Critically evaluate the extent to which the discovery of significant reserves of shale gas within the UK may lead to the development of this safe and cheap form of energy?

The play for shale gas - problems, process and progress in the UK

Introduction

With the extraordinary leap forward the production of shale gas has provided for the United States' own energy security (now 28% of total gas domestic production), it is not surprising that other countries are keen to replicate their success. In particular, advancements in hydraulic fracturing technology[1] and drilling[2] have enabled the development of shale gas[3] to become economically viable over the last decade.

The UK shale gas industry is still in its infancy while the US' commercial stage of development is described as 30 years ahead of the rest of the world. In 2011 the House of Commons Energy and Climate Change Committee reached the conclusion that while domestic resources could reduce the UK's dependence on imports, the effect on energy security is 'unlikely to be enormous'[4]. Other factors causing shale gas to be of less interest in the UK are its open gas market, large new import infrastructure and diversity of potential gas suppliers[5].

In order to gain a realistic perspective on the future development of the UK shale gas industry, this paper begins by exploring the future potential resources of shale gas production. Questions over size and recoverability of the physical resource are central to the debate, in addition to important distinctions of terminology to avoid common misconceptions.

Given the uncertainties surrounding the risks and impacts of shale gas extraction, the European Commission's Joint Research Centre ("JRC") has provided a review of the economic case for promoting shale gas in addition to

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[1] Definition: Hydraulic fracture stimulation, or "fracking', is a process that is used to create a large number of fractures in the rock, in order to allow the natural gas trapped in shales to move to the wellbore. Fracking can both increase production rates and increase the total amount of gas that can be recovered. Pump pressure causes the rock to fracture and water carries sand "proppant" into the hydraulic fracture to prop it open, allowing the flow of gas. Whilst water and sand are the main components of hydraulic fracture fluid, chemical additives are often added in small concentrations.

[2] Definition: Drilling: Horizontal drilling is one of the keys that made unconventional gas economically viable. Since the thickness of the pay zone is often insufficient, horizontal wells are drilled within each shale layer.

[3] Definition: A gas shale is an organically-rich shale formation, which in the classical definition can be both the source rock and cap rock of an oil or gas reservoir. The production of shale gas seemed impossible because of gas is tightly confined within the shale rock matrix. However, some years ago, technologies and procedures were developed that allowed industry to economically produce shale gas.

[4] HOC 2011

[5] Moore 2012

the adequacy of the current European regulatory system. While the report[6] generally supports the economic case for Europe, its emphasis on high production costs and limitations (such as water resource and extensive 'land-take'), specific to the UK, casts serious doubt over its economic viability. It also covers the key uncertainties of health, safety and environmental issues as well as the adequacy of environmental legislation. Another JRC report relied on in this paper is "*Shale Gas Extraction: The Main Environmental and Social Concerns*" which highlights the geographical and geological appropriateness of the UK and offers poignant studies unearthing the seriousness of the risks associated with fracking, in particular contamination of drinking water, the requirement of substantial volumes of freshwater, Co2 emissions and air pollution. Indicating its trajectory, the European Commission has included in its 2013 work programme the development of a Europe-wide regulatory framework focused on the efficient and environmentally sound extraction of shale gas.

While assessing how the UK is most likely to proceed in addressing the obstacles and opportunities inherent in the exploration, production and abandonment of shale gas extraction, this paper explores the costs associated with shale, the current applicable regulation and important gaps that exist in EC and UK environmental and safety instruments. Before its conclusion, the paper's final section will outline the proposed regulatory regime expected in the UK.

UK Policy Context

Following the discovery of shale resources, unconventional hydrocarbons are now more attractive. However, existing and future shale gas licences are likely to be increasingly controversial at the local level[7].

In light of differences in population density, environmental regulations, geology and tax breaks[8], it is far from certain that the UK will ever reach the scale required for commercial levels of production. During this exploratory phase, the UK Government and its relevant bodies: The Department of Energy and Climate Change ("DECC"), Health and Safety Executive ("HSE) and Environment Agency ("EA") are positively supporting the growth of the shale gas industry. For instance, much is being made of the UK's 30 years' experience of hydraulic fracturing and directional drilling for conventional gas (the UK's first shale gas well was in 1875 and 10% of 2000 wells have used fracking)[9]. Local authorities are being provided with dedicated teams and the Government has established

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[6] European Commission Joint Research Centre *Unconventional Gas: potential Energy Market Impacts in the European Union* 2012

[7] In January 2012 the Guardian carried a series of reports about local residents in West Sussex opposing plans from Cuadrilla to drill a test well under licence (*Guardian 12 Jan 2012 "No fracking in home counties, village residents tell oil company*")

[8] Stevens 2010

[9] pg 17 The Royal Society and Royal Academy of Engineering paper June 2012 *Shale Gas Extraction in the UK: A Review of Hydraulic Fracturing*

a new Office for Unconventional Oil and Gas (OUGO)[10]. Additionally, it has instigated consistent tax breaks, an anti-carbon tax, The Growth and Infrastructure Bill ("Clause 24") and the recent Energy Bill to introduce 'clean, secure and affordable' energy supplies.

The main locations for shale gas extraction in England are at five well sites in the counties of Lancashire, East Midlands, West Sussex and Kent. The first and most controversial test site is at Preese Hall in Lancashire which has generated multiple reviews, consultations and recommendations relating to mitigation of seismic activity (a moratorium was in place from 2011 to December 2012). Local planning permission has been denied at Llandow, Vale of Glamorgan (decision is being appealed with a public inquiry). In Northern Ireland, Tamboran Resources has identified an area which crosses the border between Northern Ireland and the Republic of Ireland. This site could gain interest because of the substantial water resources availability it offers.

The temporary moratorium[11] spelt slow progress at Preese Hall due to "vociferous" local opposition to exploratory drilling[12] compounded by confirmation that the small scale hydraulic fracturing, operated by Cuadrilla, had caused seismic tremors (the risk identified by the public to be the main safety issue along with contamination of ground and surface water and high density drilling in the countryside).

While local citizen and national environmental groups cause delays and express increasing opposition (on grounds of continued reliance on fossil fuels, high methane emissions, and "landtake" etc) during the pre-application stage, both the Government and the industry, led by Lord Browne (former chairman of BP) appear determined to push ahead on the grounds that shale gas provides a "bridging fuel", alongside renewables for "a low-carbon economy". Browne promises to invest 'whatever it takes'[13]. On the other hand, Friends of the Earth[14] argue Clause 24 is improperly fast-tracking shale gas applications without under-going the proper planning process. The legal position is advantageous to the industry with the ultimate decision-making power resting in the hands of the Secretary of State for Energy and Climate Change.

The Government's new Gas Generation Strategy indicates continuing support for shale gas. The real question is whether the UK shale gas industry could reach the

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[10] OUGO will work to achieve the following:
a) make the most of our natural resources; b) enable development, protect the environment and safeguard the public; c) make sure local communities benefit from development in their area; d) support public engagement; e) build our knowledge base.

[11] In December 2012 the UK Government lifted an 18 month moratorium on hydraulic fracturing. This ban was imposed in May 2011 after Cuadrilla's drilling and fracking techniques triggered two minor tremors or seismic incidents. Following extensive consultation of the risks and potential mitigation of those with the public and DECC, HSE and EA, having resumed exploration and drilling summer 2013, Cuadrilla has expressed they intend to find out more about the size and commercial potential of its reserves.

[12] 12th March *The Guardian* Lord Browne promises to invest 'whatever it takes' in UK fracking

[13] 12th March *The Guardian* Lord Browne promises to invest 'whatever it takes' in UK fracking

[14] Letters to the Editor Mon Feb 11 2013 *The Times*

industrial-scale required to achieve 'a cheap form of energy'? Or will it turn out to be an expensive and potentially environmentally damaging and polluting distraction from conventional oil and gas?[15]

Problem with estimates

In February 2013 a *Times* article entitled, '*Britain has shale gas for 1,500 years but bills won't be lower*' reported The British Geological Survey's (BGS) new 200-fold upwards estimate on shale gas reserves. Meanwhile, Secretary of State for Energy and Climate Change, Ed Davey, reportedly said, "*experts are clear they do not expect this to have a major impact on the gas price*." While the BGS' figures appear a dramatic increase in its estimates, (from 5.3 trillion cubic feet to between 1,300-1,700 trillion cubic feet), the *Times* highlighted, "*only a fifth of this gas would be technically recoverable…experts stressed it was much too early to say how much of the gas would be economic to get out of the ground*".

Previous estimates expectations produced by Cuadrilla Resources (200 trillion cubic feet of gas) have been lowered by BGS, who state only a tenth may be recoverable[16].

In JRC's 2012 report, the chapter addressing the problem over estimates stressed the inaccuracies and confusion created when interchanging terminology for conventional resources with unconventional resources (e.g. 'undiscovered resources'). Only since 2009 have countries like the UK provided estimates of *technically recoverable resources* ("TRR")[17], adding, "*it is only in the US that shale gas resources are considered proved reserves and these comprise only a small proportion[18] of the estimated TRR*. "

Terminology[19]

In a 2012 Q&A paper on the risks of hydraulic fracturing,[20] the UK Government stated the best estimates for UK shale '*could yield some 150 billion cubic meters of gas (5 trillion cubic ff) equivalent to roughly two years of UK demand'*. However, underlying the main lessons of the variability in shale gas estimates[21], they added, "*these are only estimates of the amount of gas in the rocks, not the amount of gas which could practically and commercially be produced from these rocks. They are "resource" estimates and not "reserve" estimates. No-one knows at this point what proportion, if any, of the gas in the ground will ever be practically and*

[15] Sam Sandilands 'Shale Gas - An Energy Saviour? In-House Lawyer Dec 2012
[16] "*What the Frack?" The Economist,* 1 October 2011 p.34
[17] pg 28 JRC "Unconventional Gas: Potential Energy Market Impacts in the European Union"
[18] proved resources reported by the EIA for 2009 are 1.7tcm and so comprise only 9% of the best estimates of TRR
[19] See Appendix
[20] December 2012 Q&A response to the Department of Energy and Climate Change ("DECC") consultation paper on the issue (X Synopsis of main questions raised in response to DECC consultation on mitigation of seismic risks from hydraulic fracturing for shale gas, with Government responses. Question: what about these huge numbers – bigger than the North Sea reserves – mentioned in the press? Pg 5
[21] JRC pg 16 "Unconventional Gas: Potential Energy Market Impacts in the European Union"

commercially producible." The inherent uncertainty of estimates is common for countries in the early stages of development [22]**.** The Government's "*best estimates*" are described as "*a very simple estimate of production potential…this estimate was not based on any detailed analysis of UK geology*."

It is essential not to confuse reserves with resources[23]. However, the headline for this paper, "the discovery of significant *reserves*", appears to do just that. The BGS's figures, commonly used, are estimates of *resources* not reserves.

Despite its exploration-only status, the JRC[24] gives the UK credit for its, "*extensive geological mapping of the rocks… throughout the UK*."[25] BGS's 2010 estimates of the Bowland Shale was a recoverable gas estimate for *an area based assessment*, i.e. analogous comparison between the Bowland basin and Barnett Shale.[26] In comparison Cuadrilla Resources' own gas-in-place (*volumetric based assessment*) estimate is approximately 200 tcf for its Bowland Shale licence area. However, based on US experience and current technological capability, it is expected that only 10% of this value (20 tcf) is likely to be technically recoverable.[27] Other operators, estimated the size of shale resources within their respective licence areas[28] but only Cuadrilla's estimates used the more reliable 'measured data' from two wells[29].

The most accurate estimates on offer today are BGS's recent 3d modeling analysis. Aimed to estimate the UK's total shale gas resource (based on the Carboniferous basin shales), and using organic geochemistry and fracture rock physics, it reveals the extent of prospective 'sweet spots' which may be contained in the rocks (i.e. quantities of gas estimated to be present). Highlighting the unreliability of the findings, the following weaknesses and conclusions are summarized below:

4 weaknesses identified in the BGS's 2013 Report[30]:

1) *The UK shale gas industry is in its infancy, and ahead of more drilling, fracture stimulation and testing there are no reliable indicators of potential productivity.*

2) *The Barnett Shale is probably not a good analogue for the UK Jurassic plays, but it may provide an indicator of the possible productivity of the UK Carboniferous shale gas play.*

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[22] JRC pg 16 "Unconventional Gas: Potential Energy Market Impacts in the European Union"
[23] JRC pg 16 "Unconventional Gas: Potential Energy Market Impacts in the European Union"
[24] JRC pg 31 pg 16 "Unconventional Gas: Potential Energy Market Impacts in the European Union"
[25] T. Harvey and J.Gray, "The unconventional hydrocarbon resources of Britain's onshore basins-shale gas', (London, UK: Department of Energy and Climate Change, 2011)
[26] RS/RAE Shale Gas Extraction in the UK: A Review of Hydraulic Fracturing June 2012 (2010 estimates) pg 17
[27] RS/RAE Shale Gas Extraction in the UK: A Review of Hydraulic Fracturing June 2012 it drew on measured data from two wells for permeability, gas content and other key parameters
[28] Broderick et al 2011 including Island Gas Ltd, Eden Energy, Greenpark Energy and Composite Energy
[29] RS/RAE Shale Gas Extraction in the UK: A Review of Hydraulic Fracturing June 2012 pg 17)
[30] The Conventional Hydrocarbon Resources of Britain's Onshore Basins- Shale Gas 2013 British Geological Surveys' website www.bgs.ac.uk

3) *In the absence of actual production data from the UK's Carboniferous shale gas play, UK potential is as yet untested.*

4) *There is no evidence of overpressure in UK basins, so it is unlikely that well production rates will be as high in the UK as in America.*

Conclusion "far from certain"

"*The untested shale rock volume in the UK is very large, however, more drilling, fracture stimulating and production testing is necessary to prove that shale gas development is technically and economically viable. Even if one assumes that the American shale gas producing analogies are valid, many of the operating conditions are different in the UK: The US has relatively permissive environmental regulations, low population densities, tax incentives, existing infrastructure, well-developed supply chains and access to technology. Cumulatively, these factors mean that it is far from certain that the conditions that underpin shale gas production in North America will be replicable in the UK.*"

Conclusion:

There are multiple uncertainties in assessing the recoverable volumes of shale gas for the UK and globally. Without proper testing the UK's potential is very imprecise and the levels of potential technically recoverable resources is in considerable doubt. Given the absence of production experience and the magnitude of uncertainties already described, current resource estimates provided across shale gas companies, Government and NGO's should be treated with considerable caution. On the extent to which the UK's development could provide a cheap form of energy, when viewing the UK's shale resources' potential within a global context[31] it is small-scale. At nine times smaller than its European counterparts, the EIA estimates the UK's technically recoverable resources to be 20 tcf[32]. Similarly, the ECC Committee's has admitted that with its scarcity of land for drilling and the State ownership of the rights, shale gas is unlikely to be a 'game-changer' as in the US.

'A cheap form of energy' - potential or pipedream?

The Joint Research Centre's influential report "*Unconventional Gas: Potential Energy Market Impacts in the EU*' 2012"[33], examining economic arguments surrounding shale gas extraction, answers this question. Drawing on their Chapter dedicated to revealing the "most likely" production costs of shale wells in Europe, it is clear that the perception that the UK's shale gas resources will lead to a cheap form of energy, (at least for next 10-15 years) is not economically realistic.

Benchmark Economics, Production Costs US, Europe and the UK

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[31] 1.3 'Potential global shale gas resources' RS/RAE Shale Gas Extraction in the UK: A Review of Hydraulic Fracturing June 2012 pg 17

[32] EIA 2011

[33] Chapter 3

In their report JRC explain in order to determine whether the resource is economically viable, the production costs of shale gas need to be assessed in relation to gas prices. With the caveat that, "*estimates of the so-called 'break even' price of natural gas, which is necessary to recoup per well expenditures vary and are subject to much contestation*". Firstly, they refer to an estimate for break even costs in Europe (specifically Poland and Germany) ranging between $8-12/MBtu provided by Oxford Institute for Energy Studies[34]. Secondly, a study that simulated shale gas plays in Haynesville, US, which concluded that given high initial capital expenditure for developing shale gas resources, "*the majority of wells fail to break-even on a full-cycle basis at prevailing gas prices ($4 /MBtu)*"[35].

A "crucial determinant" when considering future shale gas development in a particular country, is the production cost of shale wells in relation to general market prices. Providing a benchmark (taken from corporate presentations and consulting firms) per well production cost for shale gas in the US, range from $2.9 million. This figure contrasts with Europe's estimated per well production costs ranging from $5 million up to $20 million[36]. Highlighting this disparity with a UK example; Cuadrilla Resources provided their own estimate of approx $16 257 000 (10.5 million pounds sterling). Bearing in mind that Europe is in an early stage of assessing its shale gas potential and that their figures are "even more tentative", the JRC reports the breakdown of construction, fracturing jobs (600,000 euros), and infrastructure costs to be approx 4 million each,[37] which are estimated to be three to five times higher than in US. Costs increase due to rigorous regulations concerning surface water protection and waste management. Two major factors for this high front-end spend can be attributed to "*the goal to ensure the smallest possible environmental footprint ("aiming at zero harmful emissions") combined with the highest possible efficiency*"[38]. While this is specifically aimed at rig technology, the same onerous standards and best practices are being asked of shale gas developers across every component of production.

Another helpful comparison can be found in relation to the costs of fracturing technology[39]. Key issues pushing up costs are: water management, chemical uses, air pollution, the potential of induced seismicity, as well as surface and groundwater contamination. Although it is commonly recognized that the technological advances of '*horizontal drilling and hydraulic fracturing'* were the keys to have unlocked the US's own shale gas commercial success[40], the lack of any large-scale experience in Europe, crucial in achieving cheaper forms of energy, is predicted to be a significantly limiting factor for the UK. Consequently,

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[34] Geny 'Unconventional Gas' 87
[35] Kaiser 'Profitability assessment'
[36] JRC *Unconventional Gas: Potential Energy Market Impacts in the EU*' 2012 (pg 156 (5.1.4)
[37] Some instance construction in particular, "costs in Europe can be estimated to be three to five times higher than in the USA (estimates 4 000 000 Euros construction cost per pad, 4 337 000 Euros total well drilling cost, 600 000 fixed cost per fracturing job making up a "most likely" total field development and infrastructure cost of 4 268 500 Euros
[38] JRC *Unconventional Gas: Potential Energy Market Impacts in the EU*' 2012 pg 98
[39] JRC *Unconventional Gas: Potential Energy Market Impacts in the EU*' 2012 (3.3.4
[40] JRC *Unconventional Gas: Potential Energy Market Impacts in the EU*' 2012 (pg 59)

as there are no large-scale fracturing jobs in Europe, the following cost figures can only be provided using US examples. According to JRC's figures the average costs for hydraulic fracturing in the US is between $3.3 million and $3.7 million assuming ten fracture stages per well. In Horn River, British Colombia, fracturing costs were estimated around $300 per stage while fracturing costs for Europe are estimated to be between $500-$700,000 per well.

Cuadrilla Resources's recent study looked at the possible impact of shale gas within the UK; the scale of reserves, geography, drilling costs and royalty payments. Providing a concrete example of UK's own costs with the figures above, this study quantified the expected impact of a single test well drilled in Lancashire[41]. A single test well drilled over a 12 month period costs £10.5 million of which roughly 17% is deployed on local workers and suppliers, with the rest split between the rest of the UK, and goods and services procured overseas.[42]

As JRC concludes, "*it can be expected that infrastructure costs in Europe will be higher than in the USA. This is based on the higher labour cost, geographic situation, population density and environmental regulations. Actual costs will depend on the local situation and availability of existing infrastructure*". Despite UK's hydrocarbon exploration and production history, economies of scale and lack of infrastructure are still major factors.

JRC explains, "*the range of shale gas production costs is influenced by a number of physical and commercial factors. The former includes factors such as geological characteristics of the play in question (depth, permeability, total organic carbon content etc), the number of frac stages, the length of the horizontal section of the well bore and number of drilling days. Commercial factors. On the other hand, include taxes, royalty rates and the cost of services and materials for drilling, completion and building the supporting infrastructure for gathering, processing and compressing produced gas.*"

Based on the US experience, the JRC highlights the other major obstacle facing the UK in respect of how, "*The cost of water can significantly affect the cost-competitiveness of shale gas wells*". Citing Black and Veatch's consulting report[43], experts note that, "*an individual shale well commonly requires the acquisition and treatment of between 2-6 million gallons of water. Currently the costs of this water are estimated to range between $10.25/Mct to as high as $1.38/mcf…The World Energy Council believes that steadily increasing costs related to water reclamation and chemical clean-up have the potential to drive up production costs to $6-8/Mcf*[44]. *Other issues bearing on production costs include: changes to tax credits for unconventional fuels; environmental considerations limiting both sub-surface*

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[41] It is important to note this was based only on the sunk costs incurred by site preparation and well drilling/fracturing operations and not assuming royalties, taxes, gas production rates or additional wells drilled

[42] Cuadrilla Resources 'Economic Impact in Lancashire" pg 122

[43] 'Growing Shale Resources; Understanding Implications for North American Natural Gas Prices' 2010

[44] World Economic Council, 'Survey of Energy Resources' pg 14

drilling practices and land access for well drilling and completion activities, sufficiency of skilled human resources. An absence of these may increase the cost base and challenge the commercial viability of well-drilling projects". While The Chancellor of the Exchequer included tax incentives and exemptions in his last budget to help boost the industry, for the next 10-15 year period, it is suggested that even with such "pro-fracking" interventions, reaching beyond "break-even" to offer a cheap form of energy will continue to elude both Government and industry alike. As the JRC concludes, "*development of shale gas will only be successful in Europe if the environment and economic boundary conditions can be fulfilled*".[45]

Process: The regulatory regime for fracking and legal issue of 'land-take'

From a regulatory perspective, the UK's history of hydrocarbon production over the past 60 years provides a platform on which to establish a robust regulatory regime for shale gas. A raft of regulations and procedures governing shale gas extraction and sub-surface mining activities already exists. However, when considering the safety risks, this form of energy presents its own set of challenges. Numerous national and EU legislative tools specifically address "*well stimulation techniques*" and, in particular, the contentious issues governing water management and chemical use.[46]

As the vociferous opposition and volumes of literature show, shale gas is a highly contentious form of energy; while estimates of the technically recoverable resources (TTR) remain 'far from certain'[47], conversely, judging by the RS/RAE Report June 2012[48], the government's pro-fracking and 'goal-based' approach to the regulatory regime has a clear agenda.

Legally speaking, current shale gas extraction is self-regulated but with industry working closely alongside DECC and the relevant regulatory bodies. No specific regulatory regime covers fracking or the drilling of shale gas wells. A succession of Ministerial statements and the Government's new OUGO website indicate that a "robust regulatory framework" is being established to address the numerous safety risks in well construction, well integrity and monitoring of the pre-and-post-extraction process. In various degrees, health and safety and environmental issues are addressed at every stage of the consent requirements. The level of impartiality over implementation and enforcement remains to be seen.

The following steps and UK regulations (see footnotes) relate to the various consents required: [49]

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[45] JRC '' *Unconventional Gas: Potential Energy Market Impacts in the EU*' 2012 (Chapter 3 pg 98
[46] Stefan Lechtenbohmer et al, 'Impact of Shale Gas and Shale Oil Extraction on the Environment and on Human Health.' (Brussels: European Parliament 2011
[47] BGS, The Conventional Hydrocarbon Resources of Britain's Onshore Basins- Shale Gas 2013 British Geological Surveys' website www.bgs.ac.uk
[48] The Royal Society and Royal Academy of Engineers *Shale Gas Extraction in the UK: A Review of Hydraulic Fracturing* June 2012
[49] 'Shale Gas: the energy saviour?' The In-House Lawyer Sam Sandilands

1. Planning permission[50] including an Environmental Impact Assessment ("EIA"), proposed to become mandatory.
2. An exclusive licence[51]; issued by DECC through a competitive process under the Petroleum Act 1998.
3. Environmental permits[52]; an environmental permit may also be required where there is a risk that natural substances could pollute groundwater as a result of the fracking process.
4. A notification to the EA that the operation could affect water conservation under the Water Resources Act 1991.
5. A water abstraction licence[53] (difficult to obtain in practice. They are only granted by the EA where a sustainable water supply is available).
6. Coal Authority consent[54]for wastewater disposal.
7. Approval by the Health and Safety Executive (HSE)[55].

Following Cuadrilla's failure to notify the relevant regulatory body of a deformation of the well at the Preese Hall site after the seismic incidents in 2011, operators are reminded they are obliged to report any potential or actual contamination incidents. The Environmental Damage (Prevention and Remediation) Regulations 2009 require operators to notify, mitigate and remediate any threat of environmental damage.

If the fracking fluids contain certain hazardous chemicals the Planning (Control of Major Accident Hazards) Regulations 1999, Control of Major Accidents Hazards (COMAH) Regulations 1999, The Environmental Liability Damage (Prevention and Remediation) Regulations may apply. A licence is also required to control the transport, movement and disposal of hazardous waste under the Transfrontier Shipment of Waste Regulations 1994.

The common law principle established in *Rylands v Fletcher* (1868), could become relevant caselaw in the event of a pollution incident. Similarly, the Borehole Sites and Operations Regulations 1995, require operators of shale gas borehole sites to provide the HSE with advanced notice of significant alterations to wells or any risk of accidental release of fracking fluid or shale gas. (49 above)

Shale gas drilling is also likely to be constrained by the UK and EU's range of biodiversity policies and legislation aimed at protecting Special Areas of

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[50] The Town & Country Planning (Environmental Impact Assessment) (England & Wales) Regulations 1999 require certain developments to prepare an Environmental Statement as part of the planning process

[51] Issued by The Department of Energy and Climate Change ("DECC") through a competitive process under the Petroleum Act 1998

[52] Will be required under the Environmental Permitting (England and Wales) Regulations 2010 for fracking fluid injection where such fluid contains pollutants and is to be injected into rock formations containing groundwater and for waste water discharge. The Environment Agency ("EA") requires details of the substances that constitute the fracking fluid and will only grant an environmental permit if satisfied that there are no risks to the environment, particularly to groundwater

[53] Under the Water Resources Act 1994

[54] Under the Coal Industry Act 1994 if the operation intersects coal seams or coal mine workings, also required for wastewater in abandoned coal mines

[55] Of the design of the proposed well and ongoing monitoring by the HSE

Conservation namely; Natura 2000, EC Directive (92/43/EEC); Conservation of natural habitats and of wild fauna and flora in addition to Conservation (Natural Habitats) Regulations 1994.

Regarding the risk of air pollution and methane emissions, the UK instruments which may apply are: Environmental Protection (Controls on Substances that Deplete the Ozone Layer) Regulations 1996 and The Ozone Depleting Substances (Qualifications) Regulations 2006 SI 1510 and the Fluorinated Greenhouse Gases Regulations 2008 (S.I No 41) along with The Environmental Permitting Regulations.

<u>The process of licensing and the cost of land-take</u>

Both the JRC and the AEA have identified the issues of land-access and 'land-take', as the 'highest risk' of shale gas extraction to impact the development of shale gas in the UK[56]. In JRC's paper on '*The Main Environmental and Social Impacts of Shale Gas*' they cite UK's particular issues of dense population, strict planning laws and local authorities as factors which will inevitably slow down development. This demonstrates the balance required between economic concerns (such as cheap energy) and ensuring the necessary safeguards to address health, safety and environmental concerns.

The process of obtaining access to land for shale gas development can also be costly. In Europe the three methods to secure access to land involve a financial transaction of some kind; 1) Negotiating a fee for renting 2) Compulsory purchase by government (with compensation) 3) Acquisition of the land by the drilling company[57]. Cuadrilla Resources has acquired the majority of acreage for shale gas development in the UK to date. In a recent shale gas survey conducted by the BGS, the UK uses 100 km2 blocks in its licensing rounds (the most recent 13th onshore licence round awarded 55 new licences covering more than 7000 km2). Following the Government's decision in December 2012 to lift the moratorium on fracking exploration at Preese Hall, the 14th Round is underway with the exact areas available in this Round and timing subject to Ministerial decisions and conclusions reached in the Strategic Environmental Assessment ("SEA").

A crucial distinction between the US and the UK, certain to impact on any cost-benefit analysis for the UK, is the difference between land ownership rules. Over the last 30 years, US landowners have received generous tax break incentives and, more significantly, they own both surface and mineral rights. Conversely, UK landowners have rights to minerals on or under their land but successive Acts of Parliament have vested the right to explore and extract hydrocarbons in the Secretary of State for Energy and Climate Change. This constitutes a major drawback for the UK, as the BGS concludes, "*finding broad local support for shale gas exploration and development may prove difficult, even with the promise of jobs and benefits to the local economy*".

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[56] Ref: AEA (Agricultural Engineers Association)/ED57281/Issue Number 17 '*Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe*' 2012

[57] Geny ''*Unconventional Gas*'

As the rights granted by landward licences do not include rights of access, it places the onus upon the licensee to obtain all the relevant planning permissions from the prospective authorities and landowners'[58]. In turn, the owner of the site of the actual drilling pad will be entitled to compensation.[59] As US drilling companies compensate landowners[60], it is highly likely during the process of securing land and public acceptability, the UK shale gas industry will have to offer similar financial incentives. On this last point, the JRC have also revealed, "drilling companies' payments to private landowners in the US make up the bulk of total spending, according to Considine's report."[61]

The degree to which surface landowners have a say in granting permission to develop an area will impact the extent of development. As reported in the *Times* on February 11 2013, Clause 24 of the new Growth and Infrastructure Bill is causing environmental groups such as Friends of The Earth and Campaign To Protect Rural England to argue that the Bill will enable planning for onshore gas extraction to be fast-tracked so decisions will "*be taken out of the hands of local communities and decided by the Secretary of State in the absence of national or local planning policies or right to cross-examine the development at a public inquiry*". This raises the related issue of public acceptability, which according to the JRC report[62], "*is regularly acknowledged as a major constraint to shale operations in Europe. A key issue is related to the greater sensitivity in Europe toward activities affecting the environment, health and safety*."

Conclusion

It is highly unlikely the size and commercial viability of the UK's TRR will translate into the level of large-scale production required to achieve 'a cheap form of energy'. The main obstacle to accessing land for shale gas development is a range of environmental, technical and social issues particularly at local level. While it is important to highlight national regulations governing shale gas, in practice it will be the local authorities who will determine the extent of obstacles for shale operators. This last point is supported by the UK Government in its Gas Generation Strategy, while discussing the problem of drilling close to urban areas, they conceded that, "*in addition to securing the consent of individual landowners, securing community support and planning permission…will be crucial to sustaining shale gas activity and production. The areas in the US in which shale gas development has grown most rapidly have much lower population densities than the UK*."

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[58] Rhian Kendall, Nigel Smith and Andrew Bloodworth 'Alternative Fossil Fuels: Mineral Planning Factsheet' (Keysworth's British Geological Survey 2011

[59] Ridley, 'Shale Gas Shock', 17

[60] Considine etc al, 'An Emerging Impact in Lancashire', 11

[61] Considine et al, "An Emerging Giant', 22/JRC pg 122 "Unconventional Gas: Potential Energy Market Impacts in the European Union" 2012

[62] JRC '' *Unconventional Gas: Potential Energy Market Impacts in the EU*' 2012 (pg119)

Similarly, Harvey and Gray[63] have argued that mineral rights regimes in the UK disincentivise the local population to support drilling because surface owners are not entitled to royalties or 'signing bonuses'. The UK government's attempt to win support of local communities by proposing[64] to give local authorities "*a large portion of business tax*" is misguided as it would further burden a fledgling industry unable to 'break even', let alone pass 'cheap energy' onto the consumer.

Problems and perspectives – Is shale gas safe?

The proposition that shale gas can provide a safe form of energy for the UK depends entirely on whether there is robust implementation and enforcement of the proposed operational best practices and regulations relating to hydraulic fracturing ("fracking"), well construction and monitoring.[65]

The four key safety risks often raised by dissenters are 1) substantial requirement for water 2) potential pollution of groundwater and/or drinking water from chemical fracking fluids and/or hazardous sediments 3) seismicity (minor earthquakes) 4) air pollution and Co2 emissions. There is a debate between academics over whether shale gas really is less harmful than coal. [66]

The NGO, the Agricultural Environmental Association's (AEA) own evaluation of the potential impacts of shale gas extraction included examination of the different stages of extraction[67] . They identified one 'very high' risk and eleven ' high risks' for the environment and human health arising from fracking (distinguishing individual installations from cumulative impacts of wells). In line with the JRC's 2012 report, the AEA highlighted "land-take" as the highest risk

[63] 'Unconventional Resources of Britain'), 30 House of Commons, Shale Gas: Fifth Report of Session 2010-12', 28

[64] Shale Gas Europe website www.shalegas-europe.eu

[65] The Royal Society and Royal Academy of Engineers *Shale Gas Extraction in the UK: A Review of Hydraulic Fracturing* June 2012

[66] Fred Pearce (Author of *The Last Generation: How nature will take her revenge for climate change*) and Daniel Schrag "*Is Shale Gas Good For Climate Change*?" (Professor of Environmental Science and Engineering at Harvard). Serious Climate Change commentators; Dieter Helm author of "*The Carbon Crunch*" has argued the shale gas industry has potential to cut emissions in the first half of this century through an active energy policy to ban coal. Helm argues that where most people choose the cheapest energy, gas is the only serious pretender to King Coal. (*Fred Pearce : "Fracking: the monster we greens must embrace" 15th March 2013*). Similarly, Daniel Schrag, Professor of Environmental Science and Engineering at Harvard wrote the response to Cornell University's anti-fracking thesis which highlighted the far higher levels of emissions from methane (shale) over carbon (coal). Choosing between the lesser of two evils, Schrag reluctantly chooses methane emissions over 'the disastrous longer term consequences of coal.' Backing shale gas and for a new cumulative emissions measurement over a 100 year period; Global Temperature Warming (to replace Global Warming Potential), Schrag argues shale gas is the best chance the world has to progress towards a zero-carbon future by unlocking the 'stranglehold that the coal industry has had on the national discussion around climate policy'. Coal's share in the world energy supply rose from 25% to 30% in the past half decade (*Fred Pearce : "Fracking: the monster we greens must embrace" 15th March 2013*

[67] From site preparation, drilling, fracturing, completion, production to abandonment

for the UK[68]. The remaining 'high risks' included; release to air, surface water contamination, water resource depletion and groundwater contamination. Significantly, in line with the RS/RAE report, seismicity caused by fracking was identified as 'low risk'.

Compared with the UK's pro-fracking papers cited later, a cautionary summary of the main environmental and social risks attached to fracking is provided by the EC's JRC's report of the same name[69] and is summarised as follows:

"Current extraction technologies for shale … may undermine the potential viability of the industry. The most important environmental concerns for today's production are associated with water[70]. Other important disadvantages of industrial exploitation include impacts on biodiversity, (Natura 2000), worsened local air quality; and seismic concerns. The GHG performance of shale gas is generally poorer than that of the conventional gas… largely due to fugitive methane emissions"[71].

With contention over the level of risk these concerns present for the public and workers, alternative expert perspectives are required. The BGS "pro-fracking" analysis provides two key risks along with the UK's applicable regime:

Shale gas production in the US has become controversial particularly regarding groundwater contamination of drinking water. However, the evidence seems to show that where problems are genuinely attributable to shale gas operations, the issue lies in poor well design and construction, rather than anything distinctive to shale gas. Along with DECC, HSE is in charge of the regulatory controls and monitoring of the latter[72] as part of the scrutiny process, operators are required to disclose the content of fracking fluids to the Environment Agency.

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[68] AEA Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe 2012

[69] European Commission - Joint Research Centre - Shale Gas for Europe – Main Environmental and Social Concerns 2012

[70] *These are: 1) Large freshwater demand; 2) Freshwater contamination, mostly with methane and fine particles; 3) Underground and surface pollution with hazardous chemicals, heavy metals or radioactive elements; 4) Wastewater handling, treatment and disposal.* The Conventional Hydrocarbon Resources of Britain's Onshore Basins- Shale Gas 2013 British Geological Surveys' website www.bgs.ac.uk

[71] *There are cost-efficient techniques, e.g. flaring and capturing (green completion technologies) that can significantly reduce these fugitive emissions - BGS* www.bgs.ac.uk

[72] *In the UK, well design and construction are addressed by the Health and Safety Executive through specific regulatory controls, which, inter alia, require verification of the well design by independent third parties. Every shale gas drilling application must go through the local planning application process. Before any drilling occurs proposals must be scrutinised by the Environment Agency to make sure there is no risk to the environment and, in particular, to water sources, by the HSE and DECC to ensure best use is made of the resources. As part of this process, operators are required to disclose the content of fracking fluids to the Environment Agency. The HSE then monitors progress on the well to determine whether the Well Operator is conducting operations as planned. The HSE are also notified of any unplanned events and, if appropriate, on-site inspections may be undertaken. BGS* www.bgs.ac.uk

Water use and disposal of recovered fluids are also of concern. Re-fracturing might be repeated every 4-5 years in successful wells (with about a third of the water being returned to the surface)[73].

Seismic activity; in 2011 two earthquakes were experienced near Blackpool (mag 2.3 and 1.5)[74]. In light of the robust controls in place, DECC sees no need for any moratorium on shale gas. Following an inquiry in 2012[75]. The Energy and Climate Change Select Committee concluded that fracking itself does not pose a direct risk to water aquifers, provided that the well-casing is intact. Any risks that do arise are related to the integrity of the well, and are no different to issues encountered when exploring for hydrocarbons in conventional geological formations.

A more technical perspective on the UK's key safety concerns, is provided by The Royal Society/Royal Academy of Engineering's ("RS/RAE") Report[76] and details proposals as to how industry should '*effectively manage'* leaks and spillages of polluting gases and contaminants including Methane and NORM (Naturally Occurring Radioactive Material). Learning lessons from America, the report draws on many empirical US examples of '*improper operational practices'*. For instance, the incident in Pavillion, Wyoming[77] where an EPA study reported that fracking had contaminated groundwater and drinking water supplies as a result of poor well construction (casing and cementing) and fracking at incorrect depths (depths can range from 30-500 feet) from the freshwater bearing zones.

When considering the risk of Methanol and high concentrations of Methane[78] contamination into freshwater tables, the RS/RAE's proposal principle of 'As Low As Reasonably Practicable ' (ALARP) falls short of passing the safety test, in this authors opinion. As the JRC[79] confirm; "*the two most common types of freshwater pollution associated with shale gas extraction are Methane contamination and particulate contamination*". Drawing on a study undertaken in Pennsylvania and New York, (analysing Methane contamination in groundwater from 60 groundwater wells), methane was detected in 51 out of 60 water wells, with thermogenic methane concentrations found to be an average of 17 times higher near "active" wells. As recent gas explosions in Northern Russia and Dexter, Detroit[80] have tragically proven, Methane presents a potential for fire

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[73] *It might be possible to re-use water by a recycling process, or to reduce the potential environmental impact by changing the chemicals added but at the moment fresh water is required for fracturing. BGS* www.bgs.ac.uk

[74] *A geomechanical study was undertaken, consulted on and in December 2012 DECC approved the resumption of hydraulic fracture operations*

[75] *Took evidence from Government, regulators, the BGS, the oil and gas industry and environmental groups.* www.bgs.ac.uk

[76] (i) the risk of fractures propagating from shale formations to reach overlying aquifers'; (ii) effects of unforeseen leaks and spills; (iii) the chemical additives in fracturing fluid; (iv) seismicity induced by hydraulic fracturing; (v) methane and other contaminants such as NORM (Naturally Occurring Radioactive Material) in ground and surface water and potential leakages of methane and other gases into the atmosphere[76].

[77] DiGiulio et al 2011

[78] through surface water spills or ground water leakage

[79] European Commission - Joint Research Centre - Shale Gas for Europe – Main Environmental and Social Concerns 2012

[80] the wastewater plant

and explosion hazard. The UK's reliance on independent and competent 'well examiners' required by The Offshore Installations and Wells (Design and Construction, etc) Regulations 1996, may assist in mitigating this risk, however, the gravity of the risks outweigh the perceived benefit. As Deepwater Horizon and Chesapeake, Wyoming have proved, "*blowouts are a major safety hazard to workers"*[81]. The absence of regulation over Methane in tap water has been called "an unacceptable risk" with US The Environment Protection Agency ("EPA") soon to be introducing new rules. While Methane capture is advancing it could be as much as 15 years away from being comprehensively implemented in Europe.

On the issue of chemical additives in fracking fluids, according to a US survey, shale gas developers use 652 chemical products in hydraulic fracturing, 29 of which are regarded as toxic substances[82]. The JRC also alarmingly reports that some of the chemicals are hazardous, even in small concentrations, including Methanol: "*This compound is most widely used and is fully soluble in water … can be ingested orally or via the skin and is very difficult to detect. Very small concentrations in drinking water may cause blindness and even death. The effects of these chemical additives can include [83] toxicity to the aquatic environment or human health; carcinogenic, mutagenic or having reproductive effects.*"

A common obstacle to preserving the environment in the US has been shale gas companies unwillingness to disclose the full list of the compounds on the basis of "corporate confidentiality" along with pro-fracking policies. However, pressure is mounting for new regulatory authority to be made law[84].

The UK regulatory framework is provided by The Groundwater Daughter Directive[85]. If posing an "unacceptable risk", activity will not be permitted and if

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[81] pg 25 Shale Gas extraction in the UK: A Review of Hydraulic Fracturing June 2012 Royal Society and Royal Academy of Engineers

[82] European Commission - Joint Research Centre - Shale Gas for Europe – Main Environmental and Social Concerns 2012

[83] A review of chemical addictives used in New York State for hydraulic fracturing identified 22% as having one or more of the following properties of concern JRC 2012 Report Main Environmental and Social Concerns of Shale Gas

[84] Re drinking water contamination by fracking fluids, the operators' exemption from disclosing the type and quantity of chemicals to be used in fracturing is being answered by the Emergency Planning and Community Right to Know Act. This Act awaits legislative approval. Similarly, the 2010 FRAC ACT (Fracturing Responsibility and Awareness of Chemicals Act) was introduced in the House of Representatives and Senate but has yet to become law.

Numerous cases have arisen against shale gas operators for environmental, property damage and personal injury arising from lack of transparency of chemicals (some carcinogenic) being used in fracking fluids proven to cause drinking water contamination. However, amendments to statutory instruments are being proposed: The Safe Drinking Water Act, which regulates the injection of fluids underground, and specifically exempts injection of most fracking fluids from regulation under the same statute (The Energy Policy Act of 2005). Similarly, the Solid Waste Disposal Act, which covers industrial waste and contains exemptions for drilling fluids and other waste associated with fracking and the Comprehensive Environmental Responsibility Compensation and Liability Act from which operators are currently exempt with regard to waste disposal, are awaiting amendment. Air pollution and emissions are also attracting greater attention.

[85] Control of the release of substances into groundwater, prevention approach for "harzardous" and (non-polluting) permissible approach to "non-hazardous" on a site by site basis

posing a significant risk or an actual impact, the EA may issue a notice under the EPR requiring a permit, or in extreme situations, be prohibited. While the Government states that the EA takes a risk-based approach[86] to the regulation of shale gas chemicals, this leaves open the question as to how this fits with the new "goal-based" approach the RS/RAE has "commended" the Government for adopting.[87] The Government Q&A response on the question of their measures to fracking chemicals screening[88], suggests it is not yet ready to make full public disclosure mandatory, which it should. "*For future activities, subject to appropriate protection for commercial sensitivity, the regulators have decided that operators should disclose, either on their own websites or on third-party developed websites, the chemical constituents in fracking fluids and additives on a well-by-well basis, along with brief descriptions of their purpose and any hazards they may pose to the environment*". The Government requires chemical components to be shared only with EA for a permit approval under Environmental Permitting Regulations 2010 (EPR), including conditions[89]. On the issue of Methane, the Government's support for a National Baseline Survey of Methane, enabling environmental regulators to understand background methane levels prior to assessing permit applications, is to be commended as it will help to establish the facts for all stakeholders.

The requirement for large volumes of freshwater supply remains one of the most crucial drawbacks to shale gas in the UK, both in terms of safety and cost. The extent of the impact of freshwater consumption is best illustrated in the JRC 2012 report's[90] findings. Despite many contradictory "freshwater footprint" estimates, based on US experience, the full range is from 1 500 to 45 000 cubic metres per well[91]. These figures are based on industrial-scale production yet to be performed in Europe. The UK Government has provided its own estimate of typically 10,000 to 30,000 m3 water per well (10,000 to 30,000 tonnes). The key safety risk is in respect of freshwater availability in the UK. Due to reasons of geological and population density, the JRC highlights that while water consumption in the EU may be greater than in the US, availability of freshwater is generally lower than in the US[92]. The crux of the issue is that, "*if exploitation occurs in areas where local populations are already experiencing water deficits, the incremental pressure on available water resources could be severe*." The clear safety risk and unsuitability of the UK for industrial-scale shale gas extraction is persuasively made by JRC's statistics[93] showing all 26 EU Member States' freshwater resources per capita (on a 20 year average 1000 cubic metres). While

[86] Q&A "Government response to Royal Academy of Engineering and Royal Society report on "Shale Gas Extraction in the UK: A review of hydraulic fracturing." Version: Final A04 10th Dec 2012

[87] (pg 5) Shale Gas extraction in the UK: A Review of Hydraulic Fracturing June 2012 Royal Society and Royal Academy of Engineers

[88] Government response to Royal Academy of Engineering and Royal Society report on "Shale Gas Extraction in the UK: A review of hydraulic fracturing." Version: Final A04 10th Dec 2012

[89] Casing design and integrity testing, distance between boreholes and groundwater resources and limits on amounts of substances that can be discharged to the water environment

[90] European Commission - Joint Research Centre - Shale Gas for Europe – Main Environmental and Social Concerns 2012 Chapter 3 Environmental Dimensions of Shale Gas Exploitation (pg 18,19, 20)

[91] pg 18 footnote 29 JRC 2012 Report as above

[92] pg 19 as above

[93] pg 20

Finland had the highest resource (20 000 cm) the UK falls within the lowest ten countries with an inadequate resource of just 4 000 cm.

Regardless of precise figures, it is clear that consumption for shale gas in the UK will place a significant burden on local water utility companies and (if permitted by EA) could spell unwelcome direct abstraction from groundwater or surface waters during periods of drought. While an exemption for an abstraction licence exists for requests that do not exceed 20m3/day, the water requirements for fracking are likely to be much greater than this limit. As stated earlier, with water abstraction licences difficult to maintain, the shale gas industry will be severely constrained from the outset to reach a commercially-viable scale. The cost, safety and availability issues associated with shale gas wastewater demands are all significant drawbacks which should exclude the UK from developing domestic production.

The risk of seismicity, industry parlance for earthquakes, has generated much attention. Although played down by AEA, BGS and RS/RAE as not presenting a direct risk to water aquifers, the recent Ministerial reprimand of Cuadrilla Resources following the 2011 tremors and well casing deformations, is sufficient evidence that safety and implementation risks exist. Although the Government have promised a raft of new measures to mitigate seismicity[94], its proclamation of a "*new precautionary approach*" appears inconsistent with the RS/RAE commendation of their goal-based approach to regulation.

In its Q& A response[95], the Government proposal to use the ML 0.5 earthquake reading as the threshold for triggering "the traffic light" and their statement that "*while it is not in itself cause for concern… the analysis of the Lancashire data indicates they may be an indication of, or a precursor to, a larger earthquake*" does little to instill public confidence. The risk is, that in its hot pursuit for a cheap form of energy, despite the mitigation controls in place, the UK Government may loose sight of the 'big picture' safety issues by becoming all men to all people. Impartiality at all times between industry and regulatory bodies is vital especially given the current pro-fracking government policy.

Another serious risk is the repetitive earthquakes caused by the injection of wastewater into disposal wells. As the RS/REA confirmed, "*pressure in disposal wells can build up over time, inducing seismicity. Between 20th November and December 2008, 11 seismic events were detected near Dallas Fort Worth Airport, Texas. They were attributed to the same focus point at an estimated depth of 4.4km and less than 0.5 km from a well drilled a few months previously*"[96].

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94 Including: national stresses and faults surveys, monitoring before, during and after fracking, "traffic light monitoring systems" and greater data sharing

95 Version: Final A04 – 10th Dec 2012 Synopsis of main questions raised in responses to DECC consultation on mitigation of seismic risks from hydraulic fracturing for shale gas, with Government responses

96 Frohlich et al 2011

Conclusion

Despite the UK Government's energetic pro-fracking position, the short answer is that shale gas extraction is not only expensive but it is also unsafe. This applies to both the public and the workers involved. When the illusion that it may bring a cheap form of energy is rubbed off by the reality of extensive and uncompetitive bottom line production costs, the life-threatening safety risks will become all the more pronounced. The shale rush optimists may currently be drowning out the voice of the anti-fracking opposition but ultimately the right answer will fall squarely on their side.

Progress – the shape of shale to come

Is European legislation adequate?

Europe has been far more cautious than the US in embracing industrial-scale shale gas production 'in their own backyards'[97]. However, individual member states are pursuing their own policy paths. Countries, including Poland and Ukraine, are gearing up to exploit their resources while France and Switzerland have placed a moratorium on fracking remaining unconvinced by the safety arguments. In 2011, the European Union (EU) Heads of State concluded that Europe's potential to extract and use shale gas resources should be addressed.[98] In 2012, the European Commission judged that its existing legal framework was adequate to address shale gas extraction.[99]

The AEA argue in their report (cited earlier) that a number of important gaps exist regarding the potential risks to environment and human health. They also recommend that European regulators concentrate on strategic overview,[100] specific risk management and further research.[101]

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[97] Professor Anthony Rogers, City Law School, UK Energy Lecture Week 3

[98] European Council 2011

[99] Vopel 2012

[100] GAPS AEA SO Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe 2012 The AEA analysis of the potential inadequacies of EU legislation included reviews of the following relevant EU legislation; Strategic Environmental Impact Assessment (2001/42EC) (at discretion of Member State), Environmental Impact Assessment Directive (2011/92/EU) (at discretion of Member State), Integrated Pollution and Prevention Control – Directive (2008/1/EC), Industrial Emissions Directive (2010/75/EC), Mining Waste Directive (2006/21/EC) (waste management as covered by MWD of fracking fluids at discretion of Member State), Environmental Liability Directive (2004/35/EC), Waste Framework Directive (2008/98/EC) and (2000/60/EC) (water use during fracturing at discretion of Member State), Groundwater Directive (2006/118/EC), Air Quality Directive (2008/50/EC) (emissions to air during fracking at discretion of Member State), Biocidal Products Directive (98/8/EC), Authorization (for the prospection, exploration and production) of hydrocarbons Directive (94/22/EC) (at discretion of Member State), SEVESO II Directive (1996/82/EC), Urban wastewater Directive (97/271/EEC). IPPC Directive (2008/21/EC) (emissions to air during fracking at discretion of Member State). (Ref AEA/ED57281/Issue Number 17)

[101] AEA's SRM recommendations on specific risk management measures involving HVHF and aimed at mitigating the health and safety and environment impacts and risks of shale gas development are; (a) appropriate siting of developments (b) measures and approaches to reduce

The main concern arising from AEA 's evaluation, is the Environmental Impact Assessment (EIA) Directive 2011/92/EU not (always) being mandatory with regard to shale gas extraction activities. Falling outside Annex I and II, Member States are taking different approaches to the risks and impacts required by an EIA. Making an EIA mandatory prior to shale gas extraction is proposed in the RS/REA June 2012 Report and is currently under consideration by DECC. Another issue relates to the threshold for an EIA for gas projects, currently set at 500 000 m3 of gas extraction per day. The AEA suggest this "*is well above any feasible industrial yield of shale gas in Europe*."[102]

UK's "goal-based" approach to regulation and recommendations

In deciding how to determine the regulatory future for shale gas in the UK, DECC appears to be keeping to the recommendations in RA/RAE's June 2012 Report. This report argues that the environmental risks (including seismic and water risks) can be properly managed in the UK "*as long as operational best practices are implemented and enforced through regulation*". While claiming that fracture propagation is unlikely to cause contamination and that well integrity is the highest priority, the report calls for mandatory EIAs and robust monitoring.

Commending the Government for adopting a "goal based" approach which "*fosters innovation and continuous improvement in risk management*", the RS/RAE highlights the self-regulatory, risk-assessment and collaborative framework within which shale gas developers will operate. To provide a consistent yardstick from which to develop guidelines, operators are asked to work closely alongside UK's health and safety operators according to the principle of reducing risks to As Low As Reasonably Practicable (ALARP). Whether this sets the bar too low to ensure shale gas is 'a safe form of energy' remains to be seen. Given that it is mandatory for operators to report well failures, a rule Cuadrilla Resources have already breached, does little to win public support in an already hostile local environment. Additionally, there appears to be inconsistency in the Government's stated approach; this paper has cited three stated approaches: risk-based, precautionary and goal-based.

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land disturbance and land-take (c) Measures to address releases to air and to effectively reduce noise during drilling, fracturing and completion (d) Measures to address water resource depletion (e) Measures to reduce the negative effects caused by increased traffic movements (f) Measures to improve well integrity and to reduce the risk of ground and surface water contamination (g) Measures to reduce the pressure on biodiversity. For the areas still wrought with uncertainty, the AEA recommends research and consideration into; (h) further research over relevant provisions of the Carbon Capture and Storage Directive (209/31/EC) covering site characterisation and risk assessment, permitting, monitoring, transboundary co-operation and liability (i) The use of micro-seismic monitoring in relation to hydraulic fracturing (j) determination of chemical interactions between fracturing fluids and different shale rocks, and displacement of formation fluids (k) Induced seismicity triggered by hydraulic fracturing (l) Development of less environmentally hazardous drilling and fracturing fluid composition (m) Research into the risks and causes of methane migration to groundwater from shale gas extraction.

[102] AEA Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe 2012

Regarding regulation governing well integrity, the goal-based approach places the onus of responsibility on the operators[103], with reference to The Offshore Installations and Wells (Design and Construction, etc) Regulations 1996[104].

While the RS/RAE's 2012 recommendations[105] are to be applauded, it is this author's view that as this 'robust regulatory regime' emerges to ensure public and workers' safety, it is equally critical, in the self-regulatory environment, for the government to treat its implementation and enforcement more stringently.

Conclusion

In the JRC report[106], the EC appears to support the economic case for shale gas extraction concluding that '*unconventional gas may meet more than 40% of the increased global demand for gas by the year 2035'*. This author's view is that the successful US shale gas experience cannot be replicated in the UK as it will be more expensive to produce and the regulatory regime (for good reason) will be a key factor weighing down UK's competitiveness. This is in addition to the scarcity of freshwater availability and proportionately high ratings for substantial "land-take" required for well siting, production and completion. These factors, along with others raised elsewhere in this paper, render the UK inappropriate for hydraulic fracturing.

An important determining factor of the extent of development within the UK is its ability to address the main health, safety and environmental risks while not overburdening developers with costly regulation. The International Energy Agency's (IEA)'s "Golden Rules" could spell a heavily regulated industry for a relatively small-scale TRR. Adding to the impediments are: a lack of land, restricted water resources and heightened sensitivities of local populations to large-scale industrial developments. Even with the proposed "streamlined" regulatory regime promised by The Energy Bill and aided by Clause 24, the implementation of best practices and introduction of new technologies and infrastructure will prove too slow for shale gas production to make any meaningful impact on the UK's 'diverse energy mix'.

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[103] HOL 2006 pg 4 RS/REA 2012 Report

[104] The parameters of which ensure that wells are designed and constructed so that 'as far as is reasonably practicable, there can be no unplanned escape of fluids from the well; and risks to health and safety of persons from it or anything in it, or in strata to which it is connected, are as low as reasonably practicable'

[105] Rs/RAE June Recommendations *Shale Gas Extraction in the UK: A Review of Hydraulic Fracturing* June 2012:
1) to detect groundwater contamination 2) To ensure well integrity
3) To mitigate induced seismicity 4) To detect potential leakages of gas
5) Water should be managed in an integrated way 6) To manage environmental risks 7) Best practice for risk management should be implemented 8) In the event a shale gas industry should develop nationwide; skills gaps and trained should be identified and the numerous bodies with regulatory responsibilities should be led by a single body)

[106] JRC *'Unconventional Gas: Potential Energy Market Impacts in the European Union' 2012*

A more sensible strategy for UK's energy future, would be to explore investment in unconventional gas opportunities beyond its borders.[107] Countries such as Poland are subject to the same EU 'robust regulatory regime' managing the safety risks, but have the advantage of vast tracts of land, broad public support and the right ecological and techno-economic conditions. Poland also has the potential to improve UK's energy security and is arguably a more secure source for UK's energy supply than other countries on which it currently relies. Alternatively, within the UK, focus on Northern Ireland is a viable alternative. According to the JRC's figures,[108] the latter is ranked within the top ten Member States for its freshwater availability - so vital for shale production.

In a recent interview[109], chairman of Cuadrilla Resources, Lord Browne of Madingley, argued that shale gas has the potential to be the next North Sea. In the same interview he highlights the need to "streamline" the UK's shale gas regulatory regime; "*Right now it is not speedy, there is no certainty*."

Conversely, the EC's JRC report advises that: "*The sustainable management of environmental externalities of shale gas exploitation requires excellent knowledge of geology, prudent exploitation of shale gas deposits, full and complete disclosure of chemical components, cautious land-use planning, operational and post-operational conservation standards, and strict governmental control over operational safety and security*." This paper concludes that as the safety and economic risks continue to mount, rather than safe and cheap, this new form of energy will ultimately prove to be nothing more than a pipedream.

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[107] JRC European Commission - Joint Research Centre - Shale Gas for Europe – Main Environmental and Social Concerns 2012 Chapter 3 Environmental Dimensions of Shale Gas Exploitation

[108] European Commission - Joint Research Centre - Shale Gas for Europe – Main Environmental and Social Concerns 2012 Chapter 3 Environmental Dimensions of Shale Gas Exploitation pg 20

[109] 12th March The Guardian Lord Browne promises to invest 'whatever it takes' in UK fracking

Appendix (not to be included in wordcount)

Terminology

Given the propensity for misunderstanding due to inappropriate comparison and imprecise figures, to better understand "the discovery of significant reserves" it is helpful to include 3 definitions of the terminology:[110]
1) '*Gas in place'* refers to the entire volume of gas contained in a rock formation regardless of the ability to produce it. '*Technically recoverable resources*' (TRR) is the fraction of the gas in place estimated to be recoverable by current technology in a) discovered formations and b) undiscovered formations. (TRR) is the resource figure most frequently provided by literature[111] 2)'*Proved reserves'* refers to that volume of TRR demonstrated to be economically and legally producible under existing economic and operating conditions.
3) As not all TRR is economically recoverable, for example in fields with low production rates and high costs, a further subset of the TRR is often given; the *economically recoverable resources* (ERR). Unlike TRR, the ERR must be considered to be both technically and economically recoverable[112]. This author submits that development of the UK's resources is likely to be limited by local production rates and high costs. An opinion echoed by The Royal Society and Royal Academy of Engineering's report under the heading 'UK's proven reserves of shale gas': *"It will be some years before shale gas production data and the impact of regulatory and economic conditions allow a rigorous estimate of the UK's proven reserves of shale gas*."[113]

<u>The Potential Global Shale Gas Resources[114]</u>

In 2012 The Royal Society and Royal Academy of Engineering's Report[115] put the UK's shale as resources' potential into a global context. The comparative disadvantage of the UK's statistic for shale gas resources speaks for itself; the US Energy Information Administration (EIA) estimates the global TRR of shale gas to be 6,622 tcf. The USA has approximately 862 tcf, and China 1,275 tcf. In Europe, Poland and France are two of the most promising shale gas countries with 187 tcf and 180 tcf of technically recoverable resources, respectively. Norway, Ukraine and Sweden may also possess large technically recoverable resources. The EIA estimates that the UK's technically recoverable resources to be 20 tcf (EIA 2011).

[110] *1.3.1 pg 10 Shale Gas Extraction in the UK; A Review of Hydraulic Fracturing June 2012 The Royal Society and Royal Academy of Engineering*
[111]JCR pg 16
[112] JCR pg 18
[113] June 2012 Royal Society - 8.2.1 The UK's proven reserves of shale gas
[114] I.3.1 Chapter 1 Royal Society/RAER
[115] Shale gas extraction in the UK: A Review of Hydraulic Fracturing