DEVELOPING SHALE GAS AND MAINTAINING THE BEAUTY OF THE BRITISH COUNTRYSIDE

A report by United Kingdom Onshore Oil and Gas into the potential visual impact of shale gas production in the United Kingdom

FOREWORD

Today the UK imports approximately half of its gas from outside the UK, costing over £18m per day, and this is set to rise over the next 20 years to 80%. Gas will remain a significant component of the UK's energy usage over the next several decades, regardless of the pace of renewables development - 84% of UK homes currently use gas for heating, and gas forms a substantial proportion of industrial heating and chemical feedstock requirements. Gas usage also helps with meeting the UK's decarbonisation targets. The Committee on Climate Change also recently concluded, that a reduction of gas imports could be a key role for shale gas in the UK. Hence, the case for home grown gas is a compelling one.

So, the UK needs gas, but can shale gas be successfully developed in the UK? There are many factors that will determine the answer, but one aspect that communities have expressed concern about is the potential visual impact of a fully functioning shale gas industry in the UK. This has arisen amid a backdrop of concerns about "industrialisation of the countryside".

Our assessment shows that a material UK shale gas industry can be developed around our communities in a sensitive and measured fashion. By employing the latest subsurface drilling technology, the surface footprint of the industry will be minimal, with only a modest number of production sites, each of no more than the size of two football pitches, in every 100 km^2 licence block. Furthermore, after the initial site development and drilling period, these sites will produce gas for twenty years or more, with virtually no visual, noise, lighting or traffic impact.

A successful shale gas industry will provide natural gas for our homes, much improved UK energy security in an uncertain world, and a welcome boost to local jobs and the UK economy. It is forecast that the industry will support 64,500 direct jobs and £33bn of investment in the UK.[i]

This paper summarises the factors that determine where to site shale gas production pads, how many production sites could be in each licence block (10km by 10km), and how that compares to other developments that we already see in our local communities such as pylons, municipal waste water treatment facilities and wind farms. The report draws on experience elsewhere, and blends in the current UK legislation with respect to permitted land use.

The actual distribution of production pads within any specific licence block will depend heavily on the subsurface geology and the surface constraints. All activity will need to abide by the local planning regulations, both during the relatively short development phase (i.e. when the site is being constructed and the wells are being drilled and completed), and during the longer term operational phase, when the production pads will be silent and unobtrusive as the gas flows.

There is no single model that will cover all licence areas. However, as an illustration of a typical example (which uses a US pad development scenario, of 10 wells per production pad model), the underground area drained by each pad is between 6.5 and 11 km^2. Given surface constraints, there will generally be a modest number of such production pads within any 10km by 10km area, which will occupy 0.2% or less of the total land area.

We estimate that approximately 400 well pads developed across the UK between 2020 and 2035 could reduce our gas import dependency by at least 50%. This compares to 88,000 pylons, 9,000 municipal waste water treatment facilities and 5,300 individual wind turbines that already exist.

Shale gas provides a unique opportunity for both our economy and our energy security. We can continue to send money abroad to import our gas and support jobs and investment in other countries – or we can develop our own indigenous resource. It has been agreed by independent experts that this can be done safely, with respect and protection for the environment and with minimal impact on the communities that we will operate in.

Ken Cronin, Chief Executive UKOOG

KEY HIGHLIGHTS

There is no single model that will cover all licence areas in the UK as the geology will be different and much more will be understood once the industry has completed its exploration phase. However, in compiling this report we have used as an illustration a typical example from the US, of a 10 well site (Pad) and have formulated the following results:

- **Between 7 and 11 production pads of c. 2 hectares each required to develop a typical 10km x 10km licence area**
- **This means a total land use of 0.2% or less**
- **Only 1 to 3 production pads under development (construction and drilling) in a licence area at any one time**
- **To reduce gas import dependency by c. 50%, around 400 producing pads will be needed between 2020 and 2035.**
- **Producing sites will involve a temporary construction and drilling phase and will have no permanent drilling rigs or other tall structures and will be quiet and with screening not visible.**
- **Visual impact and disturbance is temporary compared to other installations within communities**
- **Land use significantly lower than other energy developments or other industries**

Doe Green, Warrington, 4 wells drilled c 2010

Site Location Considerations

There are several factors that will influence production pad siting and density within a given licence block. Each site location decision will include a balance of the following factors:

1. Geology – Production pads will need to be sited close to where the gas is and take account of the location and level of natural underground faulting. As a part of this process existing sites will be considered.
2. Protected areas – The government has introduced protections for certain areas through the Infrastructure Act 2015 and with respect to surface access. For example, the industry in the UK is not allowed to work in ground water source protection zone 1 or to drill on the surface of a national park for the purposes of high volume hydraulic fracturing. These areas would therefore be eliminated from consideration as potential sites.
3. Proximity to urban areas – Just like any development, all shale gas sites need to meet the requirements of planning regulations, which includes consideration of factors such urban proximity, traffic impact, and visual impact.
4. Access to water and grid – During the early stages, production pads need appropriate sources of water, and during production they require connection to gas or electricity consumers.
5. Access and transport links – As with other construction activities, in the early stages of pad preparation, drilling and hydraulic fracturing, there are truck movements which require appropriate site access and transport linkages.

Each operator, via the national planning policy framework and the local planning systems, will carefully consider these factors in combination when preparing planning applications, including any cumulative impacts of other existing sites.

Production Pad Density

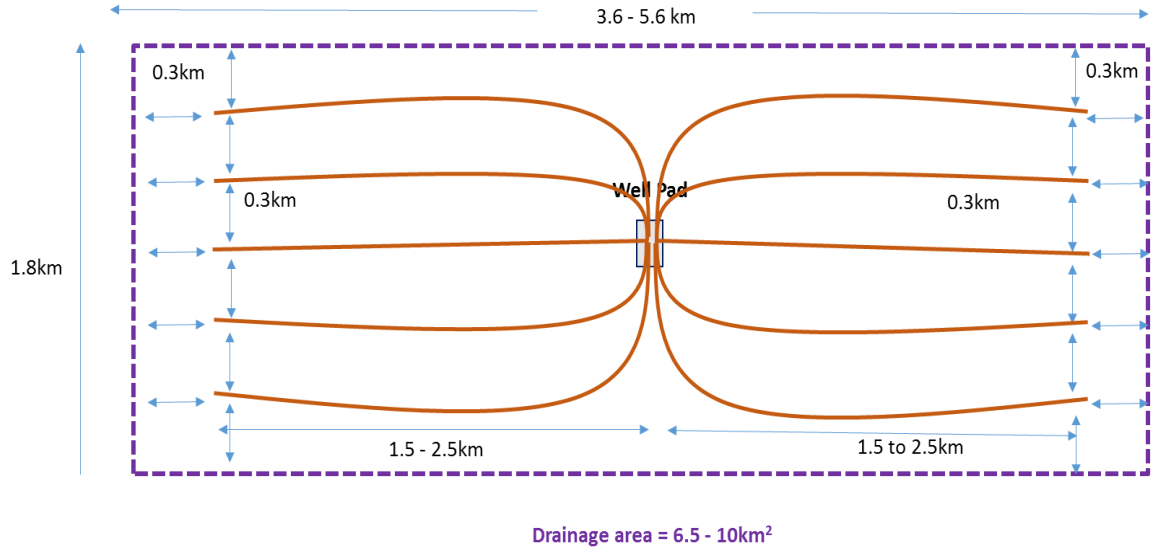
With respect to surface impact on the landscape and communities, there are two important aspects. Firstly, the number of Production Pads that will be developed in a licence area and secondly the activity on, and visual impact of, a production site and for how long that activity continues.

Number of Pads required

One of the factors that determines how many pads are likely to be located within a specific licence block (10km by 10km) is the potential gas drainage area created by the underground footprint of the wells on each individual pad. This in turn is determined by the number of wells drilled horizontally underground, the length of those wells and how far apart they are spaced.

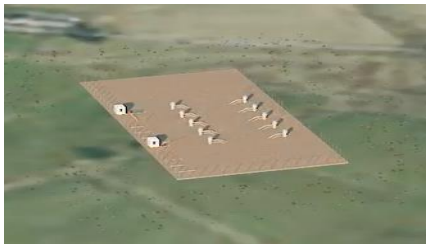
These factors are all specific to the local geology in each licence block. There is no single model that will cover all licence areas. However, a typical scenario that is commonly seen in the US would involve production site (pads) of approximately 2 hectares (2 football pitches), with 10 well heads leading to 10 horizontal wells each extending underground approximately between 1.5 to 2.5km, with a spacing of approximately 300 metres between each well.

The diagram below outlines the key measurements:



This diagram is for illustrative purposes and is not drawn to scale.

The area identified by the small grey 'Well Pad' is the only visible land impact and measures 200m by 100m, or the size of around 2 football pitches. The horizontal wells shown are drilled deep underground (typically 8,000 feet or deeper).



The length of the horizontal well and the number of wells per pad can vary. This will depend on the local geology and presence of faulting in the rock, the mechanical capacity of the drilling rig and the thickness of the shale rock formation itself. Financial considerations also play a part, as the length of well increases the contact area with the shale layer, and hence increases production of gas, but at the same time it increases costs.

Horizontal well lengths have steadily increased over the last 5 years as drilling technology has improved. The model proposed here has horizontal wells travelling between 1.5 and 2.5km, which is well within design parameters commonly used in many US shale areas and in Canada. The longest

horizontal shale well in the US was recently drilled at 5.6km. In 1998, the UK was home to the World's longest extended reach horizontal well of 10.1km.

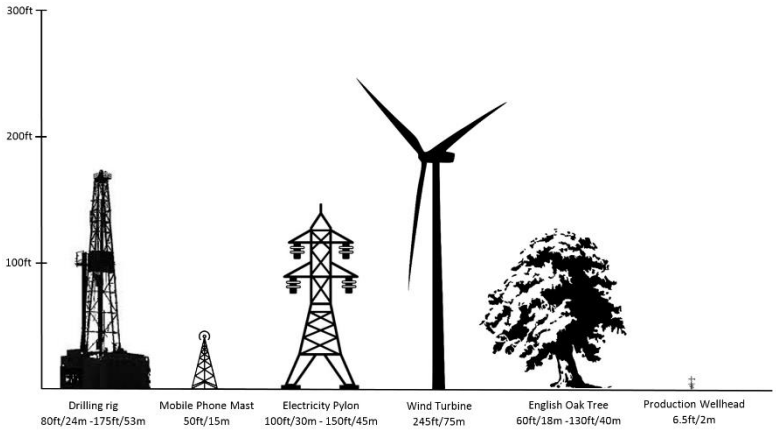
Based on the above model the drainage area will be between 6.5 and 10km ^{2}.

Therefore, in a 10 by 10km block using this model, the theoretical maximum number of pads required to develop the block will be in the order of 10 to 15. However, it is likely the actual number of pads will be lower in many areas once other limiting factors (such as protected areas, transport access, topography, and urbanisation) have been considered. There is no typical licence block and therefore refining the estimated number of pads further becomes difficult. – However, based on a national average for England at least 30% of land will not be suitable for pad development due to one or more of these limiting factors. For example, approximately 28% of the land area in England is covered by a SSSI, AONB and/or a National Park.[ii] Therefore this would bring our estimate down to an average density of between 7 and 11 pads in a 10 by 10km block.

Visual Impact

A site's visual impact will depend on whether it is in development (construction and drilling) or production. The surface impact is defined by the area of the pads, given that all the wells will be deep underground. However, it is also important to recognise that any potential community impact (from truck movements, light, and noise) is concentrated during the relatively short development phase – just like any building site. For most of its producing life (over 20 years) a shale pad will require no permanent rig or fracturing equipment and limited associated transport movements. It will be a low level, quiet and unobtrusive site.

A shale gas pad provides enough space for the drilling rig equipment, lighting, piping and storage, and other site facilities such as mobile portacabins for offices and worker restrooms. Before the main drilling rig arrives on site, similar techniques used to drill a normal water well are used to install a cement or steel conductor pipe which passes through the shallow soil and rock layers. After this, the main drilling rig is brought on-site.



A typical drilling rig which is a temporary structure will be between 80 and 175 ft high. This compares to more permanent structures which include mobile telephone masts (50ft), electricity pylons (100 to 150ft), wind turbines (on average 245ft) and an English oak tree (65 to 130ft). After the drilling rig is removed the set of well heads will be no more than c6.5 feet tall.

In terms of space requirement, during the development and drilling phase, a typical shale production pad will use about 2 hectares of land or the size of two football pitches. This is the equivalent of an out of town supermarket or the land used for one golf hole including its green and fairways. During the production phase, the footprint of many pads may be reduced.

The impact of shale gas on imports and countryside

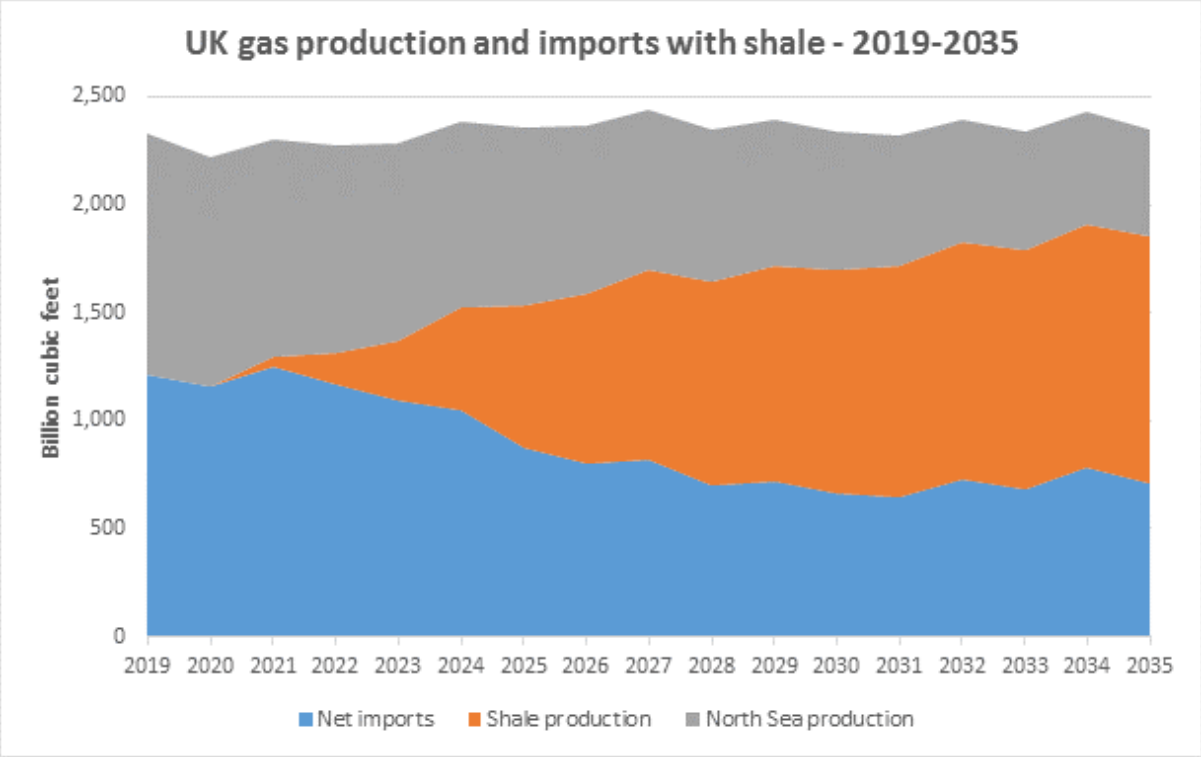
Just 12 years ago, the UK was a net exporter of gas, but foreign imports now make up nearly half of our gas demand.[iii] The Department for Business, Energy and Industrial Strategy is currently forecasting that the UK will be using roughly the same amount of gas in 2035 as it does today.[iv]

The Oil and Gas Authority projections show that between 2017 and 2035 the difference between UK gas production and requirement will be in the order of 30 trillion cubic feet (tcf) for that period, with import dependency rising to 80% by 2035.[v]

As a sense check, the National Grid 'Gone Green' scenario, which assumes all the UK's decarbonisation targets are met, envisages total net imports of gas of 28 tcf between 2016 and 2035.[vi]

Based on production data from the US,[vii] a shale well production estimate of approximately 4 billion cubic feet (bcf) of gas over its lifetime of over 20 years is not unreasonable. (As with all averages there will be many geologies that have produced more than this number)

UKOOG estimates that 140 production pads across the UK by 2025 could reduce import dependency by c. 40%. A further 260 pads would reduce total imports dependency to 50% by 2035, and a further 100 pads will maintain the contribution that domestic gas will make through to 2050.



Source UKOOG Estimates

These production pad estimates compare favourably to the visual impacts of other installation already highlighted in this report and against a backdrop of already having 120 onshore oil and gas operational sites in this country that are generally invisible to the public.

The forecasts on UK production and reducing import dependency are based on the following assumptions

- 25 production pads a year being developed by the mid 2020s and beyond
- Gas flow from each pad will peak between years 3 to 6 and then decline into a steady but nevertheless economic flow up to year 20 or beyond
- The Site construction phase (including site preparation, and drilling and completion of the wells) for a 10-well production pad will vary depending on the geology, the specific design of the wells, and the planning conditions. In the US, such pads are generally completed in a year. Pads of different sizes will take a longer or shorter time to construct and may take initially longer in the UK.
- Pads are decommissioned when gas offtake is uneconomic, which is generally in year 20 or beyond. The wells are then decommissioned and the land is restored to its previous condition.

When comparing the impact on communities and the landscape of this scenario, consideration should be given to the size of impact of other industries and their physical footprint.

	Number	Average size per unit (Hectares)	Total land coverage (Hectares)
Number of pads required to replace 50% of expected UK gas imports through to 2035	400	2	800
Wind Turbine (UK)	5,483[viii]	0.2[ix]	1,097
Golf holes (England)	35,428[x]	2.5[xi]	88,570
Electricity Pylon	88,000[xii]	0.01[xiii]	880

However, the above analysis ignores for example the relative size of each operation with respect to the amount of energy delivered and the visual impact. The late David McKay former Chief Scientist at the Department of Energy and Climate change performed this analysis looking at the energy delivered by one shale pad comparing it to how many wind turbines or solar panels would be needed to deliver similar amounts[xiv]:

	Shale gas pad	Wind farm	Solar park
	(10 wells)	87 turbines, 174 MW capacity	1,520,000 panels, 380 MW capacity
Energy delivered over 25 years	9.5 TWh (chemical)	9.5 TWh (electric)	9.5 TWh (electric)
Number of tall things	1 drilling rig	87 turbines	None

Height	26 m	100 m	2.5 m
Land area occupied by hardware, foundations, or access roads	2 ha	36 ha	308 ha
Land area of the whole facility	2 ha	1450 ha	924 ha
Area from which the facility can be seen	77 ha	5200-17,000 ha	924 ha

This research shows that when energy equivalency is calculated, the total land area required for a shale gas pad is the smallest compared to wind and solar. The research also showed the shale gas pad created the least visual intrusion. Moreover, the drilling rig might be in place for only the first few years of operations. The solar panels are the least tall, but the solar facility occupies 450 times as much land area as the shale gas pad.

There are other examples of typical developments that residents will see in their area including 8,494[xv] petrol stations, 52,500 mobile telephone masts and base stations[xvi] and 9,000 municipal waste water treatment facilities.[xvii]

Future Scenarios

As we have seen in other parts of the world, technology and innovation are continually driving improvements. In recent years, the length of horizontal wells has increased, and the use of 3D seismic testing to locate wells in the formation more accurately has also become common-place, leading to the same or greater gas production for a smaller physical footprint at the surface. These innovations will continue, but to be conservative no account has been made of that potential in this paper.

The geology in the UK varies and in this paper, we have presented one scenario to inform debate. Some parts of the country have thicker shale layers than others and it may be possible to drill into different formations from the same pad. Using the same vertical wells, multi layered lateral wells below the surface may be possible and therefore more gas flow from one pad location with more time required on site to complete. It will only become possible to understand the full potential once the industry has completed the initial exploration phase. UKOOG will continue to update the estimates made in this paper as more knowledge is gained.

[i] http://www.ey.com/Publication/vwLUAssets/Getting_ready_for_UK_shale_gas/%24FILE/EY-Getting-ready-for-UK-shale-gas-April-2014.pdf
[ii] Natural England Designations Strategy July 2012
[iii] Oil and Gas Authority, Oil and gas production and demand projections, 2015 https://www.gov.uk/guidance/oil-and-gas-uk-field-data
[iv] DECC, Updated Energy and Emissions Projections – November 2015, Annex E – Reference Scenario https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2015
[v] Oil and Gas Authority, Oil and gas production and demand projections, 2016 https://www.gov.uk/guidance/oil-and-gas-uk-field-data
[vi] National Grid, Future Energy Scenarios 2016 http://fes.nationalgrid.com/
[vii] Society of Petroleum Engineers, Economic Evaluation of Marcellus and Utica Under the Effects of Dynamic Market and Development Conditions, October 2015 https://www.onepetro.org/conference-paper/SPE-177321-MS
[viii] http://www.renewableuk.com/page/UKWEDhome
[ix] http://www.bbc.co.uk/news/uk-32225276http://www.windustry.org/how_will_wind_turbines_affect_my_farm_how_much_space_will_they_take_up
[x] http://www.scottishgolfhistory.org/news/how-many-golf-holes-are-there-in-the-world/

[xi] http://www.bbc.co.uk/news/magazine-24378868
[xii] http://www.bbc.co.uk/news/uk-32234656
[xiii] http://www2.nationalgrid.com/UK/Services/Land-and-Development/A-sense-of-place/
[xiv] http://withouthotair.blogspot.co.uk/
[xv] http://www.ukpia.com/industry_information/industry-overview.aspx
[xvi] Mobile operators association
[xvii] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69592/pb13811-waste-water-2012.pdf