

Shale Gas

the time is now



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One of the most exciting developments in recent energy history has to be the dramatic increase in the production of natural gas from shale formations,¹ or shale gas as it is commonly known amongst lovers and haters alike. Although experts have been aware of the vast deposits of shale gas around the globe, technological difficulties and the excessive financial costs associated with extraction have previously made shale no more than an impractical dream.² Increasing demand and lagging supply mean high prices for both oil and gas allowing more lucrative gas plays to penetrate the market.³ Will the US set precedent for a UK shale production or are we all simply chasing a happy ending in a well-written story?

¹ Sakmar, Susan, 'The Global Shale Gas Initiative: Will the United States be the Role Model for the Development of Shale Gas around the World?' (2010-2011) 33 *Hous K Int'l L* 370.

² www.ft.com/cms/s/0/9e6c7b40-9103-11df-b297-00144feab49a.html#axzz2EN742sJo - Accessed Dec 2012.

³ US Shale Gas, An Unconventional Resource, Unconventional Challenges, Halliburton White Paper – available at www.halliburton.com/public/solutions/contents/shale/related_docs/H063771.pdf - Accessed Dec 2012.

Every shale play is different and requires tailored exploitation. The main method of extraction, and the only reason why shale gas is now considered as a viable source of energy production, is fracking. Fracking means that the cost of natural gas in the US is now one third of the cost in the UK.⁴ The potential benefits of shale gas are evident to the Chancellor George Osborne as he consults on new tax incentives for shale gas in an attempt to stimulate the area.⁵ The particular technique employed, however, has ruffled more than a few public feathers. Shell say there is enough shale gas to supply the globe for 200 years⁶ and in parts of the US it is on the march, in others it is banned. This divide is true the world over; people favour one extreme or the other. The greenest among us may recoil at the idea of yet *more* cheap fossil fuel but in the US's dash to exploit shale, their carbon emissions dropped by 1.7 per cent in 2011 at a time when Europe's emissions rose,⁷ sparking the argument that the UK may be able to reduce emissions by replacing coal use.⁸ Economics aside, the question on everyone's lips is how will shale gas contribute to climate change mitigation? Natural gas, whether from shale or conventional sources is the cleanest burning fossil fuel. Some critics argue that methane leakage from shale-gas extraction will cancel out any climate change benefits, but this is a minority view and all measures will be taken against this possibility.⁹

Imperial College London told the Radio Four Today program that although shale gas is not the answer

to our energy needs, it will help increase security of supply and despite a lack of export value, it will reduce our reliance on gas imported from Russia.¹⁰ The UK will not benefit from massively reduced gas prices, but shale gas will be a native product giving us more control of how it is priced.

The growing interest in unconventional gas, namely shale, has been spurred on by recent experience in the United States where shale production has increased ten-fold between 2006 and 2010.¹¹ This remarkable development overturned expectations of a continuing decline in US gas production, reduced US gas prices, led to an oversupply of liquefied natural gas on world markets and stimulated business and policy interest in shale gas around the globe.¹²

This paper does not aim to contribute to the negative discussion surrounding the extraction of shale gas but rather attempts to define a history of the industry, the landscape as it stands in Europe and the US and the regulatory and legislative measures moving forward towards a secure energy future in Europe and the required developments to infrastructure in order to exploit this potential geopolitical game changer. The paper focuses on shale gas as the most promising 'unconventional'¹³ gas, the other two being tight gas and coalbed methane, due to the exposé it has received.

⁴ www.telegraph.co.uk/earth/energy/9721493/Lets-get-fracking-and-slash-our-gas-bills.html - Accessed Dec 2012.

⁵ www.guardian.co.uk/environment/2012/dec/05/gas-strategy-unveiled-george-osborne - Accessed Dec 2012.

⁶ www.guardian.co.uk/environment/interactive/2011/apr/26/shale-gas-hydraulic-fracking-graphic - Accessed Dec 2012.

⁷ www.newscientist.com/blogs/culturelab/2012/11/embracing-shale-gas-may-help-cut-emissions.html - Accessed Dec 2012.

⁸ www.guardian.co.uk/environment/2013/mar/18/shale-gas-cut-emissions - Accessed June 2013.

⁹ www.nature.com/nclimate/journal/v3/n5/pdf/nclimate1900.pdf - Accessed May 2013.

¹⁰ www.bbc.co.uk/programmes/b01p7dcs - Accessed Dec 2012.

¹¹ McGlade et al, 'Unconventional gas – A review of regional and global resource estimates' (2013) Energy (Available online 16 March 2013, In Press, Corrected Proof).

¹² H Rogers, 'Shale gas – the unfolding story' (2011) Oxford Review of Economic Policy27(1), 117-143.

¹³ The term 'unconventional' refers to the fact that gases grouped under the term require more sophisticated methods of extraction than those required for conventional natural gas.

History

In 1821 shale gas was produced from a natural seepage in the Appalachian Mountains at Fredonia, New York. The gas was trapped and piped through hollow logs, later being replaced by lead pipes. Due to the small profit margins involved, major companies failed to invest much interest in the technology and small local operators produced shale gas as 'cottage businesses'.¹⁴ In 1976 the US Department of Energy initiated the Eastern Gas Shales Project at a cost of up to \$200 million to evaluate the geology, geochemistry and petroleum production engineering of non-conventional petroleum including shale gas. Important reports¹⁵ established findings from the only shale gas production in the world based in the Devonian and Mississippian shales in the Appalachian basin.¹⁶ These reports led to the establishment of the Gas Research Institute and also stimulated research at Imperial College here in the UK, evaluating potential resources. Plate tectonic reconstruction of the opening Atlantic Ocean implied that the continuation of the Appalachian basic and fold belt extended across the UK and into mainland Europe (Fig. 1). Imperial College focussed on the US paradigm of 'cottage' industry and reviewed potential shale gas extraction from throughout the stratigraphic column. The study concluded that Pre-Cambrian and Lower Palaeozoic shales were generally too metamorphosed to be potential reservoirs and most Mesozoic and younger organic-rich shales and mudstones were deemed too immature to be considered. Carboniferous shales in general and Namurian shales in particular, were ideally suited, both in terms of maturity and in degree of natural fracturing (Fig. 2). At that time, profit made from extraction was subject to both Corporation Tax and Petroleum Revenue Tax meaning that production was nowhere near economic.

Fig. 1.

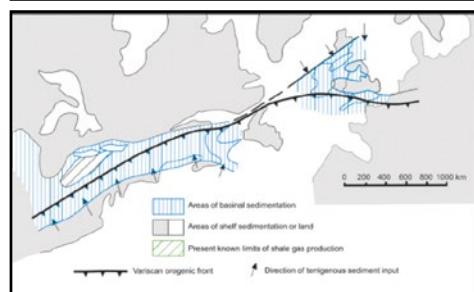
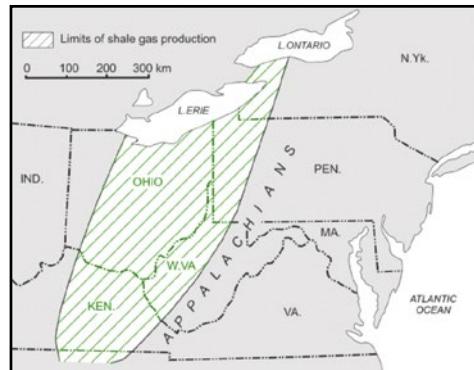
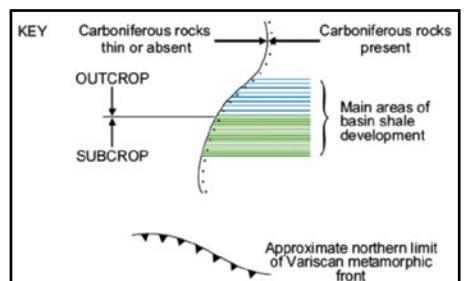
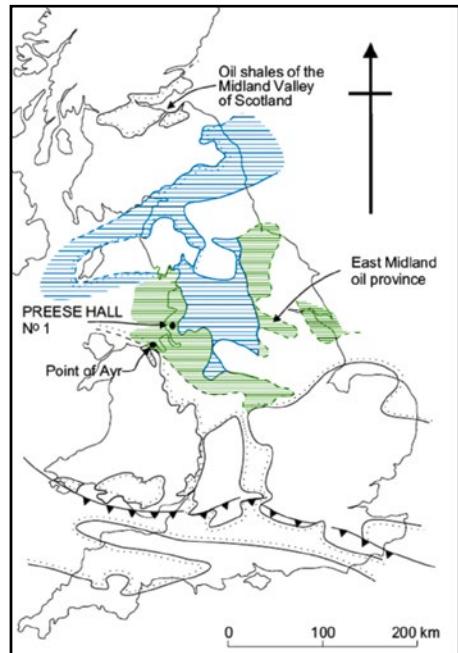


Fig. 2.



14 Richard C Selley, 'UK shale gas: The story so far' (2012) *Marine and Petroleum Geology* 31(1), 100.

15 D Donohue et al, 'Shale Gas in the Southern Central Area of New York State' US Dept of Energy, Morgantown (1981) 4 vols, 578.

16 R E Zielinski, R D McIver, 'Resources and Exploration Assessment of the Oil and Gas Potential in the Devonian Shale Gas of the Appalachian Basin' US Dept of Energy, Morgantown.

The conclusions of the Imperial College study on shale gas potential in the UK were presented to the UK Department of Energy in 1985. It was met with polite interest, but the chances of it being exempt from Petroleum Revenue tax were not countenanced. Subsequent attempts to inform the wider world failed and no reputable scientific journal would publish papers on the UK's shale gas resources. Finally, conclusions of the research were published in the US.¹⁷ Back in the US, the shale gas band wagon was being rolled out from the Appalachians, geographically, stratigraphically and technologically. The Appalachian basin from New York State through Ohio to Kentucky and Illinois was the main historic area for shale gas production, but there had been other basins where the gas was produced.¹⁸ Stimulated by the Department of Energy and the Gas Research Institute, shale plays were found in the Cretaceous Lewis Shale of the San Juan Basin, the Mississippian Barnett Shale of the Fort Worth Basin and the Devonian Antrim Shale of the Michigan Basin.¹⁹ Geochemical studies revealed that the gas was not thermogenic, but produced by bacterial methanogenesis. The bacteria had entered the fractured shale from ground water percolating down from the glacial drift cover.²⁰ This second process for gas generation opened up new areas for exploration; areas where the source rock was previously deemed immature or over mature for thermogenic gas generation.

The shale gas renaissance was also brought about by improved methods of well drilling and advances in completion technologies. The ability to drill multiple wells off a single pad was both financially and environmentally rewarding.²¹ The ability to drill wells horizontally as well as

vertically and the ability to steer the drill along 'sweet spots' enabled permeable gas-charged zones to be tapped into. This was coupled with more dramatic hydraulic fracturing techniques. Seismic techniques, which could use the fracturing process as an energy source enabled gas-charged 'sweet spots' to be mapped in three dimensions.²²

Meanwhile, back in the UK, shale gas as a potential industry was still gathering dust until the British Geological Survey noted the potential for its production in 1995.²³ Shale gas was not mentioned in reviews of future UK petroleum resources published by staff of the Oil and Gas Directorate of the Department of Trade & Industry,²⁴ published in 2003. The 6th Petroleum Geology Conference on the Global Perspectives of North West Europe was held later in the same year. The 3-day programme concluded with a session on non-conventional petroleum. This included a presentation on the UK's shale gas resources and provided a platform to disseminate updated conclusions of the Imperial College research of some 15 years prior. The advances in US shale gas exploration and production technology could now be applied to the UK. The content was published two years later.²⁵ In 2008 the British Geological Survey began to review UK shale gas resources. They delivered a presentation on their results at the 7th Petroleum Conference in March 2009.

Subsequently the Department of Energy & Climate Change commissioned the BGS to prepare a report on UK shale gas for their website.²⁶

"The shale gas renaissance was also brought about by improved methods of well drilling and advances in completion technologies."

17 Richard C Selley, 'British shale gas potential scrutinized' (1987) *Oil Gas J* 15, 62-64.

18 In the Williston Basin, for example, Bakken Shale had produced gas since 1953.

19 J B Curtis, 'Fractured shale-gas systems' (2002) *Bull Amer Assoc Petrol Geol* 86, 1921-1938.

20 Martini et al, 'Genetic and temporal relations between formation waters and biogenic methane. Upper Devonian Antrim Shale, Michigan Basin USA' (1998) *Geochim Cosmochim Acta* 62(10) 1699-1720.

21 www.wvsoro.org/resources/marcellus/horiz_drilling.html - Accessed April 2013.

22 Richard C Selley, 'UK shale gas: The story so far' (2012) *Marine and Petroleum Geology* 31(1), 100.

23 N J P Smith, 'Unconventional hydrocarbons: changing exploration strategies' (1995) *Earthwise* 7, 14-15.

24 G Swann, J Munns, *The Hydrocarbon Prospective of Britain's Onshore Basins* (DTI 2003) 17.

25 Richard C Selley, 'UK shale-gas resources' A G Dore, B A Vining (Eds.), *Petroleum Geology: North-West Europe and Global Perspectives*, Proc 6th Petroleum Geology Conference, Geological Society, London (2005) 707-714.

26 www.gov.uk/oil-and-gas-onshore-exploration-and-production#resumption-of-shale-gas-exploration – Accessed April 2013.

A Quick Lesson In Geography

Several companies were interested in applying for shale gas acreage by the time of the announcement of the 13th onshore round of UK licensing in 2006. In 2008 Wealden Petroleum Development Ltd, on behalf of Eurenergy Resources Inc, was successful in being awarded PEDL 247. This license covered large areas of the Weald where potential for shale had been recognised in Lower Jurassic shales. Island Oil and Gas, an established coal bed methane producer holds acreage in several areas of the Midlands, most notably Point of Ayr and are now considering the potential of their acreage. Cuadrilla Resources Corporation holds acreage to test for shale gas. In 2010 they embarked on a three well exploration programme. The first well, Preese Hall Number 1, was completed with attractive and promising results.²⁷ In December of 2012, the government granted Cuadrilla permission to resume fracking that was previously put on hold following a series of small earthquakes. Conditions have been imposed to minimise the risk of seismic activity as a result of further fracking.²⁸ With the exception of Cuadrilla, operators are exploring shale gas in combination with petroleum or coal bed methane extraction. Shale gas extraction in the UK has already attracting a wide following of anti-shale activists²⁹ mirroring the lobby already flourishing the US.³⁰

The Caledonide basement of Britain crops out in the Celtic rim of Scotland and Wales and is buried beneath younger over most of England. Original fine-grained mud rocks are occasionally highly carbonaceous, but have generally been deformed into slates, or metamorphosed. Lacking any

residual porosity such rocks are unlikely to be prospective. Generally the slaty deformation of the Lower Palaeozoic³¹ rocks increases in abundance north-westwards from the Welsh Borderlands to Gwynedd. Slaty cleavage is related to structural lineaments and occurs throughout the stratigraphic column.³² Thus it is present in the Bethesda-Nantlle belt (Lower Cambrian),³³ around Tremadoc (Upper Cambrian), around Blaenau (Lower Ordovician), between Corris and Aberllefenni (Upper Ordovician), around Machynlleth (Llandinian) and near Corwen and Llangollen (Wenlockian and Ludlovian respectively). Elsewhere, however, thick sequences of late Cambrian-Silurian carbonaceous mud rocks may be prospective, especially in the Welsh Borderlands. Seismic surveys have identified several fault-bounded basins such as the Worcester graben.³⁴ Seismic data shows that the Graben is filled by over 2000m of sediment. Wells drilled for conventional petroleum were dry, but encountered Late Cambrian – Tremadocian shales with TOC's of up to 5% and R0 values of 1.8-2.5%.³⁵ The organic-rich Worcester Graben shales are coeval with the Alum Shale of Southern Scandinavia, a sequence of great interest as a target for shale gas.³⁶

27 www.gov.uk/government/uploads/system/uploads/attachment_data/file/15745/5075-preese-hall-shale-gas-fracturing-review.pdf - Accessed April 2013.

28 www.bbc.co.uk/news/uk-20707574 - Accessed Dec 2012.

29 Nofrackinguk.com, campaignncc.org/fracking, frack-off.org.uk and many more sites are becoming more involved in the movement.

30 Richard C Selley, 'Shale gas: blessing or curse?' (2011) Geoscientist 21(4), 14-19.

31 The Palaeozoic lasted from about 570 to 245 million years ago, its end being marked by mass extinctions. The Lower Palaeozoic sub-era comprised the Cambrian, Ordovician, and Silurian periods.

32 B Smith, T N George, British Regional Geology: North Wales (HMSO 1961) 97.

33 The Cambrian is the first geological period of the Palaeozoic Era and is succeeded by the Ordovician.

34 N J P Smith, A W A Rushton, 'Cambrian and Ordovician stratigraphy related to structure and seismic profiles in the Western part of the English Midlands' (1993) Geol Mag 130, 665-671.

35 N J P Smith, Turner, G William, 'UK data and analysis for shale gas prospectivity' B A Vining, S C Pickering, Proc 7th Petroleum Geology Conf Geol Soc Lond (2010) 1087-1098.

36 H M Schulz, B Horsfield, R F Sachsenhofer, 'Shale gas in Europe: a regional overview and current research activities' B A Vining, S C Pickering, Proc 7th Petroleum Geology Conf Geol Soc Lond (2010) 1079-1085.

Our Energy Environment

The global energy market is changing. The emergence of increased oil and gas production in the US, teamed with a drop in nuclear momentum in some countries and the global spread of unconventional gas exploration and production is having far-reaching consequences for energy markets and trade. All developments accounted for, the world is still failing to put global energy on a more sustainable path. Energy demands across the globe have grown by a third to 2035 in the New Policies Scenario³⁷ with China, India and the Middle East accounting for 60% of the increase. Demand barely rises across OECD (Organisation for Economic Co-operation and Development) countries³⁸ although there has been a notable shift from fossil fuel consumptions towards renewables and natural gas. Despite the emerging popularity of low-carbon energy sources, fossil fuels remain a dominant element of the energy mix supported by subsidies that amounted to \$523 billion in 2011, up 30% on 2010 and six times higher than that of renewable subsidies collectively across OECD countries.

The recent advances in unlocking shale gas in the US are a profound step in energy advances and the movement is spurring economic activity. Less expensive gas and electricity prices have given the industry a competitive edge. By 2020 the US is projected to become the largest global oil producer and starts to see the impact of new fuel-efficiency measures in transport. No country, however, is an energy island. As US natural gas becomes lower priced due to the advances in industry, coal use is taking a second place in the country. This frees up coal supplies for export to Europe where in turn it has displaced higher gas prices.

In the next five years nearly two million homes will be heated by controversial shale gas imported from the US in a deal that is likely to be the first time major imports of the energy source are used in the UK.³⁹ The deal struck by Centrica marks the start of a new era in gas use and means the energy company will pay £10bn over 20 years for 89bn cubic feet of gas annually from Cheniere, one of the first US companies to receive clearance from the US federal government to export the gas,⁴⁰ breaking the tradition of the US to keep a 'tight rein on exports' since the shale boom started five years ago. This announcement comes at a crucial time as the coldest March in 50 years has led to some forecasts suggesting that gas supplies in the UK could run out in a matter of days.⁴¹ The failure of a key pipeline on Friday 22nd of March 2013 caused an immediate doubling of gas prices in the spot market.⁴² The price fell as the issue was resolved but highlighted the vulnerability of the UK to energy shocks and the dependence we place upon imported energy. Shale gas has revolutionised the US energy industry⁴³ with thousands of wells drilled across the country releasing billions of tonnes of fuel. Perhaps shale could also be a game changer in the UK. Global gas price hikes are squeezing households here in the UK. We have European legislation that is going to close a quarter of coal fired power plants⁴⁴ that currently produce 40% of our electricity cheaply, and the slow uptake of renewable energy generation is going to leave an energy gap that we will find hard to plug. Shale could alleviate some of the problems surrounding energy security, but will be hard to get at. However, 'if we don't start looking now, we won't be able to determine how much there is'.⁴⁵

³⁷ The International Energy Agency developed a scenario in the World Energy Outlook which takes account of broad policy commitments and plans that have been announced by countries, including national pledges to reduce greenhouse-gas emissions and plans to phase out fossil-energy subsidies, even if the measures to implement these commitments have yet to be identified or announced.

³⁸ www.oecd.org/general/listofoeecdmembercountries-ratificationoftheconventionontheoeecd.htm - Accessed May 2013.

³⁹ www.guardian.co.uk/environment/2013/mar/25/us-shale-gas-british-homes-five-years - Accessed March 2013.

⁴⁰ <http://phx.corporate-ir.net/phoenix.zhtml?c=101667&p=irol-newsArticle&ID=1800179&highlight=> - Accessed March 2013.

⁴¹ www.guardian.co.uk/business/2013/mar/21/gas-price-warning-short-supplies - Accessed March 2013.

⁴² www.guardian.co.uk/business/2013/mar/22/wholesale-gas-prices-soar-after-pipeline-forced-to-close - Accessed March 2013.

⁴³ www.guardian.co.uk/environment/2012/nov/12/us-biggest-oil-producer - Accessed March 2013.

⁴⁴ www.energyglobal.com/news/coal/articles/The_UK_faces_capacity_crunch_as_coal_fired_power_plants_close_132.aspx - Accessed March 2013.

⁴⁵ www.bbc.co.uk/news/uk-politics-22001787 - Accessed March 2013.

The improvements in the cost efficiency of shale gas production have made it far more economic to recover the resource. With the substantial level of global output, gas prices in Europe could fall as a result.⁴⁶ Although oil has transformed over the decades into a vibrantly traded commodity, previously, natural gas had remained fragmented with prices mirroring that of oil. The surplus of gas supply put pressure on the current market structure, helping gas to break from crude oil and trade independently.⁴⁷ Considerable price differentials arise at times between oil and gas as a result of various market shocks. To the extent that both oil and gas are substitutable, market forces will also exist which encourage price differences to iron out, but various forms of inertia mean that this can take time. For example, if gas is significantly cheaper than oil, investments will be attracted to oil projects at the expense of upstream gas developments and vice versa downstream. Gas projects do not just come to a halt however, since fields are typically already under development and new oil projects have substantial lead times. These lead times were blamed for the lack of recovery in the 2010 North Sea activity slump.⁴⁸ A large price difference of this kind prevailed at the beginning of 2011.⁴⁹ Increased production of liquefied natural gas (LNG), coal bed methane (CBM), new shale output in the USA and reduced demand and as a result of the financial crisis drove gas prices down relative to those of oil. This does not represent a permanent shift since lead times mean substitution is a lengthy process in this market.

“Energy demands across the globe will have grown by a third in 2035”

“...natural gas had remained fragmented with prices mirroring that of oil.”

46 Frank Asche, Atle Oglend, Petter Osmundsen, 'Gas versus oil prices, the impact of shale gas' (2012) *Energy Policy* 47, 117-124.

47 www.ft.com/cms/s/0/5b63b22a-ca3c-11de-a3a3-00144feabdc0.html#axzz2Q9Pmrq78 – Accessed April 2013.

48 www.independent.co.uk/news/business/news/oil-and-gas-exploration-falls-to-lowest-level-in-five-years-1868501.html - Accessed April 2013.

49 www.nytimes.com/2011/02/26/business/global/26charts.html?_r=0 – Accessed April 2013.

Markets Across The Globe

Oil, gas and electricity compete in the same market in the UK⁵⁰ and compete regionally in the US.⁵¹ In the US market, gas competes with oil on the east coast⁵² and with electricity, but not oil, on the west coast.⁵³ The European market appears well integrated⁵⁴ and there is a growing interest in the assessment of the economic feasibility of shale gas exploitation in Europe and other parts of the world. US shale developments provide important guidance for the economic development of shale extraction. In Europe, the development of the shale industry is economically risky as the estimated ultimate recovery is poorly constrained during the early stages of field development.⁵⁵ By 2009 in the US, the production of domestic gas from unconventional resources such as tight sands, coal beds and shale has surpassed the domestic output of conventional gas.⁵⁶ By 2012, shale gas accounted for over half of all the US gas produced from unconventional resources. The five potential gas plays in Europe are located in Austria, Germany, Poland, Sweden and Turkey. Smaller plays are located in Denmark, the UK, the Netherlands, Switzerland and Spain. In 2012 Austrian energy group OMV announced that it would be scrapping plans to extract shale in Austria because of 'the hoops it would have to jump through to address environmental concerns' which would make production economically unviable,⁵⁷ in the wake of test drilling estimated

to cost the company 130 million euros.⁵⁸ This has left the exploration process in Austria almost at a standstill. Poland is Europe's leading shale gas resource holder; it also has the largest proportion of coal in its primary energy supply.⁵⁹ After Poland, France holds the next largest resource base. Local opposition against shale gas developments is significant and generally the French are 'implacably opposed to shale gas'.⁶⁰ France will most likely focus on nuclear options in the future even though 'French industrial groups are up in arms as their once-celebrated nuclear-energy edge evaporates'⁶¹ at the hands of US shale embrace. Opposition to shale finds stronger political support in countries where shale gas threatens to displace existing energy sources with a strong support base like, for example, the nuclear power lobby in France. Norway holds substantial shale resources but development may be slow. Shale will have to compete with more profitable conventional gas production⁶² from the Norwegian continental shelf. Even without actualising shale potential, Norway remains, and will continue to remain, Europe's major oil and gas producer and exporter for decades to come as growth still continues in oil and gas.⁶³ Ukraine holds Europe's fourth largest shale gas deposits but has policy influenced by Russian energy strategy.⁶⁴ As a result, shale development will be more politically complex than in Poland.

⁵⁰ T Panagiotidis, E Rutledge, 'Oil and gas markets in the UK; evidence from a cointegrating approach' (2007) *Energy Economics* 29, 329-347; Ashe et al, 'The UK market for natural gas, oil and electricity: are the prices decoupled?' (2006) *Energy Journal* 27, 2.

⁵¹ A De Vany, W D Walls, 'Pipeline access and market integration in the natural gas industry: evidence from cointegration tests' (1993) *The Energy Journal* 14, 1-19; M J Doance, D F Spulber, 'Open access and the evolution of the US spot market for natural gas' (1994) *Journal of Law and Economics* 37, 477-517.

⁵² A Serletis, J Herbert, 'The message in North American energy prices' (1999) *Energy Economics* 21, 471-483.

⁵³ G W Emery, Q Lui, 'An analysis of the relationship between electricity and natural gas futures prices' (2002) *Journal of Futures Markets* 22, 95-122.

⁵⁴ Silverstovs et al, 'International market integration for natural gas? A cointegration analysis of prices in Europe, North America and Japan' (2005) *Energy Economics* 27, 603-615.

⁵⁵ Ruud Weijermars, 'Economic appraisal of shale gas plays in Continental Europe' (2013) *Applied Energy* 106, 100-115.

⁵⁶ www.fossil.energy.gov/programs/oilgas/ultra_and_unconventional/2012_annual_plan.pdf - Accessed April 2013.

⁵⁷ <http://uk.reuters.com/article/2012/09/17/omv-shale-austria-idUKL5E8KHHDG20120917> - Accessed April 2013.

⁵⁸ www.bloomberg.com/news/2011-12-02/omv-says-austrian-shale-gas-test-drilling-to-cost-175-million.html - Accessed April 2013.

⁵⁹ Ernst & Young, *Shale gas report – Poland, Tax and accounting issues for foreign investors and service companies* – Available at [www.ey.com/Publication/vwLUAssets/Shale_gas_report_-_Poland/\\$FILE/Shale_gas_report%E2%80%94Poland.pdf](http://www.ey.com/Publication/vwLUAssets/Shale_gas_report_-_Poland/$FILE/Shale_gas_report%E2%80%94Poland.pdf) – Accessed April 2013.

⁶⁰ www.economist.com/news/business/21571171-extracting-europe-s-shale-gas-and-oil-will-be-slow-and-difficult-business-frack-future - Accessed April 2013.

⁶¹ www.thegwpf.org/shale-revolution-france-faces-nuclear-meltdown/ - Accessed April 2013.

⁶² www.newsinenglish.no/2012/11/22/statoil-shale-gas-projects-absurd/ - Accessed April 2013.

⁶³ www.tnp.no/norway/economy/3662-norway-is-the-most-stable-market-in-scandinavia - Accessed April 2013.

⁶⁴ www.nytimes.com/2013/01/25/business/global/ukraine-signs-drilling-deal-with-shell-for-shale-gas.html?_r=0 – Accessed April 2013.

Sweden is Europe's smallest gas consumer with gas accounting for only 2.9% of primary energy consumption in 2010⁶⁵ and no gas retail market. The development of shale would require the development of a local gas market together with infrastructural advances. The Alum shale potential for commercial gas production has been negatively assessed by Shell engineers⁶⁶ leaving it with almost zero appeal to Shell and potentially many others in the industry. Denmark, the UK, the Netherlands and Germany are all major consumers of gas⁶⁷ with extensive infrastructure and mature retail markets.

Their domestic gas supply from conventional sources, however, is declining.⁶⁸ These countries are well located to benefit from domestic shale gas development which could delay expensive gas imports. Notably and recently, the Netherlands has been subject of research outlining the strategic importance of shale gas development.⁶⁹

While resources appear to be relatively abundant, the willingness to exploit and develop this potential varies considerably across the world. Heated debate continues as to whether the energy benefits of shale extraction outweigh the environmental impacts and it seems to be a subjective issue. Some countries such as the US, Canada and more recently the UK, have moved forward with development while France and some regional governments have placed temporary or permanent moratoria on the high-volume hydraulic fracturing process, citing concerns with respect to environmental safety, public health and consistency with existing policies.⁷⁰

"By 2012, shale gas accounted for over half of all the US gas produced from unconventional resources."

65 IEA Oil and Gas Security, Emergency Response of IEA Countries 2012 – Available at www.iea.org/publications/freepublications/publication/Sweden_OSS2012.pdf - Accessed April 2013.

66 Pool et al, 'Assessment of an unusual European Shale Gas play: the Cambro-Ordovician Alum Shale, southern Sweden' SPE/EAGE European Unconventional Resources Conference and Exhibition, 20-22 March 2012, Vienna, Austria.

67 Physical gas flows across Europe and security and diversity of gas supply in 2010 – Available at www.gov.uk/government/uploads/system/uploads/attachment_data/file/65816/3928-physical-gas-flows-europe-2010.pdf - Accessed April 2013.

68 www.reuters.com/article/2013/04/04/ln-gas-japan-idUSL5N0CR3XZ20130404 - Accessed April 2013.

69 R Weijermars, E Madsen, 'Can the Dutch gas bubble defy King Hubbert's peak?' (2011) First Break 29(4), 35-39; R Weijermars, S M Luthi, 'Dutch natural gas strategy: historic perspective & challenges ahead' (2011) Netherlands J Geosci/Geologie Mijnbouw 90(1), 3-14.

70 B G Rahm, S J Riha, 'Toward strategic management of shale gas development: Regional, collective impacts on water resources' (2012) Environmental Science & Policy 17, 12-23.

Why Shale Gas?

Supporters of the effort to replace primary fuel source hydrocarbons with carbon-free renewables often refer to natural gas as a 'bridge fuel'. This term reflects the reluctant recognition that renewable sources are nowhere near replacing our primary fuel sources soon and although natural gas is a hydrocarbon, it is less damaging to the environment than the use of other fossil fuels.⁷¹ It has been predicted that the 'peak fossil fuels' landmark may be reached in the coming decades. The concept of 'peak oil' refers to the point in time when oil production will plateau and decline, a theory popularised by Shell Oil geologist M King Hubbert who predicted in 1956 that US oil production would reach a maximum in the early 70's and gradually decline. This theory has been constantly undermined by new extraction techniques including deep-water drilling, tar-sands extraction and the recent fracking boom. The world now has enough of these fuels to last hundreds of years.⁷² Unfortunately the planet cannot take that kind of abuse for too long. The good news is advances in fuel-efficient and renewable energy technologies are curbing the demand for fossil fuels and 'by 2030, the growth in fossil fuel use will almost have stopped', 'it needs to happen by 2020' in order to prevent irreversible climate damage. 'That won't happen. But by 2030, it pretty much will'.⁷³ Setting the bigger picture aside for a moment, the shale movement has

attracted such an adverse following as it puts local communities right in the line of fire with regards to drilling and excavation. The Energy and Climate change committee said that local opposition to shale gas drilling is strong and MP's believe substantial financial incentives may be a way of 'getting to communities'.⁷⁴ Financial incentives may have to be offered as MP's also say that even if vast amounts of shale gas were captured in the UK they would do little to reduce energy bills for homeowners. Also an issue, any significant development in shale would shatter UK emissions targets for 2020 unless carbon capture and storage is successfully developed and implemented,⁷⁵ the chance of this happening soon being rather slim.



"...any significant development in shale would shatter UK emissions targets for 2020 unless carbon capture and storage is successfully developed and implemented."

⁷¹ www.epa.gov/cleanenergy/energy-and-you/affect/natural-gas.html - Accessed April 2013.

⁷² www.bloomberg.com/news/2013-04-24/-peak-fossil-fuels-is-closer-than-you-think.html – Accessed April 2013.

⁷³ Bloomberg New Energy Finance founder Michael Liebreich, BNEF Annual Summit, New York, April 22-24 2013.

⁷⁴ www.guardian.co.uk/environment/2013/apr/26/cash-locals-shale-gas-fracking-uk - Accessed April 2013.

⁷⁵ www.bbc.co.uk/news/science-environment-22300050 - Accessed April 2013.

Any Cause For Concern?

The extraction of shale gas has various environmental impacts which are obscuring its future.⁷⁶ Major concerns revolve around a set of key activities associated with fracking. Water resources and the potential for contamination figure prominently among several other major concerns, along with uninsurable homes, an industrialised countryside dotted with wells, convoys of giant water transporters breaking up entirely unsuitable rural roads, and the real possibility of seismic events such as earthquakes and toxic fumes from drill-site flares.⁷⁷ Other issues comprise potential noise, visual and air quality impacts associated with vehicle traffic, well pad construction and land clearing activities, and the use of diesel for on-site compressors and equipment. Activities associated with the establishment and construction of well pads and associated service roads and delivery pipeline networks have the positional to disrupt land use patterns, disturb sensitive habitat and introduce invasive species. Trucking demands related to the transportation of materials, water and waste have led to concerns over road use, safety and maintenance. Other impacts such as the 'boom and bust' cycle associated with extractive development in communities are also considered by those against the shale movement. The negative aspects of the environmental impacts are discussed heavily in the Oscar-award nominated film 'Gasland'.⁷⁸ The environment is a major issue of concern for the film maker Josh Fox and the film states that although there are many legislative instruments in the US designed to protect the environment, these fences have been jumped by the drilling companies with interests

investing in shale gas. In 1972 Pete Seeger reminded New York City that if they polluted the upper Hudson, drinking water in the area would be ruined.⁷⁹ In the same year Richard Nixon signed the Clean Water Act⁸⁰ into law, following the reformation of the environmental protection agency and the Clean Air Act⁸¹ in 1970, and laying the foundations for the Safe Drinking Water Act⁸² in 1974, paving the way for a large step in environmental progress. Supporters of the shale gas movement echo the calls that 'American shale basins contain an ocean of natural gas'.⁸³ It has been said that the same people who reiterate this point benefit heavily from the further development of natural gas in the US.⁸⁴ The 2005 Energy Bill⁸⁵ passed by congress exempted the Oil companies from the legislation passed above, the Superfund law⁸⁶, which identifies and ensures the cooperation of companies involved in accidents, spills and other emergency release of pollutants and contaminants into the environment, and about a dozen other environmental regulations. After this, the largest and most extensive gas drilling exploration in history was undertaken by the oil and natural gas industry spanning 34 states.

The film 'Gasland' claims that fracking blasts a mixture of water and chemicals 8000ft below surface and releases gas by mini earthquakes. The fluid used for fracking comprises 569 chemicals from the unpronounceable to the unknown, to known carcinogenics. Some of the chemicals included in the cocktail comprise lead, uranium, mercury, ethylene glycol, radium, methanol, hydrochloric acid and formaldehyde.⁸⁷ Each time a well is drilled they need between 1 and 8 million

⁷⁶ www.cnbc.com/id/100623670 - Accessed June 2013.

⁷⁷ www.telegraph.co.uk/comment/letters/10031158/Concern-about-the-impact-of-shale-gas-exploitation-on-the-countryside.html - Accessed June 2013.

⁷⁸ www.gaslandthemovie.com – Accessed April 2013.

⁷⁹ www.clearwater.org/pete-seeger-biography/ - Accessed April 2013.

⁸⁰ Clean Water Act (CWA) 33 USC § 1251 et seq (1972).

⁸¹ Clean Air Act (CAA) 42 USC § 7401 et seq (1970).

⁸² Safe Drinking Water Act (SDWA) 42 USC § 300f et seq (1974).

⁸³ Aubrey McClendon, CEO of Chesapeake Energy.

⁸⁴ <http://checksandbalancesproject.org/tag/aubrey-mcclendon/> - Accessed April 2013.

⁸⁵ Energy Policy Act (EPA) 42 USC § 15801 et seq (2005).

⁸⁶ Comprehensive Environmental Response, Compensation and Liability Act (Superfund) 42 USC § 9601 et seq (1980).

⁸⁷ www.dangersoffracking.com/ - Accessed April 2013.

gallons⁸⁸ and the same amount again every time they revisit the well. A well can be fracked up to 18 times. In 2009 there were 450000 wells, recent figures argue there are 500,000 active gas wells in the US.⁸⁹ Take those half a million wells, times them by the 8 million gallons of water per fracking and times that by the 18 times a well can be fracked. This works out at 72 trillion gallons of water all infused with the 569+ chemicals needed in fracking fluid amounting to around 360 billion gallons of chemicals needed to run current gas wells.⁹⁰ ‘Water, water everywhere, nor any drop to drink’.⁹¹

In 2004 the Environmental Protection Agency were investigating water contamination incidents due to fracking across the country but a panel rejected the investigation saying that although hazardous materials were being pumped underground, the EPA did not need to investigate further. Five of seven members of the panel were said to have conflicts of interests and would benefit from the EPA’s failure to conduct an investigation. As CEO of Halliburton, when Dick Cheney became Vice President of the United States, he met over 40 times with the oil and gas industry and is responsible for what is now known as the ‘Halliburton Loophole’.

Gasland claims that chemicals we do not know about are used in the fracturing process. We are told that triethylene glycol (Glycol ethers) is used throughout the initial process of fracking and throughout the course of the process. Effects in humans include testicular toxicity, malformation of the embryo, bone marrow depression, hemolysis, central nervous system malformations, musculoskeletal malformations and hypospadias. Birth defects and dead foetuses have been linked to the inhalation of glycol ethers in animals also.⁹² The Mayor of Dish in the US echoed the chilling realisation that hindsight brings which is a common theme throughout the film. “Once you know, you can’t not know”.⁹³

With scare stories like this circulating around the internet and in the media, public opinion is bound to be influenced due to a distinct lack of easily understandable, factual and readily available knowledge to counter the negative claims. Of course the issues discussed above are produced by the research undertaken in the film *Gasland*.

⁸⁸ www.dangersoffracking.com/ - Accessed April 2013.

⁸⁹ www.dangersoffracking.com/ - Accessed April 2013.

⁹⁰ www.dangersoffracking.com/ - Accessed April 2013.

⁹¹ *Rime of the Ancient Mariner* by Samuel Taylor Coleridge.

⁹² Ethylene Glycol Ethers (EGME, EGEE, EGMEA, EGEEA) Prioritisation of Toxic Air Contaminants – Children’s Environmental Health Protection Act October 2001.

⁹³ Calvin Tillman, Former Mayor of DISH, Texas.

Should we believe what we hear?

Here in the UK things will be very different as legislation, regulations, the landscape and the technological approach differ. There are already numerous regulations governing the shale gas industry with more to emerge including a requirement to disclose the chemicals used in the fluid. The public need to remember that existing regulatory bodies include the Department of Energy and Climate Change, The Environment Agency, Scottish Environmental Protection Agency, the Health and Safety Executive and also local authorities. The need for regulation is fully appreciated and if a gap is identified, it will more than likely be plugged rapidly. One of the main issues on the public's mind is the environmental impact of the process. The integrity of the environment is governed by law and numerous Government bodies and even the industry are showing their concern.⁹⁴ Specific risks that could arise as a result of the exploration and extraction of shale gas are well governed. Groundwater pollution is controlled by the Water Framework Directive⁹⁵ and Groundwater Daughter Directive⁹⁶, as it is commonly known, through the Water Resources Act⁹⁷ and Environmental Permitting Regulations⁹⁸ (EPR). These instruments require the disclosure of chemicals and regulate any discharges to groundwater. Surface spills are controlled by the planning regime for site construction standards and the EPR governs surface water discharges along with groundwater discharges. The disposal of the fracking fluid, or brine, is governed by the Mining Waste Directive⁹⁹ through the EPA. A waste management plan must be approved by the Environment Agency in the

UK¹⁰⁰ and the Euratom treaty¹⁰¹ applies if there are naturally occurring radioactive materials imposed by the EPR. The Water Resources Act requires abstraction licensing to avoid the over abstraction of water. The Borehole Regulations¹⁰² from the Health and Safety Executive intend to protect human health against any fugitive methane emissions and conditions under the Petroleum Licences¹⁰³ from Department of Energy and Climate Change apply for flaring and venting.¹⁰⁴ Other concerns include the potential contamination of underground water aquifers. In their investigation, the Energy and Climate Change Committee found that:

'There is no evidence that the hydraulic fracturing process poses any risk to underground water aquifers provided that the well-casing is intact before the process commences. Rather, the risks of water contamination are due to issues of well integrity, and are no different to concerns encountered during the extraction of oil and gas from conventional reservoirs. However, the large volumes of water required for shale gas could challenge resources in regions already experiencing water stress'.

⁹⁴ Four guidelines in a series being produced by the Well Life Cycle Practices Forum (WLCPF) have been published by Oil and Gas UK to improve industry understanding of well-related issues in the UK – available at www.oilandgasuk.co.uk/news/news.cfm/newsid/748 - Accessed June 2013.

⁹⁵ Directive 2000/60/EC.

⁹⁶ Directive 2006/118/EC.

⁹⁷ Water Resources Act 1991 (c. 57).

⁹⁸ The Environmental Permitting Regulations (England and Wales) 2010.

⁹⁹ Directive 2006/21/EC.

¹⁰⁰ www.environment-agency.gov.uk/static/documents/NetRegs/SWMP_Simple_Guide_Feb_2011.pdf - Accessed May 2013.

¹⁰¹ Consolidated Version of the Treaty Establishing the European Atomic Energy Community (2010/C 84/01).

¹⁰² The Borehole Sites and Operations Regulations 1995 (No. 2038).

¹⁰³ www.gov.uk/oil-and-gas-petroleum-licensing-guidance - Accessed May 2013.

¹⁰⁴ Under the Energy Act 1976, as amending by the Gas Act 1986, the Secretary of State's consent is required for the disposal of natural gas, at source or elsewhere, by flaring or unignited release into the atmosphere.

This of course highlights the reality that the industry faces; although new technologies are employed, the fundamental principles are the same as those already practised in a well established oil and gas industry. The industry do not want to be subject to further regulation and are aware that just one groundwater contamination could lead to extensive amounts of new regulation that will hinder progress further.¹⁰⁵

Planning procedures already provide for full consultation with communities who may be affected by any drilling activity and the planning authorities may require an Environmental Impact Assessment to be carried out. Some have stated that Environmental Risk Assessment should be mandatory for all shale gas operations, involving the participation of local communities at the earliest stage and that this assessment should address risks across the entire lifecycle of the operation.¹⁰⁶

DECC will take steps to enhance the existing frameworks for consultation. Licensees will be required to carry out a comprehensive high-level assessment of environmental risks, including risks to human health, and covering the full cycle of the proposed operations, including well abandonment; and to consult with stakeholders including local communities, as early as practicable in the development of their proposals. Cuadrilla has been asked to conduct such an assessment in relation to their proposals for further exploration work in Lancashire.¹⁰⁷

This high-level assessment may inform the work entailed by risk assessments already required, for example under the Environmental Permitting Regulations,¹⁰⁸ and which are consulted on separately by the Environment Agency, as well as work entailed by any Environmental Impact Assessment which may be required by the local planning authority. Together, these assessments

will provide a full picture of the risks and impacts to inform effective engagement with local communities.¹⁰⁹

Steps will be taken to open the way to new onshore licensing. DECC had already commenced a Strategic Environmental Assessment in 2010,¹¹⁰ with a view to further onshore licensing, and conducted a public consultation in the latter part of that year. DECC will now commission further work on the environmental implications of further licensing, taking account of all new knowledge arising since the earlier assessment was compiled, and will conduct a full public consultation on the extended assessment. The results of this consultation will be fully considered before any decisions are taken on new licensing.¹¹¹

¹⁰⁵ www.halliburton.com/public/pe/contents/Papers_and_Articles/web/Q_through_Z/Shale%20Gas%20in%20Europe%20Drilling%20Contractor%20article.pdf – Accessed May 2013.

¹⁰⁶ www.gov.uk/government/speeches/written-ministerial-statement-by-edward-davey-exploration-for-shale-gas - Accessed June 2013.

¹⁰⁷ www.gov.uk/government/speeches/written-ministerial-statement-by-edward-davey-exploration-for-shale-gas - Accessed June 2013.

¹⁰⁸ *The Environmental Permitting Regulations (England and Wales) 2010.*

¹⁰⁹ www.gov.uk/government/speeches/written-ministerial-statement-by-edward-davey-exploration-for-shale-gas - Accessed June 2013.

¹¹⁰ www.og.decc.gov.uk/UKpromote/onshore_paper/UK_onshore_shalegas.pdf - Accessed June 2013.

¹¹¹ www.gov.uk/government/speeches/written-ministerial-statement-by-edward-davey-exploration-for-shale-gas - Accessed June 2013.

Is there any other protection if things go wrong?

Every precaution is taken to ensure that no detriment comes to the environment but at the worst case scenario stage, if environmental damage were to occur, the risk of damage by a drilling company will be covered by insurance. The insurance industry has historically responded to environmental claims, which were firmly grounded in the law of tort, where the case law was well understood and insurers were comfortable with the parameters set out in such cases. Claims based on nuisance, trespass, negligence or strict liabilities, including liability for escaping substances, see *Rylands v Fletcher*,¹¹² were a regular feature in insurer's casebooks. Today it is a different story. Insurers are now bound by UK legislation as well as considerable legislation from the EU. Tort based claims will always arise but legislation ensures that those who cause pollution damage, or enable it to continue, will be held to account. The earliest major statutory instrument was the Environmental Protection Act¹¹³ (EPA), part 2A of which deals with contaminated land. The EPA is complemented by the Environmental Act¹¹⁴ (EA), The Groundwater Regulations,¹¹⁵ the Contaminated Land Regulations,¹¹⁶ and the Water Resources Act.¹¹⁷ The EPA places an obligation on local authorities to develop a contaminated land strategy, including recording potentially contaminated sites within their jurisdiction. This involves two classes, Class A referring to those who caused or knowingly permitted the contamination and Class B, referring to the owner or subsequent occupier of the land where no Class A is identifiable. The legislation clearly affects any party owning or occupying land, such as developers, contractors and, above all, clients who own or are purchasing the land.

Controlled waterways such as surface water groundwater and off-shore coastal waters are regulated by the Environment Agency who have powers under the Water Resources Act. Further regulations occurred in 2009. The Environmental Damage (Prevention and Remediation) Regulations, SI 2009/995 require companies operating in the EU to take necessary action to avoid causing significant damage to the environment and to rectify any significant damage that is caused. These measures are broader than those required in previous legislation, widening the net to catch those in the wrong. Regulation will not end there as the range of environmental risks continues to grow. Fracking is a major concern for lawmakers and environmental experts understand that new technologies bring these new risks. Small wonder that insurers moved in some years ago to control their general liability policies by excluding damage caused directly or indirectly by pollution or contamination other than caused by a sudden identifiable, unintended and unexpected incident. The comprehensive regulations now in place will ensure no potential polluter can escape responsibility for direct damage claims, consequential losses and clean up costs. Bespoke insurance cover is essential and the environmental impairment liability (EIL) market continues to expand to meet this demand.¹¹⁸

Insurance and legislation for the shale gas drilling industry here in the UK will be substantial. In Ohio, USA, a well owner is required to obtain liability insurance coverage of not less than one million dollars coverage for personal injury and property damages resulting from any process stage of oil and gas production.¹¹⁹ If the well is located in an urban area, the amount of insurance

¹¹² *Rylands v Fletcher* (1868) LR 3 HL 330, [1861-73] All ER Rep 1, HL.

¹¹³ Environmental Protection Act 1990 (c. 43).

¹¹⁴ Environmental Act 1995 (c. 25).

¹¹⁵ The Groundwater Regulations 1998 (No. 2746).

¹¹⁶ The Contaminated Land (England) Regulations 2000 (No. 227).

¹¹⁷ Water Resources Act 1991 (c. 57).

¹¹⁸ J D Wright, 'Environmental risk growing' (2013) 24 4 Cons Law 29 at 31.

¹¹⁹ Ohio Rev Code Ann § 1509.07 (West 2012).

coverage must be no less than three million dollars.¹²⁰ Also, the well owner must execute and file a surety bond conditioned on complying with all applicable requirements of the division.¹²¹ The scope of insurance is furthered as the state requires the transporter section of any operation to hold liability insurance in an amount not less than three hundred thousand dollars for property damage and the same figure to cover personal injury resulting from the 'brine'.¹²² 'Brine' is defined as all saline geological formation water resulting from, obtained from, or produced in connection with exploration, drilling, stimulation, production, or plugging of a well.¹²³ Statute also provides that no 'brine' shall be placed in any water or surface in a way that could reasonably be anticipated to cause water used for consumption to exceed the standards contained within the relevant legislation,¹²⁴ in this case the Safe Drinking Water Act,¹²⁵ and well stimulation must not endanger underground sources of drinking water.¹²⁶ Generally Ohio mandates that no owner shall construct a well, or permit defective casing in a well to leak fluids or gases, that cause damage to other permeable strata, underground sources of drinking water, or the surface of the land or that threatens the public health and safety or environment.¹²⁷ The environment is a hugely important issue, especially when potentially damaging techniques such as fracking are involved. It would be fair to assume that in the coming years, the legislation relating to the environment, and particularly the effect shale gas extraction has on the environment, will be vast. The benefit the UK industry has is being able to learn from the experiences in America.

There are limitations of public liability policies in respect of pollution costs and these have been highlighted in case law. In *Yorkshire Water*

*Services Ltd*¹²⁸ the Court of Appeal affirmed that the public liability wording does not contemplate some legal liability in the abstract, but rather a particular liability to a third party which has suffered loss or damage in respect of a tortious act. The peril insured is the event which results in actual legal liability established, not that which may have led to such a legal liability. This point was stressed in *Bartoline Ltd*.¹²⁹ Here costs were incurred by the policyholder in complying with statutory notices served on them by the Environment Agency. These costs were claimed against the insurers on the basis that they were covered by the phrase 'legal liability for damages' in the operative clause of the policy. The costs of complying with the statutory notices and the cleanup costs incurred were held to be those needed to protect the public interest and sustain the integrity of the environment. The damages referred to in a public liability policy on the other hand are those awarded to protect individual interests in property. The initiatives to clean up and improve the environment will no doubt continue to tax the minds of those involved with land ownership, development and occupancy, and suitable environmental impairment insurance will become a necessity in many cases.¹³⁰ For those associated with shale drilling in the future, the area of insurance to protect the environment will be a massive issue.

¹²⁰ *Ohio Rev Code Ann* § 1509.07 (West 2012).

¹²¹ *Ohio Rev Code Ann* § 1509.07 (West 2012).

¹²² *Ohio Rev Code Ann* § 1509.222 (A) (2) (West 2012).

¹²³ *Ohio Rev Code Ann* § 1509.01 (U) (West 2012).

¹²⁴ *Ohio Rev Code Ann* § 1509.22 (A) (1) (West 2012).

¹²⁵ *Safe Drinking Water Act* 42 USC.

¹²⁶ *Ohio Rev Code Ann* § 1509.19 (West 2012).

¹²⁷ *Ohio Rev Code Ann* § 1509.12 (West 2012).

¹²⁸ *Yorkshire Water Services Ltd v Sun Alliance & London Insurance plc (No 1)* [1997] 2 Lloyd's Rep 21, [1997] CLC 213, (1996) 93 (34) LSG 34.

¹²⁹ *Bartoline Limited v Royal & Sun Alliance Insurance plc and Heath Lambert Limited* [2007] All ER (d) 59.

¹³⁰ J D Wright, 'Environmental risk growing' (2013) 24 4 Cons Law 29 at 31.

Water, water everywhere, and not a drop to drink...?

The increased interest in extraction of shale gas in the UK and the experience of the growing economy in the US has led to increased awareness of possible environmental concerns, particularly the allocation and contamination of drinking water. The debate surrounding the safety of shale gas extraction and hydraulic fracturing has focussed on gas leakage and contamination of shallow groundwater¹³¹ and the atmosphere,¹³² hydraulic connectivity between deep shale formations and shallow aquifers,¹³³ water use,¹³⁴ air quality¹³⁵ and potential contamination from the fracturing fluid.¹³⁶ Using the US as an example, significant volumes of water, approximately 500m³/well for the Marcellus Shale up to 5,000m³/well for the deeper Haynesville Shale are used for drilling the well and between 10,000 and 50,000m³/well are used for the fracturing process with added sand, organic and inorganic chemicals. Several hundred wells, Fayetteville and Haynesville Shale, and close to 1000 (Barnett and Marcellus Shale) wells were completed during peak years, the total volume of fresh water used for drilling and fracturing in some cases is high, approaching 10 million m³/year for the Barnett and Marcellus Shale.¹³⁷

Calculations show that the total water used in the drilling and fracturing process is relatively low compared to the total consumptive water usage in wet regions but much higher in arid regions where water needed for extraction could be a significant constraint as its use could impact on domestic use, irrigation or other uses.¹³⁸ Reclaiming and

reusing water is quite expensive but possible where levels of salinity are low (less than 10,000 mg/L TDS) as demonstrated at Placerita oil field in California,¹³⁹ but extremely complicated and expensive for produced and flow back waters from Marcellus, Haynesville and other shales where salinity can be as high as 200,000 mg/l TDS. The high salt concentration limits the successful use of membrane technology but other options including distillation and crystallisation are being investigated.¹⁴⁰

Following the completion of fracturing, the fluid pressure that is essential for the process is dropped causing the 'flow back' of the brine which is a mixture of fracturing fluid and formation water which returns through the well casing. During the two to three week flow back period for a Marcellus shale, 10-50% of the fluid returns to the surface, initially at high rates of around 1000m³/day, decreasing steadily to around 50m³/day. The salinity of the flow back water was initially moderate at around 45,000 mg/L TDS, reflecting the composition of the water, and increasing to 170,000 mg/L TDS.

Potential contamination of groundwater and surface water by the natural and added organic and inorganic chemicals in flow back and produced waters is one of the major concerns associated with shale gas production.¹⁴¹ This concern may be warranted in the US as results of groundwater analyses indicated that private water wells in parts of Pennsylvania and New

- ¹³¹ Osborn et al, 'Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing' (2011) PNAS 108, 8172-8176.
- ¹³² Howarth et al, 'Methane and the greenhouse-gas footprint of natural gas from shale formations' (2011) Climatic Change 106, 679-690.
- ¹³³ www.pnas.org/content/suppl/2012/07/06/1121181109.DCSupplemental/pnas.1121181109_SI.pdf - Accessed June 2013.
- ¹³⁴ J P Nicot, B R Scanlon, 'Water Use for Shale-Gas Production in Texas, US' (2012) Env Sco Technol 46, 3580-3586.
- ¹³⁵ www.endocrinedisruption.com/files/HERA12-137NGAirQualityManuscriptforwebwithfigures.pdf - Accessed June 2013.
- ¹³⁶ K B Gregory, 'Water management challenges associated with the production of shale gas by hydraulic fracturing' (2011) Elements 7, 181-186.
- ¹³⁷ www.eogresources.com/responsibility/doeModernShaleGasDevelopment.pdf - Accessed June 2013.
- ¹³⁸ J P Nicot, B R Scanlon, 'Water use for shale gas production in Texas USA' (2012) Environmental Science and Technology 46, 3580-3586.
- ¹³⁹ www.spe.org/jpt/print/archives/1999/06/JPT1999_06_HSE.pdf - Accessed June 2013.
- ¹⁴⁰ www.circleofblue.org/waternews/wp-content/uploads/2010/09/ANL_EVS_R09_produced_water_volume_report_2437.pdf - Accessed June 2013.
- ¹⁴¹ Kargbo et al, 'Natural gas plays in the Marcellus Shale: Challenges and potential opportunities' (2010) Environmental Science & Technology 44, 5679-5684.

York showed an association between shale gas operations and methane contamination of drinking water.¹⁴² Groundwater samples were analysed to offer an alternative hypothesis¹⁴³ that natural fractures, not those from shale gas operations, could be responsible for the stray methane detected in the wells. Geochemical evidence also pointed the finger at natural fractures as opposed to shale gas operations to explain the connections between some shallow groundwater and deep formation water from north-eastern Pennsylvania.¹⁴⁴ Studies show that the improper management of flow back and produced water,¹⁴⁵ as is the case for conventional oil and gas operations,¹⁴⁶ posed the greatest risk to ground water contamination. Significant groundwater contamination has resulted mainly from improper disposal of saline produced water, leaks through production and improperly sealed legacy wells and from hydrocarbons and produced water discharging from malfunctioning equipment, vandalism and accidents.¹⁴⁷ It must be stressed the UK are placing great levels of importance on the safe operation of wells and protecting the environment as discussed in this paper. The industry will be far more heavily regulated here than in the US.

142 Osborn et al, 'Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing' (2011) PNAS 108, 8172-8176.

143 Molofsky et al, 'Methane in Pennsylvania groundwaters unrelated to Marcellus shale hydraulic fracturing' (2011) Oil and Gas Journal 109, 49.

144 Warner et al, 'Geochemical evidence for possible natural migration of Marcellus Formation brine to shallow aquifers in Pennsylvania' (2012) PNAS 109, 11961-11966.

145 D J Rozell, S J Reaven, 'Water pollution risk associated with natural gas extraction from the Marcellus shale' (2012) Risk Analysis 32, 1382-1393.

146 Y K Kharaka, N S Dorsey, 'Environmental issues of petroleum exploration and production: Introduction to special issue on protected water' (2005) Environmental Geosciences 12, 61-63.

147 Y K Kharaka, J K Otton, 'Preface to Special Issue on Environmental Issues Related to Oil and Gas Production' (2007) Applied Geochem 22, 2095-2098.

What is it, how do we get it and how will it tie in with the future of the grid?

GATHERING

The gathering and processing of shale gas will largely be an issue of geography and volume. Unfortunately the developments in the area of gathering and processing in the UK are few and therefore it is best to use the US framework to provide an idea of what may be required. After the gas is produced to the surface, a gathering system collects and transports the gas in its raw form from the wellhead to the processing plant.¹⁴⁸ As an example, Ohio in the US has extensive experience in developing gas gathering systems. Dominion East Ohio, the local distribution company in Ohio, is a regulated utility with 1,196 miles of transmission and storage pipelines, 1,413 miles of gathering pipelines and 19,667 miles of distribution pipeline. Dominion East gathers approximately 80 percent of all Ohio natural gas production, equivalent to supply energy to 650,000 homes.¹⁴⁹ Work is underway to ensure the readiness of gathering pipeline. Dominion is converting some natural gas transmission lines into gathering lines for wet gas in anticipation of Utica Shale production.¹⁵⁰ Typically a wellhead can accommodate from 4 to 10 wells, importance is placed upon maximising the amount of wells per wellhead to minimise environmental impact by reducing the number of well pads. As reference, 8 wellheads per well pad are considered typical design. In addition to the wellheads, the well pad comprises gas-liquid separators, one for each well, and the produced water tanks. If condensates are in the gas stream, these are separated from the gas and water streams in the separators and stored in dedicated tanks. Produced water is then loaded on trucks and moved to a central treatment facility for reuse or reinjection. All the utilities required by well pad facilities must be present unless they are not already available in the vicinity.

PROCESSING

Extracting gas from the ground is only the first step in providing fuel for energy requirements to households in the UK. In areas of wet gas extraction, significant amounts of investment and development occur at processing facilities. The composition of gas produced from shale extraction can vary widely, one method of drawing distinction between these differences can be the allocation of the 'dry' or 'wet' status. Dry gas is primarily methane with not much else. Dry gas resembles the natural gas product that is delivered to consumers. Dry gas is more 'thermally mature' due to the extremes of pressure and temperature exerted underground over time. The gas extracted from the Marcellus Shale in the US, for example, is wet. In addition to methane the gas contains amounts of butane and ethane. These liquid natural gases can be separated and sold individually.¹⁵¹ The difference between the two is important because in the US, domestic gas production has driven down the price drillers can sell the gas for. Prices in March of 2013 hit an intraday high but had been declining previously, bottoming at ten year lows in 2012.¹⁵² Natural gas is relatively cheap and will remain that way for a long time to come. Shale gas is attracting large amounts of interest because the methane and ethane make wet gas production and processing a very attractive economic endeavour. The hydrocarbons that are auxiliary to the methane delivered to homes are extremely valuable and are used in other industries such as plastics. The presence of these extra gases presents a real opportunity to develop spin off industries in those places where they are extracted.¹⁵³

So, what happens to the gas when it is pumped? The gas recovered from shales is the same natural gas we already use, it is no more 'unconventional' than the gas we already enjoy. Natural gas is

¹⁴⁸ www.naturalgas.org/naturalgas/transport.asp - Accessed June 2013.

¹⁴⁹ http://enterpriseappalachia.com/assets/shalegas_whitepaper_fnl.pdf - Accessed June 2013.

¹⁵⁰ www.gasbb.com/?PageID=157&article_id=2272 – Accessed June 2013.

¹⁵¹ <http://stateimpact.npr.org/pennsylvania/tag/natural-gas-prices/> - Accessed June 2013.

¹⁵² www.cnbc.com/id/100597089 - Accessed June 2013.

¹⁵³ Andrew Thomas, Executive in Residence, Centre for Energy Policy, Maxine Levin Goodman College of Urban Affairs, Cleveland State University.

the cleanest, safest and most efficient of energy sources.¹⁵⁴ It has a carbon dioxide emission factor of approximately 26% and 41% lower than that of oil and coal respectively when combusted.¹⁵⁵ Natural gas consists primarily of methane¹⁵⁶ and contains varying amounts of heavier hydrocarbons, acid gases, water vapour, mercury, radioactive gases and some other gases such as nitrogen and helium.¹⁵⁷ Although this is somewhat typical, the actual composition of natural gas varies from place to place.¹⁵⁸ Due to all these additives and the by-products discussed above, the raw natural gas needs to be purified in order to meet the quality standard set in the Gas Safety (Management) Regulations¹⁵⁹ and specified by major pipeline transmission and distribution companies.¹⁶⁰ Two major processes in raw natural gas processing are gas dehydration and gas sweetening.¹⁶¹ In sweetening, much more research has been dedicated to the removal of CO₂ due to its abundance in the raw natural gas than hydrogen sulphide. CO₂ removal will enhance the calorific value of natural gas thereby decreasing the volume of gas to be transported through pipelines and cylinders, prevent atmospheric pollution and reduce corrosion.¹⁶² Therefore the removal of CO₂, which is the most prominent greenhouse gas on earth,¹⁶³ has direct and indirect contributions to atmospheric control.

Shale represents an astonishingly large source of natural gas and natural gas liquids. However, a common misconception seems to be that, for

the most part, shale gases are sweet and do not require treatment to be injected in to the grid.¹⁶⁴ Although shale gases are not highly sour in the traditional sense of having a high hydrogen sulphide content, shale gas often contains tens or hundreds of parts per million of H₂S with wide variability in CO₂. Gas in the Barnett shale play for North Texas, for example, contains several hundred parts per million by volume of hydrogen sulphide and several percentages of CO₂ which makes it far from pipeline quality. There can be considerable variation from play to play and even from well to well in the same play meaning that treatment of the gas is highly subjective.

In the Haynesville and Eagleford field of the Eagleford play, hydrogen sulphide is known to be present whereas in the Antrim and New Albany plays, underlying sour Devonian formations may communicate with and contaminate the shale formations.¹⁶⁵ Some plays in Western Canada have low CO₂ but enough H₂S content to require treatment. Therefore after removing the natural gas liquids, there are situations in which the gas needs to be treated to meet pipeline specifications, at least for sulphur content.

The challenge in treating such gases is the very low H₂S-to-CO₂ ratio and the desire to meet, but not exceed, pipeline specifications on CO₂ content. In terms of economic viability, the solvent of choice for H₂S removal and CO₂ slip is N-methyldiethanolamine which is used in a traditional gas treating plant.

¹⁵⁴ Schoots et al, 'Historical variation in the capital costs of natural gas, carbon dioxide and hydrogen pipelines and implications for future infrastructure' (2011) *International Journal of Greenhouse Gas Control* 5, 1614-1623; Xiao et al, 'The strategies of molecular architecture and modification of polyimide-based membranes for CO₂ removal from natural gas – a review' (2009) *Progress in Polymer Science* 34, 561-580.

¹⁵⁵ Adewole et al, 'Current challenges in membrane separation of CO₂ from natural gas: A Review' (2013) *International Journal of Greenhouse Gas Control* 17, 46-65.

¹⁵⁶ Adewole et al, 'Bulk and surface mechanical properties of clay modified HDPE used in liner applications' (2012) *Canadian Journal of Chemical Engineering* 90, 1066-1078.

¹⁵⁷ Vincenzo Balzani, Nicola Armaroli, *Energy for a Sustainable World*, 2010.

¹⁵⁸ R W Baker, L Lokhandwala, 'Natural gas processing with membranes. An overview' (2008) *Industrial and Engineering Chemistry Research* 47, 2109-2121.

¹⁵⁹ Gas Safety (Management) Regulations 1996 (1996 No. 51).

¹⁶⁰ www.nationalgrid.com/uk/Gas/Connections/ntsentry/entry_conn_processes/ - Accessed June 2013.

¹⁶¹ Scholes et al, 'Plasticization of ultra-thin polysulfone membranes by carbon dioxide' (2010) *Journal of Membrane Science* 346, 208-214.

¹⁶² Chew et al, 'Ordered mesoporous silica (OMS) as an adsorbent and membrane for separation of carbon dioxide (CO₂)' (2010) *Advances in Colloid and Interface Science* 153, 43-57; Ren et al, 'Development of asymmetric 6FDA-2, 6DAT hollow fiber membranes for CO₂/CH₄ separation 1. The influence of dope composition and rheology on membrane morphology and separation performance' (2002) *Journal of Membrane Science* 207, 227-240.

¹⁶³ Mohammadi et al, 'Effect of synthesis parameters on single gas permeation through T-type zeolite membranes' (2008) *International Journal of Greenhouse Gas Control* 2, 531-538.

¹⁶⁴ R Weiland, N Hatcher, 'Overcome challenges in treating shale gases' (2012) *Hydrocarbon Processing* 91(1), 45.

¹⁶⁵ J C Hunter, 'The New Albany Shale from an Antrim Shale Operators Perspective' RPSEA/GTI Gas Shale Forum, Des Plains, Illinois, June 4, 2009.

DELIVERY AND STORAGE

Once extracted and processed, a well-planned and engineered delivery system is critical to deliver the gas to the consumer. Much of the US already boasts a delivery system that can quickly and efficiently transport gas across numerous states and the UK already has an extensive infrastructure which could take any produced gas to market.¹⁶⁶ The Royal Society's report has shown how shale gas can be produced safely with due care and attention.

The development of the shale gas industry not only raises new environmental, regulatory and legislative issues, but more tangible distribution issues when we consider exactly how this gas will get from the well head to our appliances at home. Unfortunately little progress has been made in this particular aspect of the industry as no gas has been extracted. Here the best framework for possible developments here in the UK, is the US where the abundance of shale gas and the resulting transportation needs have pushed investment in new gas transmission pipelines.¹⁶⁷ The federal Energy Information Administration stated that pipeline companies spent \$1.1 billion on three transmission lines which is more than half that spent national levels in 2012. The capacity of pipes was the second highest for any year since 1997¹⁶⁸ meaning that pipes are getting fatter as well as more frequent. Whether the gas is obtained from a shale formation or another source, the natural gas supply chain is the same. It encompasses wells, gathering and processing facilities, storage, transportation and distribution pipelines and ultimately, an end user in industry or a family home. Getting gas out of the ground and to the customer, however, requires significant infrastructure in a lot of places across the world.¹⁶⁹ Significant infrastructure usually goes hand-in-hand with significant investment. The UK

currently has excellent gas infrastructure. The UK gas distribution network is one of the finest in the world boasting the ability to exploit shale gas reserves without the need for large amounts of investment for vast amounts of infrastructure.

During development, the distribution network in the UK entered a rapid stage of development when, with the prospect of the introduction of natural gas, and especially with the exploration of the UK Continental Shelf and the discoveries of several extended gas fields, the Gas Council and British Gas Corporation acquired the exclusive and monopoly rights to the sale of gas.¹⁷⁰ A monopsony regime was established that defined the development of the network. The monopolist power of the Gas Council was established through the provisions of the Continental Shelf Act¹⁷¹ and the Gas Act.¹⁷² The Gas Council and the Area Boards exercised extensive power and rights in the management of the flows, distribution and the sale of natural gas. It is argued that the development of the LNG transmission network facilitated the integration of the natural gas network in providing the infrastructure for the fast and smooth implementation of natural gas.¹⁷³ Before the discovery of North Sea natural gas reserves, various schemes were devised to aid the transport and import of LNG, most notably, the import of LNG from Venezuela and from Nigeria as well the construction of a pipeline from Holland. In all cases LNG was introduced as a viable, technical solution that fitted within the previous framework that was built around the manufacture and distribution of town gas. Generally it has been acknowledged that the liquefaction of natural gas added major flexibility as its volume could be reduced by 600 times. This was a significant advantage over coal gas which could not be liquefied as the hydrogen content could only be liquefied at -252 degrees Celsius¹⁷⁴ for small scale storage and particular industrial uses.

¹⁶⁶ <http://blogs.ft.com/nick-butler/2013/06/04/shale-gas-and-competitiveness/> – Accessed June 2013.

¹⁶⁷ www.ogfj.com/articles/2013/04/shale-gas-pipelines-growing-rapidly-around-marcellus.html - Accessed June 2013.

¹⁶⁸ <http://triblive.com/business/headlines/3733713-74/billion-gas-pipeline#axzz2V9l0p9kM> – Accessed June 2013.

¹⁶⁹ www.aiche.org/sites/default/files/cep/20120834_0.pdf - Accessed June 2013.

¹⁷⁰ UK Energy Research Centre, *Natural gas network development in the UK (1960-2010)*, December 2011, UKERC/RS/CCS/2012/008.

¹⁷¹ Continental Shelf Act 1964 (c 29).

¹⁷² Gas Act 1965 (c 36).

¹⁷³ UK Energy Research Centre, *Natural gas network development in the UK (1960-2010)*, December 2011, UKERC/RS/CCS/2012/008.

¹⁷⁴ www.roymech.co.uk/Useful_Tables/Matter/Prop_Gas.htm - Accessed July 2013.

LNG first arrived from Algeria in October 1964. A transmission network was built establishing a 'backbone system' for subsequent developments and the creation of the natural gas transmission system. This new framework changed the way supply was organised a moved away from local production towards a more integrated system. 'The extension of these developments towards a fully integrated national system was always regarded as an ultimate development'.¹⁷⁵ The pace of these developments was dictated by the large amounts of LNG imported for the enrichment of town gas, as well as the discovery of natural gas in the North Sea. With the North Sea discovery and the subsequent integration of natural gas in the energy system in Britain, LNG started to be used as a backup supply of natural gas in periods of peak demand or to supply areas in which the supply grid had not reached. By 1971 a network of large diameter high pressure feeder mains and extensions had been constructed rapidly providing transmission infrastructure from the terminals to the Area Boards and to large industrial undertakings.

Currently the National Transmission System is operated and maintained by National Grid Transco. It comprises terminals, compressor stations, pipeline systems and off takes.¹⁷⁶ The gas is transported through more than 7,600km of pipelines ranging in diameter from 63mm to 1200mm, at pressures up to 85 bar.¹⁷⁷ Shale gas recovered from the ground will be processed in the same way natural gas currently is, and injected into the existing gas grid requiring very little in the way of infrastructure, unlike a lot of other places in the world.

The Climate Change Act requires the UK to reduce carbon dioxide emissions by 2050 to 80% of 1990 emissions output. Studies into how the UK can meet the targets imposed by the EU, underpinned by the UK MARKAL energy systems model, have proposed that low-pressure gas pipelines should be decommissioned by 2050 with heating provided by electric heat pumps or biomass boilers.¹⁷⁸ Since the UK gas network supplies around 22.9 million customers,¹⁷⁹ this represents a profound change to the UK energy system.

Notwithstanding these EU studies, a thirty year accelerated iron mains replacement programme is currently underway to replace around 100,000 km of low-pressure iron distribution and attached service pipes near buildings with polyethylene pipes for safety reasons.¹⁸⁰ This is a significant investment in network infrastructure. Since the lifespan of pipeline is considerable, the capital stock from the replacement programme will be retired early if gas use is curtailed by 2050. An alternative option is to use the network to pipe biomethane produced from biomass in place of the natural gas currently being piped.¹⁸¹ The Government has yet to adopt a position on the long-term future of the gas system¹⁸² but it has identified biomethane and hydrogen as potential carbon-neutral sources of heat in the future.¹⁸³ There is growing pressure from the industry for the Government to define the long-term strategy for the networks.¹⁸⁴ In response, the Government has recently decided to explore the future of the gas network through consultations with the industry¹⁸⁵ regarding whole system modelling. Not many have considered the long-term future of the network with only minor exceptions.¹⁸⁶

¹⁷⁵ W J Walters, 'Development of Natural Gas Supply System' (Aug 1971) *Institution of Gas Engineers Journal*, 549.

¹⁷⁶ www.see.ed.ac.uk/~mzaiser/4thyear/websites05/MacRonald/Website/3-2.html - Accessed July 2013.

¹⁷⁷ www.nationalgrid.com/uk/Gas/About/How+Gas+is+Delivered/ - Accessed July 2013.

¹⁷⁸ F Kesicki, 'Costs and potentials of reducing CO₂ emissions in the UK domestic stock from a systems perspective' (2012) *Energy and Buildings* 51, 203-211.

¹⁷⁹ DECC Digest of United Kingdom Energy Statistics 2012 – available at www.gov.uk/government/uploads/system/uploads/attachment_data/file/82879/5950-dukes-2012-internet.pdf - Accessed June 2013.

¹⁸⁰ www.hse.gov.uk/gas/supply/mainsreplacement/irongasmain.htm - Accessed June 2013.

¹⁸¹ www.nationalgrid.com/uk/Media+Centre/Documents/biogas.htm - Accessed June 2013.

¹⁸² www.gov.uk/government/uploads/system/uploads/attachment_data/file/47613/3702-the-carbon-plan-delivering-our-low-carbon-future.pdf - Accessed June 2013.

¹⁸³ www.gov.uk/government/uploads/system/uploads/attachment_data/file/48574/4805-future-heating-strategic-framework.pdf - Accessed June 2013.

¹⁸⁴ www.energynetworks.org/gas/futures/gas-futures-reports.html - Accessed June 2013.

¹⁸⁵ www.gov.uk/government/uploads/system/uploads/attachment_data/file/190149/16_04-DECC-The_Future_of_Heating_Accessible-10.pdf - Accessed June 2013.

¹⁸⁶ www.oxfordenergy.org/2011/05/does-natural-gas-need-a-decarbonisation-strategy-the-cases-of-the-netherlands-and-the-uk/ - Accessed June 2013.

The governments view on the future and incentives

The road to industry perfection is by no means free from hazard. Much research in the area focuses on the inroads made in the US industry and the various successes attained there. The point to be stressed is that although the basic technology is the same, we are two very different environments economically, legally and geographically. Shale plays here in the UK are smaller, deeper and contain a higher clay content. This clay will make the fracking process far more difficult. As explained, the legal environment is considerably dense in the UK and will only continue to grow. The stringent regulations regarding water and the environment are much more stringent than in the US which creates more barriers to exploration and extraction. In the UK and Poland, the full disclosure of the content of fracking fluid is required. Groundwater protection and waste treatment are stronger in the UK than they are in the US but adversely, unconventional hydrocarbons are not mentioned in the petroleum regulations. In the US, the Energy Act excludes oil and gas companies from Environmental Protection Agency's Clean Water Act among other instruments, further encouraging bad practise and corner-cutting at the expense of the environment. Regulatory uncertainty is slowing down the advance of the industry across Europe. In 1980, the Energy Act gave tax credits amounting to 50 cents per million BTU's in the US and also introduced the Intangible Drilling Cost Expensing Rule which covered in excess of 70% of well development costs which was a crucial incentive for small firms with limited cash flow. Currently in Europe only Hungary has some small tax credits for unconventional operations although recently the UK Government has started 'consulting on new tax incentives for shale gas'.¹⁸⁷ Here in the UK

we are not used to onshore oil and gas operations as they are in the US. Also, property rights in the UK reside with the state meaning that private residents will not see any compensation for disruption caused by the industry. In the US, land rights reside with the owners creating a financial incentive to allow the work to take place and also tolerate any disruptions. Industry can however contribute to significant levels of employment which could potentially enhance the attractiveness to local residents and communities. Pipeline access in the US is based upon 'common carriage' so gas producers have some access to existing pipelines transforming the economics of shale gas production, this teamed with a 'commodity supply gas market' comprising lots of buyers, sellers and a good price transparency means the gas is cheap and easy to sell. In the UK pipeline access is built upon 'third party access' which means if the pipeline is full, any gas suppliers must build their own pipeline to access the market. Europe is also a 'project supply market' with few buyers and sellers and poor price transparency leading to high transaction costs for buying and selling gas.

Natural gas consumption is expected to continue to grow significantly in coming decades due to its relatively low environmental impact,¹⁸⁸ although the actual impact is still heavily debated,¹⁸⁹ new discoveries that have led to lower prices and new access to supplies and the reduced appeal of nuclear energy after the Fukushima disaster.¹⁹⁰ Energy production throughout the world has been projected to peak between 2008 and 2040,¹⁹¹ after the peak in production, but the explosion of the Fukushima Daiichi nuclear power station affected global energy security in the short, medium and long term.¹⁹²

¹⁸⁷ www.guardian.co.uk/environment/2012/dec/05/gas-strategy-unveiled-george-osborne - Accessed May 2013.

¹⁸⁸ Energy Information Administration, *Natural Gas and the Environment* – Available at www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_trends/pdf/chapter2.pdf - Accessed April 2013.

¹⁸⁹ www.nytimes.com/2011/04/12/business/energy-environment/12gas.html?pagewanted=all&_r=0 – Accessed April 2013.

¹⁹⁰ www.bbc.co.uk/news/world-asia-21737910 - Accessed April 2013.

¹⁹¹ Imam et al, 'Multicyclic Hubbert model shows global conventional gas output peaking in 2019' (2004) *Oil and Gas Journal* 102(21), 20-28; S M Al-Fattah, R A Startzman, 'Forecasting world natural gas supply' (2000) *Journal of Petroleum Technology* 52(5), 62-72; J D Edwards, 'Crude oil and alternative energy production forecasts for the twenty-first century: the end of the hydrocarbon era' (1997) *AAPG Bulletin* 81(8), 1292-1305.

¹⁹² M Hayashi, L Hughes, 'The Fukushima nuclear accident and its effect on global energy security' (2012) *Energy Policy* (Available online 20th December 2012, In Press, Corrected Proof).

Although the UK government's position is far from set in stone, steps are being taken to make advances in the area. Energy Secretary Ed Davey has outlined the 'promising new potential' for shale gas in the UK whilst quelling any ideas of an overnight boom by stating that the UK 'are still in the very early stages of shale gas exploration in the UK and it is likely to develop slowly', as Cuadrilla are given the go-ahead to resume drilling in Lancashire.¹⁹³ To say that frameworks are not currently developing would be untrue. The Department of Energy and Climate Change (DECC) were aware in 2011 of the issues that the industry could face and were already taking steps to satisfy any potential problems. 'UK legislation needs to take account of the challenges unique to shale gas exploration and production' such as potential water contamination and further water stress on those regions already experiencing shortage.¹⁹⁴ It was stated that the Environmental Agency needed to ensure that companies declare the type, concentration and volume of all chemicals added to the hydraulic fracturing fluid. Cuadrilla declared the chemicals they intended to use for the early stage of fracking comprising 99.7% water and sand with the remainder being a friction-reducing compound found in contact lenses, a weak hydrochloric acid used in swimming pools and a low concentration biocide that may not be used.¹⁹⁵ According to industry in the US, fracturing fluid is a mixture of about 90% water, 9.5% sand and 0.5% other chemicals. Although water is the main component, the number and type of additives varies based on the conditions of the specific well being fractured. The additives used in the US include common, everyday chemicals as well as potentially hazardous chemicals that are safe when handled properly.¹⁹⁶ It was concluded that countries with a greater dependence on gas such as Poland could see significant changes due to shale and

that it was important for the UK to monitor the development in Poland – the 'barometer of Europe' – on this issue, both in terms of exploration and regulation.¹⁹⁷ George Osborne MP has announced that the government will engage with the shale gas industry to develop a targeted tax regime.¹⁹⁸ With the industry in its infancy the government believes such a regime will stimulate investment in the area. The use of field allowances to encourage investment in the North Sea has demonstrated the effectiveness of a targeted tax regime in stimulating investment and production that would not otherwise have gone ahead.¹⁹⁹

The European Parliament has said that the emergence of exploration for shale oil and shale gas in some EU countries should be backed up with 'robust regulatory regimes' including environmentally-friendly processes and best available techniques to achieve the highest safety standards. Member states should also be 'cautious' about permitting exploitation of unconventional fossil fuels pending further analysis of whether EU-level regulation is appropriate.²⁰⁰ Domestic gas production in Europe is set to decline in the future but demand for it will continue to rise, pushing up imports to 450 billion cubic metres by 2035. New sources of natural gas, along with other measures such as boosting take-up of renewable and energy efficiency can help to achieve security of supply for the EU. Although the European Commission has concluded that EU rules adequately cover licensing and early exploration and production of shale gas, the prospect of expanding exploitation of unconventional fossil fuels suggests that 'a thorough analysis' of EU regulation on these fuels is needed, say MEPs in an Environment Committee report drafted by Boguslaw Sonik (EPP, PL) and adopted with 562 votes in favour, 86 against and 43 abstentions.²⁰¹ DECC have concluded that if

¹⁹³ www.bbc.co.uk/news/uk-20707574 - Accessed April 2013.

¹⁹⁴ House of Commons, Energy and Climate Change Committee, Shale Gas, Fifth Report of Session 2010-12, Volume I: Report, together with formal minutes, oral and written evidence p3 – available at www.gov.uk/government/uploads/system/uploads/attachment_data/file/79186/scishalegasvol1.pdf - Accessed April 2013.

¹⁹⁵ www.platts.com/RSSFeedDetailedNews/RSSFeed/NaturalGas/8531807 - Accessed April 2013.

¹⁹⁶ S Sakmar, 'The Global Shale Gas Initiative: Will the United States Be the Role Model for the Development of Shale Gas around the World?' (2010-2011) 33 *Hous J Int'l L* 380.

¹⁹⁷ House of Commons, Energy and Climate Change Committee, Shale Gas, Fifth Report of Session 2010-12, Volume I: Report, together with formal minutes, oral and written evidence p18 – available at www.gov.uk/government/uploads/system/uploads/attachment_data/file/79186/scishalegasvol1.pdf - Accessed April 2013.

¹⁹⁸ www.gov.uk/government/news/government-action-to-stimulate-shale-gas-investment - Accessed May 2013.

¹⁹⁹ R Cave, 'Shale gas tax' (2012) 33 *PTN* 20, 149(3).

²⁰⁰ www.europarl.europa.eu/pdfs/news/expert/infopress/20121116IPR55711/20121116IPR55711_en.pdf - Accessed May 2013.

economic and safe, shale gas could production could commence in the second part of this decade although the industry will grow much slower than that in the US. At this time, DECC also concluded that an Office for Unconventional Gas and Oil would be set up to work with Defra and other Government Departments to align Government responsibilities and ensure a streamlined regulatory process.²⁰² On the 11th of March, 2013, the Office for Unconventional Oil and Gas had their introductory event and outlined that Government and industry need to work together with local communities and all those who have a stake to make sure that we exploit the resources the earth has to offer in a way that is sustainable and acceptable. ‘Powering the country, providing prosperity, while protecting the planet for future generations’.²⁰³ After revealing that in excess of 330 exploration licenses have been approved for shale development in the UK, 60 of which have been described as ‘substantial’, Energy Minister Michael Fallon has stated that ‘robust regulations’ which will ‘accelerate shale gas development in a responsible way’ have been created by the Government to ensure development does not get out of hand. The landscape hinges on the findings of the British Geological Society in order to determine potential reserves in the UK but this has not stopped the majority of oil and gas companies expecting a boom, further reinforced by the amount of licenses granted so far.²⁰⁴ Not everybody believes that a boom is imminent. In a blow to Government attempts to stimulate investment in the industry, Shell have stated that ‘nobody knows whether shale will succeed in the UK and it has no desire to be the company that tries to find out’. The UK has to compete with successful and growing industry in the US and great opportunities in China, Ukraine and Russia and ‘right now nobody even knows whether the gas will flow’.²⁰⁵ Despite this distinct lack of faith, Cuadrilla are set to drill 31 miles south of London in Balcombe, Sussex in the summer of 2013.

Cuadrilla have emphasised that this exploration is drilling, not hydraulic fracturing and if there is not enough gas to flow, the well would be capped and abandoned. This has attracted some local concern but the Government has remained supportive in the hope that the shale industry can help boost the moribund economy. After the lifting of December 2012’s fracking ban, Secretary of State for Energy and Climate Change Ed Davey wrote: “I consider that new controls to minimise disturbance to those living and working nearby, and to prevent the risk of any damage are now a prerequisite for further exploration”. However, a new law, the Growth and Infrastructure bill can allow shale gas exploration to be deemed a ‘national significance’ and allow the Government to override local authorities in order to grant planning permission.²⁰⁶

In the Chancellor of the Exchequer’s Budget Statement it was said that Britain need to ‘tap into new sources of low cost energy like shale gas’ and ‘by the summer, new planning guidance will be available alongside specific proposals to allow local communities to benefit.’ ‘Shale gas is part of the future. And we will make it happen’.²⁰⁷ It seems then that the overall direction is clear, we are sailing towards a shale gas future, the wind that is to fill the sails, however, is yet to be seen. At this particular time when the boat sits in the dock, only a few companies are on the hill trying to fly their kites.

In recent weeks shale gas has been given excess coverage, mainly due to the announcement of heavy tax breaks by the Treasury in an attempt to further promote advances in the area with the introduction of a financial sweetener,²⁰⁸ despite the view from some critics that it won’t lead to a gas bonanza for the UK.²⁰⁹ The British Geological Society survey has also sparked even more interest with the claim that the UK could be sitting atop 40 trillion cubic meters of shale gas.²¹⁰ It should be noted, however, that the figure addresses prospective sources, not recoverable amounts.²¹¹ The industry seems quite

²⁰¹ www.europarl.europa.eu/pdfs/news/expert/infopress/20121116IPR55711/20121116IPR55711_en.pdf - Accessed May 2013.

²⁰² www.gov.uk/government/uploads/system/uploads/attachment_data/file/65654/7165-gas-generation-strategy.pdf - Accessed May 2013.

²⁰³ www.gov.uk/government/speeches/office-of-unconventional-oil-and-gas-introductory-event - Accessed May 2013.

²⁰⁴ www.businessgreen.com/bg/news/2268328/uk-shale-gas-government-promises-responsible-development - Accessed May 2013.

²⁰⁵ www.hazardexonthenet.net/article/58093/Shell-avoids-early-involvement-in-UK-shale-gas.aspx - Accessed May 2013.

²⁰⁶ www.cnbc.com/id/100722910 - Accessed May 2013.

²⁰⁷ *Chancellor of the Exchequer’s Budget Statement, Budget Statement (extracts) 20th March 2013.*

²⁰⁸ www.politicshome.com/uk/article/82293/treasury_govt_unveils_plan_to_kick_start_shale_gas_investment_with_generous_new_tax_breaks.html - Accessed July 2013.

²⁰⁹ www.carbonbrief.org/blog/2013/07/osborne%E2%80%99s-tax-breaks-are-unlikely-to-lead-to-shale-gas-bonanza – Accessed July 2013.

conclusive on the matter; we are in an exploratory phase and we should be exploring and putting concerns to rest. Reports exist that state shale gas can be extracted safely, the process, however, will be slow and difficult.²¹² The community is the greatest obstacle to the growth of the industry; it is generally believed that 'shoddy' bribes will not persuade communities to allow drilling to take place on their doorstep.²¹³ People will require large incentives in order to allow this to take place, but time spent working out how we divide the pie before there is any pie to share is time wasted. Suggestions have been made that the creation of a sovereign fund or something equally 'arms length' needs to be established to mitigate the chances of local level corruption. The minister of state for energy Michael Fallon stated that when it comes to public opinion, we cannot be complacent or assumptive. The public need to know the facts in order to be reassured and with a new 14th round on onshore licensing planned for next year, acreage, and subsequently development, is expected to be in high volume.²¹⁴

What we need to remember is that in an exploratory stage, one needs to explore. Cuadrilla have flowed gas from the Bowland despite misrepresentation that they have not and are struggling to speed up the planning process in order to drill six, six inch holes over a 1200 square foot area to test the potential for gas.²¹⁵ When essential processes like this are slowed, a point when community incentives are required seems a long way away. Shale takes decades to develop and we will take decades to develop the industry, if we keep focussing on what will happen in ten years however, nothing will happen tomorrow.

The Government has stated that they intend to drill forty wells over the next two years in order to assess the economic viability of shale gas in the UK.²¹⁶ The issue here is that the process of

obtaining permission to frack a location can take a year²¹⁷ which is entirely disproportionate when in Texas it can take as little as three weeks from surveying a site to selling the gas for injection.²¹⁸ Some may question this target and whether or not it is really achievable.

The Government needs to stand up and help the rolling stone of energy gather momentum if we are to achieve energy security in the long term which shale will undoubtedly play a substantial part in. At a time when the energy market is in a state of flux over where the future will lead, uncertainty of supply, back-tracking and public political infighting is heavily damaging to progress. The Autumn statement demonstrates how policy develops in times of financial austerity. Prior to the release of the Autumn statement, the coalition strategy for energy had been mainly aimed at using tax and fiscal incentives to encourage investment in green energy production and use equivalent disincentives to investment in 'high carbon' energy production methods. The announcement that the government is to consult on the tax regime for shale gas strongly suggests that there will be attractive incentives for investment in this method of energy production. Whilst little is given away as to the approach that will be taken in the consultation, there is an impression that the primary concern on energy policy is to obtain a secure and affordable supply in the medium-to long-term and that renewable energy is a lower priority than previously thought.²¹⁹

²¹⁰ www.gov.uk/government/news/estimates-of-shale-gas-resource-in-north-of-england-published-alongside-a-package-of-community-benefits - Accessed July 2013.

²¹¹ Douglas Bain, Dart Energy, UK Shale Summit 2013, 17th July 2013.

²¹² Tim Yeo MP, UK Shale Summit 2013, 17th July 2013.

²¹³ Ben Wallace MP, UK Shale Summit 2013, 17th July 2013.

²¹⁴ Michael Fallon, Minister of State for Energy, UK Shale Summit 2013, 17th July 2013.

²¹⁵ Francis Egan, Cuadrilla, UK Shale Summit 2013, 17th July 2013.

²¹⁶ www.utilityweek.co.uk/news/news_story.asp?id=198922&title=More+wells+needed+to+establish+shale+gas+viability – Accessed July 2013.

²¹⁷ Lonek Wojtulewicz, Head of Planning Leicestershire County Council, UK Shale Summit 2013, 17th July 2013.

²¹⁸ William Marble, Chief Engineering Officer, Hallwood Oil, UK Shale Summit 2013, 17th July 2013.

²¹⁹ M Hodkin, 'Clean Energy' (2012) Tax Journal, Issue 1150, 10 at 15.



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