REVIEW OF THE CASE FOR GOVERNMENT SUPPORT FOR COMMERCIAL SCALE CLEANER COAL DEMONSTRATION PLANT

CONSULTATION RESPONSE BY UK COAL PLC, SEPTEMBER 2001

KEY POINTS:

UK Coal plc

- UK COAL is Europe's largest totally independently owned and most efficient deep-mined coal company.

The UK's growing dependence on natural gas

- In 1990, the remaining lifetime of total UK gas reserves stood at 36 years, by 2000 this had fallen to 14 years, with just 6 years of proven reserves.
- Natural gas is a premium fuel and the UK has depleted its own reserves on a brief foray into power generation.
- Gazprom in Russia and the Iranian National Oil Company, control almost half of global gas reserves.
- The UK, at the end of very long pipelines passing through many countries, would be subject to the highest transportation costs and greatest risk of supply interruption if, as forecast, the nation was to become largely dependent on imported gas.
- The Californians failed to value supply security within their liberalised market and so allowed an over dependency on natural gas without any regard to whether the consumer could afford this over the longer term.

Coal's role in UK energy policy

- Over the coming years, governments must strike a balance between energy security, affordability and environmental objectives.
- Coal offers long-term security and diversity of supply at an affordable cost.
- Any form of carbon taxation or emissions trading would encourage fuel switching away from coal and so reduce the security of energy supplies in the UK.
- There is a logical choice: the UK can either become dependent on gas from Russia and the Middle East, or it can take the clean coal technology route.
- Clean coal technologies can deliver carbon reductions from the ESI sector in a scenario where one third of electricity comes from CO_2 neutral sources (nuclear and renewables), one third from gas and one third from coal. This provides an unprecedented level of energy security and is a route to the "*deep cuts*" demanded by the Royal Commission on Environmental Pollution.
- Government should support a commercial demonstration programme in the UK to showcase the best available clean coal technologies, providing a shop window for the UK power generation exporting industry.
- It is important that the UK does not focus on a single export market, to do so risks imposing inappropriate restrictions on technological development.

Carbon capture and sequestration

- The costs of carbon capture and sequestration are not prohibitive.
- CCTs with carbon sequestration have a large potential to reduce CO_2 emissions at a cost below that of renewables.

A "clean coal obligation"

- UK COAL calls for a "clean coal" or a "sustainables" obligation to support the commercial demonstration of clean coal technologies.
- In terms of value for money, an obligation is the best approach: it is not a drain on public finances, the Government sets objectives, industry competes to meet these cost effectively, and the public benefits with environmental improvements, increased security of supply and affordable energy.
- A clean coal obligation would be entirely compatible with EU rules on State aid and would be the most cost effective means to support a CCT build programme.

Clean coal technologies

- UK COAL believes that the Government should not concern itself with picking technologies, and instead set the targets for technologies to meet within a programme of commercial demonstration plants which would benefit the UK economy and exports.
- If carbon capture and the use of hydrogen as a clean energy carrier are seen as long-term objectives, then this limits which technologies should be developed today.
- It is UK COAL's firm view that only one technology meets both the short-term and long-term environmental and security objectives at an affordable cost: integrated gasification combined cycle (IGCC).
- UCG cannot be considered as a viable alternative to conventional CCTs such as IGCC and electricity generation from CBM in the UK may never amount to more than a few hundred MW.

A commercial deployment programme

- UK COAL has presented the case for a commercial CCT deployment programme to demonstrate a number of technologies, including carbon capture and sequestration. A single demonstration plant would not achieve the energy policy objectives identified.

1 Background

1.1 *UK Coal plc*

1.1.1 UK COAL PLC welcomes the opportunity to respond to this important consultation on the case for Government support for commercial scale cleaner coal demonstration plant.

1.1.2 **UK COAL is Europe's largest totally independently owned and most efficient deep-mined coal company.** The company produces around 20 million tonnes of coal a year from its 13 deep mines and a similar number of surface mines. Over 7,000 people work for UK COAL at 40 locations throughout the United Kingdom, and as many again are employed on contract or in the supply of goods and services.

1.2 *The UK's growing dependency on natural gas*

1.2.1 Over the past two decades, consumption of natural gas in the UK has more than doubled, mainly due to the growing use for electricity generation. However, UK gas reserves are depleting. DTI figures show that we are using gas more quickly than new reserves are being found. **In 1990, the remaining lifetime of total UK gas reserves stood at 36 years, by 2000 this had fallen to 14 years, with just 6 years of proven reserves.** The 1998 White Paper *Energy Sources for Power Generation* (Cm 4071) states that the UK will become a net importer of gas at some point between 2003 and 2009, and import 55-90% of our gas by 2020.

1.2.2 Over 70% of the world's natural gas reserves are concentrated in the Middle East and the Former Soviet Union. Further analysis shows that two companies, **Gazprom in Russia and the Iranian National Oil Company, control almost half of global gas reserves.** These regions are subject to much political instability and uncertainty, yet oil companies wish to bring this gas to Europe with projects such as the $35 billion Yamal pipeline from Siberia. **The UK, at the end of very long pipelines passing through many countries, would be subject to the highest transportation costs and greatest risk of supply interruption if, as forecast, the nation was to become largely dependent on imported gas.**

1.3 *An early warning*

1.3.1 The Californian electricity supply crisis is worthy of examination since it provides an early warning to those countries with liberalised energy policies that fail to provide a balance between energy security, affordability and environmental objectives. In March 2001, the International Energy Agency published a fact sheet *Electricity market reform: California and after* (IEA, 2001a) in which it concludes that the decision of California's legislature in 1996 to maintain retail price controls muffled market signals to the extent that investment in new capacity became inadequate, finally resulting in a series of rolling blackouts. Rapidly rising demand and lengthy licensing procedures exacerbated the situation. The IEA promotes electricity market reforms that provide wholesale trade, non-discriminatory grid access, and a choice of supplier for consumers. By promoting the commoditisation of electricity in markets where commercial forces are allowed to operate freely, we believe the IEA has dangerously oversimplified the fundamentals of energy supply. Whilst some costs are internal to the price of electricity, such as production and supply, there are many external costs that are not, such as environmental impact and supply security (including the economic cost of supply interruptions, and even the cost of military action to protect oil and gas supplies). In California, the restrictive permitting regime has hindered the siting and construction of new power plants on environmental grounds. The only plants which have been built are natural gas-fired CCGT or OCGT (combined cycle or open cycle gas turbine) plants since these have the lowest investment risk profile (*i.e.* shortest payback). **The Californians failed to value supply security within their liberalised market and so allowed an over dependency on natural gas without any regard to whether the consumer could afford this over the longer term.** Today, 46% of Californian power generation is from gas and leaves the State vulnerable to further interruptions and price instability. Here in the UK, the Government forecasts that we will reach this level of dependency before 2005 (DTI, 2000).

1.3.2 **Natural gas is a premium fuel and the UK has depleted its own reserves on a brief foray into power generation.** The efficiency of new, utility-scale, gas-fired CCGTs (49.8% HHV) may look attractive compared to older, coal-fired generation (36.2% HHV) (DUKES, 2001), but this comparison soon turns sour when we look at the alternative uses of natural gas, in small-scale and mobile applications. Micro CHP, using gas turbines or fuel cells, usefully uses nearly 100% of the energy in natural gas (Sulzer, 2001); even a conventional domestic central heating boiler achieves an efficiency of 88% in condensing mode (SAP, 2001). In the transport sector, compressed natural gas (CNG) provides significant environmental benefits especially when compared with Diesel-engined vehicles (no particulates, no sulphur dioxide, and a 90% reduction in oxides of nitrogen); carbon dioxide emissions from petrol-engined vehicles are reduced by around 20% (PowerShift, 2001). The European Commission, in its White Paper on European transport policy for 2010 published earlier this month, argues that natural gas is the most promising road transport fuel in the medium- to long-term, and that hydrogen is in the very long term (COM(2001)370). When viewed from this perspective, burning gas in CCGT power stations appears wasteful; indeed, prior to 1991, an EEC directive prohibited the use of natural gas for power generation. Coal, on the other hand, is ideally suited to large-scale power generation.

1.4 *Coal in the UK today*

1.4.1 **Coal offers long-term security and diversity of supply at an affordable cost.** In the UK, we have at least 50 years of reserves at current production rates and internationally traded coal is available from a variety of politically stable countries. Coal can be easily transported and safely stored. It adds reliability and flexibility to the nation's electricity supply since coal-fired plants can operate as either base-load or flexible plants, responding quickly and efficiently to rapid changes in demand.

1.4.2 The revised Large Combustion Plant Directive (revisions to 88/609/EEC as detailed in C5-0323/2001, the joint text agreed during conciliation of COM(1998)415) will require all UK coal-fired plant to fit flue gas desulphurisation (FGD) equipment by 2008, otherwise their operational life will be limited to 20,000 hours. In addition, the National Emission Ceilings Directive will impose absolute caps on the SO_2 emissions from each Member State.

1.4.3 The Environment Agency (1999), in its decision on SO_2 emissions from oil- and coal-fired power stations, imposed a series of annual reductions on operators in England and Wales, limiting SO_2 emissions to 365 kt by 2005. As an incentive, additional SO_2 emission allowances are available to any operator who makes a firm commitment to retrofit FGD.

1.4.4 In the UK, there are 25 GW of coal-fired plants in operation, roughly one third of the installed capacity (DUKES, 2001). Of these plants, 14 GW have fitted FGD or have plans to install this clean coal technology over the coming years, as summarised in Table 1.1.

Table 1.1 - FGD status in the UK, September 2001

Station	Capacity	Capacity with FGD	Owner	Status
Drax	4.0 GW	4.0 GW	AES	operational
Ratcliffe	2.0 GW	2.0 GW	Powergen	operational
Fifoots Point	0.4 GW	0.4 GW	AES	operational
West Burton	2.0 GW	2.0 GW	TXU	under construction
Eggborough	2.0 GW	1.0 GW	British Energy	EPC contract let
Longannet	2.4 GW	1.2 GW	Scottish Power	call for tender published in OJ
Ferrybridge	2.0 GW	1.0 GW	Edison Mission	S36 consent granted
Fiddlers Ferry	2.0 GW	0.5 GW	Edison Mission	applied to DTI for S36 consent
Cottam	2.0 GW	1.0 GW	London Power (EdF)	applied to DTI for S36 consent
Rugeley	1.0 GW	1.0 GW	International Power	announcement expected
	total	**14.1 GW**		

The above list is not exhaustive, ownership of coal-fired power stations continues to change and it is likely that further plans for FGD will emerge.

1.4.5 With the planned FGD, the UK will be able to consume around 40 million tonnes of coal per year at power stations and remain within its internationally agreed pollutant limits. The whole of the UK coal industry produced around 30 million tonnes in 2000, supplying the industrial, commercial, public and domestic sectors, as well as the much larger power generation market. Existing power stations fitted with FGD are likely to operate for 20 years or more, so providing a market for all the coal that is likely to be produced in the UK in the medium term.

1.4.6 UK COAL is therefore confident that there will be a good market for its coal in the short-term. However, we are deeply concerned about the growing dependency on gas, particularly imported gas, for power generation and the impact this will have on energy prices and UK competitiveness. The continued displacement of coal by natural gas is seen by some as a way to further reduce CO_2 emissions from the electricity sector, perhaps accelerated by carbon trading or taxes. Such a move would be damaging to the coal industry and would lead towards energy insecurity. We have raised these concerns with Government on many occasions over the last five years, most recently with the Cabinet Office's Performance and Innovation Unit. Our determination to see clean coal technologies deployed in the UK arises therefore not for short-term, commercial reasons, but for the long-term benefit of the nation. The coal industry would of course see the benefit of a market extending well beyond 2020, a prospect that simply does not exist with existing power stations.

1.5 *Why clean coal?*

1.5.1 Coal is the most carbon intensive of all fossil fuels and the climate change debate has overtaken many of the previous concerns about criteria pollutants, many of which have been solved. **Any form of carbon taxation or emissions trading would encourage fuel switching away from coal and so reduce the security of energy supplies in the UK.** A draft proposal for an EU directive to introduce carbon trading by 2005, *i.e.* prior to the Kyoto commitment period, is presently at the stage of interservice consultation within the European Commission. A UK scheme, due to start next April, is more advanced and will exclude electricity generators from trading. **Over the coming years, governments must strike a balance between energy security, affordability and environmental objectives.** In this submission, we will show that coal alone provides this balance and that a commercial demonstration programme is crucial to achieving it.

1.5.2 There are a number of project developers hoping to build clean coal power stations in the UK (see Table 1.2). It is only the lack of a suitable support mechanism that prevents these projects from progressing.

Table 1.2 - Clean coal power station projects in the UK

project	developer(s)	size	technology	status/ commissioning date	
Ballymoney, N. Ireland	Aurion	500 MW	CFBC	planning	2004
Dowlais Valley, S. Wales	Progressive Energy	400 MW	IGCC	planning	2004
Kellingley, Yorks.	UK Coal / Texaco	420 MW	IGCC	planning	2005
Kincardine, Scotland	Alstom / Scottish Power	100 MW	ABGC	feasibility	2004
Maltby, Yorks.	UK Coal	45 MW	CFBC	planning	2003
Port Talbot, S. Wales	Acorn Power	900 MW	CFBC	planning	2004
Teesside	Acorn Power	900 MW	CFBC	planning	2004
Wansbeck, N. East	Progressive Energy	450 MW	IGCC	planning	2005
Westfield, Scotland	Global Energy	120 MW	IGCC	CCGT operational	2001
Westfield, Scotland	Global Energy	400 MW	IGCC	planning (reapplied)	2004
	total	**4,235 MW**			

1.5.3 UK COAL has its own plans for a 420 MW IGGC power station at its Kellingley Colliery. We have undertaken a full environmental impact assessment and written an Environmental Statement after consultation with statutory and non-statutory consultees. Engineering and commercial analyses have been carried out jointly with Texaco, the technology supplier, and National Power (now Innogy). This work provides us with a good understanding of the costs and characteristics of IGCC plant, allowing us to write an informed response to the DTI's consultation.

1.6 *Coal in the European Union*

1.6.1 UK COAL notes that industrial, social and energy security objectives are given a high priority within the energy policies of the other EU coal producing countries (Germany, Spain and France) and are a major factor in the high level of subsidies being paid. The EC's proposals for continuation of EU approved subsidies from 2002 to 2010 acknowledges the problems associated with the decline of coal mining and particularly the loss of access to indigenous coal reserves that represent 89% of total EU primary energy reserves (COM(2001)423). Given the EC's desire to maintain a coal mining capacity and capability within the EU, it would seem entirely reasonable that priority be given to the most viable mines, namely those found in the UK. Government support for a commercial-scale, cleaner coal demonstration programme would be a step in the right direction.

2 Coal's Role in Power Generation in the UK

2.1 *Will CCT generated power be able to compete in a market with other fossil fuels such as natural gas? What market price for electricity would need to be obtained for CCT generated power to be competitively viable? What will be the price of gas when indigenous reserves are exhausted? What will be the status of the UK CCT industry at this time?*

2.1.1 Current market liberalisation and regulation policies favour short-termism since electricity prices are driven down to the marginal cost of supply with only limited opportunities for any return on capital investment. IEA Coal Research (Scott, 2001) estimates that for coal to compete in such an environment, there has to be a large price differential (*i.e.* >2.5:1) between the energy costs of gas and coal because of the relatively low capital cost and high thermal efficiency of natural gas fired CCGT power plant. For a coal price of 120 p/GJ, this equates to a gas price of >30 p/therm [1] and suggests that gas prices in the Netherlands, Spain, the USA and Japan are today at a level where new, coal-fired power stations are economically viable (DTI, 2001a). In the UK, CCT generated power would have been competitive with natural gas during the periods of high gas prices seen last winter. However, under current policies, it is unlikely that new, coal-fired plant will be built without some form of Government support. Any new generation capacity built today would be CCGT because of its low capital cost, low technical risk, and lower regulatory risk in terms of meeting any future statutory emission limits, particularly any applying to CO_2. It is difficult to predict just how long gas prices would have to be maintained at elevated levels for investors to decide that CCTs offered an acceptable return for the greater risks.

2.1.2 Since the new electricity trading arrangements (NETA) came into being on 27 March 2001, there has been no "marker" price for electricity as there had been under the pool system. So whilst the average, demand-weighted pool price had been 2.408 p/kWh during its last year of operation, the true value of electricity generated today is not widely known. Even under the pool, "Contracts for Difference" (CfD) between generators and suppliers meant that the pool price was never a true reflection of realised value except for those generating at the margin without contract cover. In its presentation to City analysts for the year ending 31 March 2001, Innogy reported an averaged selling price of 2.684 p/kWh; the production profile from its portfolio of coal- and gas-fired plants would have yielded 2.444 p/kWh from the pool, indicating additional income from CfDs above pool prices and NGC flexibility payments. British Energy, in its annual review for 2000/01, reports achieving an average selling price of 2.25 p/kWh, being 7% below pool price and reflecting the lower unit proceeds from inflexible, base-load generation. Although technically flexible, the high capital cost of CCT plants means that they can really only be considered for base-load generation, so would face market conditions similar to (or, for a single plant, worse than) those experienced by British Energy. Some developers believe that CCT projects are viable with electricity selling prices as low as those achieved by British Energy. However, these are often niche projects using low cost fuel (*e.g.* 50:50 petcoke:coal mixes) and must assume discount rates below what UK COAL believes to be realistic given the technology risk. The financial analysis of our own 420 MWe IGCC project at Kellingley Colliery, based on the well-proven Texaco gasification process, suggests that an electricity selling price of 3.0 p/kWh would be required to make the project commercially viable. The nominal discount rate used in this analysis was 8%, a typical figure for utility-scale investments in the ESI sector (UBS Warburg, 2001). There are two ways in which the cost of electricity from CCT power stations could become competitively viable:

- as seen with CCGTs, the "*learning curve*" leads to capital cost reductions as more plants are built (the International Energy Agency reports a progress ratio of 94% for advanced coal technologies (IEA, 2000a)); and
- guaranteed, long-term, off-take contracts which would allow higher levels of (and also cheaper) debt finance, reducing the financing cost to perhaps 6%.

2.1.3 It is for these two reasons that UK COAL has lobbied for a mechanism to support a programme of 5 GW of clean coal power stations which could result in capital cost reductions of up to 20% and commercially viable plant.

2.1.4 UK COAL believes the DTI has been too optimistic in predicting the future price of gas in the UK. The projections in Energy Paper 68 (DTI, 2000) assume an oil price in the range $10 to $20 per barrel, well below the OPEC target price of $25 (FT, 2001). This assumption feeds through to the low gas prices forecast by the DTI right through to 2020, seemingly ignoring the fact that the UK will become a net importer of gas during this period. In correspondence dated 20 April 2000 with the Confederation of UK Coal Producers, the DTI stated that OPEC "*does not have* *ultimate control over prices*". We disagree: OPEC members have shown over the last 18 months that they can work collectively to control prices by raising or lowering production, and this power will be consolidated as OPEC's share of the world oil market rises from the 26% seen in 1997 to the forecast 41% in 2020 (IEA, 2000b). The price of oil is important since European gas prices are linked to oil prices and, with the opening of the Bacton-Zeebrugge Interconnector, this now has a large influence on UK gas prices as witnessed last winter. In 1998, Transco expected the UK to become dependent on imported gas by 2004/05, but revised this to 2000/01 in its *Transportation Ten Year Statement 1999* (Transco, 1999). The overhang of surplus supply did indeed dissipate last winter when gas flows through the Interconnector were reversed. Ultimately, if current trends continue, UKCS gas reserves will be depleted by 2020 (Transco, 2000). Even this exceeds the current proven reserves to production ratio of 6.4 years given in the *Brown Book* (DTI, 2001b), but is perhaps consistent with the maximum reserves position of 14.2 years. Sometime between these dates the UK will become a net importer of gas, and in Transco's opinion, "*new imports will start earlier and to a greater extent than previously envisaged*" (Transco, 2000). Given this background, we can say with certainty that the UK will have to compete with the rest of the European Union for gas from third countries: initially Norway, then from more distant producers in Russia, North Africa and the Middle East. With the UK at the end of long pipelines from these regions, the likelihood of cheap and secure supplies seems remote. Gas price projections from three sources are compared in Table 2.1. Although the figures cannot be compared directly, because of the different pricing locations, they do highlight the DTI's optimistic view of prices post 2010. Whereas others take account of the significant infrastructure investment needed to ship gas from distant sources, the DTI appears to ignore this.

Table 2.1 - Comparison of gas price projections (1999 money) [2]

source	location	2010	2020
DTI (2000)	UK beach	11.0 - 23.4 p/therm	11.0 - 23.4 p/therm
IEA (2000b)	OECD Europe	14.9 p/therm	24.5 p/therm
EC (1999)	EU	19.2 p/therm	25.0 p/therm

2.1.5 In 1995, the IEA completed a study of gas supply security and presented a cost curve for imported supplies into Europe, reproduced here in Figure 2.1. Above, in paragraph 2.1.1, it was shown that investment would switch into clean coal technologies when delivered gas prices rose above 30 p/therm. This price is shown on Figure 2.1 in 1995 money, netted back to the EU frontier assuming a gas transportation and transit cost of $0.36 /Mbtu (2.4 p/therm) [3]. **There is a logical choice: the UK can either become dependent on gas from Russia and the Middle East, or it can take the clean coal technology route.** The economics favour coal which would also bring a huge security benefit. The environmental impacts of natural gas-fired CCGT and coal-based IGCC are very similar, except for carbon emissions which are discussed more fully below in Section 3.

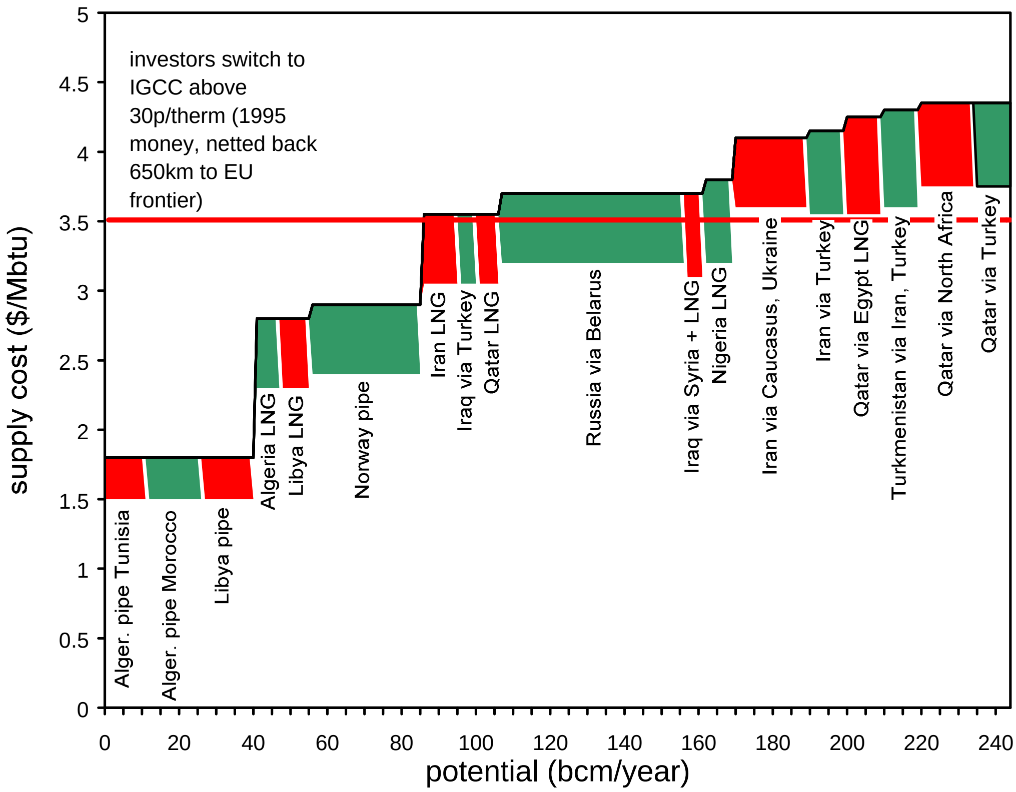

Figure 2.1 - Potential natural gas imports into EU (IEA, 1995)
(*cf* 240 bcm import demand by 2010)

2.1.6 Total EU gas demand by 2010 is projected to be 450 bcm/yr, with indigenous production satisfying 210 bcm/yr and imports supplying the shortfall of 240 bcm/yr (EC, 1999 and IEA, 1995). This will require imports from all the regions shown in Figure 2.1 including expensive liquefied natural gas (LNG); so whilst the average gas price may be as shown in Table 2.1, this hides the very high cost of supplies at the margin. Clean coal technologies will be competitive with these supplies from Russia and the Middle East and the UK should ensure it has an energy policy that reflects this.

2.1.7 The manufacture of power generation equipment is now a global business. It is unlikely that the UK alone could ever again play host to all the manufacturing capabilities and expertise needed to build utility-scale power stations. Success in today's world requires the co-ordination and management of the best resources, technologies and "know how" available, wherever they might originate. The large, multi-national companies who dominate the power generation equipment market recognise this and base their operations in regions of the world that offer the skills required at the lowest cost. The UK, being especially strong in engineering design and development, is attractive to companies wishing to establish design centres. For example, Mitsui Babcock Energy Ltd, a wholly owned subsidiary of Mitsui Engineering and Shipbuilding (MES) of Japan, survives in the UK because of its design engineering and project management skills rather than its manufacturing capability which is not competitive with those found in countries such as China and India where MES also has a presence. Similarly, Alstom must make the best use of its resources located around the world and has no special allegiance to the UK, as demonstrated by its decision in 2000 to move manufacture of large steam turbines away from Rugby. The UK Government has supported various R&D efforts in the clean coal sector with the aim of "pushing" technologies into the market place. Whilst this has not resulted in any new plants or UK leadership in turnkey construction, it has provided pockets of expertise. As a country, we should capitalise on the best of the clean coal technologies available by "pulling" them into the market place. If this demands using technologies developed elsewhere then so be it. The UK's strengths in engineering design, project management and other ancillary services would then be the exportable product and not the technology *per se*. This approach has been accepted already by the UK Government when it granted planning permission to BP's 500 MWe Baglan Bay power station which will be the first commercial demonstration of GE's 'H' technology for CCGT applications. At a press conference following the decision, David Rowe-Beddoe, Chairman of the Welsh Development Agency, saw the deployment of US technology at the Baglan Energy Park "*as a showcase of sustainable development*" and GE Power Systems Chief Executive, Bob Nardelli added that "*the Energy Park can become the core for a new centre of technological excellence in Wales*". Similarly, we believe that the **Government should support a commercial demonstration programme in the UK**

to showcase the best available clean coal technologies, providing a shop window for the UK power generation exporting industry.

2.2 *Given the potential choices for the deployment of other cleaner coal technologies such as UCG and CBM in the UK, is a CCT power plant with emission reduction technology a viable candidate for the future of coal-fired generation? Also, in the longer term do the other more advanced CCT technologies for power generation have greater potential? What are thought to be the relative benefits and costs?*

2.2.1 UCG has been promoted by the Coal Authority and the DTI over recent years as a viable means of recovering the vast coal resources found beneath the North Sea. UK COAL itself holds a licence for coal reserves in the Vale of Belvoir that could not be mined economically from Asfordby Colliery; a technology that allowed future exploitation of these reserves would be of great interest to the company.

2.2.2 In Energy Paper 67 (DTI, 1999) the DTI states that considerable work has to be done before UCG can be considered a commercial system; a ten-year development period would not be unreasonable. UK COAL believes that this development period is overly optimistic. We remain concerned that the fractured geology of UK coal reserves do not favour UCG and that the likely timescale for the development and deployment of UCG is not consistent with the medium-term challenges of energy security, diversity and sustainability that will accompany the depletion of oil and gas reserves in the UKCS. Whilst it is entirely reasonable for the DTI to support long-term R&D activities in this area, the technical hurdles and uncertainty are such that **UCG cannot be considered as a viable alternative to conventional CCTs such as IGCC**.

2.2.3 The best estimate of UK onshore CBM reserves has recently been confirmed to be 30×10^9 m^3, plus a further 107×10^9 m^3 if methane from abandoned mines is included; offshore CBM development has been dismissed as being "*prohibitively costly*" (DTI, 2001c). Onshore CBM reserves are thus potentially equivalent to 8% of the UKCS maximum natural gas reserves of $1{,}630 \times 10^9$ m^3 (DTI, 2001b). This figure suggests that CBM could provide a useful portion of the UK's primary energy needs. However, the practical reality is rather different; CBM projects are not proceeding because of difficulties including:

- poor geological conditions (in particular, low coal seam permeability);
- obtaining planning permission for the large number of wells needed;

- poor returns from the inevitably small-sized projects;
- environmental issues associated with disposal of produced water (though this may be less of a problem in the UK where seams are often dry); and,
- lack of Government support measures.

2.2.4 Whilst technical developments may allow some enhancement to production from CBM wells, it is our opinion that **electricity generation from CBM in the UK may never amount to more than a few hundred MW**. Nevertheless, we would support limited R&D aimed at achieving this potential: for example, application of the latest drilling technologies, biotechnological enhancement, and CO_2 enhanced recovery. In the USA, where tax breaks have encouraged CBM development, annual production from over 8,000 wells reached 34 bcm in 1998, equivalent to one third of the UK's natural gas consumption. The total US CBM resource is estimated to be 4,000 bcm, almost entirely from virgin coal seams. Notwithstanding the favourable combinations of coal seam gas content / permeability found in the USA, and possible biogenic enhancements, the terrain there lends itself to CBM projects having a large number of wells with associated pipeline infrastructure. Attempts have been made to transfer the US experience into the UK but without reported success. The environmental benefits of reducing methane emissions may prove to be more attractive than any economic benefit given that methane is 21 times more potent as a greenhouse gas than CO_2.

2.2.5 There are many technologies that are likely to enhance the performance of clean coal technologies:

- on-going gas turbine developments will boost the efficiency of IGCC plants;
- gas clean-up technologies will improve the environmental performance of IGCC;
- solid oxide fuel cells will increase the efficiency of IGCC plants;
- membrane separation technologies will reduce the cost of IGCC oxygen plants;
- IGCC will become more versatile as fuel-flexible gasifiers are developed; and,
- carbon capture and sequestration will make IGCC the preferred choice.

These technologies cannot all be demonstrated at a single plant; a commercial CCT deployment programme would provide the stimulus for their development.

2.2.6 Costs of commercial-scale CBM, UCG and the more advanced CCTs are uncertain. If Government established a long-term market for CCTs then those with the greatest potential would come forward.

2.3 *Capture and storage technologies raise issues about environmental security (can we be confident that the CO_2 will not escape to atmosphere over time?) and public acceptability – views are sought on the importance and impact of these*

2.3.1 The IEA Greenhouse Gas R&D Programme is best placed to respond to the technical issues, particularly in light of the monitoring work it has sponsored at the Weyburn enhanced oil recovery (EOR) and Sleipner West CO_2 sequestration projects in Canada and Norway respectively (IEA, 2001b). The CO_2 storage options available are certainly secure for hundreds of years, taking us well beyond the fossil era and into a period when atmospheric CO_2 concentrations will have declined to the point when any leakage would be immaterial. Moreover, the risk of CO_2 escape can be viewed simplistically as an economic issue, rather than an environmental issue. Should sequestered CO_2 escape back into the atmosphere, then the effect would not be acute or catastrophic in the way a natural gas or nuclear waste leakage might be. The onus would be to capture an equivalent amount of CO_2 elsewhere to ensure no net change in atmospheric concentration. The original investment in capture and sequestration would thus have been lost - an economic cost that can be heavily discounted since it is a longer-term risk. What this points to in the short-term is a need for sequestration sites that are not costly. EOR offers great potential: since the CO_2 is put to good use in extracting additional volumes of oil, the economic cost of a CO_2 escape are far less than with sequestration technologies that simply store the CO_2 with no associated benefit. In the longer term, as experience and confidence are gained, then more expensive sequestration sites can be considered.

2.4 *Given these issues, do CCTs have a realistic place in the future energy mix? What are the benefits and costs of CCT compared to other sustainable technologies?*

2.4.1 CCTs do have a place in the future energy mix; only a significant reduction in global population or economic prosperity would reduce energy demand to the point where coal was no longer required, a view confirmed by projections from the World Energy Council (WEC, 1998). Without CCTs, the world would use coal less efficiently and with greater environmental damage. If the present consensus on climate change and CO_2 emissions is upheld, then CCTs offer perhaps the only hope that mankind can address this without a severe economic slowdown.

2.4.2 For many, sustainable energy technologies mean simply renewables. This is not the case, as Dr Gro Harlem Brundtland made clear in her accepted definition of sustainability: "*development is sustainable when it meets the needs of the present without compromising the ability of future generations to meet theirs*" (UN, 1987). By this definition, CCTs are certainly sustainable, nuclear is perhaps not. The UK Government has very clearly stated the cost of the forthcoming Renewables Obligation at £312 /tC saved ($128 /t$CO_2$) (DTI, 2001d). This is significantly in excess of the cost of achieving the same objective using CCTs with carbon capture and sequestration. The IEA Greenhouse Gas R&D Programme has studied the costs of capture and storage of CO_2 from power stations and concluded that this is about $50 /t$CO_2$ or less than half the cost of the renewables option (IEA, 2001b). Even this figure might be pessimistic; one developer of IGCC power plants has calculated the marginal cost to be just $20 /t$CO_2$ (Progressive Energy, 2001). In its submission to the Cabinet Office's Energy Policy Review, British Energy estimates the cost of achieving climate change objectives using nuclear technology (British Energy, 2001). The company requests funding for a 10 GW programme of new nuclear build: a £300 million grant to cover the development cost of the first of ten new plants and a 1.0 p/kWh subsidy on electricity sales. With this level of support, British Energy claims new nuclear would be commercially competitive. Many commentators remain sceptical about the £1,000/kW cost used in the analysis (Sizewell B, commissioned in 1994, cost £2.5 billion to build or £2,050/kW) and uncertainty remains about decommissioning and waste disposal costs. The 1.0 p/kWh "carbon-free" obligation proposed by British Energy to support new nuclear plants equates to a CO_2 avoidance cost of $18 /t$CO_2$ to $38 /t$CO_2$ depending on whether new nuclear plants are built in place of new coal-fired plants or new gas-fired plants [4].

2.4.3 The reality is that British Energy's proposal would not reduce the UK's CO_2 emissions at all. The 10 GW of new plants would come on-stream as existing plants are decommissioned such that by 2025, nuclear's share of the electricity market would be 25% - much the same as today. So new nuclear would not, in fact, provide the "*deep cuts*" in CO_2 emissions demanded by the Royal Commission on

Environmental Pollution (2000). With new nuclear, the task is less Herculean, but would still require substantial CO_2 reductions from fossil fuel use.

2.5 *How significant is coal co-fired with other fossil fuels viewed as a future concept, e.g. with heavy oil, natural gas, and, of course, blends of multi-sourced coals?*

2.5.1 The Government's energy policy is frequently summarised as one of ensuring secure, diverse and sustainable energy supplies at competitive prices. Power stations that can co-fire a number of different fuels from different sources, clearly add to security and diversity and are therefore a positive benefit to the nation. Perhaps more significant is the ability of multi-fuelled plants to provide a hedge against price shocks or price manipulation by the actions of dominant suppliers (*e.g.* Gazprom or the Iranian National Oil Company) or supplier cartels (*e.g.* OPEC). Fuel switching in the electricity sector is the only significant means available to protect consumers against high energy prices. The transport sector is tied inextricably to oil, the domestic sector to gas for its heating needs, and only limited fuel switching is available to industry, mainly in the form of back-up heavy fuel oil. Outside the electricity sector, there are few who can profit from the arbitrage opportunities presented when fossil fuel prices fall out of line, *i.e.* the relative prices of coal, heavy fuel oil, natural gas, Orimulsion and petcoke.

2.5.2 In 2000, we witnessed electricity generators take such an opportunity when, with high gas prices, the past trend of rising output from gas-fired stations came to an abrupt halt and coal-fired output increased (+15%). Whilst the UK's portfolio generators can do this in an oversupplied market (the National Grid Company (2001) shows a 26% plant margin) by taking their plants into or out of service, this is not an option as plant margins are eroded in liberalised markets (as experienced in California). Only fuel-flexible plant can then respond to and eliminate the arbitrage opportunities. The newest plants in the UK (gas-fired CCGT) are inherently inflexible and provide no protection against high electricity prices.

2.5.3 Power stations designed to run on any fossil fuel thus provide significant economic benefits to all energy consumers by stabilising prices at the lowest possible level. However, governments must be wary of allowing opportunities to be exploited without regard to the environment. For example, allowing natural gas to be burnt at existing coal-fired power stations with an efficiency of 38% or less when CCGTs operate at around 50% efficiency is an unquestionable waste of a premium fuel, a view upheld by Government in the *Energy Sources* White Paper (paras.9.56 to 9.61 in Cm 4071); and burning petcoke in a pf plant may have an undesirable environmental impact. Fortunately, a technology exists that allows all the fossil fuels to be converted into electricity cleanly and at the highest possible efficiency: Integrated Gasification Combined Cycle (IGCC).

2.6 *How significant is coal co-fired with non-fossil fuels viewed as a future concept - e.g. biomass, waste and noxious materials etc.*

2.6.1 UK COAL believes that coal can provide a useful support fuel to processes that convert biomass, waste, sewerage sludge and other noxious waste materials into electricity using small-scale gasification or pyrolysis processes. The eventual commercialisation of these processes will hopefully provide solutions of the highest environmental standard to the growing problem of waste disposal, although it is doubtful whether biomass will ever be a significant source of electricity (ETSU, 2001). The potential exists to consume waste and biomass in large, utility-scale plants and so convert their energy into electricity with higher efficiency than at small-scale plants (*i.e.* >40% compared with <30%). The most appropriate technology available for this is the British Gas Lurgi gasification process since it requires a briquette feedstock which can be manufactured from almost any material, including waste. This then brings all the benefits of IGCC to co-utilisation of non-fossil fuels. UK COAL believes technologies such as that proposed by Global Energy at Westfield, Scotland should be supported by Government as part of a wider strategy to introduce clean coal technologies.

3 Cleaner Coal Generation and the Environment

3.1 *In the context of the UK's growing need for secure and diverse energy supplies in the future and the emerging alternative sustainable sources of energy, will CCT power plant effectively contribute to the Government's objectives of reducing CO_2 emissions to atmosphere in the longer term?*

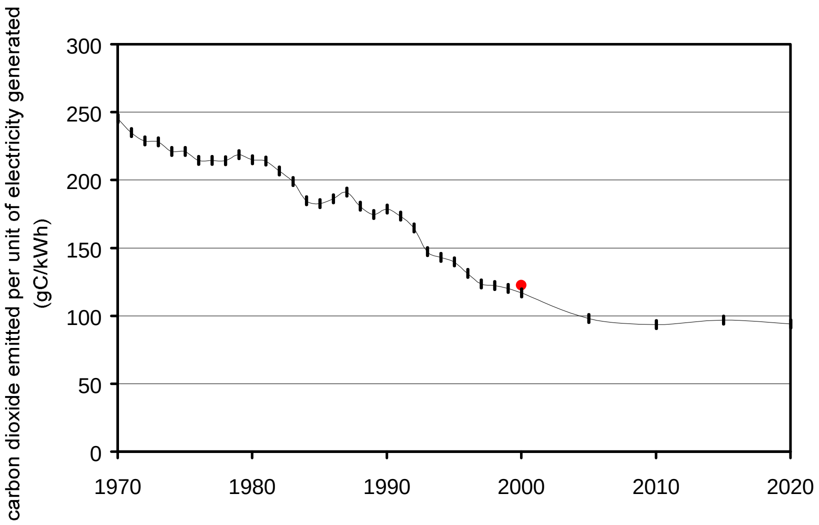

Figure 3.1 - ESI sustainability indicator (DETR/DTI, 2000) • 2000 outturn

3.1.1 Figure 3.1 shows how there has been a steady decline in the quantity of CO_2 emitted per unit of electricity generated over the last 30 years. The projection to 2010 comes from the UK's Climate Change Programme (DETR, 2000), itself based on an average of the Central Low and Central High scenarios found in Energy Paper 68 (DTI, 2000). In meeting its Kyoto targets, Government assumes that 54% of electricity will be generated in gas-fired power stations, with just 16% coming from coal. This continuation of the 1990s' "*dash for gas*" may help the UK meet targets proposed under the Kyoto protocol, but does nothing for supply security, diversity or competitiveness in the face of a future dependency on gas delivered through long pipelines from Russia, the Middle East and North Africa. We note that the Climate Change Programme has already moved off-target with the rise in CO_2 emissions during 2000. Fortunately, there are viable alternatives to the Climate Change Programme. Table 3.1 shows one where coal continues to underpin one third of electricity supplies: 16% from existing coal-fired stations fitted with FGD, 11% from 5 GW of new CCT power stations, and 7% from 3 GW of advanced CCT stations with carbon capture and sequestration. Carbon emissions from the electricity generation sector are the same as for the Climate Change Programme in the "Vision for Coal" scenario which also assumes a successful renewables programme or some nuclear renewal. In the longer-term, probably by 2025, existing coal-fired power stations would begin to be replaced by new CCT, thus allowing a continued downward trend in carbon emissions. By 2050, all coal-based plant would have carbon capture and sequestration to provide the 60% reduction in CO_2 emissions demanded by the RCEP (2000).

Table 3.1 - Carbon dioxide emissions from ESI in 2010

Sector	Emission factor gCO_2/kWh (gC/kWh)	Energy Paper 68		Vision for coal	
		supply TWh (%)	carbon emissions MtC	supply TWh (%)	carbon emissions MtC
nuclear / renewable	0	116 (30%)	0	127 (33%)	0
gas	390 (106)	205 (54%)	21.8	127 (33%)	13.5
coal	850 (232)	60 (16%)	13.9	60 (16%)	13.9
CCT	640 (175)	0	0	40 (11%)	7.0
CCT + C seq. [5]	170 (46)	0	0	27 (7%)	1.3
total	344 (94)	381 (100%)	35.7	381 (100%)	35.7

3.1.2 **Clean coal technologies can deliver carbon reductions from the ESI sector in a scenario where one third of electricity comes from CO_2 neutral sources (nuclear and renewables), one third from gas and one third from coal. This provides an unprecedented level of energy security and is a route to the "*deep cuts*" demanded by the Royal Commission on Environmental Pollution (2000).**

3.2 *How could CCT compare with other alternative technologies in terms of the cost per tonne of green house gas emissions avoided?*

3.2.1 Euriscoal, the trade association which represents UK COAL and other coal interests at the European level, has worked with the European Solid Fuels Association (CECSO) to inform the European Commission during the development of a European Climate Change Programme (COM(2000)88). In their joint position paper (Euriscoal/CECSO, 2000), the costs of alternative technologies and means of reducing CO_2 emissions are compared. Figure 3.2 presents a summary of their findings, clearly showing that **CCTs with carbon sequestration have a large potential to reduce CO_2 emissions at a cost below that of renewables**. ETSU, energy advisors to Government, has also published a schematic cost curve showing the greater potential of clean coal technologies in relation to renewables. UK COAL has not attempted to replicate the lengthy calculations carried out by our European partners nor to quantify the work of ETSU, but expects that the DTI would wish to produce its own, cost curves to inform Government as a whole, beginning with the \$128 /tCO_2 cost of the Renewables Obligation.

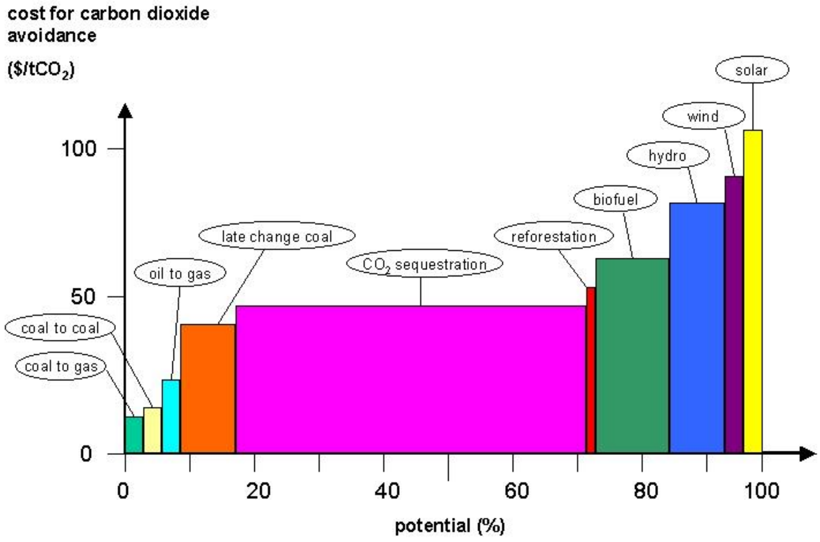

Figure 3.2 - Cost and potential of options to reduce CO_2 emissions (Euriscoal/CECSO, 2000)

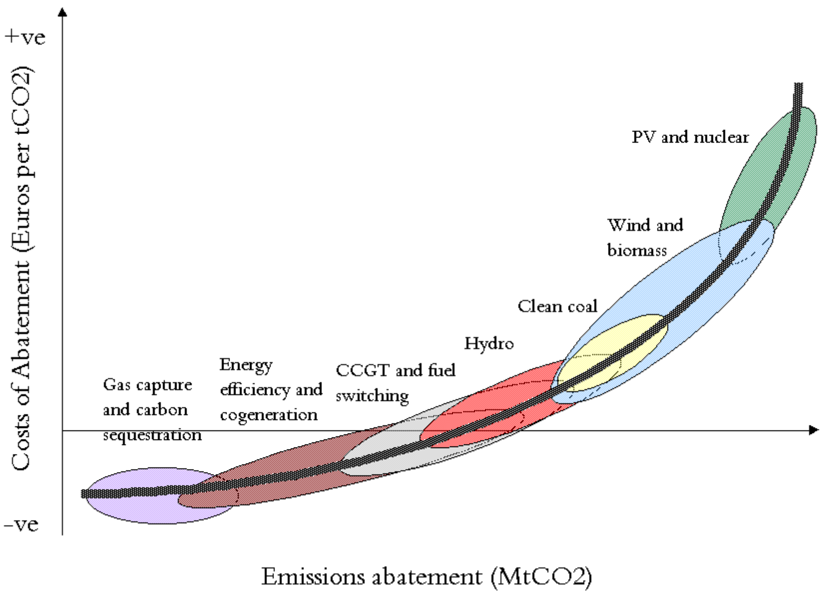

Figure 3.3 - Schematic cost-abatement curve for greenhouse gas abatement (ETSU, 2000)

3.3 *Is CO_2 capture and storage an appropriate technology for preventing CO_2 emissions to atmosphere? Would the costs of this be prohibitive compared to other sustainable technologies?*

3.3.1 CO_2 capture and storage is a proven technology to prevent atmospheric CO_2 emissions. In the UK, it is an appropriate technology to consider since CO_2 has an economic value to those oil companies wishing to enhance oil recovery from depleted North Sea oil wells. It is difficult for UK COAL to estimate this economic value. However, we are able to make a broad assessment here. The BP Forties field is nearing the end of its life with a target recovery rate of 62%. BP believes this could be increased to 70% with EOR to yield an additional 336 million barrels of oil (BP, 2001b). Assuming an EOR project was classed as a new development such that BP was not required to pay royalties or Petroleum Revenue Tax, then the UK Treasury would receive just the Corporation Tax on any profits. In 2000, BP Exploration and Production made an operating profit of $14,012 million before special items, on production of 1.2 billion barrels of oil equivalent, or about $12 per barrel. If we take just one third of this and assume that a Forties EOR project could yield a profit of $4 per barrel, then the value to the Treasury would be in the order of £300 million. This alone justifies Government investment in a 400 MW IGCC plant to supply the 2 million tonnes of CO_2 needed each year.

3.3.2 We have demonstrated above that **the costs of carbon capture and sequestration are not prohibitive**. However, it will require the co-ordination and support of Government to achieve anything meaningful in this area.

4 Potential for UK Manufacturing and Exports

4.1 *Given the relative absence in the UK of coal-fired build over the last twenty or so years, could the construction of a new generation of CCT coal-fired power stations provide a stimulus for UK industry, or will much of the equipment be imported?*

4.1.1 Power generation is an international business and UK companies contribute at many levels, including: project development, engineering design and consultancy, equipment supply, project management, civil contracting, operations and maintenance, banking, legal services and insurance. No UK company of any significance, depends solely on the home market. The absence of new coal-fired build since the final commissioning of Drax in 1986 may have disadvantaged an industry unable to showcase new technologies, but the industry has continued to win overseas business. The Power Generator Contractors Association estimates that the industry, as a whole, directly employs 150,000 in the UK and has a turnover of £13.6 billion per year. A programme of commercial demonstration projects would allow the industry to showcase new technologies and to maintain its capability at the forefront. Successful projects are likely to be led by UK project managers and system designers, with equipment sourced from international suppliers, including many in the UK. Many of the dominant players have design centres and manufacturing facilities in the UK. These companies are multi-national, some are listed on more than one stock exchange with head offices located for fiscal convenience and all have offices and factories dotted around the world. The Government should recognise this global system and not attempt to recreate an era when Britain could manufacture anything.

4.2 *Does the UK have real export opportunities here in the future, particularly in Asia?*

4.2.1 The market for new coal-based plant in Asia is potentially vast but is not the only market. **It is important that the UK does not focus on a single export market, to do so risks imposing inappropriate restrictions on technological development.** For example, North America continues to be a major consumer of coal for power generation and operates many plants that are old and relatively inefficient. The replacement market there over the next 20 years will be significant, but will demand different technologies than the Asian market.

4.2.2 The International Energy Agency (IEA, 2000b) estimates a world market for new power stations totalling $2,922 billion between 1997 and 2020. Of this, it is estimated that $460 billion will be invested in new, coal-fired plants. The UK currently has a 11-12½% share of the global market and so could expect earnings of the order of over $50 billion over the next 20 years, providing it maintains its competitive position. The ability to demonstrate technological leadership will be critical; a commercial demonstration programme will be central to this.

4.3 *Are there specific CCT technology areas which the UK has particular strengths in which a CCT demonstration project would help develop?*

4.3.1 The UK does have strengths in specialist areas of power generation equipment design, *e.g.* the application of computational fluid dynamic (CFD) techniques to steam and gas turbine blade design; low emission combustor design for both pf boilers and gas turbines; high temperature materials, including catalysts; and, expertise in the design and optimisation of gasification systems. A commercial demonstration programme would undoubtedly develop these strengths further. However, Government must not attempt to prescribe technologies to demonstrate based on UK strengths. This has failed in the past with the Advanced Gas-cooled Reactor programme and the Air Blown Gasification Cycle development, and would fail again. It is important to set agreed objectives and allow industry to meet these in the most cost effective manner.

5 Options for CCT Demonstration Plant

The Case for Demonstration Plant and for Government support.

5.1 *Given there are a range of possible options to encourage development of CCT generation, is the use of demonstration plant the most appropriate approach to encouraging the development and deployment of this technology in the UK? Views on alternative approaches and their advantages and their disadvantages would be welcome.*

5.1.1 **UK COAL calls for a "clean coal" or a "sustainables" obligation to support the commercial demonstration of clean coal technologies.** This is necessary to ensure that the UK does not become over dependent on natural gas. This is a short- to medium-term concern that demands solutions using technologies available today. There are also longer-term considerations that demand further increases in plant efficiency and environmental performance, the adoption of carbon capture and sequestration, and a possible move towards hydrogen as a clean energy carrier. We support the use of demonstration plant to pursue these longer-term objectives, but believe that the shorter-term, energy security objectives are best met under a framework support mechanism that encourages competition to meet Government criteria. In the case of IGCC, even the longer term objectives could be met via an obligation since there is little in the way of technological development required.

Government Support for Demonstration Plant

5.2 *Would the use of Government assistance contributing to the costs of building demonstration plant be cost effective? Would there be other financial arrangements which would be equally cost effective?*

5.2.1 Capital grants to demonstrate advanced clean coal technologies are an obvious method of Government support. UK COAL believes that alternative methods would be preferable: mechanisms that create a competitive market. The Renewables Obligation is a good model to examine. By offering long-term certainty, such an obligation creates an attractive environment for investment, including investment in advanced technologies that carry high risk. An obligation buy-out of 1.0 p/kWh would attract a host of clean coal technology projects, advanced technologies with carbon capture and sequestration may or may not require a greater buy-out. **In terms of value for money, an obligation is the best approach: it is not a drain on public finances, the Government sets objectives, industry competes to meet these cost effectively, and the public benefits with environmental improvements, increased security of supply and affordable energy.**

5.2.2 The US Government has supported the development of clean coal technologies in recognition of the fact that coal is the most abundant and lowest cost energy source for power generation, supplying 56% of the nation's electricity. After the 1970s' oil price shocks, coal R&D expenditure exceeded $1 billion per annum, mainly on coal conversion technologies. More recently, during the early 1990s, the US Government has supported a $5.7 billion CCT demonstration programme to which the Department of Energy (DOE) contributed $1.9 billion. The DOE's budget for coal and power systems R&D in 2002 is $244 million.

5.2.3 This year, the Bush Administration has authorised further DOE support under the Clean Coal Power Initiative which will include demonstration. $150 million has been authorised for 2002 which is in addition to the $244 million referred to above. The Administration's intention is that the $150 million is the first tranche in a 10 year programme that will see the DOE invest $2 billion in CCT, with industry investing at least as much again.

5.2.4 Research, development and demonstration is not the only means of CCT support envisaged in the USA. Two bills have been dropped before the 107th Congress: the National Electricity and Environmental Technology (NEET) Bill (S.60) and the Energy Security and Tax Incentive Policy Bill (S.596). The NEET Bill proposes a number of measure to support commercial demonstration in the newly competitive electricity markets where companies have become risk averse:

- An extension of the DOE funded R&D programme with new funding of $100 million per year between 2002 and 2012 to be matched by industry. Eligible projects would be those over 50 MW that achieve >3% efficiency improvements, significant reductions in SO_2, NO_x and mercury, or new means of recycling coal ash. NEET identifies near-zero emission plants as the ultimate goal.

- To provide tax credits equal to 10% of the capital cost of retrofitting, repowering or renewing existing coal-based plants over 300 MW to improve efficiency and protect the environment along with a generation credit of 0.34 c/kWh. Only projects achieving >38% efficiency (HHV) and a 2%age point improvement over existing plant would qualify.

- To provide tax credits equal to 10% of the capital cost that encourage the early commercial application of advanced CCTs. Projects must be located in the USA and would be selected by competitive solicitation. In addition to the tax credit, qualifying advanced CCT projects would receive production credits over a 10 year period ranging up to 1.2 c/kWh for those with the very highest efficiency (>46.2% HHV). A financial risk pool, backed by the US Treasury, would be available to offset contingency costs of up to 5% where design performance is not achieved.

5.2.5 The Energy Security and Tax Incentive Policy Bill aims to promote the efficient use of energy in many sectors of the economy, including incentives for the early commercial application of advanced clean coal technologies and for the capture of coal mine methane. The tax credits, production credits and risk pool are largely as for the NEET Bill, although different generating capacity limits are proposed for the tax credits:

maximum aggregate capacity eligible for tax credit	clean coal technology	target efficiency to qualify
2,000 MW	advanced PF or AFBC	>36.0% HHV
1,000 MW	PFBC	>40.6% HHV
5,000 MW	IGCC	>40.0% HHV
2,000 MW	other	>15% carbon reduction*

*compared with conventional technology (*i.e.* <36% efficient and <900 g/CO_2/kWh)

5.2.6 A tax credit of $1.21 per million BTU (8.6 p/therm) is proposed for the capture of coal mine methane at working coal mines.

5.2.7 US funding of CCT R&D is, without question, very substantial and we would not expect the UK Government to match this. Nevertheless, it highlights the problem faced by UK research and development teams who receive just 2% of what is available to their US counterparts. UK COAL believes that a clean coal obligation could be designed to meet similar objectives to those proposed in the US bills, but without being so prescriptive. For example, obliging electricity suppliers to purchase specified quantities of electricity from clean coal sources that, in aggregate, meet agreed environmental objectives would be more cost effective. The maintenance of coal within the generation mix would be justified on security grounds, in much the same way that renewables are guaranteed a share on environmental grounds.

5.2.8 Our call for a clean coal obligation, or a sustainables obligation that allows support of clean coal technologies, has been dismissed by some observers as being incompatible with EU rules on State aid. This is not the case; the UK Government has it within its power today to implement a clean coal obligation that would meet both the spirit and the legal interpretation of the Treaty establishing the European Community.

5.2.9 An existing provision within Directive 96/92/EC on common rules for the internal electricity market (article 8.4) provides the opportunity for the UK Government to support electricity generated from indigenous coal in order to protect energy security. This article allows support to be given for up to 15% of the overall primary energy necessary to produce electricity consumed in any Member State.

5.2.10 In addition, the European Court of Justice has ruled that an obligation on electricity suppliers to purchase at minimum prices does not constitute State aid, even where this obligation is imposed by statute (Preussen Elektra AG (now EON AG) v Schleswag AG in Case C – 379/98 determined 13 March 2001). This case concerned the allocation of additional costs of wind generated electricity. The Court found that the allocation of costs by way of a statutory obligation on suppliers gave an undeniable advantage to certain undertakings, but did not have the characteristics of State aid within the meaning of the Treaty since it did not involve a direct or indirect transfer of State resources. The Court also examined whether the obligation met the spirit of the Treaty. It agreed that such obligations were capable, at least potentially, of hindering intra-Community trade, and so were not in accord with the Treaty. However, since they are aimed at protecting the environment by contributing to the reduction of greenhouse gas emissions, such obligations are justified to achieve priority objectives of the Community under the Treaty's environment chapter.

5.2.11 Given the above, we believe that **a clean coal obligation would be entirely compatible with EU rules on State aid and would be the most cost effective means to support a CCT build programme**.

5.2.12 Whether it would require primary or secondary legislation to implement a clean coal obligation is not important. However, Section 70 of the Utilities Act 2000 would perhaps allow Government to implement an obligation based on energy efficiency targets.

Objectives of Demonstration Plant

5.3 *Are these objectives the right ones? Should they be modified, added to or are some not relevant to the purpose of demonstration plant?*

5.3.1 UK COAL would add the following objective:

- To provide a clear route towards the technology solutions that will be needed in the long-term.

5.3.2 Reference must be made to the energy policy review being conducted by the Cabinet Office's Performance and Innovation Unit. **If carbon capture and the use of hydrogen as a clean energy carrier are seen as long-term objectives, then this limits which technologies should be developed today.**

5.3.3 We would also warn against focussing on particular export markets (see section 4 above).

5.4 *Given these objectives, is demonstration plant the most appropriate approach or would alternative approaches achieve the same results?*

5.4.1 There are other means of achieving the objectives. For example, there are many proponents of a carbon tax. This would stimulate investment in carbon reduction technologies but ignores the wider energy policy issues of security and affordability. To meet all the Government's energy policy objectives demands a clearer statement of what these are. *Secure, diverse and sustainable energy at competitive prices* are well-founded objectives but should be quantified and valued. For example, a security premium would value coal, and diversity would be assured if the Government imposed limits on the fuel mix for power generation. These issues go well beyond the terms of reference of the cleaner coal demonstration review; UK COAL has made submissions to the PIU and urges the DTI to recommend actions that are consistent with the thinking of the energy policy review team.

The options for demonstration Plant

5.5 *Which of the options considered above would be the most commercially and technically feasible as a generation plant meeting the criteria described at the start of this section? What risks, both technical and commercial, are associated with each option?*

5.5.1 **It is UK COAL's firm view that only one technology meets both the short-term and long-term environmental and security objectives at an affordable cost: integrated gasification combined cycle (IGCC).** This is a view echoed in a recent United Nations report on sustainability written to inform Rio+10 (UNDP, 2000). It is an erudite report written by some of the world's leading energy experts, including, from the UK, John Baker (ex CEO National Power) and Dennis Anderson (Professor of Energy Policy and Technology at Imperial College). Whilst quite lengthy (almost 500 pages) it contains a view on coal gasification in Chapter 8 closely aligned with our own, a view reflected by the combined judgement and scrutiny of the Editorial Board in their overview of the report. For convenience, we have included a copy of the relevant chapter with this submission.

5.5.2 Conventional coal-fired steam plant is based on the Rankine cycle - a technology reaching the natural limits of its development potential. It is only the vested interests of a handful of boiler manufacturers who promote its continued development using exotic materials that may or may not be proven over the next decade. UK COAL is aware that the materials being developed are not suitable for use with the higher chlorine coals mined in the UK.

5.6 *What variants of these technologies would be most appropriate as demonstrators and which would be the most effective environmentally as a model for a CCT plant?*

5.6.1 The Government should support commercial demonstration of technologies that meet the stated criteria. Variants including IGCC bring the following benefits:

- IGCC builds on the success of gas turbines for power generation and is fully compatible with fuel cells.
- 40-45% efficient today, potential to reach 50% in the near term and >60% in the longer term (US Vision 21 programme).
- Pollutant emissions comparable to natural gas fired CCGT.
- IGCC allows coal to form part of a balanced energy portfolio AND achieve significant CO_2 reductions (25% less than conventional coal-fired plant).
- Fuel flexibility provides arbitrage opportunities between coal, petcoke, Orimulsion and natural gas at a single plant.
- CO_2 can be removed efficiently from syngas prior to combustion.
- Removal of CO_2 leaves a hydrogen rich gas – fuel for the future.
- Gasification technology provides a clean disposal route for many difficult wastes: municipal solid waste, sewage sludge, plastics, refinery residues.

5.7 *Are any of the other CCT technologies considered to be as viable?*

5.7.1 Adding hydrogen to natural gas, provides a means to reduce carbon emissions from gas usage. The hydrogen can be supplied from coal gasification so adding to diversity and security in sectors that would not otherwise use coal. Hythane, as the mixture of hydrogen and methane is called, offers a logical route forward to less carbon intensive energy systems.

5.8 *As a demonstrator which would provide the best value for money in terms of promoting the wider use of cleaner coal power plant, provide the greatest benefits for the UK economy and give potential for export sales?*

5.8.1 **UK COAL believes that the Government should not concern itself with picking technologies, and instead set the targets for technologies to meet within a programme of commercial demonstration plants which would benefit the UK economy and exports.** We acknowledge that some routes will favour particular companies who are able to design and manufacture particular components, but UK energy policy objectives should transcend the interests of individual companies. In section 4, we explain the global nature of the power generation industry and the variety of UK companies that are involved. The Government should ensure the nation's long-term objectives are met, not the short-term interests of a handful of manufacturing companies.

Timescales

5.9 *Views are sought on the timescales for each of the options considered viable, from the decision to build a demonstrator to the start of commercial deployment of the technology?*

5.9.1 The Kellingley IGCC project plan includes a 30 month construction programme which could commence within 6 months of a decision to proceed. This 3 year timescale assumes all consents are given in a timely manner which is entirely feasible given that we have completed an environmental impact assessment and have the support of Local Authorities.

5.10 *For each of the options considered viable, views are sought on the estimated costs of building demonstration plant and its associated operating costs.*

5.10.1 We are not able to provide this information in a public document, but would be happy to assist the DTI in estimating these costs. Published costs can be inaccurate and misleading. A clean coal obligation would avoid the Government having to make detailed cost assessments since these would be left to the market; it would only be necessary to set a buy-out price that correctly valued the benefits.

5.11 *Are there any other significant issues that should be taken into account not covered here? If so what are they and how do they contribute to the case for a CCT demonstration plant?*

5.11.1 **UK COAL has presented the case for a commercial CCT deployment programme to demonstrate a number of technologies, including carbon capture and sequestration. A single demonstration plant would not achieve the energy policy objectives identified.**

5.11.2 Any analysis of energy security must now include quantifying the risk of terrorist attack.

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7 Notes

[1] Coal is traded on a net CV basis (lower heating value) whereas gas is traded on a gross basis (higher heating value). A coal price of 120 p/GJ is therefore equivalent to a gas price of 12 p/therm:

$$120.0 \text{ p/GJ (net)} \equiv 114.3 \text{ p/GJ (gross)} = 12.1 \text{ p/therm (gross)}$$

[2] The table below presents the original source pricing data and assumptions made to convert this into the values shown in Table 2.1. The average US$-Sterling exchange rate in 1990 was $1.79, and 1990 prices have been inflated using the UK Retail Price Index.

source	location	year	1990 $	1990 £	1999 £
DTI (2000, p.20	UK beach	1999			14.0 p/therm
LO/HI scenarios)		2010			11.0 - 23.4 p/therm
		2020			11.0 - 23.4 p/therm
IEA (2000b,	OECD Europe	1997	$90.5 / toe	12.74 p/therm	16.7 p/therm
pp.39 & 137		1998	$79.2 / toe	11.15 p/therm	14.6 p/therm
ref. scenario)		1999	$67.3 / toe	9.47 p/therm	12.4 p/therm
		2010	$80.9 / toe	11.39 p/therm	14.9 p/therm
		2020	$132.8 / toe	18.70 p/therm	24.5 p/therm
EC (1999, p.27	EU	1990	$15.2 / boe	14.64 p/therm	19.2 p/therm
ref. case)		2010	$15.2 / boe	14.64 p/therm	19.2 p/therm
		2020	$19.8 / boe	19.07 p/therm	25.0 p/therm
BP (2001a,	EU cif money	1990	$2.82 / Mbtu	15.75 p/therm	20.6 p/therm
p.29)	of the day	1997	$2.65 / Mbtu	16.18 p/therm	17.0 p/therm
		1998	$2.27 / Mbtu	13.70 p/therm	13.9 p/therm
		1999	$1.73 / Mbtu	10.69 p/therm	10.7 p/therm
		2000	$2.85 / Mbtu	18.80 p/therm	18.3 p/therm

1 toe = 396.83 therms; 1 boe = 58.0 therms; 1 Mbtu = 10 therms

[3] The IEA estimates transportation costs of $0.40 per Mbtu per 1000 kilometres for a 10% discount rate and transit fees of $0.14 to $0.17 per Mbtu per 1000 km through "friendly" countries (IEA, 1995, p.66). Assuming an average transportation distance of 650 km within the EU, and an average transit fee then the delivered gas price would be at least $0.36 /Mbtu above the border price.

30 p/therm in today's money is equivalent to 25.8 p/therm or $3.87 /Mbtu in 1995 money (RPI adjustment equivalent to an average annual inflation of 2.5%) or $3.51 /Mbtu after deducting the transport and transit cost.

[4] A 1.0 p/kWh buy-out is equivalent to the following CO_2 avoidance costs:

sector	emission factor (gCO_2/kWh)	cost $/t$CO_2$
coal	850	18
natural gas	390	38
nuclear	0	∝
2000 average	450	33

[5] There are three promising means of capturing CO_2: chemical, physical and CO_2/O_2 recycle. Here, we assume an IGCC plant using the physical Selexol process to remove CO_2 from the syngas following a shift reactor to give the higher CO_2 concentration needed for the Selexol solvent to work effectively. The process removes about 90% of the CO_2, but some of this is removed with the H_2S and is eventually emitted to atmosphere. The Claus sulphur recovery unit of an IGCC plant also emits CO_2 and, with the additional power consumption associated with CO_2 removal and compression, results in an avoided CO_2 emission reduction of 78%. For an IGCC having a less than ambitious efficiency of 40%, this gives an emission factor of 170 gCO_2/kWh (46 gC/kWh).