UNCONVENTIONAL HYDROCARBON RESOURCES UNDERLYING THE COTSWOLDS AONB

Summary: This report attempts to find a way through the minefield of fact, claims and counter claims to provide an understanding of the unconventional hydrocarbon resource underlying and around the Cotswolds AONB and its prospectivity.

Recommendations:

That the Board:

(a) Keeps up to date on research, information and guidance on unconventional hydrocarbons and the prospectivity of the Cotswolds;
(b) Ensure that the purposes of designation of the Cotswolds AONB is taken into account in any policies for unconventional hydrocarbons in the forthcoming Minerals Local Plans;
(c) Publishes and regularly reviews a statement on the Board’s current understanding of the gas prospectivity of the Cotswolds AONB and its setting.

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Background:

1. Unconventional hydrocarbons refer to gas and oil from unconventional sources trapped in rocks deep underground instead of in a conventional reservoir where oil and gas has migrated in permeable rock such as sandstone or limestone capped by shales or other hard rocks. Advances in drilling and wells site technology and increases in wholesale prices for oil and gas now make production from the less permeable unconventional formations commercially viable.

2. Of principal interest is gas, particularly shale gas. Exploration of unconventional gas is at an early stage in the UK and there are currently no commercially active sites. Exploratory drilling and test hydraulic fracturing (‘fracking’) has taken place in Lancashire and further exploration famously in Balcombe, Sussex.

3. The British Geological Survey (BGS) recently estimated there may be 1,329 trillion cubic feet of shale gas. At a 10% recovery rate this would supply 10% of Britain’s gas needs for over 30 years. This may require 2,500 to 3,000 wells in 250 to 300 sites of around 1.5ha each. In the USA, each site or pad has up to 8 wells on 2-3ha. The productive life of a well is suggested to be up to 30 to 50 years after fracking. However, the average lifespan of fracked gas wells in Texas is around 8 years. Wells can be re-fracked up to 10 times.
4. Sources of unconventional gas are shale gas, Coalmine Gas, Coalbed Methane and Underground Coal Gasification.

5. The Petroleum Act 1998 vests all rights to the nation’s petroleum resources in the Crown but all onshore exploration of gas is controlled through Petroleum Exploration and Development Licences (PEDL) issued by the Government. A PEDL gives a company exclusive rights to pursue a range of oil and gas exploration activities subject to normal drilling/development consents, planning permission and rights of access. Most licenses follow a standard format, but DECC is flexible with this and will consider adapting new licenses to suit special scenarios. The Secretary of State has discretion in the granting of licenses, which is exercised to ensure maximum exploitation of national resource.

6. Permission of the Coal Authority is also required by licensees wishing to drill through or enter coal seams for methane. The last (13th) Onshore Licensing Round was in 2008. The next round is due in 2014.

7. About half of Britain including the entire Cotswolds AONB sits above geology described as ‘potential source rock’. Maps of this geology provided the basis for DECC’s maps, including the consultation for the next round of licenses (Map A). However, not all this geology will be productive.

8. Fracking has become an emotive issue with concerns about earthquakes, methane in water supplies and environmental impacts.

Resources of Unconventional Gas - Shale Gas

9. Shale gas is a natural gas extracted directly from shale and mudrocks. The gas is held in fractures, pore spaces and adsorbed on to the organic matter contained in shale and mudrock.

10. The most common way to extract shale gas is by cracking the rock using hydraulic fracturing (‘Fracking’). Fracturing fluid, a combination of water and chemicals, is pumped at high pressure into the rock to create narrow fractures that allow the gas to flow into the well bore and to surface. These chemicals make up less than 1% of the total fluid used.

11. Once the fractures have been created, small particles, usually sand, are pumped into the fractures to keep them open when the water is taken back up the well.

Resources of Unconventional Gas - Coalbed Methane (CBM)

12. As with shale gas, hydraulic fracturing is used to extract gas from unworked, undisturbed coal seams via boreholes drilled from the surface. Prior to gas production, the coal seam must be dewatered to lower the pressure allowing the
release of gas. The pumped water may need an extraction licence and treatment.

Resources of Unconventional Gas - Underground Coal Gasification (UCG)

13. Underground Coal Gasification (UCG) involves the gasification of the coal in-situ by drilling boreholes into the seam, injecting water/oxygen mixtures down one pipe, igniting and partially combusting the coal and extracting the gasification products (known as syngas) through the another pipe. It produces a mixture of gases, (mostly carbon monoxide, carbon dioxide, hydrogen and methane) that can be processed to provide fuels for power generation, vehicle fuels and chemical feed-stocks.

14. It is UK Government policy that carbon capture and storage (CCS) will be required if the syngas is used for power generation. However, at the present time, if the syngas is used for other purposes such as producing vehicle fuel then CCS will not be required.

Resources of Unconventional Gas - Coal Mine Methane (CMM)

15. Coal Mine Methane is extracted from worked or abandoned mines traditionally as a safety measure. Methane is released by the coal and collects in the voids left by coal extraction. CMM has no relevance to the Cotswolds.

Underlying geology of the Cotswolds

16. The Cotswolds AONB and its immediate setting comprises or overlies four types of potential source rock in the form of shale, mudrock and coal. (Map B):
   - Lias - outcrop (on the surface)
   - Lias subcrop (buried)
   - Oxford Clay outcrop
   - Two areas of the Cotswolds AONB overlie coal fields (Map C)

Prospectivity of the Cotswolds - Shale Gas

17. Jurassic Lias lies underneath the Oolitic limestone of the Cotswolds but also outcrops at the base of the scarp and in northern parts of the AONB. The Lias includes the oil shales found at Kilve on the Somerset coast and the test borehole near Balcombe in Sussex, but the lias associated with the Cotswolds is described as immature\(^1\) for gas i.e. not enough time, pressure and heat to mature the Lias for gas production.

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\(^1\) The Unconventional Hydrocarbon Resources of Britain’s Onshore Basins – Shale Gas
18. The Oxford Clay outcrop adjacent to the Cotswolds is also described as immature.

19. An outcrop of Cambrian shales lies in the Severn Vale, just west of the scarp at Stinchcombe Hill. It is unclear as to their prospectivity but there is a suggestion that underlying Cambrian shales in the Severn Vale may be a potential target.

Oxfordshire-Berkshire Coalfield

20. The area of the AONB within Oxfordshire and the eastern edge of Gloucestershire around Stow-on-the-Wold overlies the Oxfordshire-Berkshire Coalfield.

21. Coalbed Methane - No coal has been mined from this Coalfield. The methane content is low making the coal to be considered as unprospective for Coal Bed Methane\(^2\).

22. Underground Coal Gasification - Areas of the Oxfordshire-Berkshire Coalfield have potential for Underground Coal Gasification (UCG). These areas include the coalfield south of Banbury and east of Witney. Large areas of the coalfield have unverified potential due to the lack of deep boreholes, however, the areas to the west of Oxford are known to have poor potential for UCG\(^3\).

Bristol and Somerset Coalfields

23. Adjacent to the Cotswolds AONB in the Severn and Avon vales lie the Bristol and Somerset coalfields.

24. Coalbed Methane - A borehole at Priston southwest of Bath and about 2½ miles west of the AONB boundary at Combe Hay found two coal seams that meet CBM criteria. The coalfields, however, are considered to have very limited potential for CBM as they contain low volumes of methane\(^4\).

25. Underground Coal Gasification - Examination of boreholes indicate there is no UCG potential in the Bristol-Somerset coalfields. Three seams, however, meet the thickness criteria locally and other thick coals may be present in the deeper parts of the coalfield\(^5\).

\(^2\) Mineral resource Information in Support of National, Regional and Local Planning – Oxfordshire 
http://www.bgs.ac.uk/mineralsUK/planning/resource.html

\(^3\) UK Coal Resource for New Exploitation Technologies, Final Report 
http://www.bgs.ac.uk/downloads/start.cfm?id=1712

\(^4\) Mineral Resource Information in Support of National, Regional and Local Planning – Somerset 
http://www.bgs.ac.uk/mineralsUK/planning/resource.html

\(^5\) UK Coal Resource for New Exploitation Technologies, Final Report 
http://www.bgs.ac.uk/downloads/start.cfm?id=1712
Oil

26. There is no indication of oil reserves underlying the Cotswolds AONB.

Petroleum Exploration and Development Licences (PEDL)

27. To date no PEDLs have been obtained for the Cotswolds AONB. A group of four PEDLs have been awarded immediately to the south west of the AONB. One of the licences clips the AONB at Upton Cheyney and Kelston but this is coincidental as the focus of the licence is the Somerset Coal field (Map D).

28. Bath and North East Somerset Council received a planning application for a borehole to test coal for methane production North West of Keynsham in 2012. The application was withdrawn.

29. The next round of Onshore Licensing is due in 2014. The area of Britain which may be offered in the next round is currently under consultation and includes all the potential source rocks including those underlying the Cotswolds.

Impacts of prospecting and extraction

Landscape

30. There is potential damage to both the character and tranquillity of the Cotswolds particularly during the exploration of a site. This could be for around two years, after which the well is either sealed or capped for gas extraction and the majority of the site restored leaving just the wellhead within a smaller compound, although to maintain gas production re-fracking may be necessary up to every 4-5 years. Infrastructure will also be required to collect the gas and pump it into the national grid.

31. Underground Coal Gasification will have a much larger impact on the landscape as the plant needed to undertake the process and extraction of gas is more industrial in scale and on-site during the whole process.

32. The Strategic Environmental Assessment (SEA) for Further Onshore Oil and Gas Licensing, currently out for consultation, does recognise there is potential for serious effects from locating well pads in or in close proximity to AONBs and National Parks. It should be noted, however, that Government has given no additional protection to AONBs and National Parks from the exploration and production of unconventional gas.

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6 DECC Strategic Environmental Assessment for Further Onshore Oil and Gas Licensing: https://econsultation.decc.gov.uk/decc-policy/consultation-env-report-further-oil-gas-licensing/
Habitats and Biodiversity

33. The principal threats to habitats and biodiversity are the construction of the well pad, access roads, gas and water storage facilities and pipeline works, discharge of water from de-watering and spillage of flowback entering watercourses. There are also potential further impacts in the form of dust, noise and general disturbance. Impact on wildlife sites, SSSIs etc, can be avoided through directional drilling from a location some distance away.

Cultural and historical heritage

34. As with habitats and biodiversity, the principal threats are construction of the well pad, access roads, storage facilities and pipelines. Proximity of the well pad to historic sites may detract from public enjoyment and appreciation due to visual intrusion, noise and vehicle movements. Directional drilling from a site located some distance away can reduce impact.

Geological interest and Bath’s Hot Springs

35. Construction of well pad, access roads, storage facilities and pipelines have the potential to impact on the geological interest of the Cotswolds. Soils can also be damaged by land-take and compaction.

36. The Hot Springs, although not within the Cotswolds AONB, are a major feature of Bath. Water travels to the hot springs through the carboniferous limestone, being charged principally from the Mendip Hills. Bath and North East Somerset Council commissioned a report\(^7\) from the BGS to identify problems that may arise from hydrocarbon exploration and production, including potential threats to the Hot Springs. The report concludes that the greatest threats are

- Drilling wells within Bath which divert flow or allow cold water dilution
- Geothermal explorations targeting hot water.
- Exploration for coal bed methane and shale gas with vertical wells is unlikely to have a measurable effect
- Development of coal bed methane should not pose a significant risk as as the water does not flow through the coal beds
- Development of shale gas would be a potential risk is high gas flow and high density well models are used.

Water demand

37. The process of fracking requires huge quantities of water. Figures range between 20,000 - 5 million gallons per frack depending on depth and extent of drill, rock type and lifetime of the well. This would be a serious issue for the

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\(^7\) BGS 2012. Potential problems in the Bath and North East Somerset Council and surrounding area with respect to hydrocarbon and other exploration and production. (Not published)
Cotswolds which is a major aquifer, particularly as a supply of water for the south-east of England. Most of the Cotswolds is classed as 'no water available' within the various Catchment Abstraction Management Strategies and lack of water availability could be a constraint on fracking.

**Ground water contamination**

38. Potential contamination of ground water comes from two sources; the injected water carrying chemical additives and the released gases. Contamination from injected water is most likely from poor well casings and their cements or from leakages at the surface whilst contamination from released gas seems to be more associated with fracking for coal bed methane which is at a relatively shallow depth and closer to the water table. Fracking for shale gas tends to be at great depth, up to several kilometres, beyond any ground water aquifer.

**Flow-back liquid**

39. Approximately 40% of the injected water and chemicals used in a frack return to the surface as Flow-back. Flow-back contains the chemicals used in fracking and can contain a wide range of contaminants picked up from the fracked rock. These can include methane, carbon dioxide and hydrogen sulphide, trace elements such as mercury and arsenic, naturally occurring radioactive materials and volatiles such as benzene. The amount of dissolved material varies widely. Flow-back is collected and stored on site for treatment or re-use.

**Noise and disturbance to communities**

40. Figures from the USA suggest approximately 1000 vehicle movements to complete a well. In most parts of the Cotswolds this would cause problems in terms of number of vehicle movements and the potential upgrading of roads and construction of new access roads. Noise, dust and vibration tend to be produced during the drilling and fracking phases, impacting on the tranquillity and enjoyment of the area.

41. Wells are in production 24 hours a day. Consequently noise and light pollution are of concern, particularly in the exploration and fracking stages. Underground Gasification of Coal is a much more industrial process with larger plant on site all the time the well is productive.

**Air quality and greenhouse gas emissions**

42. Localised cumulative effects from emissions to air from machinery, vehicle movements, drilling, fracking and flaring during testing could impact on air quality.
43. A potential source of Green House Gas (GHG) is leakages of gas at surface level and into the aquifer mainly through poor well casings and well heads.

44. There is concern about further burning of fossil fuels for energy in the form of shale and coal bed gas and whether they are less carbon-intensive than coal and that a focus on unconventional gas will lead to reduced interest and support for renewables. The wide range of literature on this subject either concludes unconventional gas will reduce GHG or increase GHG emissions or comes to no conclusion at all after looking at both sides of the argument.

Earthquakes

45. In 2011 two earthquakes were detected in the Blackpool area. A subsequent report 8 confirmed these earthquakes were induced by fracking. The report also stated that further earthquakes cannot be ruled out but the risk is low and structural damage unlikely.

Regulation

46. A UK Petroleum Exploration and Development Licence (PEDL) issued by DECC in competitive licence rounds, grants exclusivity to an operator in the licence area. The licences do not give consent for drilling or any other operations. To drill a well, the operator also requires:
   - An access agreement with the landowner
   - Consent from the Coal Authority if the well encroaches on coal seams
   - Planning permission from the minerals planning authority (County or Unitary Council)
   - Notification to the Environment Agency who will advise the operator on any requirements under various Water Acts and Environmental Permitting Regulations.
   - A Consent to drill from DECC
   - Notification to the Health and Safety Executive of well design and operation plans

47. PEDL have an initial term of 6 years during which exploration is carried out. Licences can then be extended for 5 years to enable further activity including exploration and extended for a third term of normally 20 years to allow for extraction.

Community benefits

48. Where fracking takes place, the UK oil and gas industry, working through a Community Engagement Charter, will provide at the exploration/appraisal stage benefits to local communities of £100,000 per well site, and at production stage a

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8 Article on BGS website: http://earthquakes.bgs.ac.uk/research/earthquake_hazard_shale_gas.html
share of proceeds of 1% of revenues. The latter would be allocated approximately \( \frac{2}{3} \) to the local community and \( \frac{1}{3} \) at the county level.

**Likely impact on the Cotswolds AONB**

49. The Lias outcrop and subcrop and the Oxford Clay outcrop associated with the Cotswolds are all described as ‘immature’ for shale gas and the underlying coal fields contain low volumes of methane. The prospectivity of the nearby Cambrian rocks in the Severn Vale is unclear. It should be noted, however, that the resources underlying the Cotswolds are relatively unexplored. Other areas of the Country contain much higher potential for extracting gas and are likely to be the focus for gas prospecting and extraction (Map E). The landscape impact of such sites will be helpful in determining the likely short and long-term effects on the Cotswolds AONB where exploration is being considered.

**Conclusion**

50. From information available at present officers consider that the Cotswolds AONB and its setting can probably be seen as at low risk. However, this is a topic for which new evidence and guidance is forthcoming and will need to be kept under review.

**Supporting Documents:**

Appendix ‘A’ - Petroleum Exploration and Development Licences (PEDL) 14th Round Consultation map

Appendix ‘B’ - Shale Gas Geology map

Appendix ‘C’ - Cotswolds AONB and Coal fields map

Appendix ‘D’ - Cotswolds AONB and PEDL 2013 map

Appendix ‘E’ - Shale Gas basins map