Communities and Local Government

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Mineral Planning Factsheet

Alternative fossil fuels

*This factsheet provides and overview of '**Alternative Fossil Fuels**' (methane from coal, shale gas and underground coal gasification) 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*

October 2011

Alternative fossil fuels, sometimes also known as 'unconventional hydrocarbons' may present a viable partial replacement for the declining production of natural gas (methane) from conventional gas reservoirs located both onshore and offshore in rocks such as sandstone and limestone. These alternative fossil fuels are obtained from three distinct sources and employ extraction technologies which are very different to those used to extract conventional hydrocarbons.

Methane from coal includes gas recovered from active (coal mine methane or CMM) and abandoned mines (abandoned mine methane or AMM), as well as methane recovered from undisturbed or 'virgin' coal seams (usually known as coalbed methane or CBM). Gas from these sources is already produced on a modest scale in the UK and exploration is ongoing for further prospects.

Shale gas comprises methane recovered from mudrocks and shales which have previously been considered too impermeable ('tight') to allow economic recovery of gas. Although there is not yet any production of shale gas in the UK, there is some exploration activity.

The third unconventional source of gas involves combustion of underground coal seams in situ to produce synthetic gas ('syngas'). This process is usually known as 'underground coal gasification' (UCG). There are currently no UCG operations in the UK, although there have been some conditional licences issued by The Coal Authority for potential projects.

Exploration drilling for shale gas in Lancaster.

Markets

Between 1997 and 2003 the UK was a net exporter of natural gas, with a peak in production reached in 2000. However, the major mature gasfields have declined in production and limited opportunities to find new, significant fields means that the UK once again became a net importer of gas in 2004, with imports having increased markedly since then. In 2005 total imports of gas accounted for nearly 10% of gas used. This rose sharply in 2008, as imports accounted for 26% of total natural gas supply. If the current trend continues, early Government forecasts of imports reaching 90% of consumption by 2020 may have to be revised to sometime earlier than that (See Mineral Planning Factsheet on 'Onshore Oil and Gas' for further information).

Methane from coal is a very minor component (less that 0.06% of consumption in UK in 2009) of the gas markets in the UK. However, unconventional gas is much more important in other countries such as the United States of America, raising interest in these technologies in the UK. As UK domestic supply of conventional natural gas dwindles and security of supply becomes more of a concern, alternative sources of energy are likely to become of more interest in the future.

Methane from coal and shale gas also represent an opportunity for decentralising energy production by providing heat for businesses and homes and using surplus gas to generate electricity to feed into the grid.

Year	2005	2006	2007	2008	2009
Total Supply	1104406	1047486	1059080	1091438	1007998
Methane from coal	757	754	717	560	573
% of total	0.068	0.071	0.067	0.05	0.056

***Table 1 Supply of 'conventional' natural gas and methane from coal** (DUKES 2010) GWh.*

Supply

CMM and AMM is produced at 16 active and disused mines in England and Wales. Most of the methane produced is used to generate electricity for use on site (in the case of active mines) or to feed into the grid. A smaller number of sites supply gas direct to industrial users.

The first CBM borehole in the UK was drilled in 1992 at Sealand in Cheshire by Evergreen Resources. There are currently two CBM pilot sites in the UK producing CBM at Airth in Scotland (Dart Energy) and Doe Green in Cheshire (IGas) and a large number of onshore exploration licences were awarded in last round of Department of Energy and Climate Change (DECC) licensing. Drilling has been undertaken in the Carlisle Basin, Cheshire Basin, East Midlands and South Wales Coalfield and there are further plans to drill in other areas.

Consumption

The principal sources of energy consumed in the UK are oil and gas. Gas accounted for 41% of primary fuel used in 2009. Since the early 1990s, electricity generation is the principal use for gas. In 2009 natural gas accounted for 45% of the primary fuel used in electricity generation. The proportion of gas utilised from alternative fossil fuel sources is currently very small but this is likely to increase.

Economic importance

Oil and gas play a central role in the UK economy and the Government's energy policy is to ensure secure, diverse and sustainable supplies. The UK is a major producer of oil and gas, the total value of which was £36.2 billion in 2008, although the major proportion of this was from offshore fields. Onshore oil and gas production makes a small, but important, contribution to supply with the additional advantage of proximity to demand. The value of onshore oil and gas production was estimated at over £650 million in 2008. Of this some 90% was oil (including natural gas liquids) mainly obtained from the Wytch Farm oilfield in Dorset.

The value of gas reserves stood at around £68 billion in 2008, down on 2006 values of £69.4 billion, but considerably up on the 1998 valuation of £25.4 billion. Current production of methane from indigenous alternative fossil fuel sources is very small (Table 1).

Structure of the Industry

CBM exploration often comprises joint ventures between established international oil and gas companies and smaller UK independent companies. The Scottish-based companies Hill Farm and Coalbed Methane Ltd pioneered the first campaign of (vertical) drilling in the 1990s and Composite Energy (now owned by Dart Energy) began a second campaign utilising horizontal drilling completions. British Gas, Marathon, Nexen and Centrica are other internationally-known companies that were also awarded licences for CBM exploration by DECC in 2009. Island Gas (formerly with Nexen) produces electricity from the most advanced pilot CBM scheme in the UK (at Doe Green in Cheshire).

Shale gas exploration has been pioneered in the UK by Cuadrilla Resources, who were awarded a number of exploration licences by DECC in the latest (13th) round. The next onshore round is expected to see a larger number of applications for licences for shale gas exploration.

Since 2008, a number of companies have taken out conditional licences from The Coal Authority to investigate potential UCG sites off the coast of England, Scotland and Wales. These include Clean Coal Ltd, Europa Oil and Gas and Thornton New Energy, Riverside Energy and Five Quarter Energy.

Resources

Methane from coal 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**. 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 3.5m, although exceptionally thicker (5m) seams may occur. 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 (**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**'.

The UK has very large deep coal resources which may be accessible using technologies including coalbed methane from 'virgin' coal seams and underground coal gasification. There is also additional potential for recovering gas from active and abandoned coal mines. Almost all onshore coal resources in Britain are 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 Late 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 the Westphalian. 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 1 shows the distribution of exposed and concealed coal-bearing strata in the UK and its associated offshore area.

Gases produced during the formation of coal are either adsorbed onto the coal or dispersed into pore spaces within the coal. Immediately after the plant material is deposited, it is biodegraded by bacterial action, producing methane. This is known as 'primary biogenic production' and the gas is likely emitted to the atmosphere or trapped in overlying sediments. Most of the methane that is now found within the coal seams was produced later as the depth of burial increases. This is known as 'thermogenic' methane. The generic term for this gas is coalbed methane, although it may also contain ethane, propane, carbon dioxide, nitrogen, helium and hydrogen. Most of the gas is attached to the coal surface in micropores. The amount of gas given off depends on the gas content, rate of coal extraction from coal mines, permeability and total thickness of the coal seams present.

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The prime requirements for CBM prospects are unworked coal seams thicker than 0.4 m at depths of between 200 and 1200 m. Low permeability and high drilling costs currently make deeper targets unattractive. Good prospects should have adequate levels of methane (>7 m^3/tonne), which generally increase with maturity of the coal. However, permeability, rather than seam gas content, is the most critical factor and varies inversely with gas content and maturity. In general, UK coals exhibit low permeabilities, which limits their potential for CBM.

Shale gas Shale gas comprises methane recovered from mudrocks and shales which have previously been considered too impermeable ('tight') to allow economic recovery of gas. Unlike conventional gas, which collects in porous rocks and can be released simply by drilling boreholes into those rock formations, shale gas is locked in the matrix of less porous rocks. It can only be accessed with a specialised drilling and production technique, called hydraulic fracturing or 'fracking'. Shale gas is formed by thermal maturation (heating within the Earth) of organic (carbon) rich shales. The characteristic temperature range required to form this 'thermogenic methane' within the shale is known as 'gas window'. Methane can also be formed by methanogenic bacteria acting on shales rich in organic matter. This 'biogenic' methane forms in rocks irrespective of age and thermal history. Biogenic methane is important in shale prospects elsewhere in the world but has not yet been shown to have occurred in the UK. Rock properties such as Total Organic Carbon (TOC), together with estimates of thermal history give a good indication of the gas production potential of a shale formation.

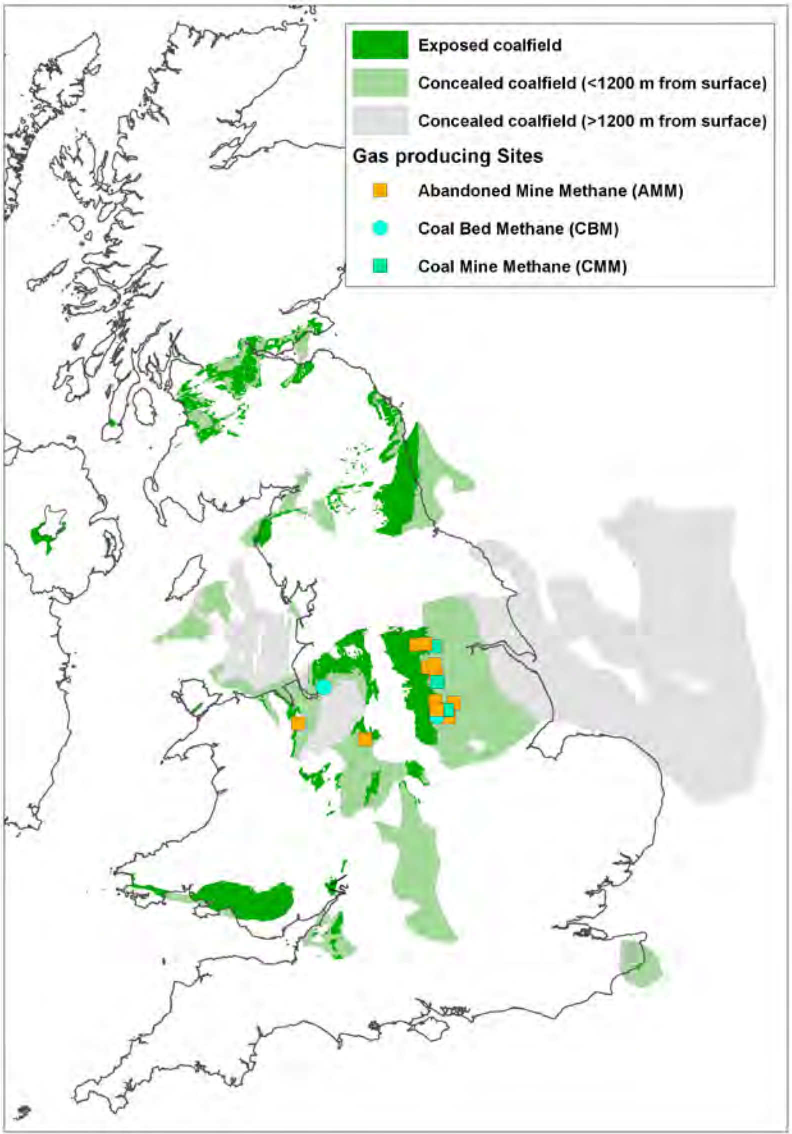

Figure 1 Distribution of exposed and concealed coal-bearing strata.

In the USA, gas has been produced from shale in commercial quantities since 1821. With the advent of horizontal drilling and other advanced techniques, there has been exploration success in the USA, followed by development in nearly all US basins in the last decade. This has led to recent interest in shale gas prospects onshore in the UK.

Shale gas prospects in the UK will most likely exist in a number of different basin settings (Figure 2). These comprise thermally mature Carboniferous basinal shales of the Pennine Basin (Namurian to Tournaisian age) in northern England and the Midlands. Elsewhere, Carboniferous shales in the Midland Valley of Scotland, and areas of Wales may also be prospective. Clays of Jurassic age (145–199 million years old) including the Lias Group, the Oxford Clay Formation and the Kimmeridge Clay Formation may have potential for both thermogenic and biogenic shale gas in the Wessex,

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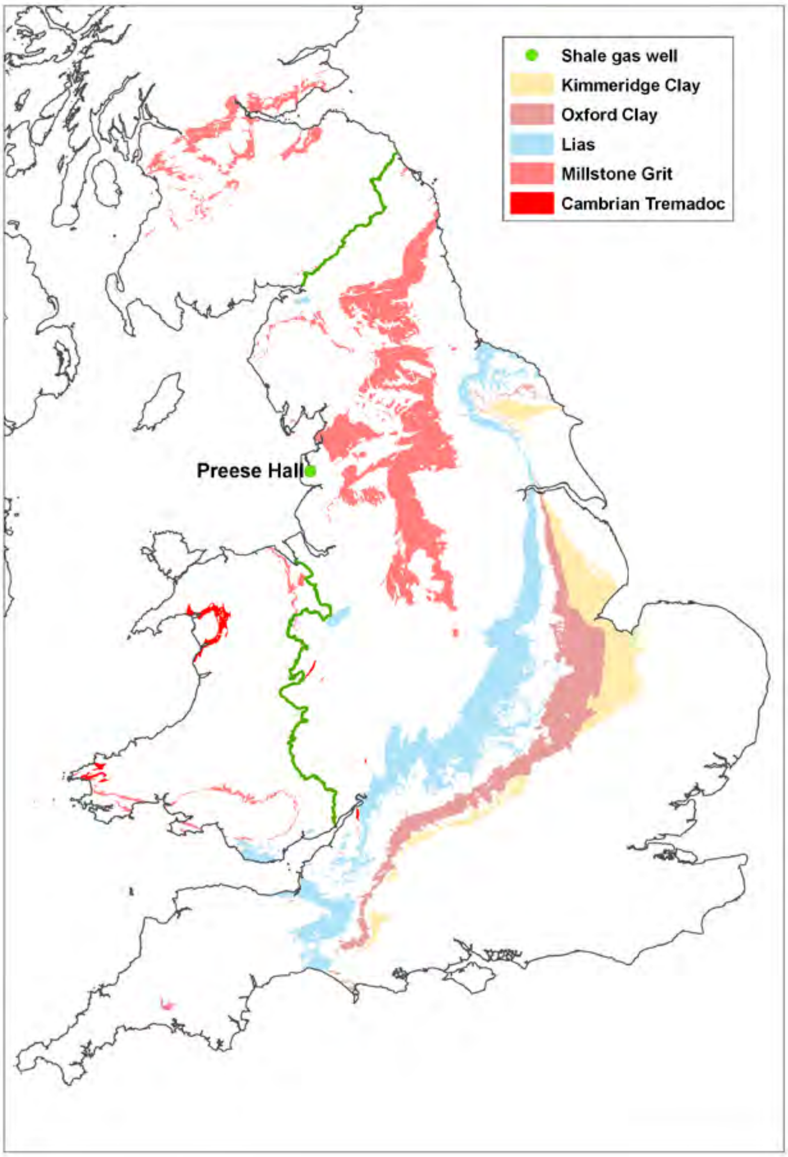

Figure 2 Surface distribution of clay and shale formations which may be prospective for shale gas (clay and shale formations concealed beneath other rocks are not shown).

Weald and Cleveland basins. Cretaceous age clay from the Gault Formation (99–112 million years old) and the Eocene age London Clay Formation (49–59 million years old) of southern England are immature and may have minor potential for biogenic shale gas.

Underground coal gasification For general description of coal resources in Britain see 'methane from coal' above. Resource criteria for UCG includes coal seams more than 2 m thick at depths of between 600 m and 1200 m. There is also a need to have standoffs from operational and abandoned mine workings, urban areas, dense faulting and major aquifers. Although onshore areas with theoretical potential are extensive and occur in a number of coalfields including Yorkshire, Lincolnshire and Warwickshire, central Scotland and South Wales, the first conditional licence awards in the UK have been made offshore (Firth of Forth, Solway Firth, off west Cumbria, off NE England, Humber Estuary, off East Anglia and Swansea Bay). There is also a licence in the Thames Estuary but BGS has no records of rocks likely to contain coal in boreholes in this area. Although the UCG process is likely to be located underground offshore, most of the surface processing facilities would need to be located onshore.

Reserves

Reserves are difficult to predict both for CBM and shale gas. CBM reserves are likely to be small because of low permeability. Small capacity boreholes close to markets might be more attractive and a more realistic model. UK shale gas potential may be much greater, although prior to any extensive programme of drilling and testing, it is not clear if domestic shales have the correct rock properties to exploit for shale gas. UCG is relatively new and productivity is unknown. Potential problems with coal seam deterioration may exist in unexplored areas offshore. Some of the licensed areas may not contain any coal seams.

Exploration and extraction

Note that in oil and gas exploration and production (including that carried out for methane from coal, shale gas and underground coal gasification), boreholes are often described as 'wells'.

Methane from coal A variety of methods can be used to recover methane associated with coal seams. This depends on whether the gas is associated with conventional mining activities or with undisturbed ('virgin') coal seams.

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The ease with which methane gas is adsorbed on, and recovered from any coal seam depends on properties such as porosity, sorption, permeability and natural fracturing.

- Porosity: Coals have both pore and micropore volume. Although micropores in coal seams are very small (up to 2 nanometres [2 thousandths of a millimetre] across), the space they occupy can represent up to 85% of the total porosity of coal. As the main mechanism by which methane is retained by coal is by physical adsorption, micropores and associated surface area are the main mechanism of methane retention.
- Sorption: Sorption qualities of coals vary according to a number of factors. Methane is adsorbed by the carbonaceous component of coal so higher mineral matter (high ash content) reduces the volume of methane that can be stored. Water also competes with methane in the search for sorption sites within the coal. Although the relationship is complex, there is a correlation between increased methane sorption with increasing rank.
- Permeability: The permeability of coal (ability to conduct fluid or gas) is relatively low and is affected by the size and shape of the pores and their interconnections. As

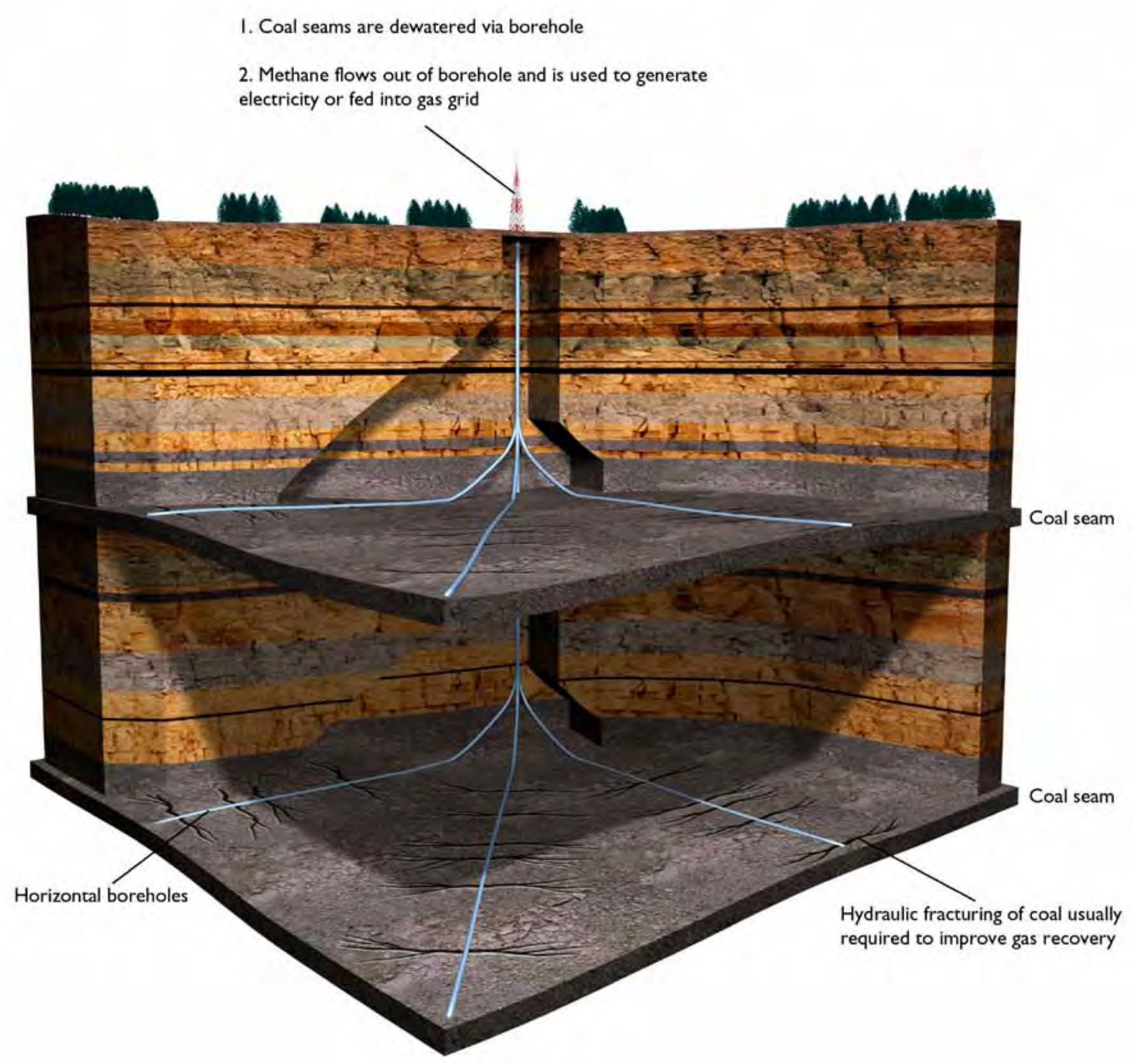

Figure 3 Schematic diagram showing coalbed methane production methodology.

a result, it may be necessary to artificially increase permeability by using techniques such as hydraulic fracturing (see below) in order to recover methane from the coal seam.

- Natural fracture pattern ('cleat'): Coal seams exhibit a natural fracture pattern which adds to the permeability of coal. These natural fractures are known as 'cleat'. Recognised by miners working coal, they understand that it is simpler to mine coal if the mining direction was such that the main joint set runs across the coal face, making it easier to extract. Cleat can also influence gas permeability, making methane flow more easily in the direction parallel to the principal line of fracture. Permeability also tends to decrease with depth as pressure increases and cleats close.

Methane extracted from operating deep mines is termed coal mine methane (CMM or sometimes termed 'mine gas' or 'coal gas') and is primarily removed as a safety measure in mine ventilation. This gas is often utilised by mining companies to meet energy needs on site.

After the closure and sealing of a coal mine, methane continues to be released by the coal. This abandoned mine methane (AMM) tends to collect in the voids left behind by coal extraction. Since methane can act as a greenhouse gas, controlled extraction of AMM represents a valuable greenhouse gas mitigation technique. Energy from AMM is obtained using modular electric generators which utilise the captured gas and can be added or removed according to gas flow.

A third potential source of methane from coal is virgin coal bed methane (CBM), where the gas is extracted from unworked, undisturbed coal seams via boreholes drilled from the surface.

Exploration for CBM may include seismic reflection surveys (a detailed description of this technique can be found in the 'Onshore oil and gas' mineral planning factsheet) followed by borehole investigations. These boreholes may be vertical or, in some cases, these may be deviated to horizontal. The size and nature of these exploration drilling operations is likely to be similar to those for oil and gas. Drilling will be followed by a testing phase to determine the quality and quantity of gas. This will also involve dewatering of coal seams in order to promote gas flow.

Prospect size, geology and permeability of an individual coal seam dictates the number of production boreholes required to produce economic quantities of gas. Boreholes may have many subsurface horizontal or multilateral sidetracks drilled from one surface location in order to penetrate more coal and thus recover more methane (Figure 3). Prior to gas production, the coal seam must be dewatered in order to lower the pressure and so release gas from the surface of the coal. This process can take several months and the pumped water may require an abstraction licence, treatment and arrangements for discharge. In most cases, hydraulic fracturing ('fracking') is required to improve gas recovery. This involves injecting water into the borehole to create and propagate fractures in the seam. Fractures are normally a few millimetres in width and are held open by sand grains which are injected along with water. The process usually involves the injection and return of large volumes of water.

Shale gas Shale gas is held within micropores and fractures and is also adsorbed onto the organic matter contained in the shale and mudrock formations. Shales and mudrocks are sedimentary rocks which are in the main, made up of clay sized particles. The flat, clay mineral grains that form layers tend to result in a sediment which has extremely low vertical permeability but some horizontal permeability. The low permeability means that gas is trapped in the shales and will not flow of its own accord so fracturing methods are used to free the gas for production. Typical permeabilities for unfractured shales are 0.01 to 0.00001 millidarcies. Horizontal drilling at multiple horizons within a borehole will maximise gas recovery whilst reducing the surface expression of exploration and production. Drilling and testing of exploration boreholes is likely to take several months. If exploration is successful in finding recoverable methane, gas is produced from the shale by further drilling and hydraulic fractur-

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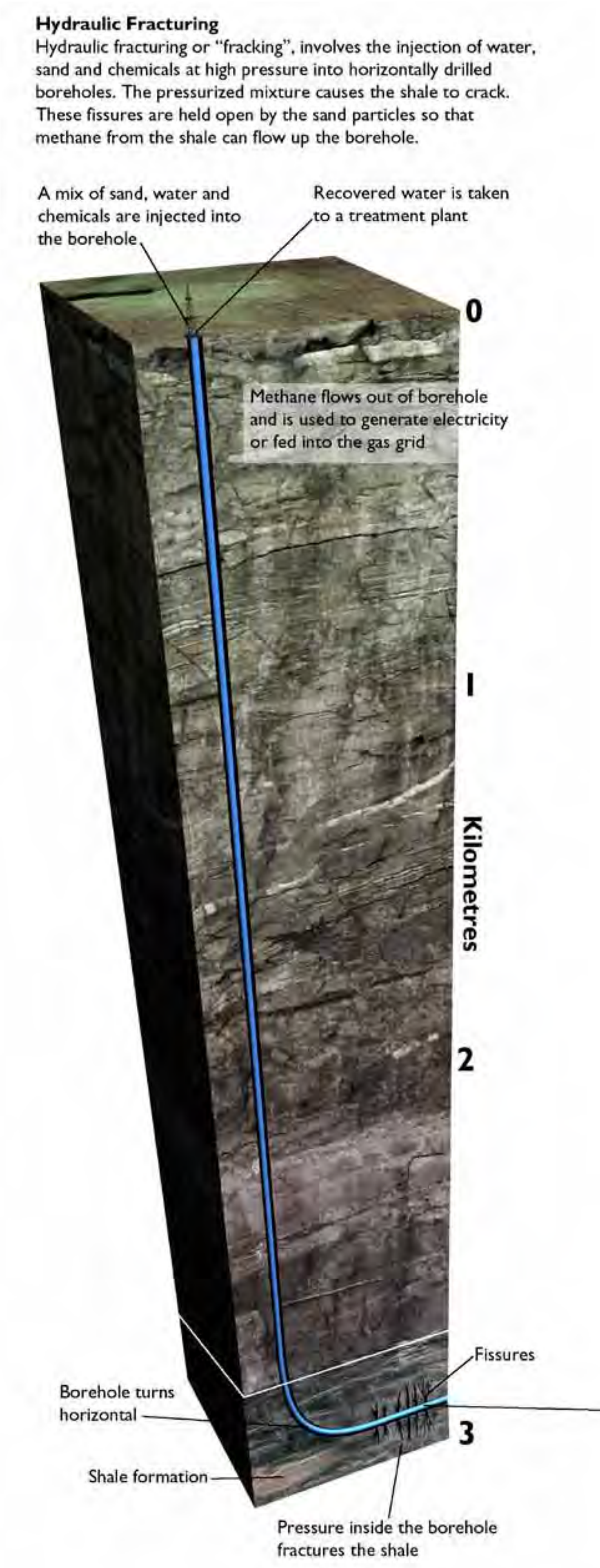

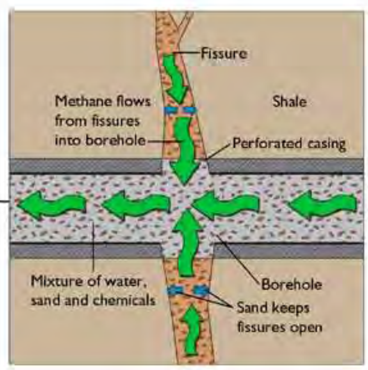

Figure 4 Schematic diagram showing shale gas production methodology.

ing (Figure 4). The fracturing process is similar to that described above in the section on CBM. The presence of quartz or chert within the shale can sometimes enhance the fracturing process. Following fracturing, sand is injected with water and other chemicals to keep the fractures open and aid the production of the gas. Sophisticated geophysical techniques are used to allow the fracturing to be targeted and controlled. In order to maintain gas production, fracture treatment to boreholes may need to be repeated every 4–5 years. The number of boreholes required depends on the size of the licence area, the local geology and the gas content of the shale.

Underground coal gasification UCG is a process by which various combinations of air, oxygen and steam are injected into one or more in-situ coal seams to initiate partial combustion. The injectant reacts with the coal underground, which produces heat and drives off gases (hydrogen, carbon monoxide and methane), which are subsequently recovered through a production borehole. The process involves the drilling of two boreholes (Figure 5) or possibly three in a different design, one to act as the gasifier and one to collect the product gases. The third borehole in the variation design is to separate ignition and injection boreholes. The mixture of gases produced (known as 'syngas') is similar to those from town gasworks produced from coal before the introduction of natural gas from beneath the North Sea. Syngas may be used for electricity generation, but the high hydrogen content offers the possibility of a move toward a

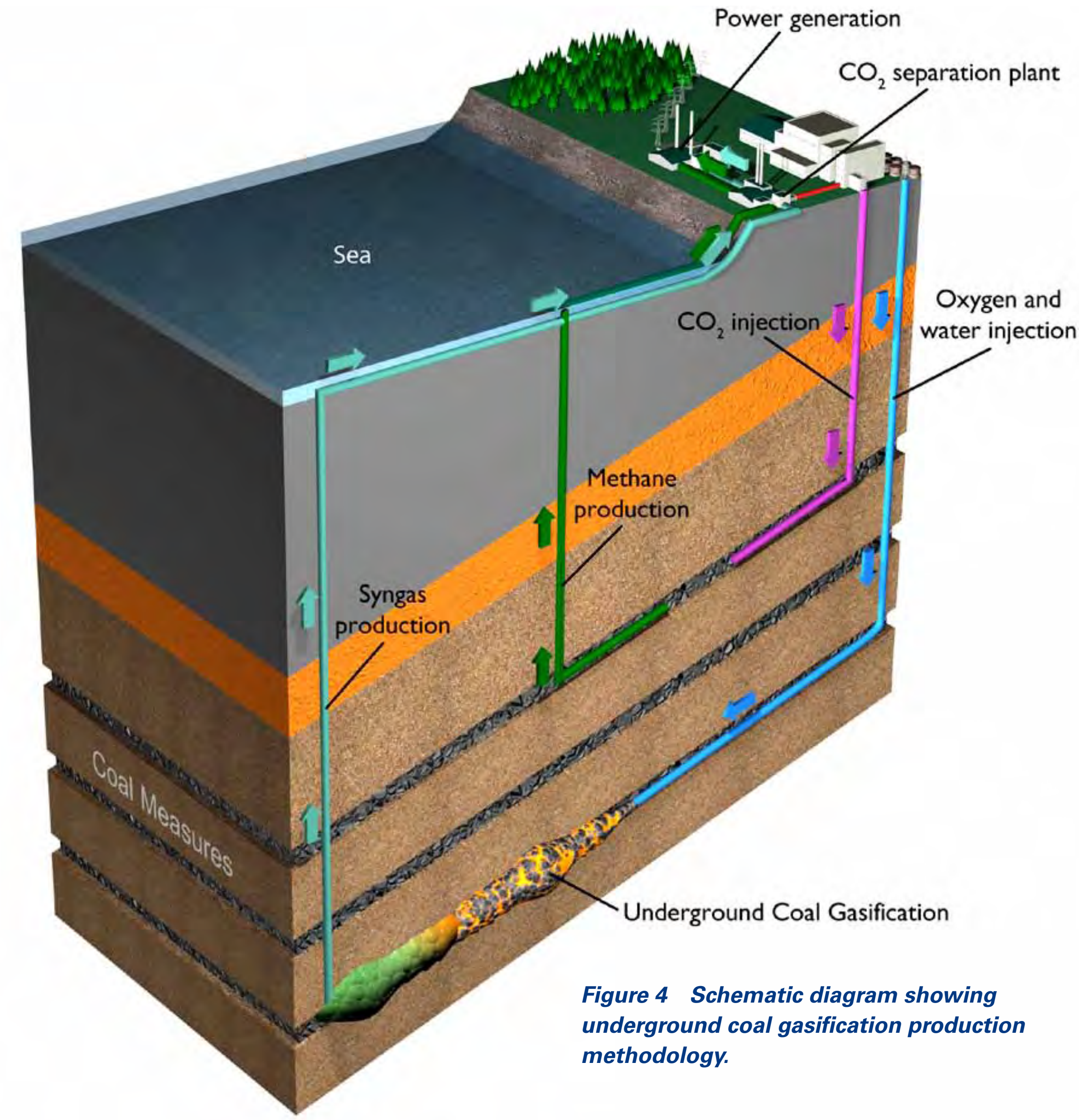

Figure 4 Schematic diagram showing underground coal gasification production methodology.

hydrogen-based economy. Alternatively, syngas can be converted into liquid fuel or chemical feedstock. CO_2 produced could be captured and stored in an unmined coal seam away from the combustion to stimulate enhanced CBM recovery (Figure 5). In Australia, a pilot UCG operation produces diesel by applying the Fischer-Tropsch process to the syngas. This process was used in factories in Germany during World War II and subsequently by SASOL in South Africa. Limited UCG pilot testing was carried out at shallow depths by the National Coal Board in Derbyshire and in Staffordshire in the 1950s. A recent European test was conducted at Tremedial, Spain (Underground Gasification Europe project).

Transport Issues

The requirement to fracture and re-fracture boreholes which produce shale gas is likely to give rise to periodic peaks in lorry movements to and from shale gas and CBM sites. The removal of water abstracted from coal seams to facilitate gas production from CBM boreholes may also give rise to increases in lorry movements as the water may need to be taken off site by tanker for treatment and discharge.

Methane will either leave the site by pipeline or be used on site to generate electricity which, in turn, will be fed into the grid.

Environmental impacts

Both CBM and shale gas extraction require careful water management. In order to promote the release of methane from coal, large amounts of water must be abstracted from coal seams before gas production. This water may be saline and/ or contain high concentrations of metals and other contaminants that might require treatment prior to discharge.

Shale gas production uses a considerable volume of water for formation fracturing (up to several million litres per day). Around 60 per cent of this water will return to the surface via the borehole. It is likely to be saline and may be contaminated with other material. As a result, this water will require treatment prior to discharge, although its re-use in the fracturing process is possible. There are concerns that fracturing may contaminate nearby aquifers with dissolved methane and exacerbate release to the atmosphere. Contamination of groundwater by the chemicals used to enhance the effectiveness of hydraulic fracturing and reduce degradation of boreholes is also of concern.

Any process that injects pressurised water into rocks at depth will cause the rock to fracture and possibly produce minor earthquakes. It is well known that injection of water or other fluids during processes such as oil extraction, geothermal engineering and shale gas production, can result in earthquake activity. Indeed, microseismic activity induced by water injection is often used to monitor the extent and nature of the hydraulic fracturing. Typically, the earthquakes are too small to be felt, however, there are a number of examples of induced or triggered earthquakes which were large enough to be felt by people. The two small earthquakes felt in the Blackpool area in April–May 2011 are thought to have been associated with hydraulic fracturing carried out at 2–3 km depth by a company exploring for shale gas on the Fylde Peninsular.

Underground coal gasification has the potential to create a number of significant environmental impacts. Surface impacts relate to the potential for atmospheric emissions, the pollution of watercourses and mining subsidence. Subsurface impacts are likely to include threats to groundwater quality and the possibility of subsidence. The UCG process is likely to produce a range of combustion products, including phenols and benzene and gases such as hydrogen sulphide and sulphur dioxide. Although these products are likely to be left in situ or removed in gas processing, the possibility remains that these and other pollutants could migrate and contaminate the local groundwater system. This is particularly the case where aquifers with good porosity and permeability characteristics (such as the Permian and Triassic age rocks in eastern England) are located in close proximity to coal seams which otherwise might be suitable for UCG. Adverse impacts on groundwater are likely to be substantially mitigated if UCG development takes place offshore.

Regulation

Licensing The Petroleum Act 1998 vests all rights and ownership of the petroleum resources (oil and gas) of Great Britain and the United Kingdom territorial waters to the Crown. For onshore gas in Great Britain, including coalbed methane, the Secretary of State for Energy and Climate Change grants licences to persons that confer exclusive rights to 'search and bore for and get' these gas resources. The rights granted by landward licences do not include any rights of access, and the onus is upon the licensee to obtain all the relevant planning permissions from the respective authorities. Licensees wishing to enter or drill through coal seams for methane must also seek the permission of the Coal Authority. If a viable resource is present, the potential operator must then obtain planning permission for extraction of CBM before a Coal Access Agreement can be issued by the Coal Authority.

Licenses related to UCG are awarded by the Coal Authority. The Coal Authority has so far granted a number of conditional near offshore UCG licences to companies keen to pursue UCG technology in Great Britain. These conditional licences enable prospective operators to secure the rights to the coal while projects are developed but do not permit UCG operations to commence until all other rights and permissions are in place.

Environmental regulation Where the fluids being injected as part of a hydraulic fracturing process contain pollutants and the injection is into rock formations that contain groundwater, or where the activity poses a potential risk of mobilising natural substances to cause pollution, the Environment Agency (EA) require the operator to hold an environmental permit under the Environmental Permitting Regulations 2010 (EPR 2010) and in Scotland the Scottish Environment Protection Agency (SEPA) require an environmental licence under the Water Environment (Controlled Activities) Regulations 2011 (WER 2011). The EA/SEPA will also require a permit for activities associated with the surface works if these involve emissions to air, surface water or groundwater. The permit will specify the limits of the activity and any requirements for monitoring and will place a general management condition on the operator to provide a written management system that identifies and minimises risks of pollution.

For aspects of the operation that would not normally be subject to EPR 2010/WER 2011 permits, such as the drilling of the borehole, the EA/SEPA also have powers to serve notices under those regulations to require the operator to cease an activity or apply for a permit if warranted.

In England and Wales, the EA will separately consider potential impacts on water resources due to the effect on groundwater levels and flows. The EA expect industry to notify them of their intention to carry out the drilling, at which time they will advise on measures that they consider necessary to protect water resources. There may be a requirement for control under the Water Resources Act 1991 on abstraction of groundwater. Depending on the proposal, a groundwater investigation consent and abstraction licence may be required. Operators making such applications would need to provide a supporting hydrogeological impact assessment. In Scotland this acitvity would be licenced under the WER 2011.

Planning issues

National policy Although there is no specific mention of shale gas, relevant planning policy for land-based exploration, appraisal, development and extraction of methane from coal, shale gas and UCG in England is currently set out in Mineral Policy Statement 1: Annex 4. *On-shore oil and gas and underground gas storage*. However, the policy context for England will be contained in the forthcoming National Planning Policy Framework in 2012. In Scotland, planning policy for onshore oil and gas is set out in *Scottish Planning Policy. Mineral Planning Policy Wales* sets out the planning framework for onshore oil and gas in Wales.

Exploration by seismic investigation
Exploration for coalbed methane or shale gas may begin with seismic investigations to identify 'prospective' geological structures. This is a temporary activity and generally has very limited environmental effects. Most mineral planning authorities regard such work as either 'not development' or as permitted development. However, for such types of surveys, the UK Government requires that a Petroleum Operation Notice (PON) form (14b: Notification of intention to carry out onshore (landward) geophysical surveys) is submitted and proposals should also be discussed with the MPA and relevant statutory agencies.

Exploration drilling and borehole testing If surveys identify geological structures which are prospective for coalbed methane or shale gas, then the only way to firmly establish if economic quantities of gas are present is to drill a borehole and then test the recovery and quality of methane produced following a process which involves hydraulic fracturing and/or dewatering. This is a major undertaking which requires planning permission. Applications for consent to drill exploration, appraisal, and development boreholes also requires completion of the PON form 4 through the DECC WONS (Well Operations Notification System). Specific issues associated with drilling and testing may include visual intrusion, noise, lighting, traffic on local roads and the round-the-clock nature of the operations. Exploration drilling and testing operations may be several months in duration. If gas is found in economic quantities, then additional appraisal boreholes may be necessary. It may be possible to sink these boreholes from the existing exploration site using deviated drilling techniques, although outlying appraisal borehole sites may also be required. These activities will obviously extend the duration of activity at the sites in question.

Location and scale of production development For coalbed methane and shale gas, production operations will generally use existing exploration borehole sites. Some of the planning issues associated with production may have been resolved as a result of the previous permitting process for exploration drilling and testing. Under some circumstances, deviation borehole drilling can enable recovery of gas at a considerable distance from the wellhead. This sometimes allows extraction sites and associated works to be moved, within limits, to less sensitive locations (see above). It is likely that surface facilities for any subsea UCG operations will be developed at or very close to the coast. Issues relating to noise, lighting and traffic associated with surface production developments for coalbed methane, shale gas and UCG are likely to be very similar to those from more standard industrial developments. Some alternative fossil fuel production sites will convert the gas they produce into electricity to feed into the grid and will therefore require co-development of generation plant.

Periodic peaks in operations In order to maintain shale gas production, formations must be re-fractured every 4–5 years. This is likely to entail a significant increase in site activity and associated impacts over and above what would constitute 'normal' gas production operations. Additional equipment and materials will be required to pump and treat the large volumes of water required for hydraulic fracturing. Lorry movements associated with transport of equipment and materials to and from the site are also likely to be significantly greater during re-fracturing operations.

Environmental concerns Alternative fossil fuel resources are being developed using a range of technologies and operational methodologies, most of which are new to the UK. Aside from the planning issues outlined above, communities are also likely to be concerned with wider impacts which these operations may have on the local environment. International experience suggests that these concerns are likely to centre on the possible negative effects of production processes on groundwater quality and ground stability (including seismic activity). Licensing authorities (Department for Energy and Climate Change and the Coal Authority) and regulators (the Environmental Agency and its equivalents in the devolved administrations) are aware of these issues and are developing a science evidence base to manage these new developments effectively and minimise their impact on the environment.

Further information

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