

# Coal in a Balanced Energy Policy

## A topical briefing paper from the Confederation of UK Coal Producers

Modern societies demand uninterrupted supplies of energy at affordable prices. The UK is no exception; Government must have a long-term strategy to secure our energy needs, alongside short- and medium-term policies that should be continually revisited and, if necessary, revised in the light of actual events. In the past, economic and social considerations dominated, but today, the principles of sustainable development mean that environmental considerations often carry an equal weight in the energy policies of many countries. Indeed, the Prime Minister has pledged to “*put the environment at the heart of Government*”. However, when considering energy policy options, the total impact of UK Government decisions must be considered. All too often, there is a focus on the emissions from fossil fuels at the point of use, and yet energy supply options have a wider impact, extending well beyond UK borders in the case of imported energy supplies.

The Confederation of UK Coal Producers (COALPRO) believes that UK energy and environment policies must respond to the global challenges faced, based on a rational analysis of the impacts and possible mitigation measures. Current energy policy is UK-centric, optimistically assumes that liberalised energy markets will deliver all policy objectives, and is able to report good environmental metrics by fortune rather than by design. The decline of heavy industry has reduced national emissions of pollutants and greenhouse gases, but emissions from developing nations have risen as we import more of their goods. In essence, we have simply exported our pollution, with no net gain for the global environment.

Over the next few decades, fossil fuels are likely to dominate the energy scene, much as they do today – accounting for over 85% of world primary energy supply. Renewables will grow from a small base, there might be an expansion of nuclear and new energy sources may be harnessed; but, to meet rising demand there will continue to be a heavy reliance on fossil fuels. The implications of this are clear: to stabilise global emissions of carbon dioxide (the most significant greenhouse gas) will require massive changes to the way we use fossil fuels – not only improved efficiency, but large-scale carbon dioxide capture and geological storage. To this end, the UK must demonstrate leadership in those technologies that reduce the impact of fossil fuel use if the worst predicted consequences of global warming and climate change are to be avoided.

COALPRO believes that uninterrupted supplies of energy at affordable prices can only be achieved by maintaining and developing a balanced and diverse portfolio of energy sources that minimises future security of supply and price risks. We propose here a balanced mix of energy sources for power generation (coal, gas, nuclear and renewables) and outline how technologies can lead to the virtual elimination of emissions from coal-fired power stations.

Rising emissions from the domestic and transport sectors cannot be ignored, since only concerted action across ALL sectors will deliver the “*deep cuts*” in carbon dioxide emissions that are called for. Hydrogen offers great potential as a transport fuel, if compact storage technologies are successfully developed. To supply the hydrogen, large-scale integrated coal gasification combined cycle power stations, coupled with carbon dioxide capture and storage, offer a clean and flexible means of converting coal, a cheap fuel, into valuable electricity and hydrogen – thus allowing coal to play an important part in a secure, low-emission economy.

Against this background, the key issues that should influence future Government energy policy are explored in this briefing paper. They lead COALPRO to make five important **recommendations for policy-makers**:

- Encourage investment in the existing fleet of coal-fired power stations to further reduce sulphur dioxide and carbon dioxide emissions: by actively encouraging the use of flue gas desulphurisation; by supporting a supercritical boiler retrofit project; and, by reviewing the rules that limit biomass co-firing.
- Introduce a “*Sustainables Incentive*” to promote the construction of a fleet of new integrated gasification combined cycle (IGCC) power stations where coal can be used to generate electricity cleanly and efficiently – ultimately with near-zero emissions<sup>1</sup>.
- Fund further research, development and commercial demonstration of clean coal technologies, including those that are needed to capture and store carbon dioxide. The benefits can go beyond electricity generation. For example, hydrogen produced from coal at IGCC power stations can play an integral part in reducing emissions from the transport sector.
- Implement EC directives, international agreements and national legislation in ways that assist the UK economy and promote British jobs. At the highest level, the Government’s national goal of a 20% carbon dioxide reduction by 2010 threatens UK industry by exporting jobs along with our emissions. Another, less publicised example, is the duty increase on off-road DERV. This tax damages the competitiveness of surface-mined coal – illegal, on-road use of DERV should be dealt with instead through the courts.
- EC rules allow coal industry investment aid, operating aid and closure aid. Government should seek to keep all of these options open and use them, if necessary, to maintain a secure base of indigenous coal production. Allied to this, should be a relaxation of the minerals planning guidance covering coal mining in England and Scotland (MPG3 and draft SPP16) to bring it in line with the guidance published by Government for other extractive industries.

The Confederation of UK Coal Producers represents the interests of UK coal mining companies who together mined around 90% of the 28 million tonnes of coal produced in the UK in 2003. As the industry’s trade association, COALPRO is naturally pro-coal, but always aims to present balanced opinions and critiques that fairly reflect the role all energy sources can play in a balanced energy policy. A series of COALPRO briefing papers, aimed at government officials, will supplement this paper with more detailed analysis of the issues covered.

### A background of rising, global energy demand

The UK has a large demand for energy: equivalent to over 230 million tonnes of oil, of which coal supplies 17%<sup>2</sup>. In the case of electricity, coal underpins 35% of total generation; over half of this is supplied by local coal producers, bringing a degree of security and price stability to an energy market that will become increasingly reliant on imported natural gas over the coming decade.

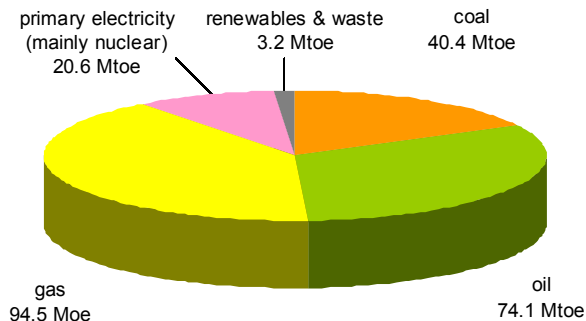


Figure 1 – UK inland energy consumption in 2003<sup>3</sup> (million tonnes oil equivalent)

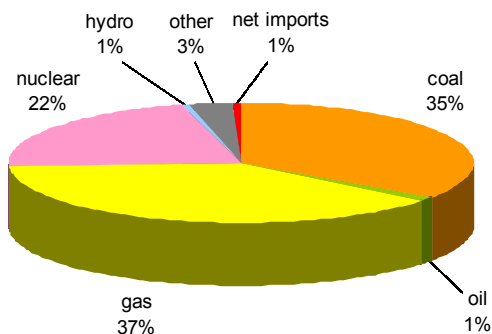


Figure 2 – Electricity generation by fuel type in the UK for 2003 when total generation was 380 TWh<sup>4</sup> (percentage shares on an electricity supplied (net) basis for all generating companies)

Global demand for fossil fuels is forecast to rise by one half over the next 25 years; across the enlarged EU, demand is forecast to rise by 23%, with demand for electricity rising by almost 60%<sup>5</sup>. Coal will continue to account for about 40% of global electricity production, principally because abundant reserves make it a secure and affordable fuel that is also safe to transport, store and use.

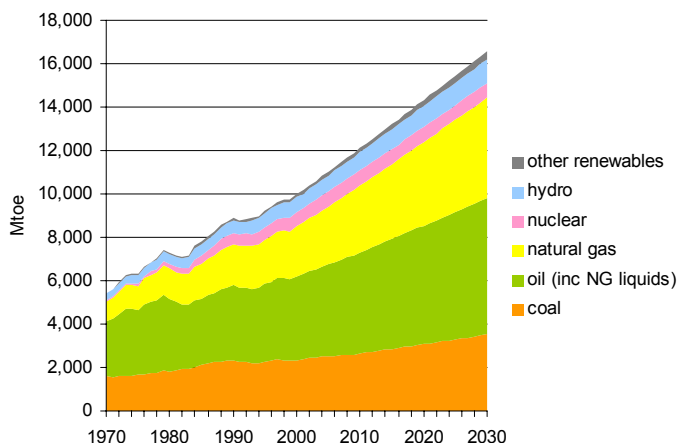


Figure 3 – World primary energy production (supply) by source, 1970-2001 and forecast to 2030<sup>6</sup>

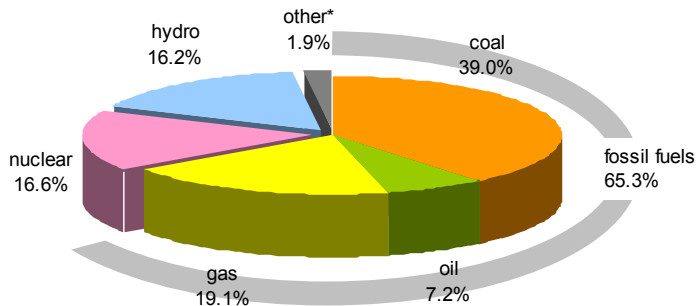


Figure 4 – Fuel share of global electricity generation in 2002<sup>7</sup> \* other includes geothermal, solar, wind, combustible renewables and waste

The world is witnessing rising and volatile energy prices, a trend that has every prospect of continuing as supplies struggle to meet demand. Given the concentration of oil and gas reserves in the “strategic ellipse” encompassing the Middle East and Russia, it seems unwise for any country to become even more dependent on energy supplied from this unsettled region. Yet, as the UK’s own oil and gas reserves dwindle, we are set to compete against other countries for gas piped from Russia and tankers of Middle Eastern oil and LNG (liquefied natural gas). The security of our future energy supplies can no longer be taken for granted.

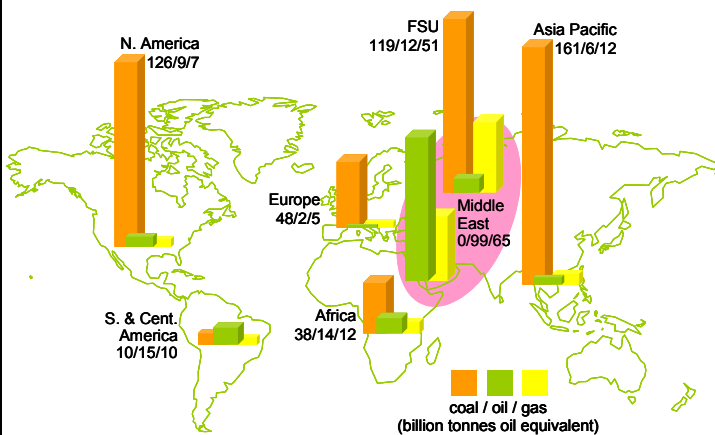


Figure 5 – Location of the world’s fossil fuel reserves, showing the so-called “strategic ellipse” where over 70% of the world’s oil and gas reserves lie<sup>8</sup>

### The UK’s growing dependence on natural gas

Much has been said and written about the risks associated with the UK’s growing dependence on natural gas, especially as we move to become a net importer. In the

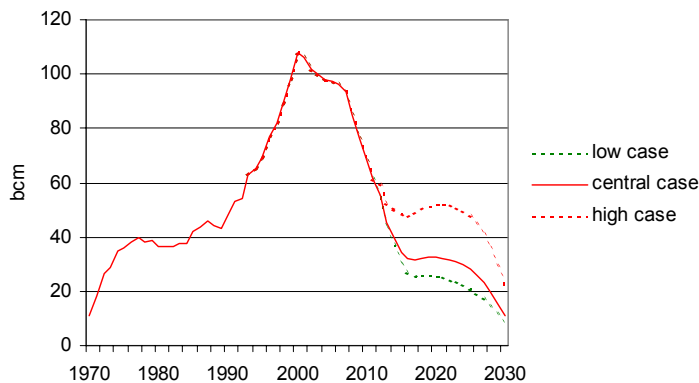


Figure 6 – UK annual gas production and projections to 2030<sup>9</sup> (billion cubic metres)

UK's current energy policy, there appears to be an acceptance that by 2020, 60% to 70% of our electricity may be generated from gas, with 80% of that gas being imported<sup>10</sup>. COALPRO believes that common sense dictates that an over dependence on a single fuel type should be avoided with a balanced energy policy that encourages fuel diversity. For electricity generation, this means coal, gas, nuclear and a mix of renewables without any one source becoming dominant. Indeed, these sources can be viewed as complementary: nuclear for base load; gas when prices allow; renewables when the wind blows; leaving coal as the reliable "swing" producer.

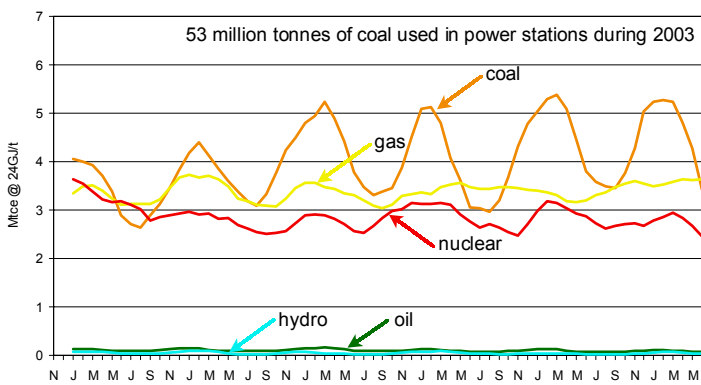


Figure 7 – Fuel used in UK electricity generation on a fuel input basis<sup>11</sup> – 3-month moving averages for major power producers (million tonnes of coal equivalent)

### Coal offers security and affordability

To secure the benefits of a balanced energy portfolio, the Government must encourage the retention of a coal-fired generation sector that is able to operate flexibly, sometimes at high load factors, to meet swings in demand. This demands a number of plants having sufficient capacity to respond effectively, with each being able to earn an economic return for its owner.

In the UK, 26 million electricity consumers in the domestic, commercial, public and industrial sectors already benefit from some of the lowest electricity prices in the world. The UK's industrial competitiveness and

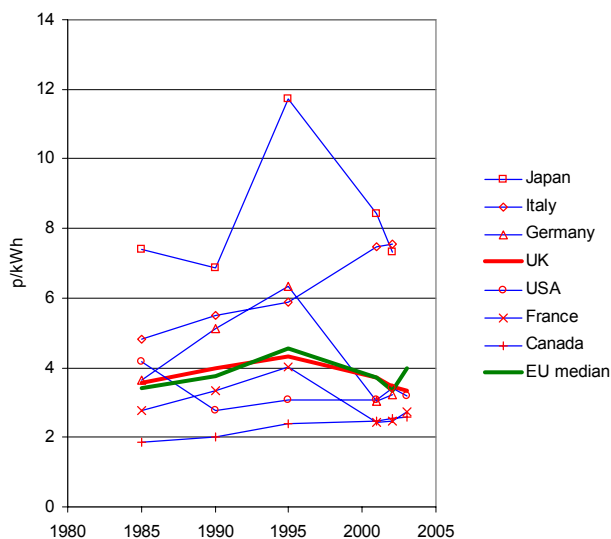


Figure 8 – Industrial electricity prices in the G7 countries compared with the EU median<sup>12</sup> (pence per unit)

elimination of fuel poverty depend heavily upon affordable electricity. It has been the availability of competitively-priced coal and a fleet of relatively efficient, coal-fired power stations that has underpinned low electricity prices. The Government risks losing this benefit if it further constrains the operation of coal-fired stations. Implementation of the EC Large Combustion Plants Directive (LCPD) and the EU Emissions Trading Scheme are two important policy matters that, if handled badly, could push investment away from coal-fired plants leaving the country over-exposed to imported natural gas. In the case of the LCPD, COALPRO welcomes the Government's recent decision to pursue a "hybrid" implementation and hopes that this is approved by the European Commission.

COALPRO is confident that with further investment in coal-fired generation, coal can continue to be the UK's reliable swing producer and meet environmental objectives. Initially, this is likely to be achieved through retrofitting pollution control equipment (e.g. flue gas desulphurisation and NOx abatement), efficiency improvements (e.g. supercritical boiler retrofits) and the use of more co-fired biomass fuel (as recommended by the Royal Commission on Environmental Pollution<sup>13</sup>). To prepare for the future, these measures should be accompanied by the large-scale demonstration of integrated gasification combined cycle (IGCC) technology designed to capture carbon dioxide (CO<sub>2</sub>) for storage and to co-produce hydrogen for transport applications.

### The changing nature of State aid in the UK coal industry

Over the last few years, the UK coal industry has moved from a position of receiving no direct subsidy, to one of modest investment aid averaging under £1/tonne. We say "modest" because this is significantly below the £60/tonne received in Germany<sup>14</sup>, where the hard coal industry is of a similar size to the UK's, for energy security and social reasons. It is also modest in comparison with the indirect State aid to the nuclear industry or the substantial sums that electricity consumers will pay for renewable electricity, the latter rising to around £1 billion by 2010.

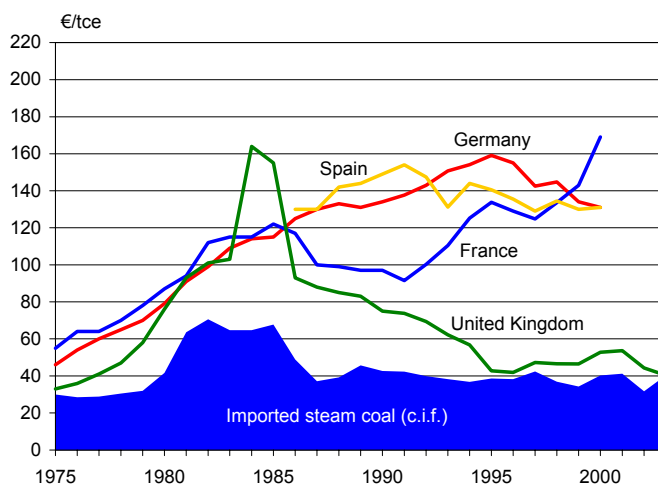


Figure 9 – EU hard coal production costs and imported steam coal prices<sup>15</sup> – with updates to 2003 for UK and imports

There is a strong rationale for the Government's continued, targeted support of coal mining in the UK, if and when necessary. The premium is relatively small and allows UK electricity generators to benefit from a long-term price stability that is absent from the international coal market. Hence, electricity consumers benefit with more predictable prices. In addition, there are other tangible benefits from indigenous production: security of energy supply, a positive contribution to the UK's balance of payments, retention of well-paid jobs and other inputs to the UK economy made by coal mining companies and mining equipment manufacturers.

EC rules allow investment aid, operating aid and closure aid for coal mining activities. International coal prices are cyclical and the underlying cost of coal production fluctuates between mines. Ideally, investment in mines would be scheduled so that periods of high cost, such as during development into new reserves, would coincide with periods of high prices. The reality is that there will often be short-term difficulties at individual mines as costs rise above proceeds. In these situations, a medium- to long-term view must be taken; otherwise, premature closure can lead to the permanent loss of valuable reserves. COALPRO believes that the Government should seek to keep the option open to pay any of the allowable forms of aid in cases where it sees a strategic need to preserve coal mining capacity; for example, if mines are threatened during periods of intense investment or by a future, temporary slump in market prices.

### **Deep mining in the UK – an understated resource**

In 2003, over 15 million tonnes of coal were produced from deep mines in the UK – a significant supply of energy used mainly for electricity generation. Productivity at these pits ranks 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 and requires a long-term view in an energy market now dominated by short-termism. 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 at Daw Mill and will raise production to over three million tonnes per year using some of the largest face equipment in the world.

There are inherent risks associated with coal mine investment, so any additional regulatory or market risks can render financing impossible. COALPRO seeks a stable investment climate through Government policies that are supportive of locally-produced coal.

### **Surface mining in the UK – ensuring policy allows adequate supply**

Almost half of UK coal is produced at surface coal mines, some of which involve the restoration of major brown field sites at no expense to the taxpayer. Many minerals are also extracted in the UK using similar methods, e.g. sand and gravel, limestone, granite and china clay. All these operations depend on a rolling programme of

resource replacement as existing surface mines and quarries deplete. The coal industry currently faces severe difficulties in gaining planning permissions for replacement surface mine sites and believes that there is no justification for the Office of the Deputy Prime Minister's more restrictive planning guidance for coal extraction compared to minerals extraction, repeated in draft guidance from the Scottish Executive (MPG3 and SPP16). Indeed, the “*presumption against*” coal mining in MPG3 is damaging not only to the future of surface mining, but also to deep mining since the planning guidance applies to coal mining in general.

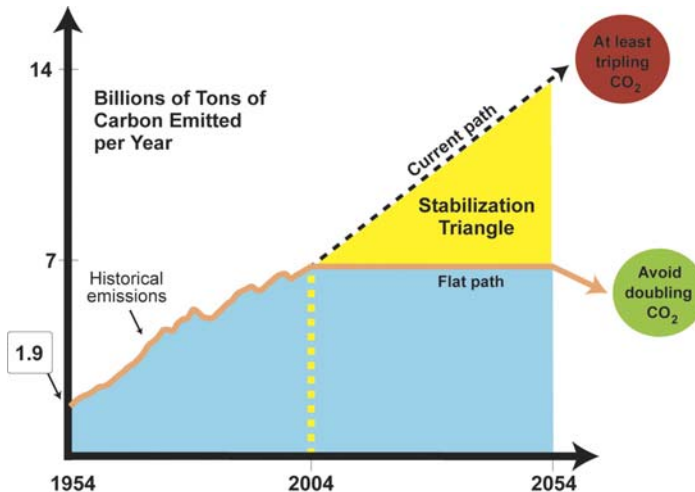


**Figure 10 – UK Coal plc's proposed Waverley surface coal mine restoration and development** – a pictorial view of the new community of 3,700 homes planned for the 730 acre Orgreave/Waverley site close to both Sheffield and Rotherham, indicating the proposed location of housing development, a new school, business parks and employment and recreational areas.

Surface mined coal output in England has fallen from eight million tonnes per year to less than 4 Mt/yr at present and, with the low rate of planning approvals, a future output of barely more than one million tonnes per year might be sustained. Yet, the industry has the reserves and resources to produce some 5 Mt/yr. The growing shortfall has to be imported and represents lost business, employment and tax revenues for the UK. A presumption against coal mining in the UK, deep or surface, is a presumption in favour of imports.

Surface mining depends exclusively on mobile machinery, much of which is fuelled by diesel (DERV) which makes up a significant cost to operators in the competitive coal market. The Government has raised the tax on off-road DERV to undermine the economics of those who illegally distribute it for on-road use. COALPRO finds this financial penalty on legitimate users to be an unjust response to criminality. The duty increase should be abandoned and the illegal, on-road use of DERV dealt with through the courts.

# The Carbon Management Initiative



Researchers at Princeton University in the USA have made an assessment of how global CO<sub>2</sub> emissions might be stabilised over the next 50 years to skirt the worst predicted consequences of climate change<sup>16</sup>. Carbon emissions would need trimming by roughly 7 billion tonnes per year by 2054 to yield a total carbon saving of ~175 billion tonnes – the yellow stabilisation triangle shown in the figure above. To meet rising energy demand at the same time requires energy technologies that emit

little or no carbon. The researchers identify fifteen strategies, each of which can deliver carbon savings of at least one billion tonnes by scaling up technologies available today. A combination of these strategies will be needed to achieve stabilisation, it is impossible to achieve with a narrow strategy. It is noteworthy that four of the fifteen strategies relate to the improved use of coal for electricity, hydrogen and synfuel production.



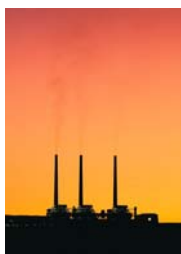
## Efficiency

1. Double fuel efficiency of 2 billion cars from 30 to 60 mpg.
2. Decrease the number of car miles travelled by half.
3. Use best efficiency practices in all residential and commercial buildings.
4. Produce current coal-based electricity with twice today's efficiency.



## Fuel Switching

5. Replace 1,400 coal power stations with natural gas-powered facilities.



## Carbon Capture and Storage

6. Capture AND store emissions from 800 coal power stations.
7. Produce hydrogen from coal at six times today's rate AND store the captured CO<sub>2</sub>.
8. Capture carbon from 180 coal-to-synfuels plants AND store the CO<sub>2</sub>.



## Nuclear

9. Add double the current global nuclear capacity to replace coal-based electricity.



## Wind

10. Increase wind electricity capacity by 50 times relative to today, for a total of 2 million large wind turbines.



## Solar

11. Install 700 times the current capacity of solar electricity.
12. Use 40,000 square kilometres of solar panel (or 4 million wind turbines) to produce hydrogen for fuel cell cars.



## Biomass Fuels

13. Increase ethanol production 50 times by creating biomass plantations with area equal to 1/6<sup>th</sup> of world cropland.



## Natural Sinks

14. Eliminate tropical deforestation AND create new plantations on non-forested land to quintuple current plantation area.
15. Adopt conservation tillage in all agricultural soils worldwide.

**Climate change – a global issue demanding a global response**

To develop a robust energy policy requires policy-makers to understand and appreciate the wider context of a rapidly rising, global energy demand and the likely environmental consequences. If action on global warming and climate change is to be a priority, as the Government states, then UK energy policy must include actions which lead to material improvement at the global scale

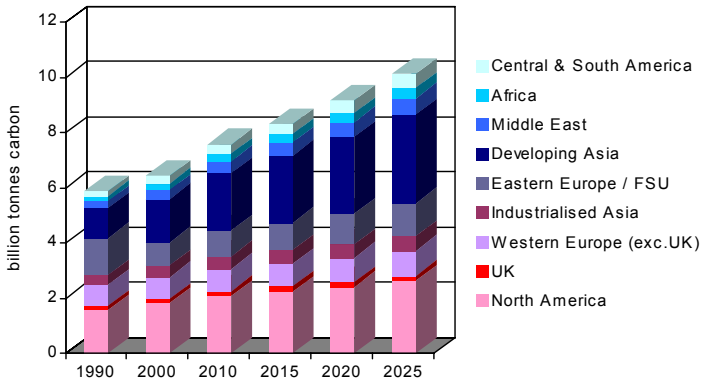


Figure 11 – Global CO<sub>2</sub> emissions from fossil fuel use<sup>17</sup>

By adopting the Royal Commission on Environmental Pollution’s recommendation to reduce the UK’s CO<sub>2</sub> emissions by 60%<sup>18 19</sup>, the Government implicitly accepts the principal of “*contraction and convergence*” whereby developed nations reduce their per capita emissions, eventually converging with those from developing nations<sup>20</sup>. A cursory analysis shows that this will require “*deep cuts*” in CO<sub>2</sub> emissions from fossil fuel use around the world. Such a reduction cannot be made solely by tinkering around at the edges with renewable energy sources and improved energy efficiency in the UK where CO<sub>2</sub> emissions account for just over 2% of the world’s total. The Government may decide to actively pursue the nuclear option as a large-scale response. COALPRO believes a complementary and more politically acceptable response is to move quickly to establish CO<sub>2</sub> capture and storage as a viable and commercially-proven technology for fossil fuels.

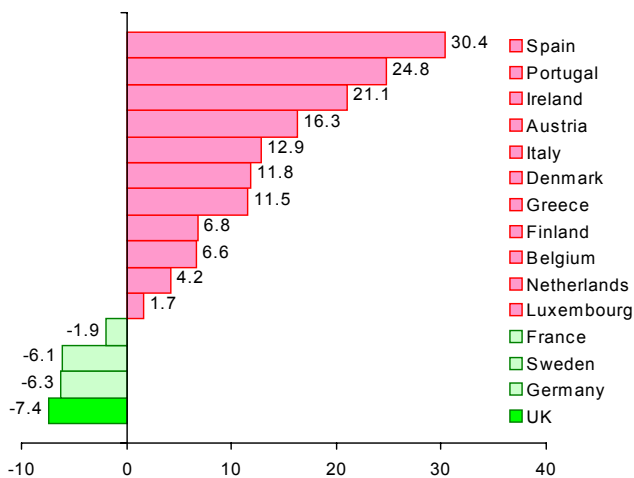


Figure 12 – Distance-to-target indicators in the EU15 for the Kyoto Protocol<sup>21</sup> – percentage deviations from 2002 target

Unilateral action by the UK is environmentally questionable; it will simply damage the UK economy

such that we gradually lose our ability to influence other nations. For the UK to go beyond its Kyoto Protocol target of a 12.5% reduction in greenhouse gas emissions by 2010 and adopt a domestic 20% CO<sub>2</sub> reduction goal is not a rational response to climate change. It would simply shift industrial production to those countries without emission constraints – shifting jobs and emissions at the same time. Instead of imposing ineffectual emission constraints, the UK should be embarking on an urgent programme of technology demonstration that would allow the linkage between economic growth and global CO<sub>2</sub> emissions to be broken forever.

**Clean coal technologies offer solutions**

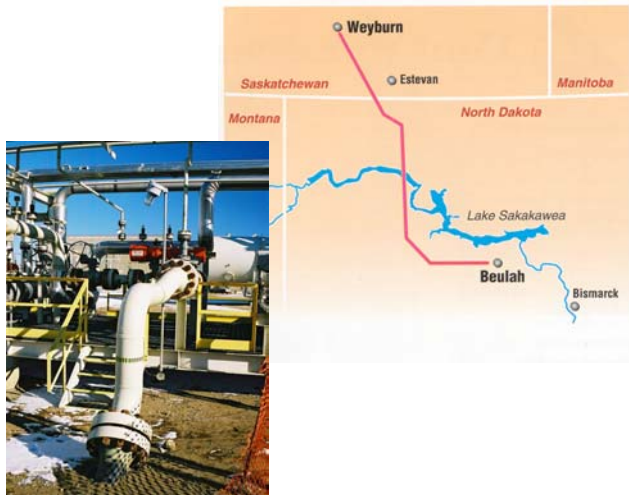
It is encouraging that clean coal technologies are available that can deliver substantial, large-scale reductions in CO<sub>2</sub> emissions from electricity generation. These include the CO<sub>2</sub> capture and storage (CCS) technologies that allow fossil fuels to be used with minimal emissions – the CO<sub>2</sub> being put back underground from where the fuel came. COALPRO believes that the support given to CCS by the Department of Trade and Industry has been valuable in raising awareness and scoping its potential, but that there is now an imperative to push ahead with commercial demonstration of the most promising technologies. Other major economies, notably the USA, Australia and Canada already have such plans in place and some have argued that the UK can simply tag along behind. Such an attitude misses the importance of this technology – it is vital if global CO<sub>2</sub> emissions are to be reduced. The UK must demonstrate leadership and commitment if it is to influence the behaviour of other nations, such as China and India where rising CO<sub>2</sub> emissions from fossil fuel use will otherwise dwarf any savings made in the UK. Each year, for example, CO<sub>2</sub> emissions from China are growing by an amount equivalent to the emissions from ALL power stations in the UK.



Figure 13 – Dakota Gasification Company’s Great Plains Synfuels Plant at Beulah, USA converts low grade coal into high quality gas that is piped to domestic and industrial users – carbon dioxide (CO<sub>2</sub>) is captured at a commercial-scale using the Rectisol process (physical absorption by a non-reacting methanol solvent) at this plant for export to Canada

The capacity of UK, coal-fired power stations is 28 GW and these operate at an average annual load factor of roughly 50%. They could operate at 85%, but do not because they are generally run only during periods of higher electricity demand, especially in the winter – these power stations are the “*swing*” producers. If this fleet was replaced, over time, with 28 GW of clean, modern integrated gasification combined cycle (IGCC) power

stations fuelled with coal, then enough hydrogen could be produced during periods of low electricity demand to power all the motor cars in the UK. Such co-production of electricity and transport fuel makes exceptionally good use of capital assets and could massively reduce CO<sub>2</sub> emissions from the transport sector. Of course, the new infrastructure for hydrogen distribution and the development of a hydrogen storage technology suitable for cars are not trivial matters.



**Figure 14 – The 205-mile CO<sub>2</sub> pipeline from the Great Plains Synfuels Plant emerges at Weyburn in Canada where the CO<sub>2</sub> is used for enhanced oil recovery (EOR)**

All forms of low-carbon energy will cost money, whether coal or gas with carbon capture, renewables or nuclear. The Renewables Obligation has encouraged some investment, particularly in wind farms, but new market mechanisms will be required to encourage investment in the other technologies needed. COALPRO recommends the use of a “Sustainables Incentive” to encourage investment in clean coal technologies – with rewards closely linked to improved environmental performance. The nature of the incentive would be defined by the Secretary of State, but need not come directly from government revenue (e.g. exemption from the Climate Change Levy, conversion of Sustainables Certificates into EU Emission Trading Scheme allowances, purchase of Sustainables Certificates using monies from the Renewables Obligation buy-out fund<sup>22</sup>, or a combination of these).



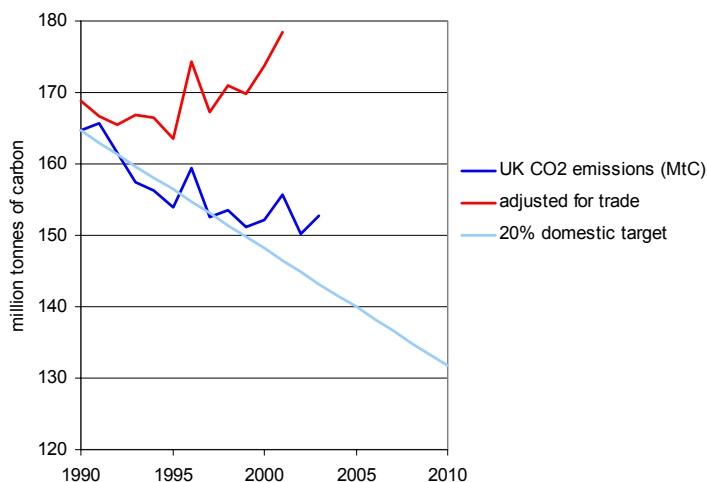
**Figure 15 – Japan’s EAGLE project will demonstrate how electricity can be generated using clean and efficient fuel cells fed with hydrogen produced from coal in an integrated gasification combined cycle (IGCC) plant**

### The need for a balanced energy policy

When considering any energy policy option, the Government must look at the total impact of its decisions on the environment. Today, there is a focus on the emissions from fossil fuels at the point of use. However, all energy supply options have a wider impact, which life cycle analysis attempts to capture, and extend well beyond UK borders in the case of imported energy supplies. For example, an extensive project carried out in Australia concludes that, on a full life cycle basis, gas-based electricity generation may have similar or even higher greenhouse gas (GHG) emissions than coal-based generation<sup>23</sup>. COALPRO believes that the Government needs to widen its analytical approach in this respect so that future energy policy is well-founded.

COALPRO observes that our current energy policy is UK-centric, optimistically assumes that liberalised energy markets will deliver all policy objectives, and is able to report good environmental metrics by fortune rather than by design. The decline of heavy industry in the UK has reduced national emissions, but emissions from other countries, notably China, have risen as we consume more and more of their manufactured exports. In essence, the UK has simply exported its pollution with no net gain for the global environment.

COALPRO believes that UK energy and environment policies must now respond more rationally to the global nature of the challenges faced, with the UK demonstrating leadership not only in the use of renewable energy technologies, but also in those technologies that will be needed to reduce the environmental impact of fossil fuel use.



**Figure 16 – UK carbon dioxide emissions: the Government’s domestic reduction target; actual, physical emissions; and, trade adjusted emissions<sup>24</sup> – accounting for the embodied CO<sub>2</sub> emissions in goods (and services) imported into and exported from the UK**

We propose above a balanced mix of energy sources for power generation (coal, gas, nuclear and renewables) and outline how technologies allow large-scale CO<sub>2</sub> reductions from coal to be made. However, the Government must also tackle emissions from the domestic and transport sectors. The decline of manufacturing and its associated emissions, that previously masked the rising emissions in other sectors, has come to an end and only concerted action across ALL

sectors will deliver “*deep cuts*” in emissions. Some commentators see hydrogen as the fuel of choice for the transport sector. We have shown how integrated coal gasification combined cycle power stations, coupled with CO<sub>2</sub> capture and storage, offer a flexible means of converting coal, a cheap fuel, into valuable electricity and hydrogen – thus allowing coal to play an important part in a secure, low-emission economy.

On the front page of this briefing paper, COALPRO outlines five, key recommendations needed to secure a properly balanced energy policy in the UK that includes coal. We commend these to policy-makers and will continue to press for their adoption.

## Notes and References

<sup>1</sup> In IGCC systems, coal is not combusted directly, but reacted with oxygen and steam to produce a ‘syngas’ composed mainly of hydrogen and carbon monoxide. The syngas is cleaned of impurities and then burned in a gas turbine to generate electricity and to produce steam for a conventional steam power cycle. IGCC lends itself to those carbon dioxide capture and storage technologies that enable emissions of carbon dioxide to be ‘captured’ and ‘stored’, that is stripped out of the syngas from coal gasification and disposed of in such a way that they do not enter the atmosphere.

<sup>2</sup> Throughout this paper, statistical data for UK energy supply and demand is taken from *Digest of UK Energy Statistics 2004*, Department of Trade and Industry, London: The Stationery Office, 2004.

<sup>3</sup> *Ibid.* Table 1.1.

<sup>4</sup> *Ibid.* Tables 5.5 and 5.6.

<sup>5</sup> *European Energy and Transport Trends to 2030*, Directorate-General for Energy and Transport, European Commission, January 2003.

<sup>6</sup> *Annual Energy Review 2002*, US Energy Information Administration, Table 11.1, p.281 and *World Energy Outlook 2002*, International Energy Agency, Table 2.1, p.26 (annual average growth rates from 2000 to 2030 are assumed by the IEA to be: coal 1.4%, oil 1.6%, gas 2.4%, nuclear 0.1%, hydro 1.6%, other renewables 3.3%).

<sup>7</sup> *Key World Energy Statistics 2004*, Paris: International Energy Agency, p.24.

<sup>8</sup> *BP Statistical Review of World Energy 2004*, London: BP plc, June 2004.

<sup>9</sup> *Digest of UK Energy Statistics 2004*, Department of Trade and Industry, Table 4.1.1 and *Transportation Ten Year Statement 2003*, National Grid Transco, Figure 4.2C.

<sup>10</sup> *The Energy Review*, Performance and Innovation Unit, Cabinet Office, February 2002.

<sup>11</sup> *Energy Trends*, Department of Trade and Industry, Table 5.3.

<sup>12</sup> *DTI Quarterly Energy Prices*, July 2004 update which presents data from *Energy Prices and Taxes Q1 2004*, IEA (includes taxes – a 4% average state sales tax is assumed in the USA). Data for Canada comes from the Canadian Electricity Association.

<sup>13</sup> *Biomass as a Renewable Energy Source*, a limited report by the Royal Commission on Environmental Pollution, June 2004.

<sup>14</sup> RAG Aktiengesellschaft: Deutsche Steinkohle Annual Report 2003.

<sup>15</sup> *Proposal for a Council Regulation on State aid to the coal industry*, COM (2001) 423, European Commission.

<sup>16</sup> *Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies*, Stephen Pacala and Robert Socolow, Science, vol. 305, issue 5686, pp. 968-972, August 13, 2004. See also [www.princeton.edu/~cmi/](http://www.princeton.edu/~cmi/).

<sup>17</sup> *International Energy Outlook*, US Energy Information Administration, DOE/EIA-0484(2004), April 2004.

<sup>18</sup> *Energy – the changing climate*, 22nd report of the Royal Commission on Environmental Pollution, Cm 4749, London: The Stationery Office, June 2000.

<sup>19</sup> *Our energy future – creating a low carbon economy*, Energy White Paper, Cm 5761, Department of Trade and Industry, London: The Stationery Office, February 2003.

<sup>20</sup> Meyer, A. (1997) *The Kyoto Protocol and the emergence of contraction and convergence as a framework for an international political solution to greenhouse gas emissions abatement*; in Hohmeyer, O. and Rennings, K. (eds.) *Man made climate change – economic aspects and policy options*; Proceedings of a ZEW conference, Mannheim.

<sup>21</sup> The distance-to-target indicator gives an indication of progress towards the Kyoto and Member States’ shared targets by measuring the deviation of actual emissions in 2002 from the (hypothetical) linear target path between 1990 and 2010. The bars show the percentage deviations between a hypothetical target (in 2002) and what was actually achieved (in 2002), assuming reductions are made linearly. It assumes that Member States meet their targets entirely on the basis of domestic measures. (*Report from the Commission under Council Decision 93/389/EEC as amended by Decision 99/296/EC for a monitoring mechanism of Community greenhouse gas emissions*, COM(2002) 702 and European Commission press release IP/04/932).

<sup>22</sup> If the Renewables Obligation is met, then there is no buy-out fund (no fines are paid). If the supply of renewable electricity lags 1%age point behind the obligation’s target (e.g. supply is only 9% in 2010 when the target is 10%), then the annual value of the fund would be c.£100 million (3p/kWh buy-out, on 3.44 TWh this being 1% of total supply). Under the Electricity Act 1989 (as amended by the Utilities Act 2000), the Secretary of State may direct by order how these funds are to be redistributed back to the electricity suppliers (S.32C). The scope therefore exists to marry the Renewables Obligation and Sustainable Incentive together. If renewables lag behind the target (despite the 3p/kWh incentive), then the buy-out fund can be used to encourage sustainable electricity generation from the fossil fuel sector that deliver equivalent (or probably greater) CO<sub>2</sub> reductions.

<sup>23</sup> *Comparing greenhouse gas emissions from different energy sources*, Coal in a Sustainable Society project report, July 2002. Accessible at [www.ciss.com.au](http://www.ciss.com.au).

<sup>24</sup> COALPRO analysis using data from *Digest of Environmental Statistics*, Department of Environment, Food and Rural Affairs, March 2004; *UK Balance of Payments – The Pink Book 2004*, National Statistics, London: The Stationery Office (with import/export data for 1990-92 from earlier editions) and *CO<sub>2</sub> Emissions from Fuel Combustion 1971-2001*, 2003 edition, Paris: International Energy Agency.

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