Communities and Local Government

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Mineral Planning Factsheet

Coal

*This factsheet provides an overview of **coal** supply in the UK. It is one of a series on economically important minerals that are extracted in Britain and is primarily intended to inform the land-use planning process. It is not a statement of planning policy or guidance; nor does it imply Government approval of any existing or potential planning application in the UK administration.*

August 2010.

Coal is a combustible sedimentary rock made of lithified plant remains. It consists of 'macerals' (organic equivalent of minerals), minerals and water. A coal seam (layer) is formed by the alteration of dead plant material. Initially, this material accumulates as peat on the land surface. As the peat becomes buried beneath younger sediments the temperature increases with increasing depth of burial. Peat is sequentially altered by the process of 'coalification' through 'brown coals', which include **lignite** and **sub-bituminous coal**, to 'black coals' or 'hard coals' that comprise **bituminous coal**, **semi-anthracite** and **anthracite**. All the coal produced in Britain and imported is bituminous coal and anthracite. As a result of subsequent faulting and folding of coal-bearing strata, coal seams occur at varying depths from the surface. In Britain coal seams vary in thickness from a few centimetres up to rarely 3.5 m, although exceptionally thicker (5 m) seams may occur. They are extracted by both underground (deep) and surface (opencast) mining methods. Apart from the Bovey Basin in Devon, Great Britain has no significant deposits of lignite, although there are large, unworked resources in Northern Ireland.

The coalification process involves the loss of water and volatile components in the form of carbon dioxide and methane. This results in an increase in carbon content, from about 60% in peat to more than 90% in bituminous coal and 95% in anthracite, which is often described as 'low-volatile coal'. The physical and chemical properties of coal, that is **coal quality**, determine whether a coal can be used commercially, either on its own or after processing/blending to improve coal quality. Calorific value (CV) is one of the main quality criteria used by coal consumers. It is the heat energy given off by the combustion of a unit quantity of fuel. It increases from about 15 megajoules per kilogram (MJ/kg) in peat, through 25 MJ/kg in brown coal to 35 MJ/kg and more in bituminous coal and anthracite. The present position of any specific coal in the coalification sequence is described as its '**rank**'. For example, anthracite has a high rank, whereas lignite has a low rank. Coal quality is important as it affects the operation of plant, and thus the costs of generating power, through possible increased costs of both maintenance and conformity with environmental legislation. Chlorine is detrimental in coal as it causes corrosion in boilers as well as causing pollution. Steam coals should have a maximum Cl content of 0.2–0.3%. Sulphur is another serious impurity in coal, causing both corrosion and, more importantly, atmospheric pollution when released as sulphur dioxide, which causes acid rain. The sulphur content of English coals is relatively high compared with world traded coals (<1% S) and those in Scotland and Wales. Based on the physical properties of different bituminous coals, a fundamental distinction is made worldwide between **steam coal** (thermal coal), used for burning in boilers, chiefly for electricity generation, and **coking coa**l, which is used to make coke for the metallurgical industries. Coking coal produces coke with sufficient strength to support the loads imposed within the blast furnace. Steam coal tends to have calorific values at the lower end of the range while coking coal, although not defined by calorific value, tends to be higher.

Various methods may be used to capture methane and other forms of energy from in situ coal seams, including coalbed methane, abandoned mine methane and underground coal gasification. Issues relating to these methodologies are covered in a separate factsheet.

Orgreave Opencast Site, Rotherham.

Markets

Coal is used either as a primary source of energy, mainly in electricity generation, or as a reductant in metal smelting, especially iron smelting. Until the 1970s coal from indigenous mines was the chief source of energy used in the UK. Although its use in electricity production continued to rise after that decade, its overall consumption declined. Around the time of coal industry privatisation in 1994 about three-quarters of electricity was generated from coal. However, following privatisation, the electricity supply industry was no longer a captive market for indigenous coal. In addition, the use of coal in electricity generation rapidly declined as it was replaced by natural gas and, to a lesser extent, by nuclear power. In 2008 some 47.8 million tonnes of coal were used in electricity generation, accounting for about one third of GB electricity output. However, around two thirds of the coal used was supplied by imports. Coal-fired generation has some advantages over other energy sources. Electricity output can vary significantly making coal-fired generation particularly useful for meeting peak demand (particularly in winter) or covering supply difficulties with other fuels. Generators can also carry large coal stocks, an option not so easily available to gas generators.

Although there remains a sizeable domestic demand for coal, British coal has some disadvantages in addition to cost. It has on average double the sulphur content of imported coal which typically contains <1% sulphur. These disadvantages are greatest for English deep mines but less so for surface mine producers in Wales and Scotland where average sulphur content is lower. This does mean that indigenous coal will have to be used almost exclusively in coal-fired power stations equipped with flue gas desulphurisation (FGD). These plants can remove about 90% of sulphur dioxide emissions, but are expensive to install and also increase carbon dioxide emissions. Sulphur is recovered as synthetic gypsum (calcium sulphate), which is used in plasterboard manufacture (see Factsheet on **Gypsum**).
The EU *Large Combustion Plants Directive*, which came into effect in 2008, seeks to limit nitrogen oxides (NOx) and sulphur dioxide emissions, particularly from power stations. The operators of almost 75% of UK coal-fired capacity have opted to fit FGD equipment to enable their power stations to continue to operate to at least 2015 in compliance with this directive. In addition, world coal prices increased significantly between 2004 and 2008 making indigenous coal more competitive with imports. Together with increases in natural gas prices, coal has, thus, become a more cost effective option. The Coal Authority's view is that indigenous coal should be part of a secure, diverse and sustainable energy supply.

Participation in the European Emissions Trading Scheme (ETS) is mandatory for all UK electricity generators who use fossil fuel, including coal (see section on 'Effects of Economic Instruments' below). The price of carbon within the ETS is likely to be a major influence on future demand for coal by UK generators. In addition, the UK Climate Change Act 2008 sets legally binding emission reduction targets for 2020 (reduction of 34 percent in greenhouse gas emissions) and for 2050 (reduction of at least 80 percent in greenhouse gas emissions), and introduces five-yearly carbon budgets to help ensure those targets are met. The ETS carbon price and UK carbon reduction targets clearly have major implications for the long-term use of coal for electricity generation. Future demand will depend increasingly on the viability of commercial-scale carbon capture and storage (CCS). Although the UK Department of Energy and Climate Change (DECC) has initiated a competition to design and build a commercial-scale post-combustion CCS scheme associated with a coal-fired powerplant by 2014, considerable uncertainties remain regarding costs. Future decisions on investment in the development of UK coal resources will have to be made against this regulatory background and, until at least 2014, uncertainties about the commercial viability of CCS.

Coking coal is chiefly consumed by the primary steel industry to make coke for use in blast furnaces, where it is irreplaceable. All requirements are currently imported, although coking coal resources remain in some UK coalfields (principally South Wales).

Other relatively small uses of coal are for domestic consumption, industry, patent fuel manufacture (i.e. smokeless fuel) and direct injection into blast furnaces. Demand for coal is on a long-term declining trend in GB but only varies slightly from year to year.

Supply

Around 71% (43.9 million tonnes in 2009) of the UK coal market is supplied by imports, the remaining 29% comes from indigenous sources. Coal is produced by both deep and surface mining in England and Wales but only by surface mining in Scotland (Figures 1 and 2). Total domestic production in 2009 was 17.26 million tonnes in 2009, of which 7.49 was from deep mines and 9.77 million tonnes was from surface mines. In addition, a small amount of coal was recovered from tip washing.

Total coal stocks increased significantly in 2008 to 18.4 million tonnes, an equivalent of about third of the annual coal consumption.

At its peak in the early 20th Century, British coal output, which was then entirely from underground mines, supplied all home demand and provided the world's largest exports of coal. By March 2009, underground production from major mines was confined to five deep mines in the East Pennine Coalfield and one in Warwickshire. There are also ten medium and small deep mines producing or developing in March 2009: six in Wales, two in Gloucestershire and two in the East Pennines.

Deep mine production is often affected by geological problems which can severely curtail output and, at worst, cause premature closure as was the case with the Selby Complex in North Yorkshire and the Asfordby Mine in Leicestershire. Tower Colliery in South Wales also closed in 2008 with reserves exhausted. Through recent investment in deep mine production, abandoned developments have been reopened including Aberpergwm Colliery and Pentreclwydau South Colliery (now called Unity Mine) in South Wales and Hatfield Colliery in Yorkshire.

Large-scale surface mining production started during the Second World War. It has supplied a total output of about 820 million tonnes up to 2010. This represents a small fraction of the tonnage produced by underground methods in the same period (26 041 million tonnes). However, with declining deep mine output, surface mining provides an increasing proportion of total UK output (almost 57% in 2009). There were 35 surface mine sites producing or developing in March 2010, of which 14 were in England, 14 in Scotland and seven in Wales.

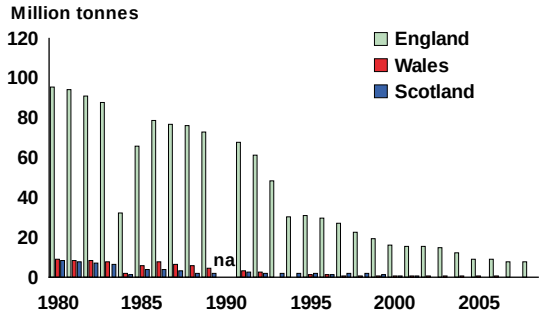

Figure 1 Great Britain: Underground coal production, 1980–2008. Source: The Coal Authority

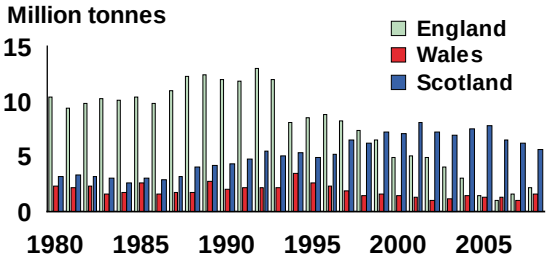

Figure 2 Great Britain: Surface mine coal production, 1980–2008. Source: The Coal Authority

Trade

The UK remained a (small) net exporter of coal until 1983. After that date, mine closures caused output to fall, imports rose rapidly and in 2001 exceeded home production for the first time. The rising trend in net imports of coal, which were valued at £1984 million in 2007 is shown in Figure 3. Domestically produced coal faces competition from imported coal on the basis of both price and quality. However, following substantial increases in the world price of coal since 2004, domestic producers are now better placed to sell their product in competition

with imported coal. Imported coal has a lower sulphur content (<1%), although with FGD fitted to many coal-fired power stations, the use of higher sulphur indigenous coal is no longer a constraint.

In 2008 imports of coal totalled 43.9million tonnes. Of these imports, 37.4 million tonnes were steam coal, 6.3 million tonnes were coking coal and 0.14 million tonnes were anthracite. The chief sources of steam coal were Russia (21.2 Mt),Columbia (5.3Mt Mt) and South Africa (4.2 Mt) which together accounted for 82% of the total. Australia supplied 49.5% of coking coal imports.

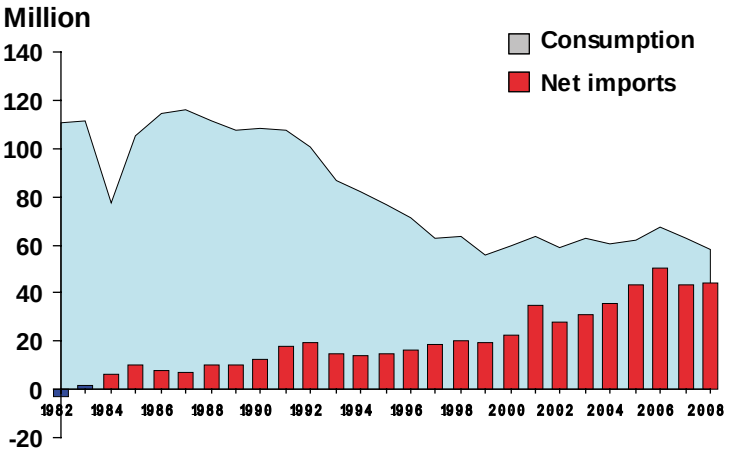

Figure 3 UK: Coal consumption and net imports, 1981–2008 Source: DECC

Consumption

UK coal consumption has generally been on a declining trend (Figure 3) although this decline has slowed considerably in the last decade. However, the recession caused a significant drop in consumption in 2009 where coal use for electricity generation was down by 28.3 % in the 3rd quarter compared to the same period of 2008. Gas and oil consumption also fell in the same period.

Despite this decline, coal remains vital to the UK energy mix. In 2008, coal consumption was 58.2 million tonnes, around 75% of which was supplied by imports. A little less that a third of the electricity generated in the UK in 2008 was from coal-fired power stations. This usage accounted for 83% of all coal consumed in the UK in 2008 (Table 1). This proportion has varied between 74% and 85.7% in the period 1999-2008. The second largest use (10%) was for coke manufacture, mainly for use in blast furnaces in the iron and steel industry.

Economic importance

In 2008, coal accounted for about 18% of the total energy used in the UK and was the third most important source of primary energy after gas (42%) and oil (33%). About one third of the coal consumed in all uses was derived from domestic sources. The value of UK coal production in 2008 was £1139 million. The value of coal imports in 2008 was £3536 million and the value of exports £125 million. Direct employment in the deep mine and surface mine coal

	Steam coal	Coking coal	Anthracite	Total
Electricity generation	46 984	-	817	47 801
Heat generation	458	-	-	458
Coke manufacture	-	5 875	-	5 875
Blast furnaces		1 170	-	1 170
Patent fuel manufacture	-	-	317	317
Industry	1 790	-	82	1 872
Domestic	521	-	164	684
Other	-	-	-	714
TOTAL	**49 753**	**7 045**	**1 380**	**58 212**

Table 1 Consumption of coal by end use in 2008 (thousand tonnes).
Source: DECC

Coal

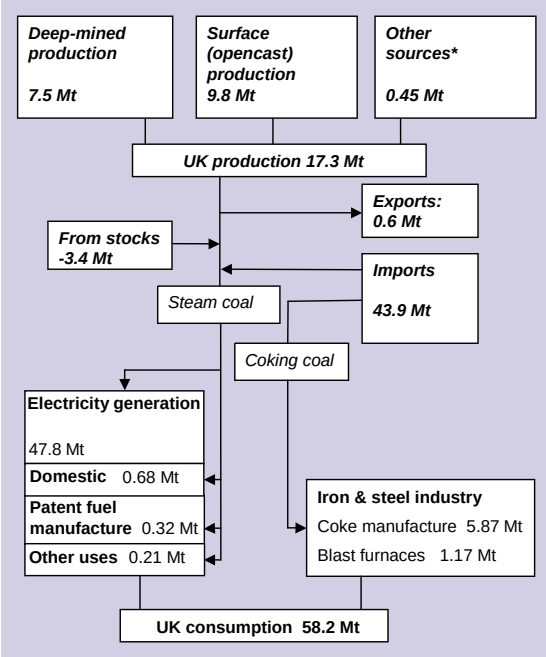

Figure 4 UK: The coal supply chain, 2009 *(totals may not add up due to rounding).*
**Slurry recovery.* Source: DECC

industries was 6479 at the end of 2009, comprising 4056 in deep mines and 2414 at surface mine sites.

Coal accounted for 36% of the primary fuel (in tonnes of oil equivalent) used in electricity generation in 2008. Of the total electricity produced in 2008, 32% was generated from coal.

Structure of the industry

The UK coal industry was, with minor exceptions, nationalised in 1947. It passed back into private ownership in 1994. The principal coal producer is *UK Coal plc*, which accounts for about 40% of total GB coal output and operates three large underground mines and six surface mines producing or developing (March 2010).

The two other large underground mines in England are operated by *Maltby Colliery Ltd* and *Powerfuel Mining Ltd*. In addition, in England, there are two small underground drift mines in Yorkshire/Derbyshire plus three other very small mines operated by individuals in the Forest of Dean.

HJ Banks & Co Ltd is the other main surface mine operator in England and at March 2010 has one site operating and one developing. There are also six other smaller surface mining sites in England producing or developing (March 2010).

In Scotland, no underground mines remain. The main surface mining operator is *The Scottish Coal Company Ltd* which works eight of the 14 surface mining sites producing or developing in Scotland (March 2010).

The other main Scottish operators are *ATH Resources plc, Kier Minerals Ltd* and *Hall Construction Services Ltd*. *UK Coal* and *HJ Banks* also having surface mining sites planned in Scotland.

In Wales there are five underground drift mines producing or developing (March 2010). The two largest are operated by *Energybuild Mining Ltd* and *Unity Mine Ltd*, the others are small operations. In addition there is a large underground mine planned by *Corus UK Ltd* to provide coking coal for its Port Talbot steelworks.

There are seven surface mines working in Wales (March 2010). Three large sites are operated by *Celtic Energy Ltd* with the other large site being operated by *Miller Argent (South Wales Ltd)*. The other three operations are much smaller sites, two of which also produce sandstone.

The *Confederation of United Kingdom Coal Producers (CoalPro)* is the trade association for the industry.

Government policy and sponsorship responsibility for the coal industry lies with the *Department of Energy and Climate Change*.

The *Coal Authority* owns coal mineral assets on behalf of the state and regulates the industry. It was set up and assumed its functions in 1994 as a Non-Departmental Public Body responsible to the Secretary of State for Trade and Industry. Its principal activities are:

- licensing coal mining operations and granting leases to extract coal reserves;

- settling subsidence damage claims not falling on coal mine operators;
- managing property in coalfield areas;
- managing minewater pollution and other environmental problems associated with, former coal mining; and
- providing geological and other information on past and future coal mining activity to house buyers, other purchasers of property and local authorities.

The former British Coal Prime Geological Data collection, including all deep mine and surface mine borehole information, has been transferred to the British Geological Survey. These records are available for inspection.

Resources

Almost all onshore coal resources in Britain occur in rocks of Carboniferous age (300–330 million years old). In England and Wales coal-bearing rocks are almost entirely confined to the Pennine and South Wales Coal Measures groups of Upper Carboniferous (Westphalian) age. Coal seams occur at fairly regular intervals, interbedded mainly with claystones, siltstones and sandstones. However, in parts of northern England, and notably in the Midland Valley of Scotland, older coals also occur in strata beneath these Westphalian aged successions. In Scotland these occur principally in the Limestone Coal and Upper Limestone formations, with locally thick coals present in the Passage Formation.

Coal-bearing strata occur at the surface in a number of discrete 'exposed coalfields' but also dip beneath younger rocks to form 'concealed coalfields'. Figure 5 shows the distribution of exposed and concealed coal-bearing strata.

Despite a long history of coal mining in Great Britain, considerable resources remain at depths readily accessible by underground mining. Although access to these resources through existing mines might be an option in some areas, new mines will be required elsewhere to access other underground prospects. New, shaft-accessed deep mines are extremely expensive to develop and potential investors

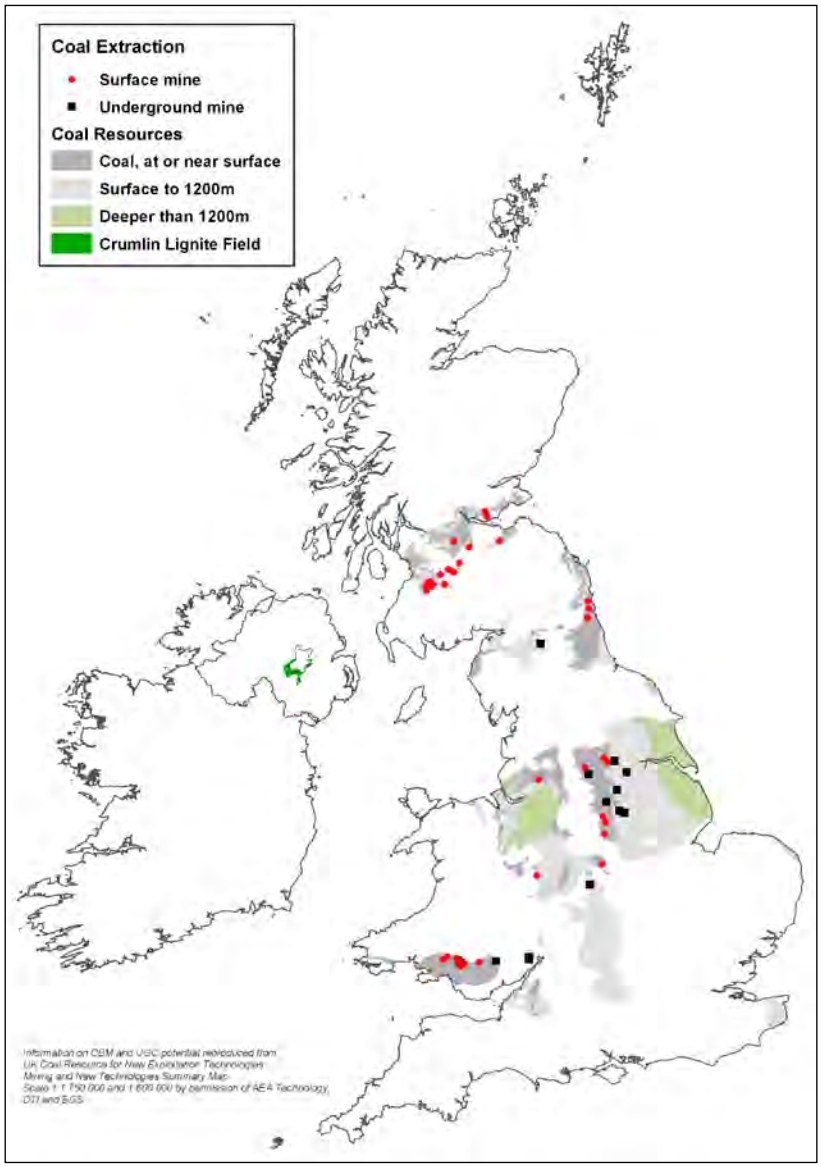

Figure 5 Distribution of coal resources in the UK, including producing and developing mines. (September 2006)

are likely to examine the likelihood continued large-scale use of coal in electricity generation, This, in turn, is linked to the prospects for a new generation of coal-fired generating plants which are integrated with carbon capture and storage schemes (see above). As such, any development of large-scale, shaft-accessed deep mines in the UK in the short-term seems unlikely. In the immediate future, interest in coal extraction is therefore likely to be mainly

Coal

confined to material that can be worked by surface mining methods. Surface mine mining provides an efficient way of extracting shallow coal resources. It has the advantage of extracting coals that were either too thin to be extracted by underground methods, or were only partially extracted due to the need to leave supporting pillars in the workings. Significant resources amenable to surface extraction remain but the method is severely constrained by environmental and planning considerations (see below).

Very large resources of Carboniferous coal remain at depths greater than 1200 m (the normal limit of conventional mining). This is particularly the case in the eastward extension of the East Pennine Coalfield, both within the UK land area and, in particular, below the North Sea. Here, and in other parts of the UK Continental Shelf, there exist large resources of coal, as yet not quantified in detail, in Carboniferous, Mesozoic and Palaeogene strata. However, much of this is lignite rather than bituminous coal.

In England and Scotland the coal raised is almost entirely used as steam coal, that is for use chiefly in steam-raising boilers at power stations. Only a very small proportion is coking coal, for coke manufacture. Coal from deep mines contains varying amounts of deleterious elements, in particular, sulphur and chlorine. Coal from surface mine operations contains, as a rule, lower amounts of these elements and blending is often undertaken in order to minimise the sulphur and chlorine content of coal delivered to power stations. In the South Wales Coalfield coal rank increases from the east to the northwest, where anthracite occurs, the only source in Britain. It is sold to industry, domestic customers and specialised local power stations. Lignite is produced in minor quantities as a by-product of ball clay extraction in the Bovey Basin in Devon. No lignite has been produced commercially in Northern Ireland, although in the vicinity of Lough Neagh, there are large resources that have been evaluated for power generation.

Reserves

Debate on the size, and hence the life expectancy of Britain's coal reserves, began in the 19th century. During the era of the nationalised industry (1947–1994), coal reserves were claimed to be extremely large. However, the statistical data presented on coal reserves were not subject to economic rigour and tended to indicate the tonnages of coal that were deemed to be *technically* recoverable. Of this, only a very small proportion is currently economically viable and has the necessary licences and planning permissions to be worked by underground

Estimated tonnage remaining in licences in the UK (million tonnes)											
Type	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Underground											
Operating	447	426	415	328	122	106	112	104	143	131	125
Closed	190	191	192	311	227	226	79	170	183	191	290
Conditional	27	27	27	27	27	27	27	57	57	53	130
Opencast											
Operating	51	43	37	48	46	51	46	48	43	41	42
Closed	4	4	4	5	4	2	1	3	3	3	3
Conditional	203	205	202	188	156	154	7	3	3	4	3

Table 2 Tonnages remaining in licences in the UK at end of financial year to March 2009.
Source: The Coal Authority.

or surface mining methods. The approximate tonnage of coal in underground and surface mine sites licensed by the Coal Authority is shown in Table 2. This includes reserves of coal in sites with planning permission (operating and not yet worked), coal within licence at closed sites and coal within conditional licences, which do not have planning permission. Conditional surface mine licences formed part of the assets transferred to the private sector at the time of privatisation but the bulk of these expired at the end of 2004, hence the fall from 154 million tonnes to seven million tonnes in this category. Whist they broadly represented measured resources they do not have planning permission.

	Thousand tonnes			
Year ending	**2006**	**2007**	**2008**	**2009**
England	4 212	8 243	8 841	11 598
Wales	18 575	16 831	15 435	14 046
Scotland	29 080	29 726	32 585	33 021
Total	**51 866**	**54 801**	**56 861**	**58 665**

Table 3 Great Britain: Total permitted reserves of opencast coal in worked and unworked sites, 2006 to 2009. Source: The Coal Authority

Permitted reserves of surface mine coal in operational sites and those with planning permission but not yet worked at end of December 2006, 2007, 2008 and 2009 are shown in Table 3.

These figures show a modest overall increase in surface mine coal reserves in Great Britain between 2006 and 2009. The reserves in operational sites were 40.7 million tonnes while reserves in sites not being worked at the end of 2009 were 18.0 million tonnes.

Extraction and processing

Coal is mined by both underground and surface methods. Underground mining involves chiefly two methods; *longwall* mining where mined-out areas are allowed to undergo controlled collapse as mining proceeds, and *pillar* and *stall* mining where 'pillars' of coal are left in place to support the excavation.

All large, deep mines in Great Britain use the longwall method where a 'panel' of coal (a defined area of the seam) is accessed by driving parallel tunnels (called gates) within the seam along two sides of the panel, about 250–350 m apart. These are joined by a further cut at right angles that becomes the working face. A coal-cutting machine (called a coal shearer) then cuts coal by repeated passes along the working face, which either advances into areas of virgin coal ('longwall advance') or retreats towards the main roadways within the mine ('longwall retreat'). Coal is removed by conveyor belt along the gates. The roof strata along the coal face is supported by hydraulic roof supports (chocks) that are moved sequentially, allowing the roof strata to collapse into an area behind the chocks termed the goaf (or gob). It is this roof collapse, associated with the extraction of thick seams close to the surface that may cause some subsidence at the surface. Depending on seam thickness, practically all the coal in a panel may be removed by this method, but for technical reasons typically only 50% of 'available' coal in an underground mine is recovered. More than one panel may be worked at a time, but remaining British mines usually have a single working panel. The length of a face run may in exceptional circumstances extend for many kilometres, but up to two kilometres is more typical.

The pillar and stall (also called room and pillar or bord and pillar) mining method is used generally at shallow depths, either dictated by geological conditions or by the need to avoid disturbance at the land surface. Extraction from the 'rooms' proceeds on a rectangular plan and up to 60% of the coal may be taken, leaving 'pillars' to support the roof. A competent roof rock is a pre-requisite but an optional final phase is to 'rob' the pillars until the roof collapses. In the UK the method is used only in some small underground mines.

During modern longwall mining, some rock above the coal seam (generally mudstone) and beneath the coal seam (seatearth) may be extracted with the coal. Thin beds of mudstone also occur interbedded within the coal seams. This mixture of coal and dirt is not saleable. Coal preparation transforms the mined coal

into a saleable product and thereby adds economic value. Environmental concern about harmful emissions, such as sulphur dioxide, means that coal preparation involves the removal of both inert material, thus increasing the calorific value of the coal, and some of the inorganic sulphur. All deep mines have coal preparation facilities. There are a number of separation processes, most of which are based on the differences in the densities of coal and other rock types, mainly mudstone. The most widely-used method is treatment in an oscillating column of water, where the unwanted rock fragments sink faster than coal; such plant is normally known as a 'washery'. Alternative treatments include use of a heavy medium such as a suspension of magnetite in water and froth flotation where the coal is finely crushed. Other methods using water are also used. The waste (colliery spoil) separated from the coal is disposed on an adjacent tip. Waste tips are generally landscaped and vegetated to reduce environmental impact. Some waste may be utilised as a source of low-grade aggregate.

Surface mining is essentially a quarrying method. It is viable where one or more seams are relatively near the land surface, normally down to 100 m in the UK, but exceptionally to 200 m. The ratio of coal to overburden, (the 'stripping ratio'), and the nature of the overburden, (generally sandstone and/or mudstone) is also very important. Overburden to coal ratios are variable but currently ratios up to about 20 to 1 are economic. The rock that lies above and between each seam (the 'overburden' and 'interburden') is excavated in a succession of cuts and cast into the void created by the previous cut allowing progressive restoration to be undertaken. Surface working frequently exposes areas of ancient, shallow, underground workings. Surface mine mining can, therefore, be used to remove and stabilise old shallow pillar and stall workings. Elsewhere surface mining has been used for land reclamation and remedial work with subsequent redevelopment for other uses. However, there are now few 'brownfields' sites remaining that would benefit from this type of remedial work and future surface mine sites will be greenfield in nature, which has major impacts on communities and landscape.

Surface mine sites tend to be worked quickly, and thus only give very temporary disruption to the landscape. However, they involve intensive earth movement as overburden and interburden is removed, temporarily stockpiled and eventually replaced in the void. Extensions and adjacent sites may prolong activity in a particular area raising concerns about cumulative impacts.

In surface coal mining operations, seams can be worked cleanly to bed thicknesses as little as 0.1 m. Coal worked by surface mining does not, therefore, normally require further processing. It also tends to have lower chlorine contents (< 0.1%), than deep mine coals,. Blending surface mine and deep mine coals helps to improve the average quality of domestic coal supplies. The technology and economics of surface coal extraction now allows coal seams with high overburden ratios to be extracted and very high levels of coal recovery.

Enhanced recovery of coal at surface mines can be aided by highwall or auger mining. This is a 'hybrid' method used to maximise output. It involves the use of remotely-operated cutting or boring machines that excavate slots or tunnels in the seam exposed at the foot of the highwall (the final wall in an open pit) as well as the foot of the final wall. This includes recovering coal from intermediate seams in the section by augering them once the backfill has reached their level. It is effectively a way of mining underground, to a limited extent, using 'surface' operators.

By-products

Deep mining of coal releases methane, which for safety reasons needs to be controlled prior to entering the mine air stream. This methane (CMM) is used as a process fuel on site. Abandoned mine methane (AMM) can also be extracted for use in electricity generation.

Most of the colliery spoil from former extensive deep mining operations has now either been restored or removed for alternative use. New arisings, mainly of claystone and siltstone, continue to be produced at all deep mine operations. This may be of use as a low-grade

aggregate, for example, as bulk engineering fill. An estimated 810 000 tonnes was used for fill in England and Wales in 2003, out of total produced volume of 8 million tonnes. Old colliery spoil is used on a small scale in brickmaking, for example in east Kent, and at one site in North Wales it is used as the clay feedstock for cement manufacture. Some old coal tips may be reworked to recover any remaining coal present.

During surface coal mining the recovery of ancillary minerals may also be feasible. Locally sand and gravel resources overlying the coal-bearing strata have been recovered. However, more commonly it is the rocks comprising the interburden that are of economic interest. The most important are fireclays, which are mudstones that occur beneath almost all coal seams and represent the soils on which coal-forming vegetation once grew. Fireclays were formerly valued as refractory raw materials but are now primarily used for the manufacture of buff-coloured facing bricks and pavers. The close association of fireclays and coals means that surface mine coal operations provide one of the few viable sources of the mineral. Most of current fireclay is derived either from stockpiles on former surface mine coal sites or from operating surface mine coal sites. Only a small proportion (about 20%) of surface coal mining sites normally produce fireclay. This may be due to the poor quality of the fireclays, or may be the result of operational or planning restrictions. However, the size and speed of surface mining invariably creates a mismatch between potential supply and immediate market demand. Where reserves of fireclays cannot be used where extracted, planning guidance urges that consideration should be given to stockpiling on an environmentally acceptable site, at the surface or underground. (see **Fireclay** Factsheet).

Mudstones are commonly interbedded with coals in surface mine coal sites and these too may be recovered for brickmaking. In addition, sandstone has locally been recovered in South Wales for high specification aggregate suitable for use in road surfacing and elsewhere as a source of blockstone for dimension stone production.

By-products of the combustion of coal at coal-fired power stations are furnace bottom ash (FBA) and pulverised fuel ash (PFA). FBA is used as a lightweight aggregate in concrete block production and PFA is used mainly in cement manufacture and for fill.

Alternatives and recycling

Coal is consumed in the combustion processes in which it is used and thus cannot be recycled. However, there is much potential for using the heat energy produced by coal combustion more efficiently.

Most indigenous coal is used in electricity generation. Here, along with imported coal it forms part of an energy mix composed of natural gas, nuclear, and renewables. In the short-term, the key alternative energy source to coal is gas. Gas's share of UK electricity generation has risen rapidly from 2 per cent in 1992 to 46 per cent in 2008. Domestic natural gas production (mostly from the North Sea) is declining rapidly and the UK became a net importer in 2004. With a commitment given by the Government in 2006 that 'nuclear should be part of the UK's low carbon energy mix' progress is being made toward replacing ageing nuclear stations with new build. Government has also stated that it aims to generate 15 per cent of UK electricity from renewable sources by 2020.

Offshore gas production is rapidly declining and the UK became a net importer in 2004. It is planned that future supplies, replacing both coal and, presumably, nuclear power, will come from Norway and the Netherlands, initially, and then, probably, from Russia, by pipeline, and Algeria and elsewhere as liquefied natural gas (LNG). This scenario has provoked the foremost argument for maintaining domestic coal production, namely security of supply. However, competition from coal imports from other countries is strong and presents a continual challenge for the UK coal industry. The European Commission has concluded that the EU's dependence on external energy supplies will rise from 54% in 2008 to levels around 60% in 2020 (Europe's current and future energy position, Com [2008] 781). The EC is concerned to help maintain coal reserves and ensure that

Coal

A coal cutting machine shearing a two metre thick slice from the Warwickshire Thick seam at Daw Mill Colliery in the West Midlands. Picture courtesy of MRP Photography.

a certain coal production capacity remains available to cover any contingencies that might affect the energy market in the future. Nevertheless the EC remains committed to gradually removing support for loss-making operations and transferring such aid to renewable energy sources. Measures allowed by EU rules that provide financial assistance to European mines are described in the following section.

Alternative or clean coal technologies reduce the environmental impact of coal, particularly for electricity generation, by increasing the efficiency of its conversion to energy and by reducing harmful emissions, notably of carbon dioxide and sulphur dioxide. Improving the efficiency of coal-fired power stations leads directly to reductions in carbon dioxide emissions, a major contributor to climate change. These technologies include the various methods used to capture methane and other forms of energy from in situ coal seams, including coalbed methane (CBM), abandoned mine methane (AMM) and underground coal gasification (UCG). Issues relating to these methodologies are covered in a separate factsheet.

There are also proposals for carbon capture and storage (CCS) from existing and new build coal-fired power stations, which would then be compressed and pumped to depleted oil and gasfields, as well as in deep saline groundwater reservoirs and in coal. Storage in coal would have the additional benefit of increasing coalbed methane yield if schemes were run in association. Uncertainties remain regarding the commercial viability of CCS (see section on 'Markets' above).

One future opportunity is that methane utilisation that results in a greenhouse gas (GHG) emission reduction could qualify for emissions reduction credits in carbon trading markets. Selling or flaring methane would result in GHG reduction. Joint Implementation projects, which result in emissions reductions, are awarded Emissions Reduction Units (ERU's) or 'Carbon Credits', which are tradable commodities.

Effects of economic instruments

The Government has provided support for UK coal producers. Following the UK Government's 'Coal Operating Aid Scheme' for coal mines, which approved £163 million to pay operating aid (April 2000 to December 2002), the EU's Coal State Aid regulation (2002–2010) has enabled the UK to pay investment aid to mines that have a viable future. Coal Investment Aid (CIA) was introduced in 2003 to provide up to £60 million of support for capital investment by 2008.

The EU Emissions Trading Scheme, which came into effect in 2005, aims to reduce the EU's carbon dioxide emissions. Coal is a high carbon fuel and coal-fired stations emit roughly twice the level of carbon dioxide as Combined Cycle Gas Turbines per unit of electricity generated. Phase II of ETS runs from 2008 to 2012. The Large Electricity Producers (LEP) sector which includes coal-fired power stations received a lower CO_2 allocation in Phase II. The UK Government decided that the LEP sector would be responsible for delivering the additional carbon savings which the UK expects the EU ETS to achieve. It considered that this sector is more insulated from international competition and has more low cost abatement opportunities than other sectors. In Phase I, 100 per cent of allowances were allocated for free. Phase II has seen the introduction of auctioning in the UK. The UK's Phase II

National Allocation Plan states that it will auction or otherwise sell 7 per cent of the total number of allowances in Phase II.

Transport issues

Most of the remaining deep underground mines have on-site rail connections to the national rail system and supply power stations by 'merry-go-round' services using dedicated trains. This is exemplified by the relationship of the mines in the East Pennine Coalfield to the large power stations in the Trent Valley. The power station farthest from domestic coal sources is Didcot, in Oxfordshire. The Ferrybridge power station in Yorkshire is supplied with coal from the nearby Kellingley mine by canal barge. Due to their transient nature, permanent rail connection to surface mines is normally impractical and the output from these operations is either transported by truck or conveyor belt to railhead depots, and then distributed by rail, or transferred direct by road. The chief inter-regional movements of coal are from Scotland to England and, in lesser amounts, from North-east England to Yorkshire. Coal imports are transported from ports by rail. Whilst there is sufficient port capacity to meet current coal import requirements, an update of UK port demand forecasts commissioned by the Department for Transport in 2007* suggested that 'there may be a requirement for additional deep-water capacity at specific locations to handle deepsea coal imports'.

Regulation

Licensing

Ownership of almost all UK coal (but not lignite) now resides with The Coal Authority on behalf of the state (see 'Structure of the industry'). Operators must obtain a licence from the Authority to explore for, and to work coal. As well as a licence for these activities, the operator will also require any necessary surface access rights and a valid planning consent.

Planning issues

Sustainable development: Policy in England, Wales and Scotland requires that in applying the principles of sustainable development to coal extraction, whether surface or deep-mine (including colliery spoil disposal), there should normally be a presumption against development regardless of the location, unless the proposal would meet a number of tests. No such presumption exists for other minerals. The tests in relation to National Parks, SSSIs, Green Belts and other designated areas are no different than required for any other mineral development. However, the key initial test requires demonstration that the development

*MPS Transmodal (2007) Update of UK Port Demand Forecasts to 2030. www.dft.gov.uk/pgr/shippingports/ports/portspolicyreview/207015_Final_Report_2.pdf

is environmentally acceptable, or can be made so. If not environmentally acceptable, the presumption against development can be set aside if the development would provide resulting community benefits. This too is a unique provision in planning policy.

Minerals Planning Guidance Note 3 (revised), March 1999, *Coal mining and colliery spoil disposal*, sets out planning policy for England. MPG3 has a presumption against development unless a proposal is environmentally acceptable or provides local and community benefits. Other relevant guidance is MPG 5: Stability in surface mineral workings and tips.

Scottish Planning Policy sets the planning policy framework for surface working of coal in Scotland. It has a presumption against development unless a proposal is environmentally acceptable or provides local and community benefits. It also states that surface coal extraction is unlikely to be environmentally acceptable if proposed site boundaries are within 500m of the edge of a community.

Minerals Planning Policy Wales together with Minerals Technical Advice Note (MTAN) 2: Coal requires that proposals (surface or deep mining) should be environmentally acceptable and make no lasting environmental damage but, where this cannot be achieved, the local or community benefits must outweigh the disbenefits of the likely impacts. MTAN 2 states that coal working will not generally be acceptable within 500 m of settlements.

Safeguarding: Coal is a valuable resource and there is a need to ensure that it is safeguarded from surface developments such as housing or industry which could result in either its unnecessary sterilisation or could severely hinder its extraction in the future. This mainly applies to coals suitable for surface mining. Areas of shallow coal resources therefore need to be identified in development plan documents for safeguarding. Policies to prevent unnecessary sterilisation of such identified resources also need to be provided in such documents. The BGS and the Coal Authority has completed an evaluation of the remaining coal resources in Britain which are capable of extraction by surface mining methods. These data provide the basis for defining safeguarding shallow coal resource areas.

Deep (underground) mining: Deep mining of coal can raise a number of planning considerations of which the need for an industrial complex with associated transport infrastructure at the mine head, and the disposal of colliery spoil and its sympathetic integration into the landscape are all substantive issues. Mining can also give rise to subsidence, although this can be carefully controlled with modern mining methods.

Surface (opencast) mining: Surface coal mining operations share many similarities with other surface quarrying operations in relation to the amenity issues of noise, dust, pollution and traffic. There are, however, notable differences in relation to the scale and rapidity of operations and their possible concentration, which may be perceived as having an unacceptable cumulative impact in an area. Compared to many other minerals, relatively large amounts of overburden are often removed to access coal and the management of this material during surface mining operations can also give rise to concerns. Some overburden can be utilised to assist in screening works but all will normally be deposited back into the worked-out void to assist restoration.

Restoration: Restoration and visual impact issues associated with surface coal extraction are a major planning consideration. Some past restoration was poor, unrelated to the local landscape and some sites have degraded. Good quality restoration can be successful in creating semi-natural habitat, lost elsewhere by other non-mineral development, in tune with the local landscape character. Restoration following surface extraction of coal can help to remove dereliction, eliminate hazards, clear up contamination, control external pollution effects and recover coal left behind by earlier underground mining. In so doing, such operations provide planning gains and are assisting sustainability objectives in relation to pollution, ground stability and biodiversity.

Co-working of other minerals: Surface extraction of coal may also enable the recovery of

Ratcliffe-on-Soar coal-fired power station (2000 MW) and FGD plant (in foreground).

other minerals, mainly fireclay. However, the extraction of these materials may create complications in the planning process, particularly if the rate of extraction is out of phase with coal recovery, or may be simple and without any additional external impacts. Recovery should be encouraged, because of sustainability considerations, where acceptable in planning terms. Prior extraction of coal and any other associated minerals in advance of other development prevents sterilisation of these minerals and can assist in addressing any potential land instability arising from historic mineral workings.

Colliery spoil: Despite the restoration of many colliery spoil tips, some still remain and produce a feature that is incongruous in the landscape, potentially polluting and with possible long-term stability problems. Some of the older tips may have a significant percentage of coal (>25%) and justify reworking. Treating the tips and recovering coal meets sustainability objectives, although the 'stock' of tips where treatment is necessary for amenity reasons has substantially declined. Reworking these tips raises planning issues similar to opening a new mineral working. The planning issues associated with their treatment needs, therefore, to be considered carefully, especially where remaining tips may be located in areas, such as the mountain plateau in South Wales, where significant access or other planning difficulties and constraints arise. Planning policy for England is laid out in MPG 3 and MPG 5: Stability in surface mineral workings and tips.

Legacy of historic coal mining: Britain's long history of underground coal mining (see above) has left a considerable environmental legacy which impacts on land use in some former mining areas. This legacy is chiefly associated with pollution from minewater entering streams and rivers, and from ground stability (subsidence) problems associated with former underground mine workings and entries (shafts and adits). The Coal Authority is the public body which deals with public safety risks arising from past coal mining activities. These include mine entry and mine working collapses, gas emissions, mine water emissions and spontaneous combustion of coal. The Coal Authority is pro-actively working with all coalfield planning authorities to ensure that mining legacy is being addressed

in development plans and the development management process.

Further information

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To make an appointment to inspect or enquire about obtaining copies of the former British Coal Prime Geological Data collection lodged with the British Geological Survey please contact BGS Central Enquiries 0115 936 3143 enquiries@bgs.ac.uk

Authorship and acknowledgements

This factsheet was produced by the British Geological Survey for the Department for Communities and Local Government as part of the research project 'DCLG-BGS Joint Minerals Information Programme.'

It was compiled by Andrew Bloodworth and Rhian Kendall (BGS) with the assistance of Tom Bide and Deborah Rayner (BGS).

The advice and assistance of the Department for Communities and Local Government, The Coal Authority and CoalPro are gratefully acknowledged.

Mineral Planning Factsheets for a range of other minerals produced in Britain are available for download from www.mineralsUK.com

Bibliographic reference:
British Geological Survey (2010) Mineral Planning Factsheet: Coal http://www.bgs.ac.uk/downloads/start.cfm?id=1354