Unconventional hydrocarbon resources in the Weald Basin

Information Note

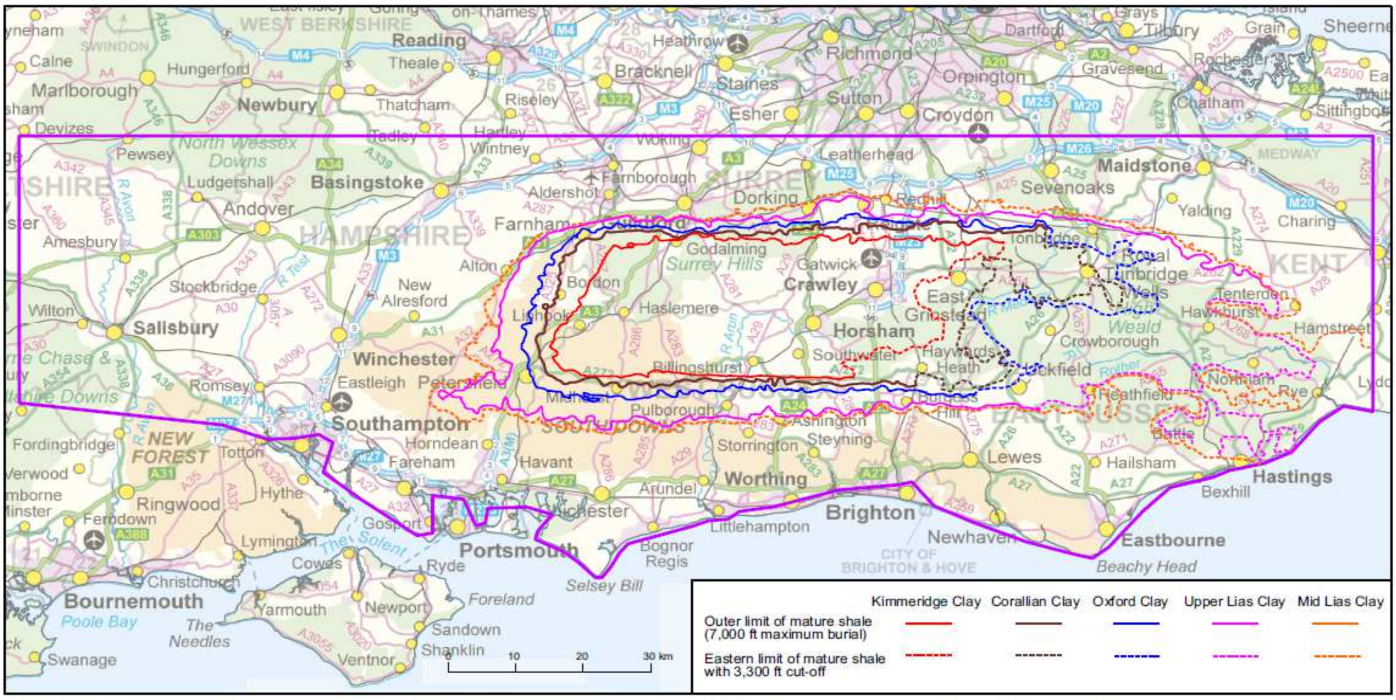
Produced by the High Weald AONB Partnership, June 2014

In light of the recent British Geological Survey (BGS) report on the unconventional hydrocarbon resources of the Weald Basin (see: www.gov.uk/government/publications/bgs-weald-basin-jurassic-shale-reports), this information note presents a summary of the report's findings, illustrates its significance for our future energy requirements, and highlights the uncertainty and important caveats that should be attached.

The geological context

- Marine shales were deposited in the Weald Basin at several intervals during the Jurassic (c.145-200 Ma).
- Five units within the Jurassic of the Weald Basin contain organic-rich, marine shale: the Mid and Upper Lias Clays (Lower Jurassic) and the Oxford Clay, Corallian Clay and Kimmeridge Clay (Upper Jurassic).

Figure 1. Summary of areas considered prospective for oil in the Jurassic Shale units in southern Britain. AONBs are indicated in pale green and National Parks in pale orange.



The unconventional hydrocarbon resource

- The most significant organic-rich shales in the Weald Basin occur in the lowermost Oxford Clay (which has a Total Organic Content – TOC – up to 7.8%) and middle Kimmeridge Clay (TOC up to 21.3%) and these represent potential 'sweet-spots' considered worthy of further investigation.
- None of the Jurassic shales analysed in the Weald Basin has an "oil saturation index" of greater than 50 – i.e. much of the "oil" may be physically associated with kerogen, rather than present in pore space. This is low in comparison to shale oil producing areas in North America, so it may be that only limited amounts of shale within the Jurassic of the Weald Basin have any potential to produce oil in commercial quantities.

- However, it may be that some horizons within the Mid and Upper Lias, lower Oxford Clay and Kimmeridge Clay exceed the 100 required for the oil to be 'producible.' Also, the fact that oil has migrated into conventional reservoirs suggests that optimum conditions are reached at least locally within the basin.

- The study indicates that there is no shale gas potential in the Jurassic shales – even the deepest Lias shales are unlikely to have attained sufficient maturity to allow for significant gas generation.

- In-place oil resource estimates for the various Jurassic shales of the Weald Basin are 2.2 – 4.4 – 8.6 billion bbl (0.29 – 0.59 – 1.14 billion tonnes). It should be emphasised that these 'oil-in-place' resource figures refer to an estimate for the entire volume of oil contained in the rock formation, not how much can be recovered.

How significant are the "in-place" shale oil resources of the Wealden Basin?

The lower, mid, and upper in-place shale oil resource estimates from the BGS report for the Weald Basin were used in conjunction with Department of Energy & Climate Change (DECC) UK energy consumption figures to calculate the number of years this resource could supply the country's energy requirements. The results of these calculations may be seen in Table 1, below.

Table 1. Number of years the Weald Basin's in-place shale oil resource would be capable of supplying the UK's energy demands (assuming a recovery factor of 5%, as recommended by the US Energy Information Administration, and a level of energy consumption equivalent to the year 2012) by sector – and in total – for each of the British Geological Survey's lower, mid and upper resource estimates.

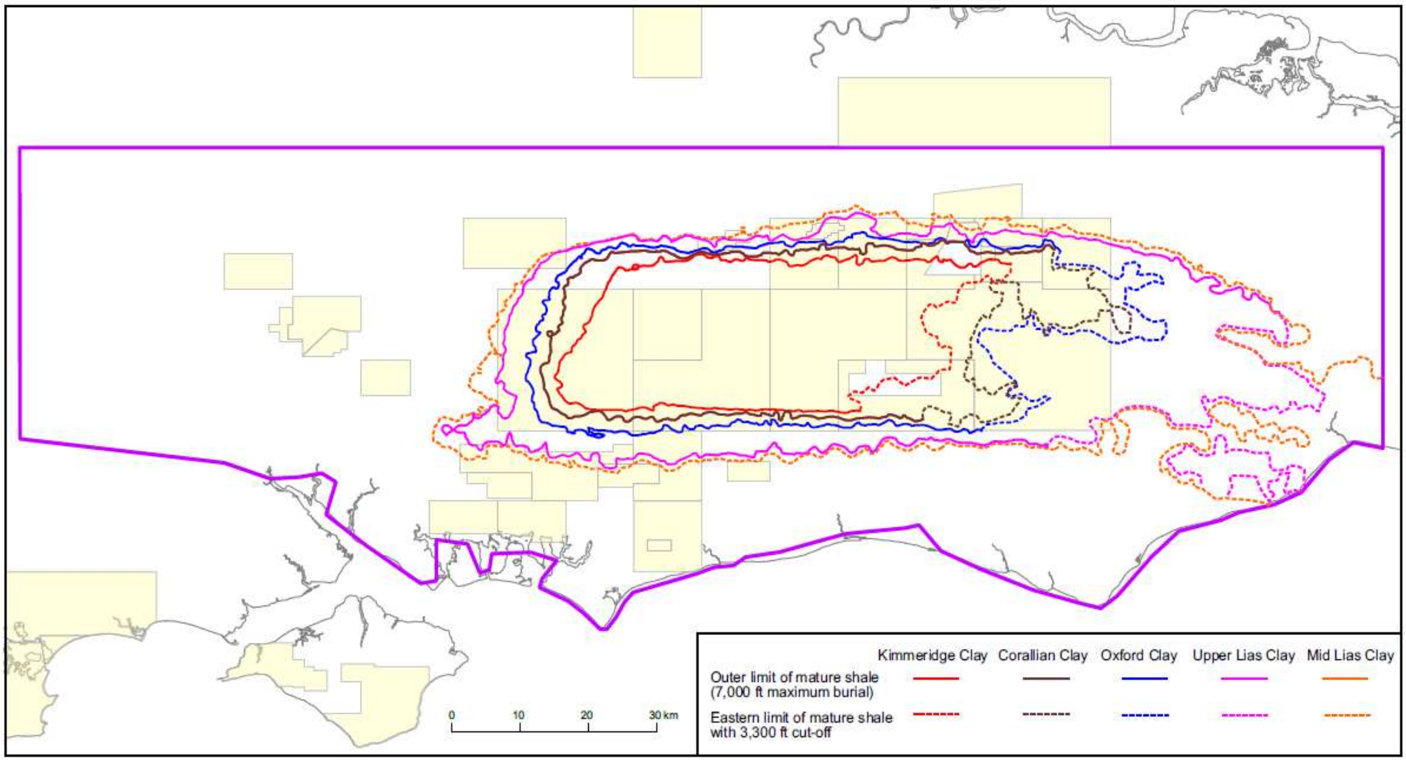
	No. of years of UK energy supply for each of the BGS Weald Basin shale oil resource estimates		
Sector	Lower BGS estimate	Mid BGS estimate	Upper BGS estimate
Transport	0.25	0.51	0.98
Industry	0.32	0.66	1.37
Domestic	0.22	0.45	0.87
Services	0.39	0.79	1.53
TOTAL	**0.07**	**0.14**	**0.28**

NB: See p.5, following the glossary, for a note on the DECC figures used in these calculations.

- When interpreting the above figures it should be noted that, given that none of the Jurassic shales analysed by the BGS were found to have an oil saturation index of more than 50, there may be only very limited amounts of shale within the Weald Basin that have any potential to produce oil in commercial quantities. Even assuming a 5% recovery factor – a perfectly reasonable assumption in the context of US shale oil plays, where oil saturation indices are regularly significantly higher than 50 – is likely to significantly overestimate the Weald Basin's producible shale oil resource.

- However, most of the identified shale oil potential falls on extant licenses, so shale oil drilling and testing in the Weald Basin will NOT rely on the award of new licenses (see Figure 2 p.3). This could prove significant given that the only way to be certain about the extent to which the Weald Basin's shale oil resources are "producible" is to undertake test drilling.

Figure 2. Summary of areas considered prospective for oil in the Jurassic Shale units in southern Britain with licensed acreage (as of April 2014) also shown.



Caveats and uncertainty

- The net energy yield of unconventional hydrocarbons – shale oil and gas – is low relative to conventional hydrocarbons, due to the fact that their production is comparatively so energy intensive. Lower "energy returned on energy invested" (EROEI) translates to higher production costs, lower production rates and usually more collateral environmental damage in extraction.

- Unconventional reserves (i.e. shale oil and shale gas) experience high rates of decline relative to conventional reserves. According to Austin, Texas-based Drillinginfo Inc., the output of shale wells falls by 60 to 70 percent in the first year alone, whilst traditional wells take two years to fall by about 55 percent before flattening out. To put this into perspective, according to the Paris-based International Energy Agency, it will take 2,500 new wells a year just to sustain an output of 1 million barrels a day in North Dakota's Bakken shale. Iraq could do the same with 60.

- The Weald Basin shale oil resources are "unproven" – i.e. they have a high level of uncertainty attached to their potential future recovery/production. Such unproven resources are either "probable" (with a 50% confidence level of recovery) or "possible" (with at least a 10% certainty of being produced) – due to the present lack of exploration and production in the Weald Basin, any unconventional hydrocarbons should be considered "unproven" "possible" resources. By contrast, proven reserves have at least 90% confidence of being recoverable under existing economic, technological and political conditions.

- There is a high degree of uncertainty in the BGS figures. Given that the 'oil saturation index' is considerably less than 100, there is a chance that there may be little or no 'free oil', and that what oil there is exists in the form of kerogen and would thus require heating (in a process known as "retorting") to extract it.

- A significant proportion of the Weald Basin's shale oil reserves will almost certainly NOT be technically or economically recoverable; although the economic impetus to recover what shale oil there is will vary according to external market conditions.

- Based on the US experience, the recovery factors for shale gas generally range from 20% to 30%, with values as low as 15% and as high as 35% in exceptional cases. Because of oil's viscosity and capillary forces, oil does not flow through rock fractures as easily as natural gas. Consequently, the recovery factors for shale oil are typically lower than they are for shale gas, ranging from 3% to 7% of the oil in-place with exceptional cases being as high as 10% or as low as 1%.

- Because most shale oil and gas wells are only a few years old, there is still considerable uncertainty as to the lifetime of shale wells and their ultimate recovery levels. Therefore the aforementioned recovery rates are based on extrapolations of shale well production over 30 years. A shale formation's resource potential cannot be fully determined until extensive well production tests are conducted across the formation.

- Even in the US, where the industry is at its most advanced, and the geological and legal-regulatory framework is comparatively favourable, fracking for shale oil is largely uneconomic. This year, independent producers will spend $1.50 on drilling for every dollar they get back. In part this is due to the inherent expense of extracting unconventional hydrocarbons; but it is also because of the sheer frequency of drilling required to sustain production levels in the face of high rates of decline compared to conventional reserves.

- In order to sustain the rapid expansion of unconventional hydrocarbon production in the US (which has driven an unprecedented 39% gain in U.S. oil production since the end of 2011), the industry depends on high oil prices (the per barrel price of crude oil has consistently remained above $100 since 2011) and cheap credit (in the US this has been significantly aided by the Federal Reserve holding interest rates near zero since 2008, effectively shrinking returns on safer bets and making investors more willing to lend to unprofitable drilling companies). And even with crude above $100 a barrel, shale producers are spending money faster than they make it. This year Sanchez Energy Corp, a Houston-based exploration company, plans to spend $600 million on the Eagle Ford shale formation in south Texas, almost double its estimated 2013 revenue.

- According to Leonardo Maugeri, a researcher into the geopolitics of energy at Harvard University's Belfer Center for Science and International Affairs, a prolonged slide in prices below $85 a barrel would put pressure on operators that have struggled to contain costs or that don't own acreage in the prolific "sweet spots" of the shale oil fields. While the boom could survive a brief dip in oil prices, a long slump could slow drilling and cause production to fall swiftly. "To sustain in the short term, the U.S. needs prices at $65 a barrel," Maugeri said. "That's a critical level. Below that level, many opportunities will vanish."

- Whether the geological, technological, economic and legal-regulatory environment in the UK will prove favourable enough to sustain – or even induce – shale oil exploration and production in Weald Basin remains to be seen. What is clear, however, is that are sufficient obstacles to unconventional hydrocarbon exploration and extraction to make widespread exploitation unlikely.

Glossary

Conventional oil and natural gas production: Crude oil and natural gas that is produced by a well drilled into a geologic formation in which the reservoir and fluid characteristics permit the oil and natural gas to readily flow to the wellbore.

Final energy consumption (end use): This refers to energy consumed by final end users after energy has been transformed, as opposed to primary energy consumption which is energy in its original state.

Oil shale: Kerogen-rich shale – i.e. organic matter still in its solid state. It does not contain liquid oil but is the source rock for conventional oil fields. Oil is extracted from oil shale by: a) in-situ heating of shale at depth, or b) mining of the shale at/near the surface which is then retorted (i.e. heated to a high temperature to accelerate the maturation process and extract the oil fractions from the mineral fraction). Oil shale cannot be extracted through the use of fracture simulation.

Primary energy equivalents: This is the amount of the fuel used directly for consumption in a sector plus the amount of that fuel used to produce another fuel in that sector. For example, gas used to produce electricity (and other fuels) in the industrial sector plus the direct use of gas in the industrial sector would give the primary energy equivalents for gas in the industrial sector. The primary energy equivalent figures will include any losses incurred during the transformation process and energy used by the energy industry. In order that the total primary energy equivalents correspond with the primary energy totals, it is necessary to estimate factors which apportion these loses and uses.

Recovery factor: The recovery factor pertains to the percentage of the original oil or natural gas in-place that is produced over the life of a production well. Because most shale oil and shale gas wells are only a few years old, there is still considerable uncertainty as to the expected life of U.S. shale wells and their ultimate recovery. The recovery rates used in this analysis are based on an extrapolation of shale well production over 30 years. Because a shale play's geophysical characteristics vary significantly throughout the formation and analogue matching is never exact, a shale formation's resource potential cannot be fully determined until extensive well production tests are conducted across the formation.

Shale gas: Natural gas produced from wells that are open to shale formations. Shale is a fine-grained, sedimentary rock composed of mud from flakes of clay minerals and tiny fragments (silt-sized particles) of other materials. The shale acts as both the source and the reservoir for the natural gas.

Shale oil: Oil that occurs in largely impermeable lithologies. These can be shale, but also sandstone, limestone etc. Shale oil may also be referred to as "tight shale oil", "tight light oil (TLO)", "tight oil", "oil-bearing shale" or "shale-hosted oil". Shale oil is extracted by horizontal drilling and hydraulic fracturing.

Shale play: The term "play" is used in the oil and gas industry to refer to a geographic area which has been targeted for exploration due to favourable geo-seismic survey results, well logs or production results from a new, or "wildcat well", in the area.

Total Organic Content (TOC): Total weight percent of organic carbon (% or wt%).

Unconventional oil and natural gas production: An umbrella term for oil and natural gas that is produced by means that do not meet the criteria for conventional production. What has qualified as "unconventional" at any particular time is a complex interactive function of resource characteristics, the available exploration and production technologies, the current economic environment, and the scale, frequency, and duration of production from the resource.

NB: The numbers in Table 1 are derived from calculations using "primary energy equivalents" taken from DECC's 2012 UK energy consumption figures. DECC's definition of "primary energy equivalents" is provided below, along with its counterpart "final energy consumption".

References

ANDREWS, I. J., 2014. The Jurassic shales of the Weald Basin: geology and shale oil and shale gas resource estimation. London, UK: British Geological Survey for the Department of Energy and Climate Change. Available from: https://www.gov.uk/government/publications/bgs-weald-basin-jurassic-shale-reports [Accessed 16th June 2014].

Department of Energy & Climate Change, 2013. Energy consumption in the UK. Available from: https://www.gov.uk/government/publications/energy-consumption-in-the-uk [Accessed 16th June 2014].

Financial Times, 2014. Commodities: ICE Brent Crude Oil Front Month. Available from: http://markets.ft.com/research/Markets/Tearsheets/Summary?s=1054972 [Accessed 18th June 2014].

HART, N., 2010. What Is A Shale Gas Play? Available from: http://eaglefordshaleblog.com/2010/03/03/what-is-a-shale-gas-play/ [Accessed 16th June 2014].

HUGHES, D., 2013. Drill, Baby, Drill: Can Unconventional Fuels Usher in a New Era of Energy Abundance? Santa Rosa, California, USA: Post Carbon Institute. Available from: http://www.postcarbon.org/drill-baby-drill/report [Accessed 18th June 2014].

LODER, A., 2014. Dream of U.S. Oil Independence Slams Against Shale Costs. Available from: http://www.bloomberg.com/news/2014-02-27/dream-of-u-s-oil-independence-slams-against-shale-costs.html [Accessed 16th June 2014].

U.S. Energy Information Administration, 2013. Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States. Available from: http://www.eia.gov/analysis/studies/worldshalegas/ [Accessed 16th June 2014].

U.S. Energy Information Administration, 2013. Glossary. Available from: http://www.eia.gov/tools/glossary/ [Accessed 16th June 2014].