UK Shale Gas: The Manufacturers' View
November 2014

The Manufacturers' Organisation

EXECUTIVE SUMMARY

Much of the public debate over whether the UK should exploit its shale gas reserves has been highly polarised. Many opponents are set against shale gas extraction under any circumstances while some supporters are in danger of overstating the potential benefits.

The real situation is less dramatic. There are risks and justifiable reasons for concern, but these can and are being addressed by the industry and regulators. The manufacturing boom in the US, much of which still has to be realised, will not be repeated in the UK, but domestic shale gas extraction is still likely to help the wider UK economy, energy security and bring opportunities to the manufacturing sector. The government needs to help ensure this potential is fully realised.

The continued need for gas

Even with rapid expansion of renewable energy technologies and improvements in energy efficiency, demand for back-up electricity generation and difficulties with decarbonising heat mean the UK is likely to still be using natural gas at broadly comparable rates to today in 2030. It is not a question of whether we need gas but rather where are we to source it from.

North Sea output is declining, creating an increasing shortfall against demand which must be met by alternative sources. A domestic supply of shale gas could help limit our import requirements and strengthen our resilience against supply disruptions and accompanying price spikes.

If 10% of the shale gas the British Geological Survey believes can be found in Northern England's Bowland Basin is extracted, that alone would meet 40 years of UK demand at current consumption rates (although in reality extraction rates will be too low to ever meet more than a proportion of annual demand).

Energy Prices

Whilst there has been much talk of replications of the energy price reductions seen in the US, it should be said that these claims are unfounded. The case for UK shale gas extraction should not be made on the grounds of reduced UK energy prices.

Energy prices have dropped so dramatically in the US because of a glut of gas coupled with a current lack of export opportunities. The UK will not be in the same situation. Indeed, the numerous factors impacting on UK and EU gas prices make it very difficult to estimate what the net impact of UK shale gas extraction will be on prices here. What we can say is that it should help to reduce future gas price increases and diminish the gap between EU and US prices. This should help to improve the investment outlook for energy intensive industries (EII) here in the UK.

Opportunities for manufacturers

In the US, one of the biggest winners from the shale gas boom has been the chemicals industry which has capitalised on the natural gas liquids (NGLs) often found alongside methane in shale gas deposits.

With poorer projected earnings from natural gas itself, US producers are beginning to actively select deposits with NGLs, and processors are expanding their capacity to such an extent that petrochemical powerhouses like Saudi Arabia are seeing their positions threatened. Continued growth in this market threatens the EU chemicals industry, especially where it is set up to use alternative feedstocks. A UK supply of NGLs could help counter the trend.

There should also be opportunities for UK-based manufacturers to supply an emerging shale gas industry, and potentially position themselves to export equipment globally. Estimates of the total number of jobs UK extraction could bring are still uncertain but stretch up to 74,000[1] during peak production in the mid-2020s.

A report from EY for the onshore oil and gas industry suggests a total estimated spend of £33bn by 2032 to bring UK shale wells into production, including £17bn on specialised equipment, such as high pressure pumps and mixers, and £2.3bn on steel casing.[2]

There must be a coordinated approach from industry and the government to build the business case for the development of a UK shale gas industry supply chain. A repeat of the UK's offshore wind experience, where we are the number one market in the world but still lack any significant supply chain, must not be repeated.

What about the risks?

The main concerns currently associated with shale gas extraction and use are its greenhouse gas emissions, potential to cause seismic events, the volume of water used, and possible pollution of groundwater, surface water and land. These, and fears about local disturbance, have resulted in considerable public opposition which threatens to limit even the most well-managed and justifiable UK operations.

With the UK heavily dependent on natural gas for some considerable time, concerns related to increased GHG emissions should be limited to the net impact on global emissions of exploiting UK shale gas as compared to a scenario in which the UK consumes increasingly large quantities of imported gas. The vast range of factors involved, including volumes extracted, global gas prices, consumption patterns elsewhere and government energy policy in various countries, make it impossible at this stage to estimate the net impact on gas consumption globally. However, if

[1] IOD (2013) Getting shale gas working. The 74,000 figure represents the most optimistic of the scenarios considered.
[2] EY (2014) Getting ready for UK shale gas

shale gas, alongside that from conventional sources, can start to offset and reduce coal consumption it can provide us with an invaluable tool to reduce global emissions.

There are valid concerns relating to the lifecycle emissions of shale gas compared to gas from conventional sources, but a combination of the correct regulatory framework to minimise fugitive emissions, related to production, and a cap on UK emissions, as set by the UK's Climate Change Act, can mean extraction and consumption of domestic shale gas should not result in any net increase in domestic emissions.

Although fracturing has already caused tremors in the north of England, any events of this nature are expected to be small – even smaller than those that occur naturally in the UK and of a lower magnitude than those caused by coal mining.

Experts also state there is very little likelihood of gas and fracturing fluids escaping directly into groundwater as deposits are so much deeper than groundwater reserves, and controls are in place to protect against leaking well casings and surface spills. Shale gas producers would not be awarded water extraction licences in water stressed areas and can coordinate activity closely with water companies to avoid operations during the most sensitive periods.

Making a positive case

However, none of these reassurances count for anything if the general public and people living near potential shale gas operations are not persuaded. Some sweeteners are being offered to local communities but so far they have been viewed with a measure of cynicism. The government and onshore oil and gas industry need to do more to make a positive case for extraction in terms of safeguards in place, the benefits it can bring to the UK as well as of the practical implications of deciding not to develop these resources.

Simplifying the regulatory landscape

The UK's nascent shale industry is also worried about the number of regulators and separate legislative hoops that have to be negotiated before it can begin operations. There needs to be some attempt to streamline the system but in a manner that does not weaken the ability of regulations to provide the necessary safeguards.

Our recommendations

- The government must work with the onshore oil and gas industry to ensure the supply chain opportunities highlighted in the EY report are realised.

- This must include the devel0pment of a business case for investment in manufacturing capacity for a UK based supply chain.
- Politicians that back shale gas extraction need to be more honest and vocal about its potential benefits. There is currently a vacuum being filled by mistruths and overstatements from both sides.
- The government needs to take a more prominent role in addressing local communities' concerns.
- Public confidence could be boosted by moving industry guidelines and best practice into regulation.
- The regulatory framework for gaining access for exploration and production needs to be streamlined, simplified and brought together under a single body without weakening its impact on regulating the industry.

INTRODUCTION

The debate surrounding the exploitation of the UK's domestic onshore gas has been unnecessarily polarised; clouded by hyperbole, exaggerated claims and misleading information from many quarters, the debate has reached a stalemate situation in which progress in developing a UK industry is being made painfully, slowly and often against public opinion. If the UK is to develop a viable and sustainable industry, and access the benefits that accompany it, this situation cannot continue.

Neither onshore oil and gas operations nor hydraulic fracturing are new to the UK; onshore operations have existed in the UK since the latter half of the 19th century and to date there have been some 2,000 wells drilled with around 200 of them having been hydraulically fractured.[3] This activity has received very little public attention and the debate has arisen in recent years primarily as a result of widespread use of 'high volume hydraulic fracturing' in the US, the environmental and public health issues that have arisen with it, and fears of a like for like replication in the UK. It is therefore perhaps better to view opponents to hydraulic fracturing more specifically as opponents to the widespread use of high volume hydraulic fracturing.

Understandably, as the level of fracturing activity increases so does the opportunity for detrimental impacts and this is largely where the bulk of opposition comes from in the UK. This is crucial starting point for winning over public opinion and both government and industry must use the significant positive experience of onshore extraction and fracturing in the UK to show that a larger industry can be progressively developed here without damage to the environment, risking public health or causing major local disruption.

There are increasingly more balanced voices coming through in the debate, but the headline, and publically visible, terms of the debate are still largely seen as a replication of US energy price reductions and a manufacturing boom on the one hand and portrayals of exploration companies degrading the environment for economic gain on other. The

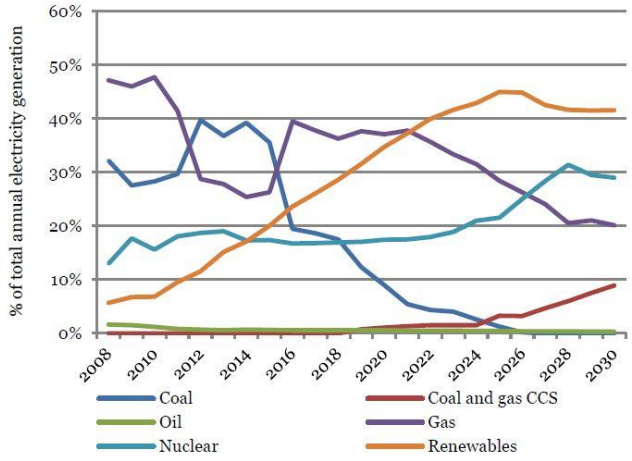
[3] UK Onshore Operators Group (2013) The History of Onshore Oil and Gas

reality is far less stalk than this, and whilst some opponents will never be convinced, public opinion of shale gas extraction can be vastly improved by a reasoned presentation of the facts. The risks related to hydraulic fracturing can be guarded against with a rigorous regulatory framework and this must be communicated far more effectively. At the same time, we are not about to witness a shale induced bonanza and claims of such only serve to increase public distrust.

THE BENEFITS OF UK SHALE GAS

There is no escaping the fact that natural gas will continue to be a major part of the UK's energy mix for the foreseeable future. Central projections from the Department of Energy & Climate Change (DECC)[4] suggest that gas power stations will still be generating some 20% of our electricity in 2030, whilst power stations equipped with carbon capture and storage (CCS) are expected to be contributing increasing amounts. The continued requirement for gas power plants over the next decade arises both from the sheer scale of the challenge of completely decarbonising our electricity supply by 2030 as well as the vital need to provide flexible back up generation, for when the sun doesn't shine and the wind doesn't blow and renewables aren't able to meet demand. Until energy storage technology vastly improves, gas is the only suitable solution to this intermittency challenge. Our reliance on natural gas for electricity generation will lessen, and ultimately may disappear completely, but in the short to medium term we cannot do without it.

Chart 1: Actual and projected electricity generation by source – 2008 to 2030



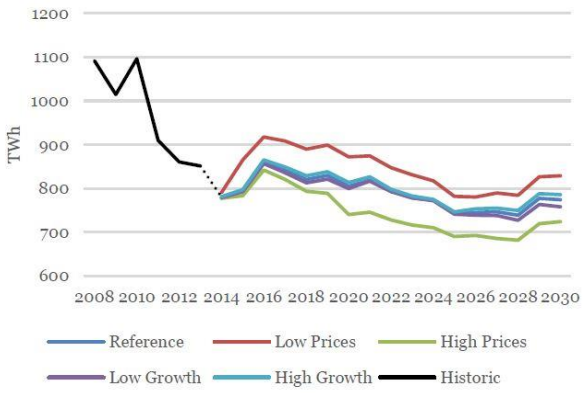
Source: Reference scenario in DECC (2014) *Updated Energy and Emissions Projections*

[4] DECC (2014) Updated Energy and Emissions Projections: Reference Scenario.

Even if the UK managed to completely decarbonise its electricity supply by 2030 we would still be heavily reliant on natural gas for heating purposes; we are a long way from the widespread use of electricity and renewables for heating, and the additional electricity demand required by this switch would make grid decarbonisation even more challenging. Around 80% of the UK's heat demand is currently met by natural gas and, with relatively limited alternative options in the short to medium term, we can expect total final gas use (i.e. excluding that used for electricity generation) to only reduce by 16% between now and 2030 (484 TWh down from 578 TWh in 2013)[5].

Continued heavy reliance on natural gas for heating and electricity generation coupled with increasing heat and electricity demand naturally point to a growing overall use of gas in the UK. All DECC's projection scenarios point to markedly less consumption than in the 2000s, but still a broadly comparable to today.

Chart 2: Actual and projected UK primary gas consumption

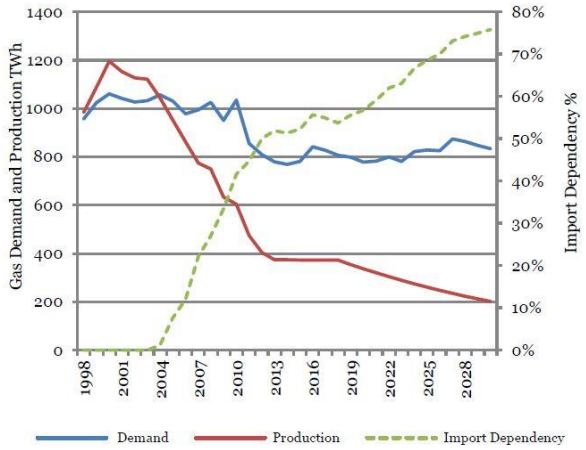


Source: DECC (2014) *Updated Energy and Emissions Projections*

However, this continued reliance on natural gas contrasts sharply with declining levels of North Sea production. By 2030, the UK is projected to move from being a net exporter to almost 80% reliant on imports.

[5] Ibid.

Chart 3: UK actual and projected gas consumption and production



Source: DECC (2014) *UK Continental Shelf Oil and Gas Production Projections*

National Grid has developed a range of projections[6] of future UK gas consumption and corresponding sourcing implications. With UK offshore gas production falling significantly in all scenarios, the increasing shortfall will come from a range of import sources (Norway, LNG, continental pipeline) as well as UK shale. While ambitious climate targets and renewable energy deployment reduce gas consumption and import dependency, the most important determinate of import requirements in relative and absolute terms is shale gas production.

Table 1: UK gas supply patterns 2030 (billion cubic metres/year)[7]

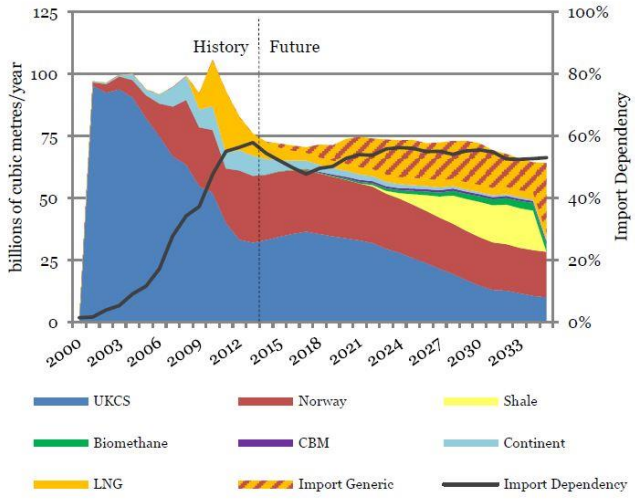
	National Grid Scenarios[7]			
	Gone Green	Slow Progression	No Progression	Low Carbon Life
UK Offshore	15	11	9	18
Norway	19	24	27	15
Shale	14	6	0	32
Biomethane	2	1	0	2
Coal bed methane	1	1	1	1
Continent	1	1	3	1
LNG	3	3	5	3
Import Generic	17	19	33	7
Demand	72	65	77	77
Import Dependency	55%	71%	87%	33%

Source: National Grid (2014) *UK Future Energy Scenarios*

[6] National Grid (2014) UK Future Energy Scenarios
[7] For description of scenarios see National Grid (2014) UK Future Energy Scenarios p. 5

National Grid's most optimistic scenario in terms of climate targets, renewable energy deployment and economic recovery still relies significantly on imports and shale gas production to make up for falling domestic conventional sources. Lower shale gas output would simply mean an increased reliance on imports.

Chart 4: Source of UK natural gas supply: actual and projected



Source: National Grid (2014) *UK Future Energy Scenarios, 'Gone* Green' scenario

The British Geological Survey estimates that the Bowland Basin in Northern England could hold around 1,329 trillion cubic feet (tcf) of gas[8]: if 10% of this is recoverable it would represent 40 years of UK supply at current consumption rates. But it is important to note that imports would still provide the majority of supply as annual extraction levels would be well below annual UK consumption rates.[9]

In spite of the significant unknowns surrounding how large a role shale gas could play in the UK's future energy mix, we can have confidence its production would help reduce future dependence on LNG and continental imports. The extent to which this will minimise the UK's exposure to shortages and price spikes will be heavily dependent on a wide range of issues beyond the rate of production of shale gas; most obviously gas production and consumption elsewhere, other states' domestic energy policy (for example Germany's phase out of nuclear power or Japan's gradual return to nuclear power), provision of gas storage and of course geopolitical developments. But if shale gas

[8] Central estimate from British Geological Survey/DECC (2013) The Carboniferous Bowland Shale gas study: geology and resource estimation

[9] According to the Institute of Directors 2013 report Getting shale gas working, peak production could reach 1tcf compared to an average UK consumption of 3 tcf.

can be recovered at a commercially viable rate in the UK it will have an important role to play in reducing import reliance and exposure to price volatility.

Energy prices and energy-intensive industry

Expectations that the UK will see the kind of energy price depression experienced in the US as a result of shale gas are largely unfounded. US gas prices have fallen dramatically since 2008 primarily due to a surge in US domestic production coupled with a lack of export capacity. The UK will not produce enough gas to create a surplus and, even if it could, there would not be price reductions due to the interconnection with the European market. It makes little sense to try and assess the impacts of domestic shale gas production on UK gas prices, or their level relative to prices elsewhere, in isolation. There are a vast range of other factors that could prove more significant.

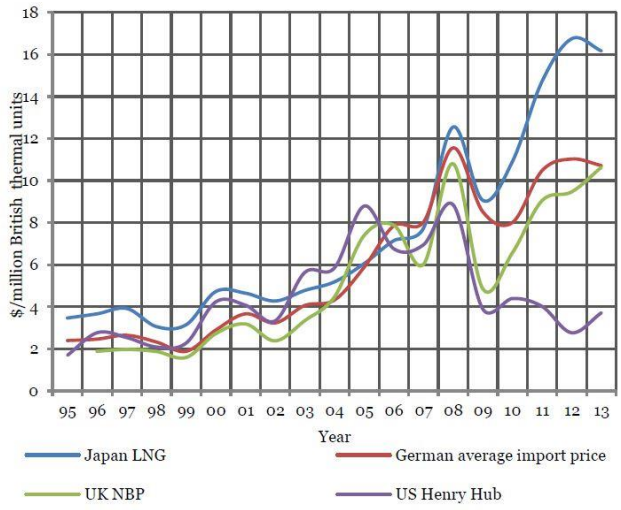
First, gas markets are gradually becoming more global; currently around 30% of global gas supply is traded internationally, either through pipelines or LNG, and this is growing at around 6.5% a year.[10] As this trend continues we can expect some convergence of gas prices and pricing structures and also a likely increase in gas-to-gas pricing[11] (as currently operates in the UK and US) as opposed to the dominant gas-to-oil pricing found in most regions.

Second, the quantity of LNG available and traded in the international market is projected to increase significantly as a result of US shale gas production and developments elsewhere, exerting a downward impact on global prices. US shale gas production is already arguably having an impact on global prices because it has dramatically cut US demand for LNG imports.

This does not mean that Europe will start to feel the direct effects of the gas price discount available in the US (i.e the depression of prices caused by shale gas production): the cost of transportation and liquefaction will ensure that gas arrives here at similar prices to those already seen and, until US LNG production ramps up significantly, the primary market will be Asia where prices are currently 50-60% higher than in Europe. As the US starts to export we may see small prices increases in the US as surplus is reduced. This could help reduce the current price differential between Europe and the US, but a significant gap will remain due to transport costs.

[10] Navigant (2013) Unconventional Gas: The potential impact of UK gas prices
[11] In gas-to-gas pricing, gas prices within long-term contracts is linked to the wholesale price of gas traded on hubs. With gas-to-oil pricing, pricing within long-terms contracts is linked to oil prices.

Chart 5: Comparison of regional gas prices



Source: BP (2014) *Statistical Review of World Energy*

Indeed, as LNG and pipeline gas trades increase, transport costs will become an increasingly important factor in regional price variations. Depending on the transportation method, the distance travelled and the regional pricing mechanism, the cost of transportation can be over half of the final gas price. US LNG company Cheniere's transport costs make up 50% of its European price and 60% of its Asian price[12].

As mentioned above, the domestic energy policy of other states will naturally also have a significant impact on the availability, and therefore the price, of gas globally. For example, Germany's closure of its nuclear power stations could increase demand for gas if a rising carbon price starts to make it competitive with coal again. Conversely, as Japan starts up its nuclear fleet again its imports of LNG will fall substantially. China's exploitation of its own shale gas reserves could be a major game changer too. Beyond this, increasing geopolitical uncertainty, not least in relation to supplies from Gazprom, will have a major impact on availability and price.

Given the vast range of factors affecting prices and the uncertainty surrounding them it is difficult, and largely futile, to attempt to make any grand conclusions about the impact of UK shale gas production on prices. All we can say with any sense of certainty is that it has the potential to increase availability and reliability of supply and to reduce the UK's exposure to imports and the transport costs and uncertainty that accompany them. It should also help limit any future widening of the gap in prices between the UK and US.

Subsequently, current assessments of the knock-on effect for energy-intensive industry remain largely conjecture. What we can be fairly certain of is that the US experience will not be replicated here but it is also important to note that

[12] Navigant (2013) Unconventional Gas: The potential impact of UK gas prices

so far much of the shale-induced boost to US manufacturing is anticipated rather than already in motion. As such, an element of caution should be taken even when talking about the US experience. PWC[13] estimated that over the long term, lower energy prices in the US could lead to one million additional manufacturing jobs up to 2025 and two million by 2035 and reduce energy costs for manufacturers by up to $11.6 billion a year. But this scenario is far from certain. To date the industrial boost emanating from lower energy prices has been largely limited to gas-intensive sectors (particularly those using gas as a feedstock: see below) which have seen net exports increase from $10.5bn in 2006 to $27.5bn in 2012. Whilst representing a significant boost for these sectors, it should be considered in the light of an overall US manufacturing trade deficit that grew from $662.2bn to $779.4bn over the same period; shale has provided a boost for some sectors but certainly not all.[14]

It is clear the case for exploiting the UK's shale gas reserves cannot rest on visions of a UK manufacturing renaissance; this is not going to be the reality. The most that can be expected is that it might help maintain investment levels for gas-intensive, and possibly electro-intensive, sectors. Putting the right policies in place to develop a UK shale gas industry will send a positive signal to those energy-intensive companies considering their long-term presence in the UK.

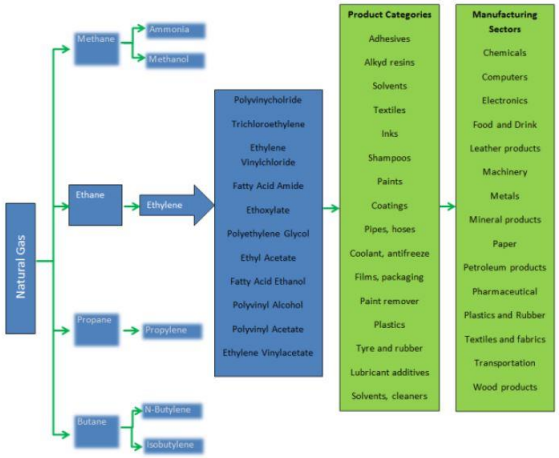
Natural gas as a feedstock

Notwithstanding the need to avoid exaggerated claims of a shale-induced manufacturing boom, the US chemicals industry has clearly benefitted enormously from shale gas production. In addition to energy, natural gas provides us with valuable feedstocks for petrochemical and fertiliser production. Natural gas can be described as either dry, which is almost entirely methane, or wet, where the methane is accompanied by what are known as 'natural gas liquids' (NGLs).

NGLs can be processed into the petrochemicals that form the building blocks of the entire chemical industry and also provide the raw materials for multiple manufacturing sectors. Petrochemical sales account for 25% of total EU chemical sales but underpin a value chain representing over 80% of the total EU chemicals industry.[15] Ethane is the most prolifically utilised NGL in the industry and has a vast range of applications.

[13] PWC (2011) Shale Gas – A renaissance in US Manufacturing
[14] IDDRI (2014) Unconventional wisdom: an economic analysis of US shale gas and implications for the EU
[15] European Chemical Industry Council (2013) The implications of the shale gas revolution for the European chemical industry

Figure 1: Shale Gas through the ethane chain into manufactured products



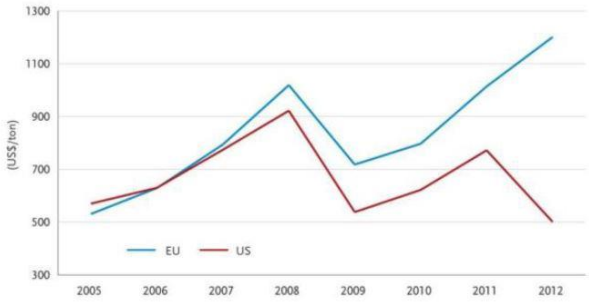
Source: PWC (2012) *Shale Gas: Reshaping the US chemicals industry*

Shale gas production in the US has seen feedstock costs reduce sharply. As US natural gas prices continue to remain extremely low, production companies are increasingly interested in reserves where they can extract NGLs in addition to gas and offset the loss in revenue resulting from low gas prices. NGL production from US separation plants is expected to increase by 40% between 2012 and 2016.[16]

The sharp reduction in NGL prices has so far given US chemical manufacturers a major competitive advantage over their competitors in the EU and Asia. Most ethane made in the EU is produced from naptha, a refined form of crude oil that is significantly more expensive than US shale gas ethane. With ethylene-based materials used in so many manufacturing sectors it is feasible this could also have a knock-on impact on wider manufacturing costs and innovation strategies.

[16] PWC (2012) Shale Gas: Reshaping the US chemicals industry

Chart 6: Average ethane costs in the EU and US



Source: European Chemicals Industry Council (2013) *The implications of the shale gas revolution for the European chemicals industry*

US ethane price reductions have been so drastic that even petrochemical powerhouses such as Saudi Arabia are seeing their competitive advantage threatened.[17] The shale revolution has led to 7-10 million tonnes of additional petrochemicals production capacity being built in the US which is due to come on-stream in the next few years. Levels of production in the US will vastly outstrip domestic demand resulting in an increase in exports which poses a significant threat to European production and could ultimately result in the closure of facilities.[18]

Development of UK shale gas resources has the potential to counteract this impact; not only could it provide UK and EU production facilities with access to ethane but it would also develop the business case for continued investment here.

The manufacturing supply chain & job creation

There have been several estimates of the number of jobs that could be expected from the development of a UK shale industry ranging from 16,000[19] to as many as 74,00020[20] direct, indirect and induced jobs during peak production in the mid-2020s. The variation in these estimates is a reflection of differing assumptions about the number of wells associated with each shale gas pad and which elements of the supply chain are included.

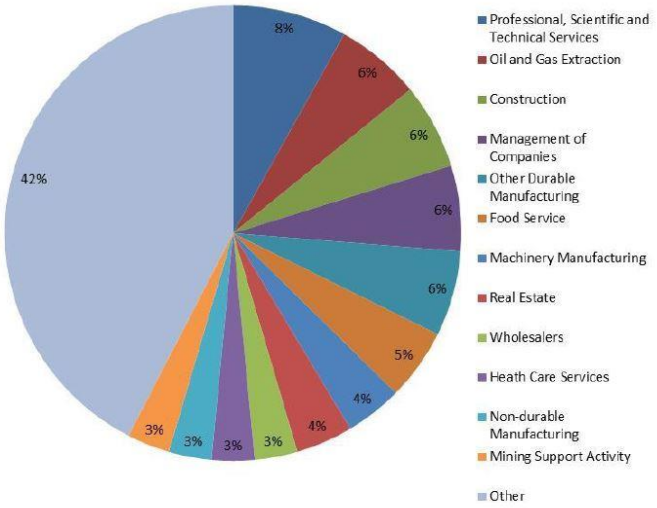
[17] Ibid
[18] European Chemicals Industry Council (2013) The implications of the shale gas revolution for the European chemicals industry
[19] AMEC (2013) Strategic Environmental Assessment for Further Onshore Oil and Gas Licencing
[20] IOD (2013) Getting shale gas working. The 74,000 figure represents the most optimistic of the scenarios considered.

- There is little detail in the reports published so far on where in the supply chain these jobs might appear. An EY report[21] commissioned by UK Oil and Gas (UKOOG), which represents operators, provides a low-level breakdown with the following figures:
- Total estimated spend of £33bn to bring UK shale wells into production between 2016 and 2032. 6,092 direct jobs, 39,405 indirect supply chain jobs and 19,036 induced jobs. Manufacturing jobs would fall under "indirect jobs".
- An estimated £17bn could be spent on specialised equipment (pumps, trucks and blenders) and personnel. The majority of pumps are currently manufactured outside the UK with some assembly done here. There is significant potential to increase UK production of these but building an investment case will require coordination from government and industry.
- Silica sand for fracking will come from existing quarries and could represent a £2bn spend in the UK over 2016-2032.
- The low volume of chemicals required for shale gas operations means there is unlikely to be a reasonable investment case for building production capabilities in the UK.
- £2.3bn of steel casing would be required for wells; product development is being considered by UK-based steel manufacturers. Manufacturing activity in the UK is likely to be limited to finishing of product as the necessary production facilities no longer exist in the UK but significant overcapacity exists elsewhere.
- The UK supply chain is currently ill-equipped for the manufacture of drilling rig components and the level of investment required to deliver these may not provide for a strong investment case. The greater potential is believed to lie in upgrading rig components to UK standards and through the provision of ancillary equipment. This market could be worth £1.2bn.
- £819m market for cement, which would come from the UK's four cement manufacturers.

Whilst a number of key differences exist between the US and UK experience, particularly in the size and maturity of relevant sections of the supply chain, the breakdown of jobs created by the US shale gas industry provides us with some idea of what the UK experience may look like in terms of sector job share.

[21] EY (2014) Getting ready for UK shale gas: supply chain and skills requirements and opportunities

Chart 7: Job creation by sector resulting from US shale gas production, 2012



Source: IHS (2012) *America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy*

We could not expect to see the same level of job creation in gas-intensive sectors or wider manufacturing in the UK because we do not expect to see major energy price reductions. Creation of manufacturing jobs here would be largely limited to those directly or indirectly linked to the shale gas industry and possibly the petrochemicals sector. In order to bring jobs and investment to the UK it is vital that a strong business case is developed and fostered by the onshore oil and gas industry and the government; we must avoid a repetition of an 'offshore wind scenario' in which manufacturing occurs largely outside the UK.

Longer term thinking should also look towards the potential for the UK to export expertise and equipment to supply a possible global shale industry. Developing our own domestic resources, a skills base and a strong business case for investment in manufacturing capabilities is of the utmost importance if we are to seize this opportunity.

Key recommendations from the EY/UKOOG report that will help develop a UK manufacturing base to supply the shale gas industry are as follows:

- UKOOG working with the supply chain to gain a common understanding of requirements, identifying in particular R&D needs.
- Expanding the Fabricators' Directory[22] to include detailed specifications of components required for onshore shale development and promote UK suppliers domestically and abroad.

[22] Oil and Gas UK (2014) The UK Offshore Oil and Gas Fabricators Directory

- Capitalising on existing government schemes such as the Manufacturing Advisory Service to raise awareness of the supply chain opportunities for existing businesses.
- The government, UKOOG and supply chain firms working together to build an investment case for development of UK-based capabilities, including recommendations on bridging finance options to allow the supply chain to invest early enough to deliver on time.
- Innovate UK to identify where there are opportunities to develop and deploy new technologies and align support through its innovation programme.[23]
- For the government to review existing early-stage financing options, including inward investment.[24]

BARRIERS TO UK SHALE DEVELOPMENT

Public Opinion

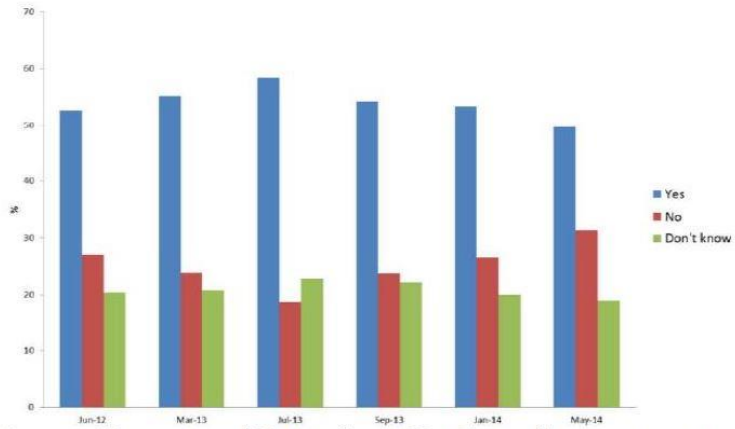
Local and wider public opposition is quite possibly the greatest barrier to the development of a UK shale gas industry. Both the government and industry have a key role in addressing this.

Broad public opinion on shale gas is far from clear cut and a sizeable minority of the public has not even heard of it. DECC's public awareness tracker, published in August 2014, showed 74% of people were to some degree aware of hydraulic fracturing for shale gas, compared to 52% in a similar February 2014 survey. The August survey found 24% of people supported shale gas extraction with 24% opposing it and 47% taking a neutral stance. Regular polls by YouGov and the University of Nottingham show higher levels of support with 50% in favour of shale extraction in their most recent May 2014 survey.

[23] Innovate UK has allocated £2m to feasibility studies looking at 'developing technologies for safe and responsible exploitation of shale gas' - https://www.innovateuk.org/-/developing-technologies-for-safe-and-responsible-exploitation-of-shale-gas

[24] For further information on EY & UKOOG recommendations for development of a UK shale gas supply chain see section 4.2 of the report available here - http://www.ey.com/UK/en/Industries/Oil---Gas/EY-getting-ready-for-shale-gas

Chart 8: Should shale gas extraction in the UK be allowed?



Source: University of Nottingham/YouGov polls 2012 to 2014

The YouGov/University of Nottingham surveys also show how particular beliefs and concerns wax and wane. In September 2014 some 49% of those questioned associated shale gas with earth tremors, down from a peak of 72% in the May 2012 poll, which followed the publication of a report linking tremors in the Blackpool area to hydraulic fracturing by Cuadrilla Resources.

The level of people associating shale gas extraction with water contamination has stayed more stable at around 45% of respondents. The September 2014 survey[25] showed little difference to earlier versions in the percentage of the public viewing (28%) or not viewing shale gas (45%) as a clean source of energy, and the notion that shale gas will be cheap source of energy continues to be a commonly held belief with 50% holding this view and 27% not.

Not surprisingly support for shale gas extraction reduces significantly when posed as a question relating to people's own 'backyards'.[26] Both industry and the government have made moves to win over public opinion. UKOOG announced a 'community benefit mechanism' last year, whereby 1% of revenue from wells would be given to local communities and the government has confirmed that business rates from production activities will remain with local authorities. However, there remains a strong element of scepticism about these initiatives[27] and more needs to be done.

Climate change concerns

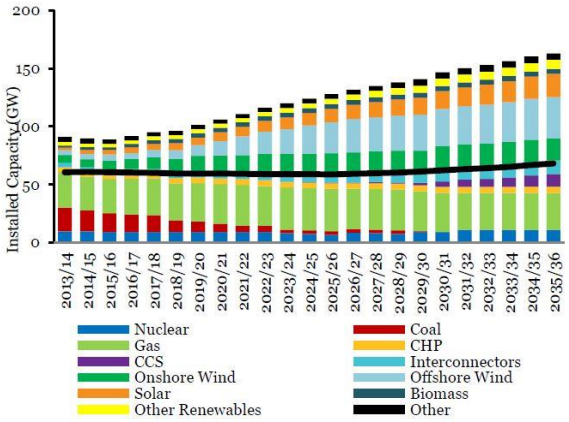
[25] University of Nottingham (September 2014) Public Perceptions of Shale Gas in the UK
[26] YouGov/Sunday Times survey August 2013
[27] A University of Nottingham/YouGov survey in January 2014 showed 57% of respondents viewed the compensation as a means to get local communities on side.

Environmental groups are also strongly opposed to UK shale gas production, principally on the grounds that extraction of more fossil fuels is at odds with UK climate change goals. Their concerns is that exploiting UK shale gas reserves will establish infrastructure and a strong financial incentive that will ensure we are reliant on natural gas well into the future. Instead, they argue, resources should be directed towards renewable energy.

This view largely ignores the fact that, as noted above, the UK will be heavily reliant on natural gas for the foreseeable future. This is completely independent of whether the UK develops its own shale gas industry. There is also a realistic limit to how much renewable capacity we can install in a given time period, especially for heat provision, and gas-fired power plants will still be needed to even out variable renewable energy generation. The types and levels of renewables needed to significantly reduce levels of back-up gas generation are not yet practical or affordable.

As indicated by National Grid's 'Gone Green' scenario, even with optimistic assumptions about climate targets, economic growth and renewables deployment, the level of gas generation required will remain largely unchanged between now and 2035.

Chart 9: Projected UK electricity demand, and sources of supply, 2013/14 to 2035/36



Source: National Grid (2014) *Future Energy Scenarios* - 'Gone Green' scenario

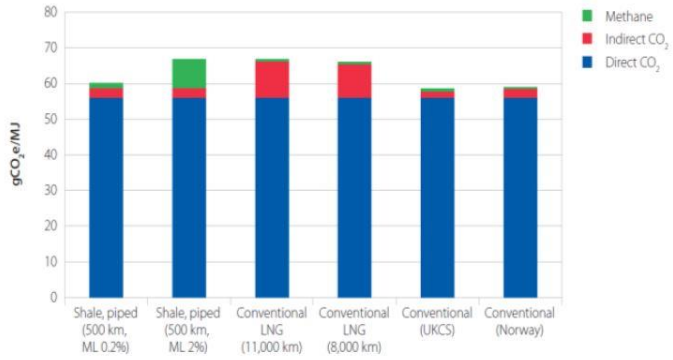
Given the only additional infrastructure the UK will require to develop a domestic shale gas industry will be that directly required for its extraction, it is a stretch to say shale gas will lock the UK into reliance on natural gas.

In addition, Professor Dieter Helm, in giving evidence to the House of Lords Economic Affairs Committee[28], noted that lock-in is less of a problem for gas: "the difference between gas stations, coal stations, nuclear stations… is that gas stations are very cheap to build relative to other technologies and they can be built very quickly. Therefore they can be depreciated very fast, so you get your economic return back pretty early on in your cycle."

Given the UK will still require large quantities of natural gas, the question is which is the best source of that gas. Would shale gas produced in the UK have a higher carbon footprint than the gas imports it displaces? The 2013 report Reducing the UK's carbon footprint from the Committee on Climate Change (CCC) gave a range of estimates for the carbon footprint of gas from different sources. The key variables are the methane released during fracking, the energy used to liquefy and transport LNG, and the escape of methane during pipeline transportation.

The CCC concluded that provided fracking operations are well regulated to minimise methane release, the carbon footprint of shale gas would compare favourably with conventional gas from the UK or Norway. More importantly, given UK shale gas would displace imports from further afield, it could have a noticeably lower carbon footprint than either LNG or non-European pipeline gas.

Chart 10: Total lifecycle carbon intensity of natural gas from different sources (CO2 equivalent per megajoule)[29]



Source: Committee on Climate Change (2013) *Reducing the UK's carbon footprint* [29]

A 2013 report for DECC[30] had much the same findings, concluding that methane emitted during shale gas's

[28] Select Committee on Economic Affairs: The Economic Impact on UK Energy Policy of Shale Gas and Oil, Oral and Written Evidence, evidence session nine, 19th November 2013.
[29] CCC analysis based on estimates developed by Ricardo AEA
[30] Professor David Mackay and Dr Timothy Stone for DECC (2013) Potential Greenhouse Gas Emissions Associated with Shale Gas Extraction and Use

What about the risks?

extraction should only represent a small proportion of its total carbon footprint, which will be dominated by carbon dioxide released during combustion, and that the total footprint is comparable to that of gas from conventional sources.

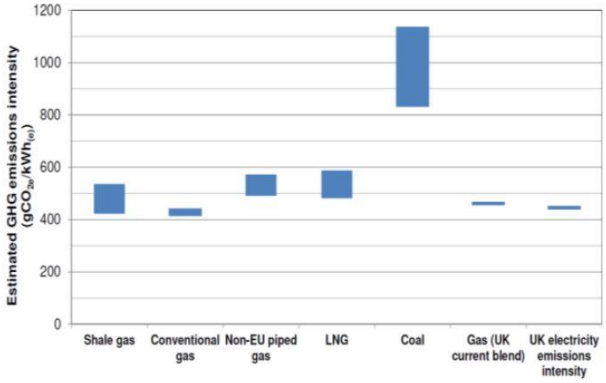
It also noted that any emissions from shale gas extraction would fall within the non-traded section of the UK's carbon budgets. If the carbon budgets impose a binding constraint, any increase this generates would have to be offset by emissions cuts elsewhere in the economy.

The report recommended shale gas producers should adopt the principle of reducing emissions to "as low a level as reasonably practicable". In particular, "reduced emissions completions" or "green completions"[31] should be adopted at all stages following exploration. It also suggested the government should require producers to closely document greenhouse gas emissions from all aspects of exploration, pre-production and production at least until a particular technique is well understood and documented within the UK context. Thereafter operators should continue to monitor their sites to ensure there is early warning of any unexpected leakages and obtain emissions estimates for regulators and the government. In its response to the report, the government fully accepted these recommendations, noting that it was committed to green completions and would seek to build on existing regulations to minimise waste gas.[32]

The Environment Agency published a detailed report in July 2014 on monitoring methane releases from shale gas operations.[33] This will be used to develop system of controls for the industry.

Chart 11: Lifecycle emissions for electricity generation from various sources

[31] Green completions are techniques and technologies employed to minimise emissions of gases to air. For further information see UKOOG (2013) Guidelines covering best practice for shale well operations in the UK
[32] DECC (2014) The Government's response to the Mackay-Stone report
[33] Environment Agency (2014) Considerations for quantifying fugitive methane releases from shale gas operations



Source: DECC (2013) *Potential GHG emissions associated with shale gas extraction and use*

It is reasonable to conclude that the extraction and use of UK shale gas would not have any meaningful impact on total national greenhouse gas (GHG) emissions. A question of more importance, but of considerable greater complexity, would be whether or not the exploitation of these resources would have any impact on global emissions. Given the vast range of unknowns in global energy production, consumption, markets and government policy it is almost impossible to know whether UK shale production would lead to a net increase in global GHGs (for example by increasing the total volume of gas burnt without an equivalent reduction in coal) or a net decrease (for example by reducing the amount of coal burnt globally or reducing overall need for LNG).

It could be argued that because of continued growth in global energy demand any additional fossil fuels produced will be used in addition to existing resources rather than instead of them.[34] Similarly, in the absence of a global commitment to cap greenhouse gas emissions, any move to cut fossil fuel consumption in the UK could arguably lower global prices and incentivise their use elsewhere. The answer to these challenges is not to abandon the prospect of an additional source of domestic gas but to continue to push for a global climate agreement and use all the tools at our disposal to reduce emissions at home.

Local environmental concerns

Beyond these climate-related concerns, there remain a number of more local environmental issues that must be discussed and addressed in any honest debate about the potential of UK shale gas. These are: seismic activity; groundwater contamination; pollution of land and surface water; water consumption; and wastewater treatment/disposal.

[34] Tyndall Centre for Climate Change Research (2011) Shale gas: a provisional assessment of climate change and environmental impacts p54

Seismic activity

As noted above, this is a significant public concern and needs to be addressed. However, tremors associated with fracking are expected to be very small.

The well-documented 2011 seismic events caused by Cuadrilla Resources' fracking at Preese Hall registered only 2.3ML[35] and 1.5ML on the Richter scale.[36] Cuadrilla and DECC commissioned reports to identify the probable cause with both concluding it was likely to be the flow of fracturing fluid into a nearby pre-stressed fault which subsequently slipped and released its energy.

To place this in context, the UK's largest naturally occurring seismic activity measures 5ML or less, resulting in little or no surface damage and occurring perhaps once every twenty years.[37] The UK also experiences seismic events from coal mining which tend to be less than 1ML. The conclusions of the joint Royal Society (RS) and Royal Academy of Engineering (RAEng) 2012 report on the risks associated with shale gas extraction noted that: "Seismicity induced by hydraulic fracturing is likely to be of an even smaller magnitude. There is an emerging consensus that the magnitude of seismicity induced by hydraulic fracturing would be no greater than 3ML (felt by few people and resulting in negligible, if any, surface impacts)."[38]

DECC's 2014 briefing on the subject[39] says:

- There is no documented evidence of hydraulic fracturing leading to surface damage or subsidence, unlike mining which requires the removal of large quantities of rock and can lead to subsidence.
- Subsidence can occur when rock is compressed but shale rock is very difficult to compress making this unlikely.
- After a decade of intensive fracking in the US there is no evidence that ongoing activity increases the likelihood of earthquakes.

Following expert advice from a range of sources, DECC has now established a system of additional controls, including requirements to assess seismic risk before beginning fracking and the submission of a plan to DECC showing how any risks will be addressed, regular onsite monitoring, and the creation of a traffic light system to categorise risk levels and

[35] Local (Richter) magnitude
[36] The Royal Society and the Royal Academy of Engineering (2012) Shale gas extraction in the UK: a review of hydraulic fracturing p41
[37] Ibid p40
[38] Ibid p4
[39] DECC (2014) Fracking UK Shale: understanding earthquake risk

set out necessary responses, including halting operations.

Groundwater contamination

Perhaps the most widely voiced and most publicised concern is that gas and fracturing fluid will travel up through fractures and contaminate groundwater. The RS & RAEng report concluded, on the basis of evidence from the US, that the likelihood of this occurring is extremely slim. Shale gas deposits are hundreds of meters below ground, significantly deeper then groundwater reserves, and the properties of shale formations limit the extent to which fractures, and therefore gas and fluid, can extend.

To mitigate any risks, the RS & RAEng report recommended the establishment of national baseline surveys for groundwater contaminants, site-specific monitoring, monitoring of abandoned wells and data publication. All recommendations have been accepted by the government and are being implemented.

Shale gas wells are lined with steel casing which is then cemented in place but experience from the US has shown groundwater can also be contaminated by poorly constructed wells. Again the RS & RAEng report made a comprehensive list of recommendations which have been accepted by the government. Indeed, many are already required under existing oil and gas regulations[40] and are further enhanced by guidelines from UKOOG.[41]

With specific regard to contamination from fracking fluid, it is important to note that the only fracking fluid that has been used in UK operations, and has approval from the Environment Agency, is over 99.9% water and sand. The chemicals that make up the other 0.1% are published on Cuadrilla Resources' website.[42] Furthermore, provisions in the Water Resources Act 1991 give the environmental regulator the power to demand disclosure of the composition of fracturing fluids. This, coupled with the implementation of the RS & RAEng recommendations to ensure well integrity, provide robust assurances against the possibility of contamination of this nature.

Pollution of land and surface water

Contamination of land and surface water can occur as a result of surface spills or accidental release of used fracking fluid that has returned to the surface; 25-75% of water used in fracturing returns to the surface as 'flow-back' water[43]. Spillages have occurred in the US principally due to regulations allowing wastewater to be stored in open pits. UK regulations require them to be stored in closed metal tanks before being treated and disposed of or reused.

[40] Regulation 18 of the Offshore Installations and Wells (Design and Construction etc.) Regulations 1996
[41] UKOOG (2013) Guidelines covering best practice for shale well operations in the UK
[42] http://www.cuadrillaresources.com/what-we-do/hydraulic-fracturing/fracturing-fluid/
[43] RS and RAEng (2012) Shale gas extraction in the UK: a review of hydraulic fracturing p20

As the RS & RAEng report notes, spillages can also be prevented by implementing current best practice techniques such as the installation of bunding.

Wastewater treatment/disposal

Wastewater from hydraulic fracturing is considered an 'extractive waste' and so its disposal is controlled by the Mining Waste Directive (MWD) which requires operators to obtain permits from the relevant environmental regulator and have a waste management plan in place. The Environmental Permitting Regulations (EPR) also require a comprehensive review of all disposal options to be conducted before a disposal licence is granted. The RS & RAEng recommendations are for wastewater to be recycled and reused where possible, and treatment and disposal plans developed from the outset. Once again these have been fully supported by the government and industry, and are already stipulated by the MWD and EPR.

Water resource use

There are concerns that high levels of hydraulic fracturing in the UK could lead to more water shortages and stress in certain areas. UK regulations[44] require operators to hold an abstraction licence when seeking to abstract over 20m3 a day. A licence would not be granted if water resources in the area were unable to cope with the demand.

It should be noted that fracking's water consumption is not extensive compared to many other industrial activities. For example, it is estimated that the volume of water required to operate a fracked well for ten years is equivalent to watering a golf course for a month or to operating a 1,000 megawatt coal-fired power station for 12 hours.[45] Furthermore, fracturing activities only use water periodically; operators could easily consult

Regulatory barriers

The recent report on shale gas by the House of Lords Economic Affairs Committee[46] highlighted regulatory requirements, in particular planning permission and environmental permitting, as a major barrier to the establishment of a UK shale gas industry. Companies wishing to perform exploratory activity must first go through a lengthy process involving DECC, the Environment Agency, local authorities and the Health & Safety Executive (HSE) before permission is given for any activity to start.

The full details of the requirements are laid out in DECC's regulatory roadmap for onshore oil and gas[47] but the limited number of applications to date mean very few indicative timescales are available yet. When it was giving evidence to

[44] Water Resources Act 1991
[45] RS and RAEng (2012) Shale gas extraction in the UK: a review of hydraulic fracturing p20
[46] House of Lords Economic Affairs Committee (2014) The Economic Impact on UK Energy Policy of Shale Gas and Oil
[47] DECC (2013) Onshore oil and gas exploration in the UK: regulation and best practice

the House of Lords committee, Cuadrilla Resources noted that just getting planning permission could take around 16 months. In addition, eight or nine different permits[48] must be sought from the Environment Agency as well a range of other approvals from DECC and the HSE. The RS & RAEng report recommended a single body be given all responsibilities relating to shale gas to streamline the approvals process and reduce duplication. This would also help address industry concerns about the lack of resources in public bodies but must not be done at the expense of environmental concerns.

RECOMMENDATIONS

- The government should seek to work with UKOOG and other relevant stakeholders to implement the recommendations of the EY report.
- In particular, the government must prioritise the development of a business case for investment in manufacturing capacity in the UK to supply a UK, and possible global, shale gas industry.
- All supportive political parties should be more vocal and honest about the potential benefits of shale gas. There is currently a vacuum that is being filled by mistruths or overstatements from both sides of the debate and this must be addressed by political leaders. Clear statements on shale gas should be made in party manifestos.
- The government needs to take a more prominent role in addressing the concerns of local communities. There is a natural limit to the influence companies involved in exploration and production can have.
- The regulatory framework is currently overly complex, time consuming and split between various public bodies. Where possible the requirements should be streamlined, simplified and brought together under the authority of one body.
- Public confidence in the industry could be boosted by moving the industry guidelines and best practice established by UKOOG into regulation.

CONCLUSION

The exploitation of the UK's shale gas resources could provide significant benefits to the economy, not least through increased tax revenues, money earmarked for local communities, job creation in the shale gas supply chain, reduced reliance on natural gas imports, and possible downward pressure on energy and chemical feedstock prices. However there remain significant barriers to the establishment of a viable industry including environmental and climate change concerns and regulatory complexity. Industry and the government will need to work closely together to ensure they are overcome at the same time as effectively addressing public and local concerns.

[48] House of Lords Economic Affairs Committee (2014) The Economic Impact on UK Energy Policy of Shale Gas and Oil

Whilst burdensome and overly complex, the regulatory arrangements in the UK are of an extremely high standard and provide the industry with a gold standard framework to work within, ensuring that the negative publicity associated with the US experience is not repeated in the UK.

Key to the long-term viability of the industry is an open and honest debate and public education based on clear facts. Claims about a replication of the US experience, cheap energy and a manufacturing sector boom are not helpful and could well prove counterproductive. Development of a domestic shale gas industry could deliver a significant prize for the UK, but it is crucial that this prize is not overstated.

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