfuel PLC

Powerfuel PLC intends to construct one of Britain's first clean coal (IGCC) power stations alongside the Hatfield colliery in northern England. Richard Budge is the former Chairman of RJB Mining, now UK Coal Ltd.

CHAPTER ONE
INTRODUCTION

Energy prices have been driven to new highs. Across the world, increasing populations and increasing per-capita energy consumption, together with consistent economic growth, are likely to prolong this trend.

Over the last decade, Britain has become increasingly dependent on imported gas. This over-dependence on gas – much of which comes from politically volatile regions – could have economic, political and future security problems. These problems can be avoided, however, if a more balanced and sustainable energy policy is pursued.

Coupled with investment and political backing for new nuclear power stations, coal can now be utilised in a clean way to produce cheap, abundant and reliable energy.

In particular, the UK can utilise another important indigenous energy asset: coal. Coupled with investment and political backing for new nuclear power stations, coal can now be utilised in a clean way to produce cheap, abundant and reliable energy.

Coal is a plentiful and relatively cheap source of fuel. It generates about 40% of the world's electricity (compared with about 10% each for gas and nuclear). A substantial part of the world's growth in power generation will be based on coal for at least the next 20 to 30 years.

At the same time, there is increasing pressure for reduction of CO_2 emissions from coal-fired power stations. Significant reductions in CO_2 emissions may be achieved by the use of clean coal technologies. These increase the net efficiency of coal-fired plants, so that less CO_2 is emitted per unit of electricity generated whilst maintaining crucial baseload electricity output.[1] There are various forms of clean coal technology which this paper will set out and discuss.

So far, generating electricity from coal has failed the environmental test because of carbon emissions. But clean coal offers a number of strategic advantages, including the ability to:

- ensure that sustainable and competitively priced electricity is available to UK customers;
- offset the security risks and costs of importing gas from the Middle East, Russia and elsewhere;
- meet rising electricity demand;
- 'smooth' the less predictable output from renewables;
- replace lost generating capacity as older nuclear and coal power stations are decommissioned;
- foster and promote a high growth, low carbon economy.

New clean coal technologies can allow the UK, the US and other coal rich countries to develop new technologies which harness Carbon Capture and Storage (CCS). They can thereby demonstrate to the developing world the practical importance of embracing the cleaner and more efficient use of coal.

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1 A baseload power plant provides a steady flow of power regardless of total power demand by the grid.

CHAPTER TWO
THE PRESENT POSITION

The reduction in the British deep mine coal industry has been on a considerable scale. In 1981 211 pits produced 110.3 million tonnes of coal. The industry, then managed by the National Coal Board, had a workforce of 293,000 but faced demand for little more than 100 million tonnes a year; largely from the power generators and the then British Steel Corporation. In 1983 coal production was supported by a £1.3 billion public subsidy. The industry had failed to record a profit since 1977.[2]

The last 20 years have witnessed the dramatic contraction of the UK's deep mine coal industry. There are several well documented reasons for this decline ranging from the 1984/85 miners' strike which had a disastrous effect on morale and future planning and investment, the failure of British Coal to secure and extend markets at home and the exhaustion of economically viable reserves.

As at August 2006, the UK coal industry employed just 6,000 people, with approximately 4,000 employed in deep mines and the remainder in the opencast sector. In 2005, total UK coal production was 20 million tonnes, with 9.6 million tonnes from deep mined production and opencast accounting for 10.4 million tonnes. Overall coal consumption in 2005 was up 2.3% at 61.8 million tonnes., with about 40 million tonnes now being imported.

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[2] National Coal Board Accounts, 1984.

Coal burn by major electricity generators, who accounted for 80% of total coal use, was up by 3% in 2005. Coal burn in UK power stations was 23% higher in the third quarter of 2006 compared with the same period in 2005.[3] Coal demand is rising.

Productivity at surviving UK pits is among the highest in Europe with the use of highly automated, long wall face equipment that cuts coal from "panels" up to 350 metres wide and extending three kilometres or more through the underground coal seam. The investment needed to maintain access to reserves, as existing reserves become exhausted, is substantial. For example, Daw Mill Colliery near Coventry will require over £100 million to access 43 million tonnes of new reserves later this decade. Its owner, UK Coal, has already invested £80 million and will raise production to over 3 million tonnes per year using some of the largest face equipment in the world.[4] There is also much scope for increased capacity at Kellingley Colliery in West Yorkshire, Britain's second biggest pit, which is set to produce over 2 million tonnes this year. Plans are being costed at the moment to increase output to over 2.34 million tonnes by 2009.[5] The mine has proven reserves of 24 million tonnes.

COAL-FIRED ELECTRICITY GENERATION IN THE UK

The UK has an installed electricity generating capacity of 77 GW. However much of this capacity will come off-stream over the next decade as older nuclear and coal stations are decommissioned. Unless the capacity problems are addressed rapidly, then the UK could face an estimated 32 GW electricity generation capacity shortage by 2016.[6] EDF Energy argues that this generation gap will be a direct result of paying off older coal and nuclear stations without swift replacement with clean coal and new nuclear. If nuclear energy and clean coal technology are to fill this fast-approaching energy gap (and also reduce emissions), planning must start now.

13 GW of coal plant and 7.5 GW of nuclear plant will close by 2016. The UK will then face an energy shortfall of 32 GW.

Between now and 2016, EFD Energy highlights 13 GW of coal and oil baseload plant which will close. Other ageing coal plants may also close by 2016. 7.5 GW of nuclear closures are scheduled by 2015. EDF reach their figure of a 32 GW shortfall through working in with the expected closures the expected electricity demand growth and the expected growth in renewables in line with the Renewables Obligation.

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3 *Utility Week*, January 2007.

4 Association of UK Coal Producers, Media Briefing 2005.

5 UK Coal *Newscene*, April 2005.

6 EDF, Energy Review Submission 2006

The present capacity of UK coal-fired power stations is 28 GW. These operate at an average annual load factor of roughly 50%. They are crucial to the country's baseload energy supply as they can be activated swiftly and thereby offer crucial flexibility at times of peak demand. They have also historically provided a cheap source of electricity as against other power sources. As the Select Committee on Trade and Industry pointed out:[7]

> Coal has a number of advantages for electricity production. The raw material is in plentiful supply. It can be (and is) stockpiled at power stations and, in generating terms, it is a fairly flexible fuel, providing baseload but also some capability of being turned up and down to meet peaks in demand.

However, if the UK's coal-fired power stations were replaced, over time with clean coal plants, then the UK would stand at the head of an energy revolution. It would be secure in her supply and comfortably within environmental emissions targets.[8] Encouragingly, more than 5 GW of new clean coal projects have already been announced, but this trend must be maintained and supported.[9]

PLANNING

One crucial issue of planning for the energy industry is the slowness of the planning system. In the past, these have delayed energy projects substantially. Two important recent examples include the plans for the Sizewell B Nuclear Power Station and the Asfordby coal-mine in Leicestershire where it took 16 years and 20 years respectively to reach full production.

In 2001, the then Secretary of State with responsibility for planning, John Prescott MP, said that approval in principle for the need for and the location of future big projects such as new power stations should be a matter for Parliament. He expanded that this should meet concerns about time being "wasted" at inquiries and:[10]

> …not going over issues which have been settled. We want the overall process for deciding [major infrastructure] projects to be shorter and more focussed whilst ensuring the people affected have a full right to make their views known.

A specific commitment to a stream-lined planning policy is eagerly awaited in the Government's 2007 Energy White Paper. This can then allow planners to look at future prospects with a degree of confidence.

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7 Security of Energy Supply, second report 2001/2002, Trade and Industry Select Committee, para 16.

8 Association of UK Coal Producers, Media Briefing 2005.

9 Minutes of the First Meeting of the UK Coal Forum, 14 November 2006.

10 DTLR, 2001a, page 3.

CHAPTER THREE
CLEAN COAL PROJECTS IN THE UK AND ACROSS THE WORLD

At current global energy consumption rates, it is estimated that there are enough recoverable coal reserves to provide the entire planet with all of its energy for the next 600 years.[11] With increasing fears over security of supply and with increasing popular demands to meet Kyoto targets on carbon emissions, the development of clean coal technology has been growing in recent years across the world.

FLUE GAS DESULPHERISATION

At some elderly coal burning stations in the UK, new Flue Gas Desulpherisation (FGD) and denitrification filters are being fitted to remove over 90% of the sulphur emissions.

FGD works by mixing limestone with water which is then sprayed into the power station chimneys through which the flue gasses pass after burning coal. The sulphur in the flue gas reacts chemically with the injected spray and forms calcium sulphate, only a small proportion of sulphur being ejected into the atmosphere. The resultant slurry is pumped away and dried – gypsum is the result, which can then be used in manufacturing.

UK coal is high in sulphur and FGD is therefore a useful asset. FGD equipment also allows coal-fired plants to meet the requirements of the EU Large Combustion Plant Directive (LCPD). Most British plants, as can be seen in the following table, are now equipped or are being equipped with FGD.

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[11] Energy Information Administration, *Annual Energy Outlook*, 2006.

COAL-FIRED POWER STATIONS IN THE UK: FGD STATUS

Power Station & Location	Capacity Owner	Installed Capacity (MW)	FGD (MW)	Status
Kilroot N. Ireland	AES	440	440	Announced Jan '06
Eggborough Yorkshire	British Energy	2,000	1,000	Operational
Drax* Yorkshire	Drax	4,000	4,000	Operational
Cottam Nottinghamshire	EDF Energy	2,000	2,000	Commissioning
West Burton Nottinghamshire	EDF Energy	2,000	2,000	Operational
Ironbridge Shropshire	E.ON UK	1,000	0	To be closed by 2015
Kingsnorth Kent	E.ON UK	2,000	0	To be closed by 2015
Ratcliffe Nottinghamshire	E.ON UK	2,000	2,000	Operational
Rugeley Staffordshire	International Power	1,000	1,000	Announced Dec '05
Aberthaw Wales	RWE npower	1,500	1,500	Under Construction
Didcot† Oxfordshire	RWE npower	2,000	0	No
Tilbury Essex	RWE npower	1,000	0	No
Ferrybridge Yorkshire	Scottish & Southern	2,000	1,000	Announced Nov '05
Fiddler's Ferry Cheshire	Scottish & Southern	2,000	2,000	Announced Nov '05
Cockenzie Scotland	Scottish Power	1,200	0	No
Longannet Scotland	Scottish Power	2,300	2,300	Announced Feb '06
Uskmouth Wales	Uskmouth Power	360	360	Operational

Source: IPA Consulting

* At Drax, £100m is intended to be spent improving the efficiency of Europe's largest coal-fired power station, a move which will cut carbon emissions by 1 million tonnes a year. The money will be invested on reblading and updating the turbines used to generate electricity.

† Nitrogen oxide reduction work is planned at Didcot in tandem with biomass co-firing.

SUPERCRITICAL COAL-FIRED PLANTS

Coupled with the installation of FGD technology, new supercritical plants are being examined for ongoing coal-fired stations. More than 400 supercritical power plants are operating in the US, Europe, Russia and in Japan. Supercritical coal-fired power plants with efficiencies of 45% have much lower emissions than standard subcritical plants. Supercritical power plants operate at temperatures and pressures above conventional plants, resulting in higher efficiency. Proposals are in place for British supercritical stations to be fitted with carbon capture and storage potential, which is examined later in this paper.

Supercritical steam generators are used for the production of electric power. They operate at 'supercritical pressure'. In contrast to a conventional 'subcritical boiler', a supercritical steam generator operates at such a high pressure that boiling ceases to occur – that is, there is no water/steam separation. There is no generation of steam bubbles within the water, because the pressure is above the 'critical point' at which steam bubbles can form. So 'supercritical' describes the state of a substance where there is no clear distinction between the liquid and the gaseous phase. Importantly, by eliminating this transition into steam the efficiency of the process can be improved and this process results in slightly less coal use and therefore less greenhouse gas production.

The benefits of operating a supercritical power plant over a conventional plant are clear. Conventional boilers have an operating efficiency of about 30%. This means that only 30% of the energy in the coal is converted into electricity –the rest is lost as heat. Supercritical boilers have an efficiency level of around 42-46%. So more energy is directed to turning the turbines to generate electricity, and much less energy is lost as heat.

Fitting clean coal technology to the UK's 16 power plant would cost an estimated £6 bn. In comparison, 2,000 wind turbines are being put up in the UK over the next six years at a cost of £9bn.

So, improving the efficiency of boilers used in coal-fired power stations not only reduces CO_2 emissions because less coal is needed to generate the heat energy that turns the steam turbines, it also results in higher generator efficiencies in the provision of electricity. One feature helping with the development of supercritical power plants is their similarities with conventional power plants. Boilers are available commercially and can be "retrofitted" to existing coal-fired plants. This allows supercritical plants to be constructed and operated without significant retraining, enabling faster deployment. Importantly, it also means the operator can improve efficiency while keeping capital costs down by using the existing infrastructure at the site.

A leading British power station manufacturer, Doosan Babcock Energy, has stated that Britain could cut the cost of reducing greenhouse gases by £3 billion if it fitted such clean coal technology to its ageing power stations.

Some 2,000 wind turbines will be put up in Britain over the next six years at a total cost of approximately £9 billion as power companies seek to comply with a government demand to increase supplies of renewable energy. In comparison, Doosan Babcock Energy estimates that fitting clean coal technology to the UK's 16 power stations would cost £6 billion.

Doosan Babcock has lobbied the Government to introduce a form of incentive, similar to the Renewable Obligation Certificate, for power generators to invest in clean-coal technology. Iain Miller, Chief Operating Officer of Doosan Babcock Energy asserts:[12]

> Solutions are available now that will allow us to secure our electricity supply and cut emissions but the industry will not commit to carbon-abatement improvements without active leadership from Government.

Doosan Babcock says that its technology, applied to existing UK coal-fired power stations, would be similar to the impact in increased power output terms of erecting 7,000 to 10,000 wind turbines.

INSTALLED COST PER MEGAWATT OF COAL-FIRED POWER STATIONS

Typical construction costs for current designs of coal-fired power station are in the region of £0.7 to £0.9 million per MW. More advanced Integrated Gasification Combined Cycle plants (IGCC) cost around £0.9 – £1.2 million per MW, although lower capital costs are predicted, coming down to £0.75 – 0.9 million per MW post 2010. [13]

LIFETIME LEVELISED COSTS

Responses summarised in the 1998 Energy White Paper put the lifetime costs of new coal-fired power in the range 2.6 – 3.25 pence/kWh.

The 2002 Energy Review by the Performance and Innovation Unit put forecast costs of coal fired power by 2020 in the range 3.0 to 3.5 pence/kWh. This makes coal competitive with nuclear power (if the costs of nuclear decommissioning are included). The nuclear industry estimates that it can build new stations in the range of 3p/kWh. However, such a result is dependent on a number of sensitive factors, including achieving low construction costs, short construction times, and high operating availability, building a series of 10 identical reactors and on regulatory stability. Such an outcome is possible, but not particularly certain.[14]

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[12] *The Times*, 22 November 2004.

[13] Digest of UK Energy Statistics, DTI, Table 5.11.

[14] The Energy Review, Performance and Innovation Unit, Annex 6.

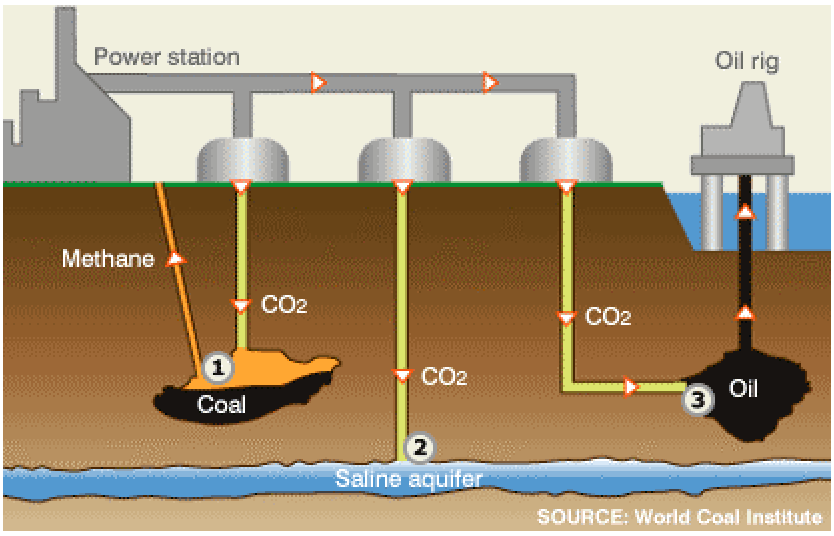
OPTIONS FOR CARBON ABATEMENT/CAPTURE AND STORAGE (CCS)

Carbon Capture and Storage (CCS) technologies allow fossil fuels to be used with minimum emissions. The idea of carbon sequestration is simple and powerful: segregate the CO_2 from the fossil fuel combustion products, and then deposit it in a place where it will remain. The emission of CO_2 from such a plant could be reduced to virtually zero if the clean coal plant was designed to sequester carbon, the CO_2 could be disposed of in, for example, the emptying oil fields of the North Sea which consequently can extend the lives of oil fields through pressure being applied on old and difficult to extract reserves, thereby prolonging production. [15]

CCS is a three step process, which includes capturing the CO_2 from power plants, transporting it, usually via pipelines, and finally storing it. The Minister for Science told the House of Commons on 27 February 2007: [16]

> CCS could help reduce emissions from the new coal-fired power stations that are planned over the next decades, especially in India and China, that is why the proposal is so attractive… We have strongly encouraged the market to proceed with bringing the technology forward, and UK industry is well placed to undertake future CCS projects.

The British Geological Survey estimates that potential carbon dioxide storage capacity in the UK sector of the North Sea is 755 gigatonnes, which is a considerable amount, given that worldwide CO_2 output is 8 gigatonnes annually. This means that almost a century's worth of the CO_2 produced in the world could theoretically at least, be stored in the North Sea alone.



Graphic Source: World Coal Institute

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[15] 'Economic Instruments for the reduction of carbon dioxide emissions', The Royal Society, November 2002.

[16] Hansard, 27 February 2007, Col 248 WH.

The costs of CCS, which are crucial to its long term viability, have been examined by PÖYRY Energy Consulting for the Department of Trade and Industry. It concluded that CCS costs in a coal-fired plant would be just above £20/tonne CO_2 while for a gas fired plant, it is £30/tonne CO_2. A key reason for this difference is that the volume of CO_2 emitted from a coal-fired plant is far greater than that from a gas fired plant, so the volume abated will also be far higher, therefore reducing the cost of abatement.

The PÖYRY report also sets out other ways the costs of CCS can fall:

- Using CO_2 for Enhanced Oil Recovery (EOR can generate revenue which offsets the other costs of CCS (before any taxation issues are considered).
- The cost of storing CO_2 in aquifers is close to £1/tonne.
- The cost of storing CO_2 in oil and gas fields plant ranges from £1/tonne to £20/ tonne. The low unit costs of using aquifers is due to them being in shallow water, minimising the platform costs, being in shallow rock formations thereby minimising drilling costs and their large reservoir nature, reducing the unit cost of storage.
- Overall, the PÖYRY report states that there is clear potential for abatement of around prices below £30/tonne.[17]

NEW UK PROJECTS

Powerfuel Hatfield Project (Yorkshire) 1000MW IGCC (UK)

Former UK Coal and RJB mining chief, Richard Budge, has unveiled plans to reopen the large Hatfield colliery in Yorkshire. The colliery will resume full-scale mining operations in 2007. Hatfield's redevelopment will involve the construction of a 1000 MW Integrated Gas Combined Cycle (IGCC) clean coal power station alongside the colliery, which will supply the station's coal. Russian coal giant, Kuzbassrazrezugol, has secured a 51% interest in Powerfuel, the company formed to manage the project, for an initial outlay reported at around £30m. However, Hatfield's full development to a 2.2 million tonnes a year mine is estimated by Powerfuel to require £110m of capital injection. In addition, the development of the IGCC, for which Powerfuel has applied for Section 36 permission, will need another £800m. Symbolically and importantly, the Hatfield Project is backed by Friends of the Earth. [18]

The Hatfield project represents a tripartite strategy which links indigenous mining and the generation of base-load electricity coupled with carbon capture. The colliery sits on considerable reserves which, it is hoped, could

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[17] PÖYRY, *Analysis of Carbon Capture and Storage Cost-Supply Curves for the UK (DTI)*, January 2007.

[18] *Coal UK*, September 2006.

maintain a 50 year operation. Additionally, there is also scope to develop fuel cells from captured hydrogen from the power station to produce enough energy to power local hydrogen adapted public transport.

The IGCC is now considered to be one of the cleanest and most environmentally friendly systems of fossil fuel power generation available today. As already illustrated, construction capital costs of these plants will come down post 2010.

Centrica Teesside 800 MW IGCC (UK)
Centrica, owner of British Gas, and Progressive Energy Ltd announced in November 2006 plans to build an £1bn 800MW IGCC in Teesside, North East England. The plant would be equipped with carbon capture and storage. Importantly, this plant will be located on the coast, therefore in close proximity to disused wells for CCS and therefore requiring less transportation infrastructure and build. Centrica stated that the station would be fuelled by coal from the UK and would generate enough electricity for one million homes. Provided the company gets Government approval and planning permission, construction would start in 2009, enabling the station to open in 2012 or 2013.

Scottish and Southern Energy Ferrybridge (Yorkshire) 500MW Supercritical Plant and CCS (UK)
Scottish and Southern Energy have teamed up with Doosan Babcock Energy, UK Coal and Siemens to look into the prospect of building a £350m 500MW clean coal plant at Ferrybridge power station with a supercritical plant and carbon capture and storage. This technology at Ferrybridge Power Station, in Yorkshire, would save around 500,000 tonnes of carbon dioxide a year, compared with the current plant. The plant would receive coal from the neighbouring Kellingley Colliery.[19]

Powergen Kingsnorth (Kent) New power station featuring two 800MW Supercritical plants with potential CCS (UK)
Powergen, owned by E.ON of Germany, is planning to invest £1 billion in two supercritical plants expected at 800MW each. They will be located at the same site. This plant, according to E.ON will use a mix of British and imported coal. The power stations will be suitable for carbon capture and storage. If approved these would be the UK's first supercritical coal-fired units, and they would produce enough electricity to supply around 1.5m homes. On December 11th 2006 E.ON submitted a Section 36 planning application to the Government.

RWEnpower Tilbury (Essex) 1000MW supercritical plant (UK)
This station is at the feasibility stage.

[19] *The Scottish Herald*, 1 June 2006.

Powergen Lincolnshire 450MW CCS (UK)
Powergen has also announced a feasibility study into building a clean coal power station at Killingholme on the Lincolnshire coast. This station will act as a test facility for carbon capture and storage.

NEW PROJECTS IN OTHER COUNTRIES

FutureGen Alliance (US)
The FutureGen project represents the future of power generation by coal, a fuel source the US has in abundance. FutureGen will use coal gasification to produce electricity and hydrogen as well as provide a test bed for developing future technologies. The project is a partnership between the US Department of Energy and industry. The alliance includes eight companies from the US, China, and Australia, plus the Indian Government. The site of the project has been narrowed down to four sites – two in Texas and two in Illinois. The US is the second largest coal producing state in the world, after China.

ZeroGen (Australia)
ZeroGen involves IGCC power plant technology with CCS. Announced in 2006, ZeroGen hopes to be the first commercial scale 'zero-emissions' coal-fired power plant anywhere in the world. Australia is one of the world's largest coal producers.

In 2004 the Australian Government produced a White Paper entitled 'Securing Australia's Energy Future' which backed the use of clean coal technology with coal from indigenous reserves. The Australians will provide $500 million for a Low Emission Technology fund to help develop cleaner options.[20] ZeroGen is a direct result of this policy push. UK Climate change economist Sir Nicholas Stern recently told an Australian audience:[21]

> We're starting to understand much better how to make coal clean again and I think Australia will be in the forefront of that technology. Making coal clean is an absolutely fundamental part of the technological challenge going forward.

UNDERGROUND COAL GASIFICATION (UCG)

Underground coal gasification is not a new concept or a new technology. What is new is the growing interest and activity in the field, prompted by increasing concerns over security of energy supplies and the challenge of CO_2 emissions. UCG is a method of converting unworked coal into a combustible gas, which can be used for industrial heating, power generation or the manufacture of hydrogen, synthetic natural gas or diesel fuel. The basic UCG process involves drilling two wells into the coal, one for the injection of oxidants (water/air or water oxygen mixtures) and another well

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20 'Australia stays with Coal', *NATTA Journal* Jan-Feb 2005.

21 Sir Nicholas Stern speech to National Press Club, Canberra, 28 March 2007.

some distance away to bring the product gas to the surface. UCG exposes the coal to temperatures that would normally cause the coal to combust but by regulating the amount of oxygen in the gasifier and adding steam, the coal does not burn but separates into a syngas. The gas can be processed to remove its CO_2 content, thereby providing a source of clean energy with minimal greenhouse gas emissions.

Cost estimates of UCG clean gas stand at £2.5 a gigajoule as against the current price of natural gas at £6 a gigajoule. The rapid disappearance of cheap natural gas is putting UCG in a prime position as an exploitation and conversion technology, taking advantage of recent advances in drilling and exploration technology. New oil and gas technology offers access to much deeper coal seams, where environmental challenges are easier to overcome.

A feasibility study has just been completed beneath the Firth of Forth and suggests that UCG could be viable in the present energy market, especially when combined with carbon capture and storage (CCS).

CHAPTER FOUR

POLITICAL SUPPORT FOR CLEAN COAL

The benefits and potential of clean coal technology are being increasingly appreciated. Other major economies, and coal producers, notably the US and Australia, already have plans in place.

In the US, coal production is at full capacity. In 2005, 951 million tonnes were produced from indigenous reserves for energy supply and industrial use in steel and associated industries (its proven recoverable reserves of coal are estimated to be 250,000 million tonnes).[23]

In the 2004 US Presidential Elections, both main candidates supported the need for the US to embrace clean coal technology and in October 2006 the US Energy Secretary, Samuel Bodman, announced $450 million in grants over the next decade for further research into technology that would lessen the environmental impacts of coal use. Bodman said, "Sequestration technology holds the key to the continued environmentally-responsible use of coal." The US Department of Energy projects that coal sequestration could play a major role in meeting the Bush administration's goal of reducing the intensity of greenhouse gas emissions by 18% by 2012.

Democratic Presidential hopeful Barack Obama of coal rich Illinois has also supported clean coal technology:[24]

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[23] US Department for Energy Report, 2003.

[24] Speech by Senator Barack Obama, 'Energy Independence and the Safety of Our Planet', 4 March , 2006.

> We need to invest in clean coal technology so that we can continue to use our most abundant energy source. We need to act now and make the United States a leader in putting in place the incentives that ensure developing countries also embrace clean coal.

The EU is also adopting a positive attitude towards clean coal, with President Jose Manuel Barroso stressing to an audience in February 2007 the need for "an acceleration of the commercial use of clean coal."[25]

In 2004 the Australian Government produced a White Paper entitled *Securing Australia's Energy Future* which backed the use of clean coal technology with coal from indigenous reserves. The Australians will provide $500 million for a Low Emission Technology fund to help develop cleaner options.[26] ZeroGen (see earlier chapter) is a direct result of this policy push.

In the UK, in February 2005, the Government's Chief Scientific Adviser, Professor Sir David King, stated that it was "critically important" to investigate the technology of "carbon sequestration". Professor King went on to say, "None of us know whether carbon sequestration is feasible but if it is, it is a way of using coal reserves all over the World."[27]

Similarly, Tony Blair has referred to the need to embrace clean coal in speeches both to the Labour Conference and in the House of Commons in 2006. He went further in his support for clean coal in his statement to the Commons following the March 2007 European Summit:[28]

> The single biggest opportunity of developing the technology is the possibility of exporting it to India and China – and America which has huge reserves of coal. Clean coal technology could offer a wholly different future for our own coal industry. Clean coal can be part of the future.

In addition, the UK must demonstrate a firm commitment to clean coal technology if it wishes to influence the behaviour of other nations, such as China and India where rising CO_2 emissions from fossil fuel use will otherwise dwarf any savings made by the UK. It is unrealistic to expect India and China to walk away from their own cheap and accessible coal reserves as they face surges in energy demand.[29] Each year, for example, CO_2 emissions from China are growing by an amount equivalent to the emissions from all power stations in the UK. By 2020 China's consumption of electricity is forecast to six-fold and be some 30 times the size of the UK.

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[25] *Financial Times*, 25 February 2007.

[26] 'Australia stays with Coal', *NATTA Journal*, Jan-Feb 2005.

[27] *Daily Telegraph*, 2 February 2005.

[28] Hansard,12 March 2007, Col 31.

[29] China has proven recoverable coal reserves estimated at 115,000 million tonnes; India has 85,000 million tonnes.

CHAPTER FIVE
SUSTAINABLE FOSSIL FUELS AND RENEWABLES

The Government's renewable energy policy is, at present, over-dependent on wind energy. This imbalance is largely the result of the Renewables Obligation which provides no clear boundary as regards the merits of the various renewable technologies. Therefore, the cheapest option in terms of start up costs – wind power – has been pursued, irrespective of wind's failures on grounds of unreliability and secure energy provision.

The dangers of over-relying on wind power was illustrated on 4 December 2003 when the Irish Electricity Regulator had to take emergency measures to reduce the amount of wind power on the Irish electric grid following major concerns about "the security and stability of the power system".[30]

Michael Laughton, Professor of Electrical Engineering at Queen Mary, University of London has highlighted three key points on wind energy:[31]

- With or without wind generation in the electricity system, security of power supply is governed by the probability of the available plant being able to meet power demand at all times, especially at or near peak periods.
- Wind generation on its own cannot provide a reliable supply of power. It must be backed up by other baseload sources.

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30 *The Irish Times*, 5 December 2003.

31 Professor M Laughton's submission to *REF Response to the Energy Review*, 13 April 2006.

- By way of illustration if 25 GW of wind capacity were to be added to the electricity supply system only 5 GW of conventional plant capacity could be retired. This is because of existing security of supply standards (loss of load probability or LOLP) where in general the capacity credit is of the order of the square root of the GW of wind installed. With a 30% annual load factor this 25 GW of wind capacity would generate annually the same energy on average as 5 GW.

Wind power is also expensive as can be seen from the table below:

COST OF WIND POWER COMPARED WITH CLEAN COAL TECHNOLOGIES

The generating costs from onshore and offshore wind power compared with that from retrofitting advanced supercritical (ASC) boiler technology to existing coal-fired units and from a new integrated gasification combined cycle (IGCC) equipped with CO_2 capture and storage (CCS) are:

	p/KWh
Onshore Wind	3.7
Offshore Wind	5.5
Existing Coal-fired ASC Retrofit	2.0
New IGCC with CCS (Hatfield Project + Centrica/Teesside)	2.8

This comparison assumes wind power operates at a capacity factor of 25%. It excludes the necessary backup costs that would be required for wind power and any costs that might be required to strengthen the electricity grid.

Source: Doosan Babcock Energy, 2006

In addition, clean coal and carbon capture would have a further price advantage if it included the value of enhanced oil recovery (EOR) generated for HM Treasury.

THE RENEWABLES OBLIGATION

The Renewables Obligation is the Government's principal policy instrument to encourage the development of the renewable electricity sector. It is an indirect subsidy system drawing funds from consumer bills, and passing them to renewable electricity generators. This currently amounts to £1 billion a year, and by the end of this scheme will have totalled some £32 billion. This scheme has come under repeated criticism, notably from the National Audit Office, the Carbon Trust and the European Commission. OFGEM has also criticised the Renewable Obligation, concluding that:[32]

> We fully support the Government's aims of reducing carbon emissions and promoting renewable generation but we think there are cheaper and simpler ways of meeting these aims than the RO scheme which is forecast to cost business and domestic customers over £30bn.

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[32] OFGEM, *Renewable Obligations Annual Report 2005-6.*

Proponents of renewable energies such as wind have failed to provide clear answers to the crucial questions concerning reliability, capacity and cost. However, Tony Juniper, the Executive Director of Friends of the Earth has made an important concession:[35]

> Another way of making fossil energy cleaner is to fit carbon-capture technology to new super-efficient coal-burning power stations. Carbon can then be stored below ground in old gas and oil wells, thus preventing emissions to the atmosphere. This technology is new, but it is believed to offer major potential and should be championed urgently.

Would the substantial subsidies that currently go to wind power be better spent on projects such as clean coal on grounds of reliability and cheaper electricity prices for the consumer?

Would the substantial subsidies that currently go to wind power be better spent on projects such as clean coal? The clear benefits would be increased reliability of supply and cheaper electricity prices for the consumer.

A new Sustainable Obligation Certificate (SOC) would allow clean coal and carbon capture and storage to be competitive. Clean coal should enjoy the incentives which are equal to those enjoyed by renewable energy.

David Brewer, Director General of the Confederation of UK Coal Producers, (COALPRO) explains further and starkly concludes:[36]

> The Government's aspiration is to produce 20% of the country's electricity from renewable sources by 2020, up from about 3% today. At best this will merely fill the gap created by growth in demand. Moreover, the great majority of renewable generation will be from wind power which is intermittent, needing support by flexible generation from fossil fuels. Coal burn at UK power stations exceeds 50m tonnes a year and has increased in recent years as gas prices have risen. Coal-fired power stations produce a third of the country's electricity and up to half in winter. Without coal, the lights would go out.

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35 *Yorkshire Post*, 3 January 2007.

36 Correspondence with author, 1 March 2007.

CHAPTER SIX
CONCLUSION

Issues of energy security, the future of our energy dependency and the forthcoming Energy White Paper have rightly pushed energy to the top of politicians' priorities.

UK coal reserves are considerable and accessible but a problem remains for those wishing to invest in the industry. Support from Government, both moral and in policy terms, is crucial for any privately owned industry whose retention is in the nation's security and economic interest.

Such a policy should be in tandem with the implementation of less draconian environmental planning rules for sites of any proposed new mines (deep or opencast), increases in coal investment aid and a genuine embracing in rhetoric and policy of the principle of clean coal technology, coupled with clear intentions to support new clean coal stations.

In addition, if the Government's CO_2 targets are to be met, then support for nuclear energy and for clean coal and carbon capture and storage on a large scale are essential. An early start to this programme is vital.

The government should also recognise that an over-zealous policy in support of renewables can be counter-productive: indeed, it can lead to a *rise* in carbon emissions, as older less efficient stations have to be brought back on stream to plug the gap left by underperforming renewable sources.

One example of this is in Denmark which has the most intense concentration of wind generation in Europe. At peak output the Danish wind farms can account for nearly 64% of Danish peak power demand, but this rarely occurs when it is needed. Last year Danish carbon emissions rose as the Danish grid fell back on older fossil fuel generation to plug the gap left by underperforming wind farms. Danish power stations used 50% more coal than in 2005 to cover wind's failings whilst wind turbines generated 21.7% of electricity, down from 29.4% in 2005. The increase in the demand for coal meant that Danish carbon emissions rose by 36% in 2006.[37]

Encouragingly, in the November 2006 Pre-Budget Report, the Chancellor of the Exchequer announced the Government was launching a new feasibility study for a new infrastructure for carbon capture and storage (CCS) under the North Sea. He announced that the DTI would be appointing engineers ahead of a decision for the UK's first carbon capture demonstration plant. However, two parts of Government are proceeding at a slower pace than the scientists and commercial companies would like. A Government task force (including the DTI and DEFRA) is now examining the case for funding a demonstration plant but the Treasury, which has been stringing CCS along in Budgets and pre-Budget reports for a couple of years, appears to be holding back. The Treasury is working out how to develop and protect an efficient market for CCS. One possible way is to put CCS plants within the EU Emissions Scheme for carbon, giving them an allocation of carbon permits. As these plants will emit only a small amount of CO_2, they could sell their unused quota of carbon to traditional power generators and manufacturers. In this competitive and highly lucrative world of energy technology, Britain must not be left behind because of slow Whitehall decision making. The export potential for the UK is considerable.

The Government has also announced the setting up of an Energy Technologies Institute (ETI) to fund the translation of new energy technologies into industrially useful outcomes that can help the UK face the challenge of future energy shortages and climate change. This new body will focus on clean coal and carbon capture and storage and will come under the Joint Chairmanship of Dr Paul Golby, Chief Executive of E.ON UK and Sir David King. It has committed itself to raising substantial sums of private investment. The DTI has announced that it is prepared to provide £500 million, creating the potential for a £1 billion ETI over 10 years.

Barriers to clean coal technology being embraced and pursued are not technical. The technology exists and has existed for some time. If the Government wishes to genuinely embrace a competitive, market-orientated energy policy which reduces CO_2 and maintains crucial baseload energy provision then it must support clean coal, alongside new nuclear stations. Over-reliance on renewables and imported gas is a recipe for power cuts and price hikes – and consequently the inevitable social and economic implications which, as history has shown, would be almost certain. If Government can set out a strategic policy for nuclear power and renewables, why not clean coal?

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[37] *Energinet* (Danish grid operator journal), February 2007.

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The Centre for Policy Studies was founded by Sir Keith Joseph and Margaret Thatcher in 1974 and is one of Britain's best-known and most respected centre-right policy research centres. Its Chairman is Lord Blackwell, a former Head of the Prime Minister's Policy Unit with extensive business experience. Its Director is Ruth Lea, whose career spans the civil service, the City, and the media (ITN). She was also the Head of the Policy Unit at the Institute of Directors.

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