British Geological Survey

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.

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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 and surface 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'.

Surface working of coal at the (now closed) Muir Dean site, Scotland © BGS/ UKRI.

The physical and chemical properties of coal determine whether a coal can be used commercially, either on its own or after processing/blending to improve coal quality. Important properties will vary depending on the intended end use but may include calorific value, ash content, levels of sulphur and chlorine (and other impurities), moisture content, density and strength. Sulphur is a serious impurity in coal, causing both corrosion and, more importantly, atmospheric pollution when released as sulphur dioxide, which causes acid rain.

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. Based on the physical properties of different bituminous coals, a distinction is made worldwide between thermal coal (also sometimes referred to as steam coal), and coking coal. Thermal coal is principally used for burning for heat generation and in boilers, chiefly for electricity generation and industrial process such as the production of cement, chemicals and fuel manufacture. Coking coal however is used only by the metallurgical industries in the iron and steel making process. Coking coal produces coke which has specific physical and chemical properties required for iron and steel making and sufficient strength to support the loads imposed within the blast furnace. This division of thermal and coking coals can, however, be simplistic due to the wide range of specifications coal is produced to. For example, non-coking coals (via pulverised fuel injection) are required in modern steelmaking within a blast furnace. End use cannot be defined on properties alone and will be reliant on a combination of closely defined specifications (often met by careful blending of different coals) and market demand. A single seam, or combination of seams, from a mine may be able to provide a range of products from feedstocks for steel making to power generation. End users of coal commonly require consistency in supply as the plant in operation will be tuned to a specific coal quality for efficiency and to conform with environmental legislation.

The combustion of coal emits CO_2, which is well known 'greenhouse gas' and contributing factor in climate change. As such, policies regarding the

extraction and use of coal in the UK in recent years have been subject to government review.

This factsheet deals with the extraction, and subsequent use of coal, from underground and surface mines. 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 by underground coal gasification. Issues relating to these methodologies are covered in a separate factsheet on **alternative fossil fuels**. In addition, disused coal mines are a potential source of geothermal energy.

Markets

Coal is used either as a primary source of energy, such as for electricity generation or industrial processes, or as a reductant in metal smelting, especially iron smelting. UK demand for coal is on a long-term declining trend, having fallen dramatically in recent years. This decline is principally due to a reduction in coal used for electricity generation (see Figure 4) driven by policies aimed at curbing the harmful emissions and anthropogenic climate change impacts associated with burning coal.

Coal remains, however, an important feedstock for many industrial processes in the UK (see Figure 1), with 18% of coal consumption used for industrial uses in 2019 (excluding for use in the steel industry, discussed later). One of the largest industrial uses of coal, outside steel manufacturing, is for mineral products processing (8%). The majority of this is for cement manufacture, where coal, often mixed with other alternative fuels (see alternatives and recycling section), provides the heat for the high temperature chemical reaction required to produce cement clinker. There are also several other minor uses of coal for mineral processing. In brick production a small amount (less than 1% of UK brick production) of specialist kilns use coal as both an energy source and to impart a specific appearance on bricks. In the production of mineral wool coke is required as both energy source and as a chemical feedstock in the manufacturing process. Such examples, although consuming small amounts of coal, rely on the chemical and physical properties of coal and cannot easily be replaced by other energy sources. Coal is also used to provide heat for some chemical manufacturing as well as to dry intermediate products in food and paper manufacture. Coal has the ability to supply a consistent heat baseload which is much valued in industrial applications. These coals are often marketed in terms of lump size. Common sizes include smalls (0–50 mm) singles (12.5–25 mm), doubles (25–50 mm) and cobbles (50–100 mm). Larger size fractions are more commonly used in domestic heating and finer sized fractions are used in industrial boilers. Although the volumes consumed in these industries are much smaller compared to what was historically consumed for electricity generation these markets are unlikely to decline in the short term due to costs of replacing existing infrastructure and the research and development required for alternatives. Alternatives are available (such as fuel from waste products, biomass or natural gas) but these are unsuitable for boilers designed for coal and there may be less certainty regarding long term supply and availability for some waste products. Other smaller industrial uses include anthracite used in water filtration, fuel for heritage railways, patent fuel manufacture (i.e. smokeless fuel) and domestic consumption (however burning of non-processed 'house' coal is set to be phased out by 2023 to limit air pollution).

The kiln at Dunbar cement works, this uses a mix of coal and waste derived fuels. ©NERC/BGS.

Coking coal is chiefly consumed by the primary iron and steel industry to make coke for use in blast furnaces to reduce iron ore to molten iron, where it is irreplaceable. With 23% of coal consumed in the UK in 2019 being used for coke manufacture, there

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remains a sizeable market for coking coal. Coke plays an important role in the iron making process as it acts as a fuel source, provides the supporting matrix for the iron ore and carbon in the reaction. Almost all requirements for coking coal are currently imported, although resources remain in some UK coalfields. There are currently plans to extract coking coal from deposits offshore of Cumbria and there are also some unworked resources in the South Wales coalfield and in the north east (which have historically produced coking coal). An additional important market in steelmaking in the UK is coal used in pulverised coal injection (PCI) (14% of UK coal consumption in 2019). PCI (blowing particles of coal into the blast furnace) reduces the quantities of coking coal required and makes the process more efficient.

Historically the UK coal industry was dominated by electricity generation, this is no longer the case. The use of coal in electricity generation has declined rapidly in recent years, being replaced by natural gas, renewable energy and to a lesser extent, by nuclear power. In 2019 coal accounted for only 3% of electricity generation in the UK. This decline has been influenced by numerous UK and EU policies aimed at curbing harmful emissions and anthropogenic climate change impacts associated with burning coal. Such policies have culminated in The UK Climate Change Act 2008, as amended in 2019. This sets legally binding emission reduction targets for 2050 (reduction of 100% in greenhouse gas emissions, against a baseline of emissions in 1990, to achieve 'net zero'), and introduces five-yearly carbon budgets to help ensure these targets are met. In February 2020 the UK Government announced that thermal coal would be phased out of the UK's energy system by October 2024, some 12 months earlier than previously planned. In 2019 some 2.9 million tonnes of coal (81% of which was imported) were used in electricity generation. This represents a drop of over 90% in the last 10 years.

Coal-fired generation retains some operational advantages over other energy sources. Electricity output can vary significantly throughout the day making coal-fired generation particularly useful for meeting peak demand (particularly in winter, during extreme cold snaps) or covering supply difficulties with other fuels or renewable energy sources (such as during periods of little wind). Coal-fired power generators can also hold large coal stocks, due to ease of storage, an option not so easily available to gas generators and have the ability restart after a total loss of power.

Supply

Around 82% (6.5 million tonnes in 2019) of the UK coal market is supplied by imports, with the remaining 18% (2.16 million tonnes) coming from indigenous sources. Coal is produced in the UK by both

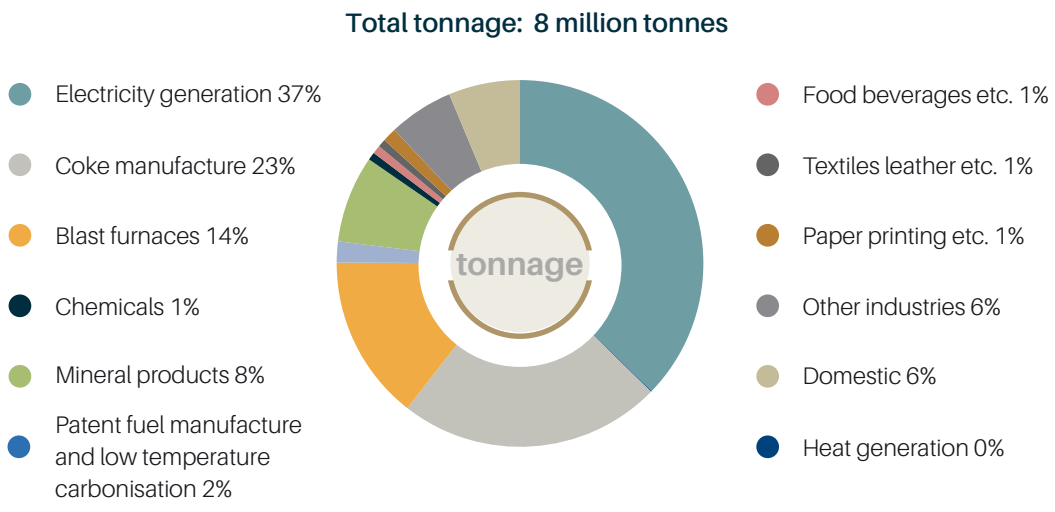

Figure 1 UK: Coal consumption by market in 2019. Source: BEIS.

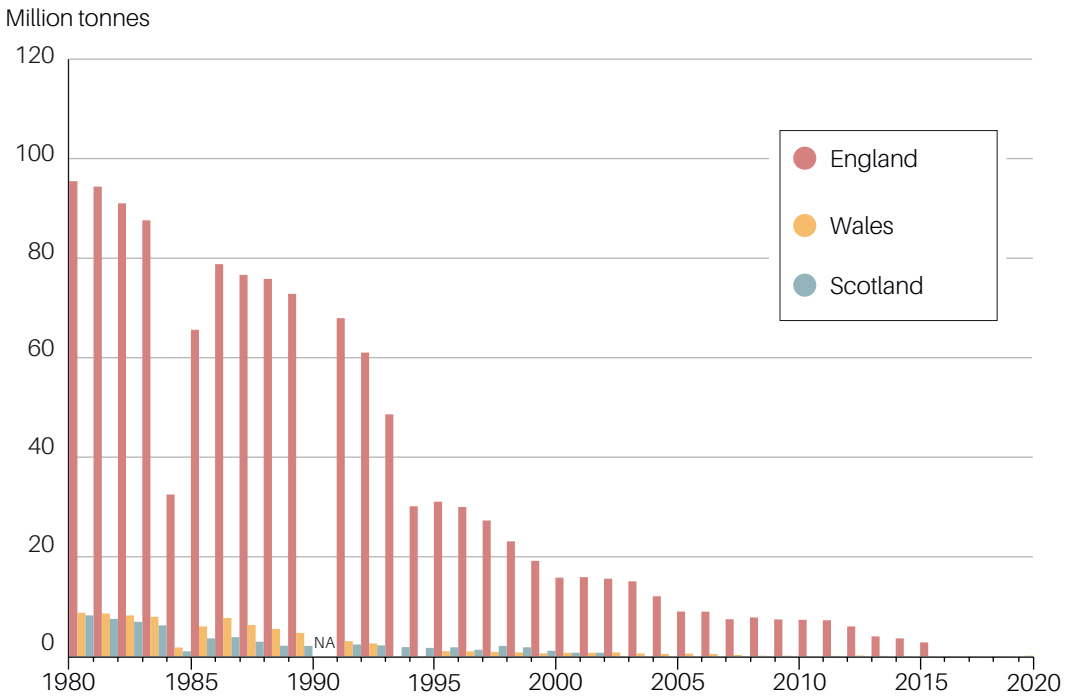

Figure 2 Great Britain: underground coal production, 1980–2019. Source: The Coal Authority.

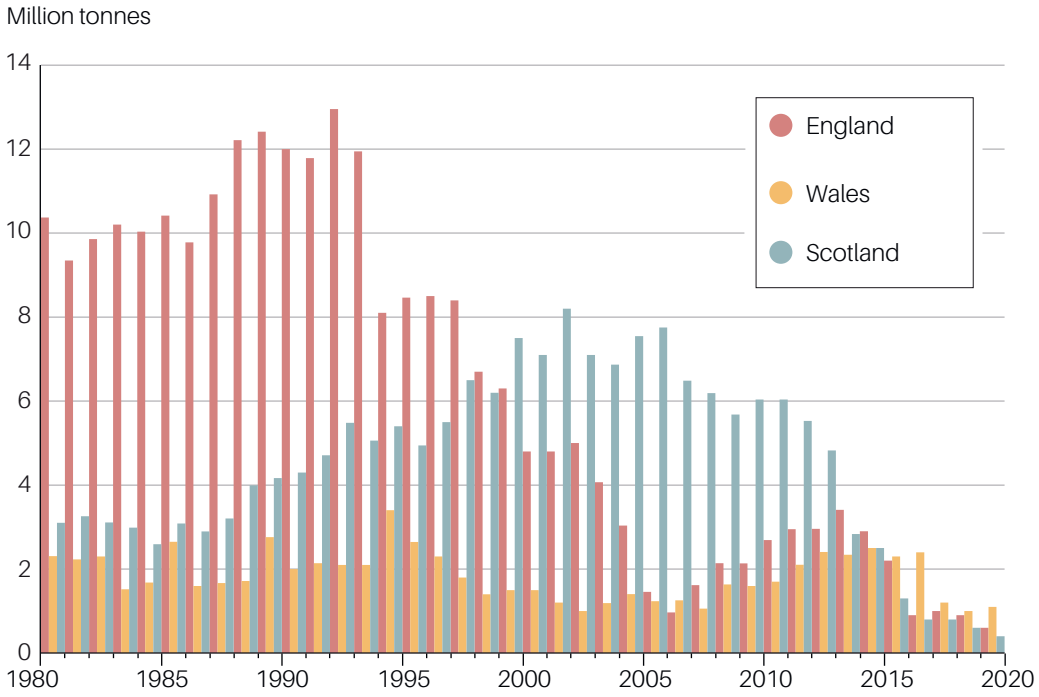

Figure 3 Great Britain: surface coal production, 1980–2019. Source: The Coal Authority.

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underground and surface mining (Figure 3) although the majority of production is from surface mining. By the end of 2015, no large underground mines remained operational. Underground production has since been limited to several small drift mines in South Wales, Gloucestershire and Northumberland.

Of the 2.16 million tonnes total UK domestic production in 2019, 95% (2.1 million tonnes) was from surface mines and 5% (0.1 million tonnes) was from underground mines. Coal can also be recovered from colliery spoil heaps, by means of 'tip washing' however this practice has not been used in recent years.

Total coal stocks (held at stockpiles at mine sites and by end users) have decreased significantly since 2014 in line with falling demand from electricity generation. Stocks were 5.3 million tonnes in 2019, equivalent to about 40% of annual coal consumption.

During 2020, 9 surface mine sites extracted coal, of which 5 were in England, 1 in Scotland and 3 in Wales. The majority of these sites (4 in England, 1 in Scotland, 1 in Wales) closed during 2020, due to depletion of reserves, failure to gain planning permission to release additional reserves or economic reasons (see structure of the industry section).

Trade

The UK was a (small) net exporter of coal until 1983. After that date, mine closures caused output to fall, with imports rising rapidly and in 2001 they exceeded home production for the first time. In recent years the UK has become increasingly reliant on imports, principally due to a lack of indigenous supply as existing sites close. The rising trend in net imports of coal is shown in Figure 4.

In 2019 imports of coal totalled 6.5 million tonnes. Of these imports, 4.2 million tonnes were for use in power generation, 2.3 million tonnes were coking coal and 0.1 million tonnes were anthracite. The chief sources of coal for power generation — Russia (1.7 Mt), USA (0.8 Mt) and Colombia (1.1 Mt) — together accounted for 84% of the total. The USA supplied 44.5% of coking coal imports. Some specialised uses of coal, for example heritage rail, require volumes of particular specifications that are too small to economically import and are therefore currently rely solely on indigenous production.

Consumption

UK coal consumption has generally been on a declining trend for the last 40 years (Figure 4). Historically consumption has principally been driven by demand from coal-fired power stations, but this has now been overtaken by other uses as coal-fired electricity generation is phased out (Figure 5). Indeed, there was no coal-fired power input into the national grid from the 9th of April to 16th June 2020.

In 2019, coal consumption was 8 million tonnes, around 82% of which was supplied by imports. Elec-

	Steam coal	Coking coal	Anthracite	Total
Electricity generation	2906	0	0	2906
Heat generation	6	0	0	6
Coke manufacture	0	1809	0	1809
Blast furnaces	0	1135	0	1135
Patent fuel manufacture	0	0	144	144
Industry	1205	0	221	1426
Other	340	0	182	522
TOTAL	**4457**	**2943**	**548**	**7948**

Table 1 Consumption of coal by end use in 2019 in the UK (thousand tonnes) Source: BEIS.

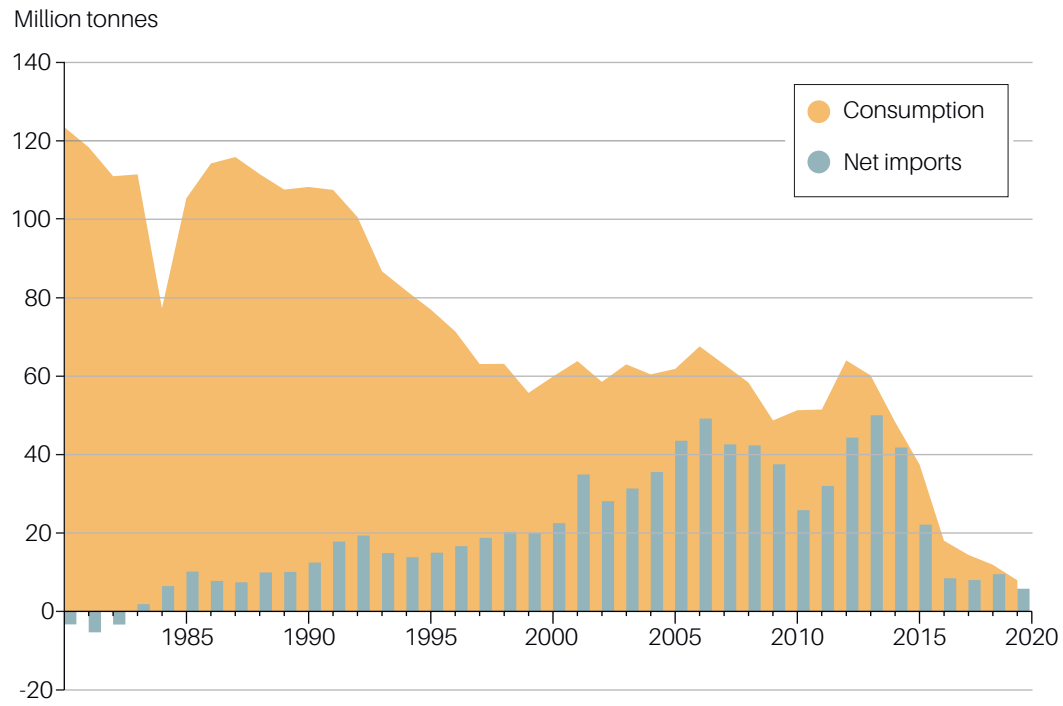

Figure 4 UK coal consumption and net imports, 1980–2019. Source: BEIS.

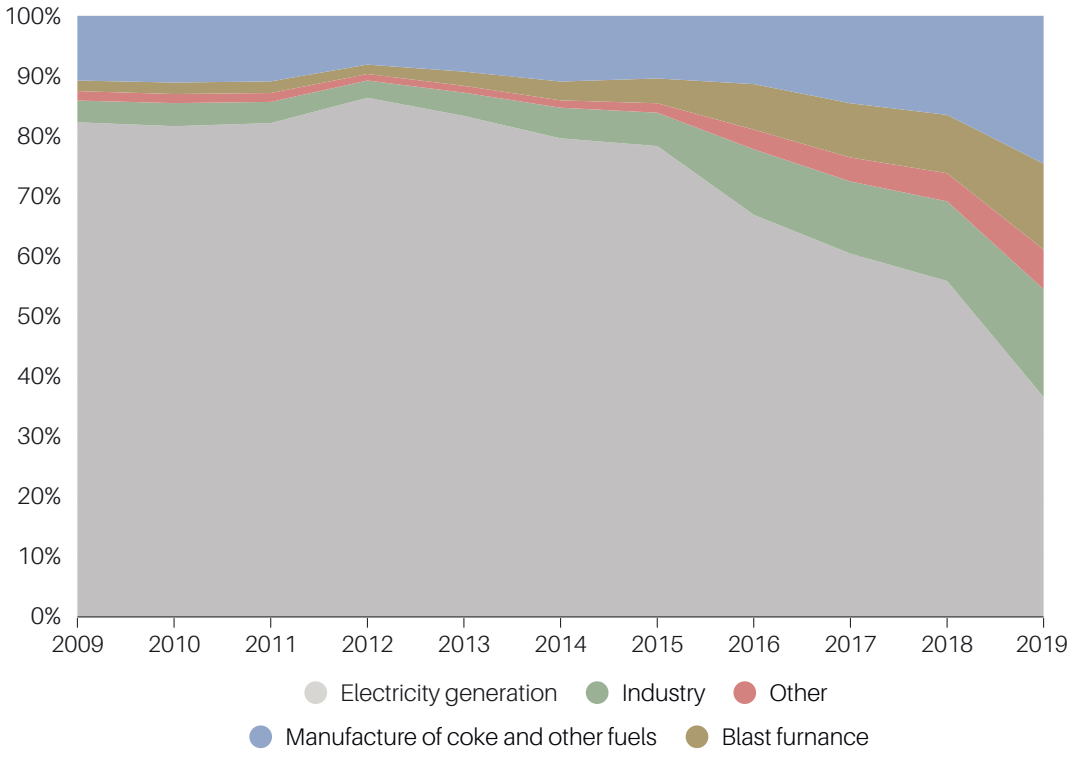

Figure 5 Percentage of coal consumed in the UK in major sectors 2009–2019. Source: BEIS.

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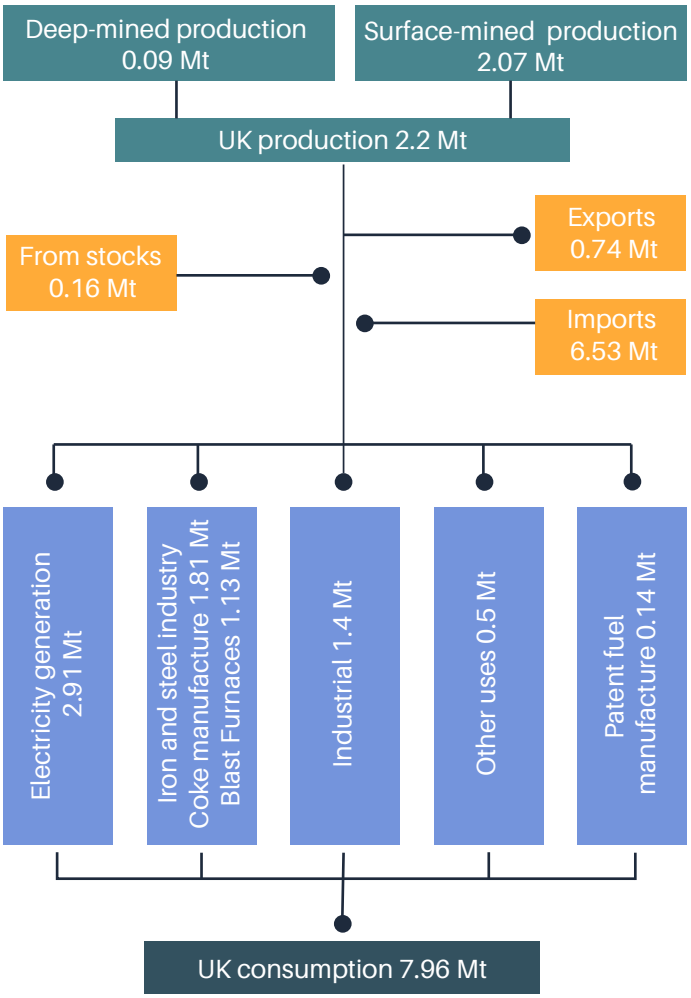

Figure 6 The UK coal supply chain, 2019 (totals may not add up due to rounding). Source: BEIS.

tricity generation accounted for the largest share with 37% of all coal consumed in the UK in 2019 (Table 1 and Figure 1). Although this is still the single largest end use of coal this is rapidly changing. Demand for coal for electricity generation is predicted to be zero by 2024 in line with Government policy. The second largest use (23%) was for coke manufacture, mainly for use in blast furnaces in the iron and steel industry. Demand for coal for this and other industrial uses is likely to continue in the short to medium term due to the significant infrastructure investment required to replace existing boilers and furnaces or to develop the required alternative technologies allowing a switch to different fuel types.

Economic importance

In 2019 the value of UK coal production was £132 million. The value of coal imports in the same year was £574 million and the value of exports £103 million. Direct employment in the surface and underground mine coal industries was 699 at the end of 2019, comprising 557 at surface mines and 142 in underground mines.

No figures are available for the value of coal for energy compared with industrial uses. However, it is estimated in the UK Minerals Strategy that the UK coal industry adds around £0.1 billion to UK GVA (Gross Value Added), increasing to £2.4 billion if downstream products and manufacturing is taken into account.

Structure of the industry

The UK coal industry was, with minor exceptions, nationalised in 1947. It passed back into private ownership in 1994. Coal production is dominated by surface mining which now consists of only three separate operators owning three remaining surface mine sites. A number of small underground drift mines are also operational in the UK.

In England there is only one operational surface site, Hartington Reclamation, operated by *Fitzwise Ltd*, working deep-mined colliery spoil tip in Derbyshire. It is due to cease production in the summer of 2021. One site is currently in the planning process, Dewley Hill, near Newcastle.

In England, there is one small drift mine in Northumberland (operated by *Ayle Colliery Co Ltd*) and also five other small mines licensed in the Forest of Dean which are operated by individuals. Working is on and ad-hoc basis, supplying small amounts of coal for local use. A new large deep underground mine is currently being planned offshore in west Cumbria, operated by *West Cumbria Mining*. This mine plans to extract coking coal from offshore deposits to supply the indigenous steel industry and the export market.

In Wales there are two underground drift mines producing, Aberpergwm and Dan-y-Graig operated by *Energybuild Mining Ltd* and *Three D's Mining Ltd* respectively (October 2020). There are two surface mines working in Wales, Nant Helen in Powys oper-

ated by *Celtic Energy Ltd* and Ffos-y-Fran operated by *Merthyr (South Wales) Ltd* which are due to cease production in the summer of 2021 and September 2022 respectively. Both produce anthracite used to supply the Port Talbot steelworks (as well as other grades).

In Scotland, no underground mines remain. The only remaining surface mine closed in September 2020, this was operated by *OCCW (House of Water) Ltd* .

CoalImP is the Association for UK Coal Importers and Producers and is the trade association for the industry. Government policy and sponsorship responsibility for the coal industry lies with the Department for Business, Energy and Industrial Strategy (BEIS).

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. It currently reports to BEIS. 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 (Pennsylvanian) 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 Pennsylvanian aged successions. In Scotland these occur principally in the Limestone Coal and Upper Limestone formations, with locally thick coals present in the Passage Formation.

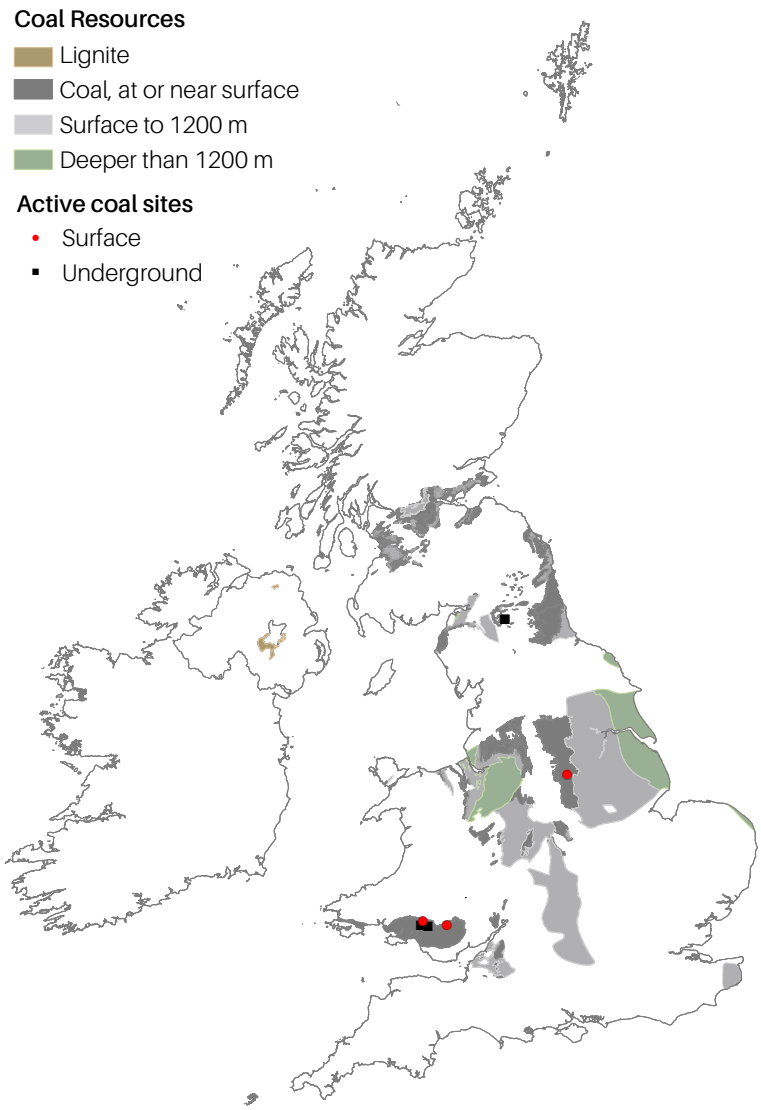

Figure 7 Distribution of coal resources in the UK. Including producing sites (October 2020).

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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 7 shows the distribution of exposed and concealed coal-bearing strata.

Despite a long history of coal mining in Great Britain, considerable quantities of coal remain at depths accessible by underground mining. However, any new, shaft-accessed deep mines would be extremely expensive to develop and with the demise of the main market for electricity generation, any foreseeable future development seems highly unlikely. This does not preclude deep mine development to access specialised coking coals, as the current proposal in West Cumbria exemplifies. In the immediate future, interest in coal extraction is therefore likely to be mainly 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 former workings.

Coal from surface mines typically contain lower amounts of deleterious impurities, in particular sulphur and chlorine, than deep mined coal. 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 and domestic customers. However, whilst significant resources amenable to surface extraction remain, mining is severely constrained by environmental and planning considerations (see planning issues section). Very large volumes 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, and additionally in Mesozoic and Palaeogene strata. However, much of this is lignite rather than bituminous coal. Most of the UK's coal deposits are of the thermal type. Only a very small proportion can be classified as coking coal. 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 quantities that have been evaluated for power generation.

Reserves

No data is currently collected on a centralised basis or is publicly available for permitted reserves of coal in operational or planned sites (surface mined or underground). Currently all active surface sites are due to close by the end of 2022 at the latest, which will reduce reserves to zero unless new sites or extensions are granted before then, see section on planning issues.

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

Type	2016	2017	2018	2019	2020
Surface mined					
Operating	14	13	13	5	2
Closed	0	0	0	0	0
In planning process	10	5	5	4	4
Underground					
Operating	1	26	25	23	23
Closed	53	0	0	0	0
In planning process	5	345	345	345	340

Table 2 Tonnages remaining in licences in Great Britain (million tonnes) at 19 June 2019. Source: The Coal Authority.

sites currently going through the planning process but with licence from the Coal Authority. Additional resources have been defined by 'prospects' and 'pre-planning' in Coal Authority statistics, these are not included here as they do not have planning permission and are speculative with low levels of confidence regarding the geological, economical or technical feasibility of extraction.

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 or surface mining methods.

Extraction and processing

Coal is mined by both surface and underground methods.

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 occasionally exposes areas of ancient, shallow, underground pillar and stall workings and can, therefore, be used to remove and stabilise these. Elsewhere surface mining has been used for land reclamation and remedial work with subsequent redevelopment for other uses. There are now few 'brownfield' sites remaining that would benefit from this type of remedial work and all new applications for new sites in recent years have been greenfield in nature. 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. Surface mining is undertaken in a phased manner, and only a small section of the overall mined area is worked at any one time, with progressive restoration to previously worked areas as mining progresses.

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 low chlorine contents (< 0.1%). 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' operations.

Whilst underground mining is now confined to a handful of small sites, it formerly involved 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. The longwall method was used by all large deep mines in the UK when they were operational. 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. The only large underground mine planned for the UK, offshore from west Cumbria, plans to use a combination of the two methods, known as 'run out and pocket'.

During mining, some rock above the coal seam (generally mudstone) and beneath the coal seam (seatearth) was often extracted with the coal. Thin beds of mudstone also occur interbedded within the coal seams. This mixture of coal and dirt is not saleable hence leading to waste stockpiles. Coal preparation transforms the mined coal into a saleable product and thereby adds economic value. Environmental concern about harmful emissions, such as sulphur

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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. 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 for fine coal (used where coal is unavoidably crushed in other mining or treatment processes). Other methods using water are also used. Historically the waste (colliery spoil) separated from the coal was disposed of 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.

By-products

Methane trapped within coal can be released on mining. In active underground mines, the concentration of methane in the air is actively monitored and controlled for safety reasons. It is sometimes possible to capture this methane (Coal Mine Methane, CMM) and pipe it to surface for fuel or electricity generation. It is also possible to capture methane from closed mines (Abandoned Mine Methane, AMM). Geothermal energy can also potentially be extracted from water flowing through abandoned deep workings, this is especially applicable where such workings underlie urban areas. Currently the BGS is investigating the feasibility of this energy source around Glasgow and South Wales.

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 from operating sites. This may be of use as a low-grade aggregate, for example, as bulk engineering fill. 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 such as sand and gravel resources overlying the coalbearing strata have been recovered. However, more commonly it is the rocks comprising the interburden that are of economic interest. An important by-product of surface mines are fireclays, which are mudstones that occur beneath almost all coal seams and which have provided an important source of light-firing clay for brick manufacture. The close association of fireclays and coals means that surface mine coal operations provide one of the few viable sources of the mineral and the decline of surface mined coal production has caused supply restrictions for fireclay. Most of current fireclay supply is derived either from stockpiles on former surface mine coal sites or from operating surface mine coal sites. It is estimated that 90% of fireclay supply is derived from surface mined coal workings therefore, sites with suitable clays are important industrial mineral resources. Fireclays are generally produced in specific areas within the coalfields, for example clays from the north east are highly sought after for their firing and buff colouring properties. Although surface mine production forms an important part of fireclay supply not all surface mines can produce fireclay. This may be due to the poor quality of the fireclays, or the result of operational or planning restrictions. The size and speed of surface mining may create a mismatch between potential supply and immediate market demand, careful planning and design of proposals in conjunction with clay users is required to enable stockpiles and a working scheme to maximise reserves. Where reserves of fireclays cannot be used where extracted, planning guidance urges that consideration should be given to stockpiling on an environmentally acceptable site. (See Factsheet on **Fireclay**).

Mudstones suitable for brickclay are commonly interbedded with coals in surface mine coal sites and these too may be recovered for brickmaking (see Factsheet on **brickclay**). 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 primarily used as a lightweight aggregate in concrete block production though it can also be used as a lightweight fill and drainage material and in the raw mix for cement clinker production. PFA is used mainly in autoclaved aerated concrete blocks, blended cements and con-

Ratcliffe-on-Soar coal fired power station and FGD plant (in foreground) ©NERC/BGS.

crete, grouts and stabilisation materials and in the raw mix for cement clinker production. Alternatives are now being sought for these materials due to the planned cessation of coal-fired-power generation. However, in the case of PFA, it is estimated that there is >100 million tonnes of material available in stockpiles of single use deposits at currently operating and recently closed power stations.

The remaining coal-fired power stations in the UK are equipped with flue gas desulphurisation (FGD) in order to reduce sulphur emissions. These plants can remove about 90% of sulphur dioxide emissions but at the expense of efficiency. Sulphur is recovered as synthetic gypsum (calcium sulphate), which is used in plasterboard manufacture (see Factsheet on **Gypsum**). The use of FGD is mandated by the Industrial Emissions Directive, which came into effect 1 January, 2016 setting limits on nitrogen oxides (NOx) and sulphur dioxide emissions. FGD production has declined significantly in recent years alongside coal-fired power generation and will cease entirely with the planned closure of the UK's coal-fired power stations. This will be the loss of an important source of gypsum.

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.

Whilst coal-fired power stations are planned to be phased out over the next few years, some indigenous coal will still be used in electricity generation during this period. Here, along with imported coal it forms part of an energy mix composed of natural gas, nuclear, and renewables, all of which have risen rapidly in recent years to replace the contribution historically made by coal.

The majority of indigenous production has now been replaced with imported coal, however it should be noted that imported coal will have higher associated greenhouse gas emissions due to the transport distances involved, different working practices and coal qualities (such as methane content) found outside the UK.

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Carbon capture and storage (CCS) is the process of capturing carbon dioxide at large emission sources, including coal-fired power plant, and heavy industry and compressing and transporting it to locations suitable for permanent disposal in depleted oil and gas fields and deep saline aquifer formations. Storage in deep coal seams has also been investigated offshore UK. Storage in coal may have the additional benefit of enabling production of coalbed methane. The development of CCS technologies is planned to enable substantial reductions in greenhouse gas (GHG) emissions linked to future consumption.

Many industrial users of coal are working to reduce their carbon emissions by substituting or switching to alternative fuels. For example, in cement manufacture coal use has been significantly reduced by combining waste products and biomass with coal. Between 2005–2019 43% of fossil fuel use (mainly coal) in the UK cement sector was replaced with waste derived fuels. However, there are limits as to how much coal can be substituted for in this way using different fuel mixes due the heating requirements of various types of existing kiln, plant and boilers that cannot be adapted. If alternative heat sources are designed in to new plant, as old plant is replaced, further reductions in coal use can be expected.

There are currently no alternatives for coke for the manufacture of primary steel made in blast furnaces that are currently viable at an industrial scale in the UK. Alternative methods of production of iron for use in steelmaking exist, for example via the use of methane in Direct Reduced Iron (DRI). The decarbonisation of the steel sector is a rapidly developing area of research. Alternatives to coke, such as direct hydrogen or oxygen injection, alongside other emerging coal free technologies are being developed. Such technologies remain energy intensive processes and barriers, such as hydrogen supply and electricity requirements, need to be overcome if coke is to be phased out of the primary steel production process.

Alternative or clean coal technologies reduce the environmental impact of coal, particularly for electricity generation, this is achieved by increasing the efficiency of its conversion to energy or by reducing harmful emissions, notably of carbon dioxide and sulphur dioxide. 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 on **alternative fossil fuels**.

Effects of economic instruments

One of the main drivers in phasing out coal for electricity generation, and replacement in coal intensive industries, is carbon taxation. 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 III of ETS runs from 2013 to 30 April 2021. Phase III differs from Phase II in that there are no longer national caps, but EU-wide caps. Post Brexit the EU ETS has now been replaced by a UK ETS with the same objectives.

Transport issues

All indigenously produced coal is now transferred direct by road. Due to the transient nature of surface mines, permanent rail connections are normally impractical. Previously, deep underground mines had rail connections to the national rail system and supplied power stations by 'merry-go-round' services using dedicated trains. This ended with the cessation of deep mining in the UK, although power stations are still rail-linked and imported coal is transferred from ports by rail. Due to a reduced demand much wharf infrastructure that previously served coal has been converted for other commodities, for instance coal handling facilities in Newcastle have been replaced to deal with biomass 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, which are regulated by the Coal 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 permission.

Planning issues

Sustainable development: Policy in England, Wales and Scotland requires that in applying the princi-

ples of sustainable development to coal extraction, whether surface or underground (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 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.

The National Planning Policy Framework (NPPF) states that coal is a mineral of national and local importance, however, that planning permission should not be granted for the extraction of coal unless the proposal is environmentally acceptable, or can be made so by planning conditions or obligations; or if it is not environmentally acceptable, then it provides national, local or community benefits which clearly outweigh its likely impacts (taking all relevant matters into account, including any residual environmental impacts) (paragraph 211). Other coal related policies in NPPF state that fireclay must be extracted separately and stockpiled if possible and that Mineral Planning Authorities should indicate areas that may be acceptable for coal extraction.

The extraction of coal, as with other hydrocarbons, is subject to great public and political interest due to the national and global issues relating to climate change and CO_2 emissions from the use of coal. As such, gaining planning consent for new mining sites or extension to existing ones has proven a challenging and protracted process in recent years. There is currently a low level of new applications and almost all recent planning decisions regarding coal extraction have resulted in permission being denied. Recent examples include a rejection for an extension at the now closed Bradley West site, County Durham, and a rejection, after the application was called in by the Secretary of State, for the Highthorn site, Northumberland. The application, by West Cumbria Mining, for a new coking coal mine in Cumbria is currently with central Government after a decision by the Secretary of Sate to call the application in.

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.

Planning Policy Wales states that continued extraction of all fossil fuels is not compatible with the Welsh Government's targets to decarbonise energy generation and that proposals for opencast, underground development or colliery spoil disposal should not be permitted except in exceptional circumstances. All new applications for fossil fuel development should be referred to the Welsh Government if planning authorities are minded to approve them. Polices specifically related to coal are detailed in Minerals Technical Advice Note (MTAN) 2, Coal.

Safeguarding: Along with other economic minerals there is a need to ensure that coal 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. NPPF requires areas of shallow coal resources 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. There is no requirement for safeguarding of surface coal resources in Wales and the decision to safeguard is left to local authorities. In Scotland local development plans should identify areas of search for surface coal extraction and set out the preferred programme for the development of other safeguarded areas beyond the plan period.

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 areas for shallow coal resource. As coal-fired power stations are phased out across the UK the option exists to safeguard stockpiles of by-products of the combustion process such as PFA and FBA.

Deep (underground) mining: Deep mining of coal can raise a number of planning considerations. Of

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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. 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. The only specific guidance within the National Planning Policy Guidance (NPPG) on minerals states that the environmental impacts of coal extraction should be considered, in the same way as other minerals, but with regard to other relevant national legislation.

Restoration: Restoration and visual impact issues associated with surface coal extraction are a major planning consideration. The Environment Bill, planned to be enacted during 2021, will require all new development to demonstrate biodiversity net gain. 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 of modern sites is tightly controlled and planned from the outset of operations and many recently closed sites provide examples of good practice with local environmental improvements made. The large amounts of material movement associated with surface coal mining provides considerable opportunities for landscape enhancement and biodiversity gain. This can be done using overburden stockpiles during the working life of mines or post-restoration. The Northumberlandia country park, constructed from material from the Shotton surface mine site, is an example of what can be achieved.

View of restored surface workings from the Former Widdrington surface mine, Northumberland © BGS/ UKRI.

Co-working of other minerals: Surface extraction of coal may also enable the recovery of other minerals, mainly fireclay, but also including brickclay, sandstone and sand and gravel. The extraction of these materials require early consideration in the planning process, particularly if the rate of extraction is out of phase with coal recovery. 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%) offering potential for 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 in south Wales, where significant access or other planning difficulties and constraints arise.

Legacy of historic coal mining: Britain's long history of underground and surface coal mining has left a considerable environmental legacy which impacts on land use in some former mining areas. Some past restoration of surface sites was poor, unrelated to the local landscape, may pose environmental risks from landslides or pollution and some sites have degraded. There have also been significant issues associated with abandonment of sites due to insolvency of the operator and insufficient bonds to adequately undertake restoration. Restoration following surface extraction of coal from brownfield sites can help to remove dereliction left behind by earlier underground mining as well as control external pollution, contamination and recover any remaining coal. The legacy from underground mining 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 proactively 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

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