Landscape Institute Technical Information Note

Fracking

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This Note is provided for information only.

Its aims include providing information in support of future LI guidance and policy publications and increasing awareness of Fracking as a concern for landscape practitioners.

1. Geological context

Since the "conventional" gas and oil reservoirs of the UK both on-shore and off-shore in the North Sea are becoming increasingly depleted, so-called unconventional reservoirs, i.e. oil and gas reserves in shales, are being explored.

Shale is a sedimentary rock with a high organic content. Pressure converts the organic content into methane. However, the gas is trapped within the rock strata which are impermeable. This is an unconventional source of gas (sometimes called "tight" gas) as it is not found in a reservoir void between layers of rock like other sources of oil and gas (such as under the North Sea). To free such gas, it is necessary to fracture the shale and provide a pathway for the gas to the production well.

The British Geological Survey (2013) estimate ranges, reflecting geological uncertainty, from 822 trillion cubic feet (tcf) to 2281 tcf with a central estimate of 1329 tcf. This shale gas estimate is a so-called "gas-in-place" estimate and represents the gas that is present but not the gas that might be possible to extract. The BGS points out that only with further shale gas exploration drilling and testing over an extended period will it be possible to determine whether this identified shale gas potential can be exploited commercially and what the contribution to a future UK energy mix could be. Other resource estimates are available, for example www.madalenaenergy.com puts UK resource estimates at 20 trillion cubic feet (0.56cu.m) of technically recoverable shale gas.

Looking at the UK, the primary known reserves underlie North West England and Yorkshire extending into the North Midlands and Lincolnshire. There are also tracts of shale in southern England.

Very significant volumes of shale oil and gas are being commercially produced in the USA and many estimates in the UK are based on experiences from the US. Much of the technology is transferable, although shale deposits in Britain exist at greater depths and thicknesses and in more variable subsurface geology. The legislative framework, e.g. planning consent and environmental regulations, labour costs, social acceptance, community benefits as well as the market price of gas at the time are also likely to be factors in determining profitability and the pace of exploration in the UK. As such the process of exploration and extraction of shale gas is likely to be significantly different from the US experience.



Fig. 2: Licensed Areas and SEA Areas for shale gas extraction (Department of Energy and Climate Change 2014).



Fig. 3: The map shows PEDL areas with the areas auctioned during the 14th licensing round in August 2016 in different colours for the major operators and older licenses in grey

(Source: Oil and Gas Authority Open Data September 21, 2016, <u>https://www.ogauthority.co.uk/data-centre/interactive-maps-and-tools/</u>, Downloaded: May 2017; with background map based GB Overview [Shape geospatial data], Scale 1:2000000, Tile(s): UK, Updated: Month Year, Ordnance Survey, Using: EDINA Digimap Ordnance Survey Service, http://digimap.edina.ac.uk , Downloaded: May 2017)

2. What is Hydraulic Fracturing or Fracking?

Hydraulic fracturing (also called *fracking* or sometimes *fraccing;* in this Technical Note the terms are used synonymously) is a way of extracting gas (and sometimes oil) from shale rock. Both terms refer to the injection of water, sand and chemicals into the rock at high pressure to break the shale and release the gas, a process sometimes called well stimulation.

To reach the shale a vertical bore hole well is drilled from the ground surface and then turned to continue horizontally within the rock layers. Large amounts of water with sand and chemicals are pumped into the borehole at pressure to fracture the shale rock. The sand keeps the fissures open, which allows the gas to escape along the fracture paths to the borehole and up to the wellhead to be collected at the surface. The chemicals include surfactants to break the water's surface tension to improve its penetration, and biocides to inhibit organic growth that might impede gas movement. The gas can usually be fed straight into the national gas grid once entrained water and accompanying higher-order hydrocarbons such as ethane and propane are removed.

While hydraulic fracturing has been in use for many years to stimulate gas production, a major technical advancement came from the introduction of directional drilling, which allows exploitation of an area of a few square miles around each well. When hydraulic fracturing and directional drilling were combined in the mid-2000s, vast reserves of natural gas entrapped in shale deposits became economic to develop (See Fig. 4 and Fig. 5).

In consequence, the location of the wells is driven by the geology as well as the range of directional drilling (2-6 km). In order to exploit as much as possible of the reserves in shale strata, it is necessary to locate wells in a regular grid arrangement covering as wide an area as possible.

A different but related technology is the extraction of *coal-bed methane*, which is usually stored in coal seams. Coal-bed methane has already been extracted from former deep coal mines but the new technologies directional drilling and hydraulic fracturing allow a more effective extraction of coal-bed methane. Several companies have applied for licenses in the old coal mining areas of Britain.



Fig. 4: Hydraulic Fracturing (BBC 2015, <u>http://www.bbc.co.uk/news/uk-england-lancashire-</u> <u>30913269</u>, downloaded 22 May 2017)

New technologies might soon replace the need for the actual 'fracturing' part of the process and companies already argue that many extractions are technically not 'fracking'. Interestingly, this distinction might not only have a major impact on public perception but also in legal terms if future legislation allows that 'non-fracking drilling will be treated as permitted development' as proposed in the Conservative Party Manifesto 2017.



Fig. 5: 3-dimensional diagram of directional drilling and how it looks underground (Gov.uk 2017)

3. Lifecycle and layout of a typical exploratory well pad

A typical well pad goes through a number of development stages. It is important to note that there is no equivalent information about operational stages as no operational sites have so far been progressed in the UK.

Development stage	Description
Construction of well pad	Low level excavators, concrete lorries, 4m bunding,
	4m security fencing/ hoardings
Installation of the drill floor	Low level borehole rig, 1.5m fencing, 1-2 days per installation
Drilling	35-53m high drilling rig in operation for 6 weeks – 4 months
Hydraulic fracturing	36m high rig and 10m flare stack in use for 2 months per well, storage tanks for fresh water and "produced" (contaminated) water
Initial flow testing	36m high rig for maximum 90 days
Extended flow testing construction	Single storey buildings, storage tanks but no flare stack
Extended flow testing operation	In use for 18-24 months per well
Decommission/restoration	Site restored to previous condition (optional under current planning consent)

Table 1: Key stages for an *exploratory* well site, NOT an operational well site

Typically an exploratory well pad will be about 1.5 -2 hectares in size (equivalent to the area of about 2 football pitches), possibly larger for a well site for commercial extraction, plus the surface area of the access track. For the Preston New Road exploratory well, the application proposed 5ha of access areas in addition to the well pad. Each pad requires a solid foundation, usually crushed limestone or similar, and will contain multiple drill holes, containers, security fences, water and gas storage and car parking (Fig. 6).



Fig. 6: Layout of a well pad (SLR for iGas, 2015).

Stage 1: Preparation/Construction of well pad (exploratory site)

The preparation and construction of an exploratory well pad will take approximately three months and include clearing the site and levelling the site. New site features may also include the construction of an access road and on-site facilities for staff. Any existing vegetation including trees or sections of hedgerow will be removed as required. It is likely that boundary or security fencing and hoardings, up to 4m high, along with CCTV equipment, will be installed. Top-soil will be stripped and stored, often as a screening mound, and replaced by a hardscaped area (see Fig. 6). Mitigation planting may be undertaken at this stage, in order that it becomes established at the earliest opportunity and to avoid the screening mound becoming a negative visual impact in itself.



Fig. 7: Well pad at Singleton in Lancashire after the completion of Stage 1, i.e. with only the limestone foundation, security fences and screening mounds at two sides illustrating this particular stage in the lifecycle of a well (Schroth, 2015)

Stage 2: Drilling for exploration

In applications for exploratory wells in the UK proposed drilling operations are shown to take place over a 6-week to three months period, possibly on multiple occasions. This includes the installation and removal of the drill rig with an approximately 50m – 60m high structure above ground (see Fig. 8 and 9). The site will operate 24 hours a day, 7 days a week during this stage with the site floodlit at night for safety reasons. It should be noted that commercially operating wells in the US usually complete the drilling process in much shorter periods.

The level of vehicular movement for the actual drilling process is likely to be low. During the preceding and following two week periods, for initial delivery and subsequent removal of the rig equipment, there will be an increase in the movements of heavy goods vehicles. Once the rig is constructed, traffic to and from an exploration site will comprise deliveries of well liners, associated drilling materials and workers' vehicles.



Fig. 8: Section of the Tinker Lane well pad (Nottinghamshire) during the drilling stage with 60m drill rig (iGas, 2016).



Fig. 9: Photomontage of proposed exploratory well at Preston New Road with a 53m high drilling rig from a viewpoint in 0.47km distance (JBA Consulting 2016).

Stage 3: Well stimulation through hydraulic fracturing

After drilling is completed, the rig will be removed and taken to another well site. At this stage, deliveries of high pressure pumps and water and removal of waste water are necessary for the well stimulation through hydraulic fracturing.

Waste water reinjection is a controversial issue and one that is hazy under current Environment Agency regulations.

In terms of visual impact this is similar to Stage 2 but with potentially a lower 'workover' rig (up to 36m in height) and significantly higher frequency of vehicular movements to bring in water, sand and chemical additives. Lighting will be required and the fracking process can also create considerable noise. Hydraulic fracturing should be completed after two months although it might be necessary to "re-frack" after a few years.

As soon as the hydraulic fracturing starts, the main logistical issue will be to maintain a supply of water and to remove contaminated returned water ("flowback"). If water is supplied by road tanker and taken away afterwards to be treated then this will generate a considerable number of HGV movements. On-site water recycling, which may be feasible, could significantly reduce this traffic volume but increase the size of the well pad. However there would still need to be deliveries of sand and chemicals, to be added to the water as it is pumped down into the well. Based on Broderick et al. (2015), Goodman et al. (2016) estimate 3870 – 5750 Heavy Duty Vehicle (HDV) visits during the fracturing and flowback (i.e. the returned contaminated water) process of a well with a 6-year life expectancy.

As with drilling, fracturing does not take much time. That is good in terms of the time of disruption, less good in that the intensity of water and sand truck traffic is enormous and would be hugely challenging on UK country roads

Stage 4: Flow testing (for exploratory sites) or Production (for operational sites)

Once a site is operating in the production or flow testing stage, the built structures such as containers and storage tanks on the site would only need to be low in height, no higher than a single storey building (e.g. about 10m max).

The well-head will be suspended while equipment at ground level will be removed, with the exception of offices, security fencing and the well-head. For an exploratory well, monitoring of the site is expected to produce traffic movements at a low level. No night lighting or activities are necessary for monitoring. The prospective timescale for this stage is up to two years for an exploratory well.

During production, extraction wells at full operation will produce regular (usually weekly) traffic movements to bring in water and chemicals and to remove "produced water". According to Cuadrilla (2014), the single well at Preese Hall (Lancashire) required 8400m3 of water during its relatively short period of operation between 2009 and 2011. However, the amount of required water can vary significantly as Goodman et al. (2016). If there are multiple wells on a site, these volumes will be substantially greater.

In full production mode, it will be necessary to maintain gas flows and there could be a resumption of new well drilling or possibly re-fracturing (Stage 3) of existing wells in future years. In the US, fracking wells have been proposed to operate for up to 15-20 years. Re-fracturing activities could add a further 2000–3000 HDV trips (Goodman et al., 2016). Shale gas extraction will also require

new pipelines and compressor stations, so that the produced gas must be piped into the nearest National Grid gas pipeline.



Fig. 10: Photo of the exploratory well site Doe Green near Warrington (Cheshire) during the flow testing operational phase. Storage tanks, containers and a road tanker can be seen in the background concealed through screening vegetation (Schroth, 2015).



Fig. 11: Kirby Misperton, North Yorkshire from above (JBA Consulting, Year)

Stage 5: De-commissioning and Restoration

By the grant of planning permission, the Local Planning Authority will normally impose conditions to ensure that the site is decommissioned and restored in an appropriate manner (Figure 12). However, experiences from the US and from the Grange Road exploratory well near Singleton in Lancashire have shown that often restoration is not as straightforward.



Fig. 12: Former exploratory well site Anna's Road in Lancashire after decommissioning and restoration. The extent of the well pad is still visible (Schroth, 2015).

4. Third-party guidance relevant to landscape planning

The Oil and Gas Authority OGA is responsible for issuing *Petroleum Exploration and Development Licences (PEDLs)*. The 14th Onshore Oil and Gas Licensing Round was launched in 2014 and resulted in 93 new licences being awarded to successful applicants in 2016. Licences do not themselves give consent for drilling or any other operations.

In 2014, the *Minerals Planning Statement, MPS1,* and the accompanying *Planning and Minerals Practice Guide* (DCLG 2006) were withdrawn, archived and replaced by the National Planning Policy Framework (NPPF 2012) and web-based Planning Practice Guidance (NPPG 2014). NPPF (2018) is at present subject to consultation; the draft adds no further detail to the text of NPPF 2012.

The Infrastructure Act 2015

- Allows a person a right to use deep-level land in any way to exploit petroleum [s43(1)] (Deep-level land is defined as any land at a depth of at least 300 metres below surface level)

- The right of use includes the right to leave the deep-level land in a different condition [s44(3)] (including by leaving any infrastructure or substance in the land)

- Excludes liability of the landowner for mining-related loss or damage [s44(5)]

The Infrastructure Act 2015 also requires methane in groundwater to be monitored over a twelvemonth period before hydraulic fracturing can occur, independent well inspections and restoration conditions.

Regulation 2 of the *Onshore Hydraulic Fracturing (Protected Areas) Regulations 2016* defines protected groundwater source areas as any land at a depth of less than 1,200 metres beneath a relevant surface area; Regulation 3 defines other protected areas as areas of land at a depth of less than 1,200 metres beneath a National Park, the Broads, an AONB, or a World Heritage Site.

In the Infrastructure Act 2015, National Parks and AONBs were exempted from surface fracking operations but operators are still permitted to extract under the area of a National Park using horizontal drilling techniques. In consequence, there are potential incentives for developers to locate their wells as close to the border of a National Park as possible, which is likely to produce visual and landscape impacts reaching into the protected area. The North Yorkshire County Council has therefore introduced the concept of 'visual buffer zones' into its draft Minerals and Waste Joint plan.

Currently Class K in Part 17 of *The Town and Country Planning (General Permitted Development) (England) Order 2015 (GPDO 2015)* contains a prohibition for 'the drilling of boreholes for petroleum exploration'. Therefore oil and gas exploration currently requires planning permission.

However, the *Conservative Party Manifesto* of June 2017 describes the Government's intentions as follows:

'We will legislate to change planning law for shale applications. **Non-fracking drilling will be treated as permitted development,** expert planning functions will be established to support local councils, and, when necessary, major shale planning decisions will be made the responsibility of the National Planning Regime.

We will set up a new Shale Environmental Regulator, which will assume the relevant functions of the Health and Safety Executive, the Environment Agency and the Department for Business, Energy

and Industrial Strategy. This will provide clear governance and accountability, become a source of expertise, and allow decisions to be made fairly but swiftly.'

The changing political context

All current EIA applications in the UK have been made for exploratory well sites and it is not yet clear how subsequent operational applications will be judged. It may be that each extraction well pad will require a separate EIA. Otherwise, multiple well applications may be considered as national infrastructure projects. The legal and political context keeps changing.

The general election in 2017 may prove to have been a crossroads in terms of hydraulic fracturing. The two main parties made very different proposals. While the Labour Party proposed to ban fracking, the Conservative Party manifesto promised to change planning law in favour of faster shale gas applications. 'Non-fracking drilling will be treated as permitted development, expert planning functions will be established to support local councils, and, when necessary, major shale planning decisions will be made the responsibility of the National Planning Regime'. Furthermore, the manifesto stated that a new 'Shale Environmental Regulator' will be established to assume the various roles of the Health and Safety Executive, the Environment Agency and the Department for Business, Energy and Industrial Strategy for shale gas applications.

Questions of community engagement and environmental justice

The 2017 Conservative Party manifesto also proposed changes in the distribution of the proposed '*Shale Wealth Fund*' in order to "*directly benefit the communities that host the extraction sites*". However, fracking proposals have a tendency to create high-tension arguments in local communities, and high levels of local opposition. Cotton (2016) points out that the uneven distribution of risks and social impacts to local communities must be balanced against the economic benefits, and that these decisions have to be made at local scale if political equity is to be ensured. In this context, the proposed role of the National Planning Regime seems contradictory to the Government's localism agenda.

The government believes it has addressed these issues by requiring developers to pay financial contributions towards community benefits. £100,000 per well-site and 1% of revenues at production are proposed to be paid out to local communities. However, it has not yet been decided when, how and in what form these benefits will be paid.

Difficult to measure but of great public importance are the social and cultural dimensions of landscape, such as memories, associations and preferences. Given the level of public interest in 'their' landscape, it could be argued that shale gas fracking has a deep-rooted effect in terms of a disrupted 'sense of place', that may not always be visible or measurable, even when only small-scale abandoned wells remain.



Fig. 18: Protest sign near the proposed Roseacre exploratory well site in Lancashire (Schroth, 2015).

5. Examples of Practice

Department of Energy and Climate Change. (2015). Onshore oil and gas exploration in the UK: regulation and best practice. London: DECC.

This document by the former DECC was intended as a first point of reference to understand the permitting and permissions process for exploratory work in unconventional onshore oil and gas development in the UK, specifically shale gas and coal bed methane developments. However, the authors pointed out that it should not be considered as definitive policy statement and parts of it might have been superseded already or will be superseded in the near future.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/265988/Onshore_ UK_oil_and_gas_exploration_England_Dec13_contents.pdf

The Pennsylvania State University (2016): Marcellus by Design

This is the online archive of a studio and research project at the Pennsylvania State University, sponsored by the National Science Foundation and the Hamer Center for Community Design. Beginning in 2011, faculty and students in the Stuckeman School of Architecture and Landscape Architecture have engaged communities in the near-by Marcellus shale experiencing new energy extraction, to offer design thinking to these complex landscape issues.

http://sites.psu.edu/marcellusbydesign/

<u>City of York Council, North York Moors National Park Authority, & North Yorkshire County Council.</u> (2017). *Minerals and Waste Joint Plan Publication Draft Responses February 2017*. York.

The emerging North Yorkshire County Council Joint mineral plan contains a section on shale gas including the provision of a buffer zone to safeguard the setting of the National Park and AONB in North Yorkshire. This is the first attempt of addressing hydraulic fracturing in local planning policy but as such, some of the wording such as "unacceptable impact" or "suitable access" is open to interpretation and could be contested.

http://www.northyorks.gov.uk/article/26218/Minerals-and-waste-joint-plan

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Authored and illustrations sourced by Chris Stratton FLI and Prof Olaf Schroth

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