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THE REGULATION OF THE TECHNICAL, ENVIRONMENTAL AND HEALTH ASPECTS OF CURRENT EXPLORATORY SHALE GAS EXTRACTION IN THE UNITED KINGDOM: INITIAL LESSONS FOR THE FUTURE OF EU ENERGY POLICY

ABSTRACT

The shale gas revolution has reached the United Kingdom. Licenses for exploratory shale gas extraction have already been issued and a recent independent review commissioned by the British government concluded that shale gas extraction can proceed. However, the regulation of these activities is based on the broader regulatory framework for oil and gas, which does not fully account for the particular technical challenges and environmental and health impacts of unconventional gas extraction, resulting in gaps in authorization and monitoring procedures. This article analyses the relevant EU and domestic provisions regarding the licensing and permitting system, hydraulic fracturing and water management, as well as the mitigation of the risk of induced seismicity.

KEYWORDS

Shale gas, hydraulic fracturing, energy, regulation

INTRODUCTION

Shale gas extraction refers to the process of extracting hydrocarbons (usually methane gas) from shale, a type of sedimentary rock formed from deposits of mud, silt, clay and organic matter. Shale gas is classified as a type of 'unconventional' gas source – as opposed to the easily accessible conventional sources of natural gas - because of the challenges associated with its extraction.

First, shale formations are located kilometres below the surface, and constitute a very thin, compressed layer with 'shallow dips, meaning they are almost horizontal'.[1] Commercial production of shale gas thus requires the drilling of a horizontal well once vertical drilling reaches the shale formation, in order to maximize the volume of shale gas accessed. In addition to horizontal drilling, the newer technology of multilateral drilling is increasingly preferred, as it 'enables drainage of multiple target zones, enlarges recoverable reserves, and increases productivity'.[2] Secondly, the gas is trapped within tiny pore spaces with very limited permeability,[3] meaning that 'shale gas does not readily flow into a well'.[4] The gas flow has to be stimulated by widening fractures or creating new ones in the formation through the hydraulic fracturing (fracking) method, which involves the pumping of a large volume of high-pressure fracturing fluid - consisting of water, sand as propping agent for the engineered fractures, and chemicals - into the well.[5]

These drilling and extraction challenges meant that only in the last decade did advances in horizontal drilling and hydraulic fracturing technologies, coupled with rising gas prices,[6] make commercial shale gas production a profitable option, despite the fact the some form of these technologies have been used in oil and conventional gas production in the US and the

[1] The Royal Society and the Royal Academy of Engineering, *Shale Gas Extraction in the UK: A Review of Hydraulic Fracturing* (2012), at 10.
[2] D.M. Kargbo, R.G. Wilhelm and D.J. Campbell, 'Natural Gas Plays in the Marcellus Shale: Challenges and Potential Opportunities', 44:15 *Environmental Science & Technology* (2010), 5679, at 5682.
[3] Ibid., at 5680.
[4] Review, n. 1 above, at 9.
[5] Ibid.
[6] See specific argument in relation to the Marcellus shale formation in North East coast of the US in D.J. Soeder and W. M. Kappel, *Water Resources and Natural Gas Production from the Marcellus Shale* (US Department of the Interior, 2009), at 3. More generally in relation to global gas markets see P. Stevens, *The 'Shale Gas Revolution': Hype and Reality* (Chatham House, 2010).

UK for decades.[7] In the US, the primary producer of shale gas, production rose from 2% in 2000 to 23% of overall gas production in 2010, with projections that it may rise to 49% by 2035.[8] In Europe, France, Poland and Norway are estimated to possess significant reserves of technically recoverable shale gas.[9]

Shale gas is being promoted as a 'transition'[10] fuel that can replace coal[11] and bridge the gap between fossil fuels and widespread use of renewable sources of energy. It is more efficient and clean compared to coal, possessing high energy content and emitting half the CO_2 compared to burning coal.[12] However, it has also been argued that the development of shale gas industry will inevitably delay investment in low carbon technologies[13] and may indeed have exactly the opposite effect of locking states into a fossil fuel economy.[14] On the other hand, shale gas extraction carries with it a significant amount of environmental and public health risk, mostly related to water contamination and the issue of induced seismicity. Furthermore, despite the fact that methane gas is a significant greenhouse gas, there is very little understanding of the climate impact of commercial shale gas production.[15]

The United States-driven 'shale gas revolution'[16] has made a tentative landing on the shores of the United Kingdom. While there is no shale gas production or fully fledged industry, the drilling of exploratory vertical wells has commenced.[17] Potential sites for exploration have

[7] Review, n. 1 above, at 11-18.
[8] US Energy Information Administration, *Annual Energy Outlook 2012* (2012), at 3.
[9] US Energy Information Administration, *Gas Resources: An Initial Assessment of 14 Regions outside the USA* (2011).
[10] Review, n.1 above, at 11.
[11] M. Brinded, *The Case for Shale and Tight Gas* (Foundation for Science and Technology, 2011), at 3.
[12] D.M. Kargbo, R.G. Wilhelm and D.J. Campbell, n. 2 above, at 5679.
[13] P. Stevens, n. 6 above, at 26.
[14] J. Broderick *et al.*, *Shale Gas: An Updated Assessment of Environmental and Climate Change Impacts* (Tyndall Centre for Climate Change Research, 2011), at 118-119.
[15] Ibid., at 117.
[16] P. Stevens, n. 6 above.
[17] Review, n. 1 above, at 17. There were 97 Petroleum Exploration and Development licenses for shale has exploration granted in the 13th onshore licensing round of 2008. A 14th round is currently underway. More information found at <http://og.decc.gov.uk/en/olgs/cms/licences/lic_rounds/lic_rounds.aspx>.

been identified in Lancashire, Sussex and Kent by Cuadrilla Resources (Cuadrilla). As interest in shale gas is increasing in anticipation of the next round of licenses and the formulation of an official government stance on the matter, this article outlines and evaluates the existing regulatory framework for shale gas extraction in the UK and identify possible implications for the operation of EU law in this field

REGULATORY FRAMEWORK

As in most European member states,[18] there is no regulatory framework applicable specifically to shale gas extraction or its technologies of directional drilling and hydraulic fracturing. Relevant legislation belongs under the general category of the hydrocarbon (oil and gas) regulation. Therefore, the following analysis is an extrapolation from the regulatory framework applying to generic onshore oil and gas extraction. The addition of an energy chapter in the shape of Article 194 of the Lisbon Treaty[19] towards the pursuit of an internal energy market has not created a full new Union competence and has not affected national sovereignty over resources.[20] By consequence, the analysis will have to encompass a complex tableau of EU regulations and directives, acts of parliament and statutory instruments of relevance to the regulation of shale gas extraction in the UK. The lack of specific mention or adaptation to the particular characteristics of unconventional sources such as shale gas has resulted in legal gaps and loopholes at both the European and the UK level, especially as regards the interpretation and implementation of existing provisions. These gaps can be easily observed in the lack of full examination of the environmental impacts of these extractive activities.

[18] Philippe & Partners, *Final Report on Unconventional Gas in Europe* (European Commission, 2011); L. Reins, 'The Shale Gas Extraction Process and Its Impacts on Water Resources', 20:3 *Review of European Community and International Environmental Law* (2011), 300.
[19] Consolidated Version of the Treaty on the Functioning of the European Union, [2010] OJ C83/47.
[20] Ibid., Art. 194(2).

In simplified terms, there are four steps to initiating exploratory drilling, followed by additional requirements for initiating commercial production of shale gas. For this regulatory process to protect the natural environment and human health, three interrelated areas of particular concern have to be addressed. These are: (i) the environmental and health impacts of the technology of hydraulic fracturing, (ii) the management of the produced water and solid waste, and (iii) the maintenance of well integrity, i.e. the 'normal operation' of the shale gas well.

LICENSES AND PERMITS FOR EXPLORATION AND PRODUCTION

Land ownership in the UK does not confer rights over hydrocarbons below the surface (including oil and gas); by consequence all shale gas deposits in the UK are State-owned.[21] As with all hydrocarbons, the general authorization procedures for shale gas exploration and production are set out in the Hydrocarbons Directive[22] and further given effect as a licensing system in the UK context through the Hydrocarbons Licensing Directive Regulations 1995[23] and the Petroleum Licensing (Exploration and Production) (Seaward and Landward Areas) Regulations 2004.[24] The overall goal of these procedures is to ensure non-discriminatory access to and exercise of 'the activities of prospecting, exploring for and producing hydrocarbons',[25] including the creation of geographical monopolies. The criteria for the grant of a license are set out in Regulation 3 of the 1995 regulations, and include technical and financial capability; prospecting, exploratory and production methods; tender price offered; lack of efficiency or responsibility for previous license holders. For onshore shale gas

[21] Petroleum Act 1998 (c. 17), Sec. 2.
[22] Directive 94/22/EC of 30 May 1994 on The Conditions For Granting And Using Authorizations For The Prospection, Exploration And Production Of Hydrocarbons, [1994] OJ L 164.
[23] S.I. 1995/1434.
[24] S.I. 2004/352.
[25] Directive 94/22/EC, n. 22 above, Art. 2.

extraction, initial six-year 'Petroleum[26] Exploration and Development Licences' are currently granted by the Department of Energy and Climate Change (DECC) in competitive licensing rounds. A license grants exclusivity to an operator in a specific area, and a variety of terms and conditions can be attached (known as 'model clauses'), and are made known to the applicants by way of publication in delegated legislation.[27] Therefore, directional drilling and hydraulic fracturing constitute activities that are authorized by the DECC within the conditions of the exploration license, but do not require any separate authorization.[28]

Furthermore, a license does not equate with a permit to initiate exploratory drilling or any other preparatory operations. A second step, in the shape of the planning application, is required in order for the licensee to proceed with its shale gas exploration plans. As an operational development of the land (mining operation),[29] the construction of the exploratory gas wells is subject to planning permission[30] from the local planning authority[31] with responsibility for mineral planning (known in this context as the Mineral Planning Authority[32]). A separate permit may have to be sought from the Coal Authority if the drilling operations affect existing coals deposits. The lack of specific consideration of shale gas extraction is again obvious in the absence of unconventional gas sources from the government's policy statement in regard to minerals and planning.[33]

Since there is a considerable environmental impact associated with mining activities and in particular with some of the innovative technologies used in shale gas extraction, it would be

[26] Petroleum 'includes any mineral oil or relative hydrocarbon and natural gas existing in its natural condition in strata', Petroleum Act, n. 21 above, Sec. 1(a).
[27] See licensing regulations, n. 24 above
[28] Although additional environmental permits may be required. See hydraulic fracturing section below.
[29] Town and Country Planning Act 1990 (c. 8), Sec. 55(4).
[30] Ibid., Sec. 57.
[31] Planning and Compulsory Purchase Act 2004 (c. 5), Part II.
[32] Town and Country Planning Act, n. 29 above, Sec. 1(4).
[33] Minerals Policy Statement 1: Planning and Minerals (Department of Communities and Local Government 2006)

logical to expect that an Environmental Impact Assessment (EIA) would be an important component in the mineral planning authority's decision process,[34] as part of the broader EU regulatory framework.[35] However, the EIA directive and by consequence the planning regulations that give effect to it differentiate between Annex I (Schedule I in the regulations) projects, for which there is a mandatory EIA requirement,[36] and Annex II (Schedule II in regulations) projects, where the request of EIA is left up to discretion of the local planning authority ('screening' in the regulations).

This distinction creates certain gaps, which have been exploited in the case of the first exploratory shale gas planning applications. For example, the first planning permission granted to Cuadrilla for exploratory drilling in the Lancashire region was not subject to an EIA at all, due to clever classification by Cuadrilla during the planning application.[37]More specifically, the proposed mining operations did not fall under schedule I as they were exploratory and not commercial. In addition, they were also presented as not large enough to constitute schedule II developmentseither; they were declared as covering an area of 0.99 hectares, whereas the screening threshold for 'deep drillings' under Schedule 2 is 1 hectare. Such a classification meant that the overall project was not even subject to a screening decision by the MPA on whether an EIA would be required. As Broderick et al note however,[38] an EIA could still have been required if these operations were classified as 'surface industrial installations for the extraction of coal, petroleum, natural gas and ores, as well as bituminous shale',[39] since the threshold in that case is only 0.5 hectares. From the

[34] See The Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999, S.I. 1999/293.
[35] Directive 85/337/EEC of 27 June 1984 on The Assessment Of The Effects Of Certain Public And Private Projects On The Environment, [1985] OJ L/175 as amended by Directives 97/11/EC and 2003/35/EC.
[36] For shale gas extraction, a mandatory EIA would be required in the case of commercial (not exploratory) extraction, where the amount exceeds 500 000 cubic metres/day. Ibid., Annex I, par. 14.
[37] J. Broderick *et al.,* n. 13 above, at 105.
[38] Ibid.
[39] EIA Regulations, n. 34 above, Schedule 2.

above example of Cuadrilla's application in the UK, it is easy to conclude that there can be significant discretion in the implementation of the EIA directive by national authorities as it relates to shale gas extraction.

Even without an EIA, the planning permission may still be subject to a variety of conditions and limitations,[40] which is certainly the case for shale gas extraction which falls under 'mineral working'.[41] The national policy on minerals planning[42] is not only guided by the idea of sustainable development,[43] but also contains a number of objectives that relate to environmental protection.[44] In this pursuit of sustainable development, the Environmental Agency is a statutory consultee of the local planning process[45]. In addition to strictly environmental impacts, cooperation on public health impacts will also have to take place indirectly, through the Environment Agency consulting with the Health Protection Agency.

Once this conditional planning permission from the MPA is secured on top of the exploration license from the DECC, the operator has to proceed by notifying the Health and Safety Executive (HSE) of its intention to drill at least 21 days in advance.[46] This notification requires a significant amount of information from the part of the operator, including equipment used, scale diagrams of directional path and terminal depth, particulars of geological strata, formations and fluids that the drilled well will pass through, programme of work and details of operations and resultant risks and hazards, amongst others.[47] This enables the HSE to further review the operator's plans for the design, construction and operation of a

[40] Town and Country Planning Act, n. 29 above, Sec. 72.
[41] Ibid., Schedule 5.
[42] Minerals Policy Statement I, n. 33 above, at 5.
[43] Planning Act 2004, n. 31 above, Sec. 39.
[44] E.g. 'to protect internationally and nationally designated areas of landscape value and nature conservation importance from minerals development'.
[45] Planning Act 2004, n.31 above, Sec. 33A; The Town and Country Planning (Local Planning) (England) Regulations 2012, S.I. 2012/767, Reg. 4.
[46] The Borehole Sites and Operations Regulations 1995, S.I. 1995/2038, Reg. 6.
[47] For a full list of particulars see Ibid., Schedule 1, Part I.

gas well at the specific site from a health and safety perspective and issue the relevant health and safety document. At this point, the operator will also have to arrange a well examination scheme using an independent well examiner[48]. In similar fashion to the involvement of the HSE, this well examination scheme does not take into account environmental risks. It simply aims to ensure that:

> the well is so designed and constructed, and is maintained in such repair and condition, that— (a) so far as is reasonably practicable, there can be no unplanned escape of fluids from the well; and (b) risks to the health and safety of persons from it or anything in it, or in strata to which it is connected, are as low as is reasonably practicable.[49]

The Environmental Agency should also be notified regarding the intention to commence drilling and construct a well.[50] An additional set of environmental permits, regarding water use and waste management,[51] are required for the site to begin operations.[52] The last step is a return to the beginning of the whole licensing process. The final 'well consent' is given by the DECC after consultation with the regulators involved, i.e. the EA, the HPA and the HSE. This well consent will also set limits on the extraction of shale gas.

After these exploratory activities, if the operator wants to move on to production it will need to go through a similar planning and permit process, although no additional PEDL license would be required. In addition to reapplying for planning permission, the operator would

[48] Under The Offshore Installations and Wells (Design and Construction, etc.) Regulations 1996, S.I. 1996/913, Part IV, Reg. 18.
[49] Ibid.
[50] Water Resources Act 1991 (c. 57), Sec. 199.
[51] These permits are further discussed below as part of the regulation of hydraulic fracturing.
[52] The Environmental Permitting (England and Wales) Regulations 2010, S.I. 2010/675, Reg. 12.

need to submit a Field Development Plan[53] in order to be granted a Field Development Consent from DECC, which will of course include different conditions and limits compared to the exploration well consent.

HYDRAULIC FRACTURING AND WATER RESOURCES

The above licensing and permit system constitutes the standard procedure for all landward hydrocarbon extraction. However, one of the particular characteristics of unconventional shale gas extraction is its water-intensive nature due to the reliance on the technology of hydraulic fracturing, as explained in the introduction. Water may be removed, injected into the shale, and then flow back to the surface as wastewater. All these processes have significant environmental and health impacts. Once more, the following regulation is presented solely by analogy as there are no acts or statutory instruments dealing specifically with shale gas or hydraulic fracturing. Nevertheless, it is clear that additional procedures, conditions and limits apply for shale gas extraction, particularly in relation to its impact on water resources.

Hydraulic fracturing by definition requires the injection of significant amounts of water, which may be removed either from surfacewater (rivers, lakes etc.) or groundwater (aquifers) sources. The Environment Agency is generally responsible for protecting and sustainably managing these water resources[54]. At the very least, if this removal ('abstraction') of water is to take place, one of the environmental permits required prior to well consent being given by the DECC is to have an 'abstraction license' from the EA[55]. This is required if more than 20

[53] The details of which are specified in the model clauses of the PEDL license. See The Petroleum (Current Model Clauses) Order 1999, S.I. 1999/160.
[54] Environment Act 1995 (c. 25), Sec. 6.
[55] Water Resources Act 1991, n. 49 above, Sec. 24.

cubic metres of water is taken from surface or groundwater,[56] which would invariably be the case for use in hydraulic fracturing. The British government has reiterated that 'a license will only be issued where a sustainable water supply is available',[57] although the potential effectiveness of such a policy statement depends entirely on the sustainability criteria used by the EA in reaching these licencing decisions.

An alternative option for the operator that obviates the need for an abstraction permit and its considerations is to negotiate with the water utilities company for mains supply. Cuadrilla does intend to use mains supply in its wells, rather than abstracted, water.[58] However, such an arrangement may require the transfer of additional amounts of water by road, if the mains supply to fairly remote drilling sites lacks sufficient capacity. The impact of this train of heavy lorries ferrying equipment and resources on site, in terms of noise, pollution and damage, consistently remains a major factor driving local opposition to shale gas extraction in the US.[59] Such an arrangement may also affect the planning application if the gas well is turned into a production operation.

Depending on the geology of each sale formation, the technical characteristics of the well and the frequency of use of hydraulic fracturing, the amount of water required will vary. It is accepted that water use may be quite significant during drilling, fracturing and production phases.[60] For this reason, reliable generic predictions regarding water use cannot be made. For the Marcellus shale formation in North East US, it is estimated by a Pennsylvania Department of Conservation and Natural Resources geologist that a horizontal well

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[56] Ibid., Sec. 27.

[57] House of Commons Energy and Climate Change Committee, *Shale Gas: Government Response to the Committee's Fifth Report of Session 2010-2012* (2011), at 6.

[58] S. Moore, *Gas Works? Shale Gas and its Policy Implications* (Policy Exchange, 2012), at 49.

[59] K. J. Brasier .*et al.*, 'Residents' Perceptions of Community and Environmental Impacts from Development of Natural Gas in the Marcellus Shale', 26:1 *Journal of Rural Social Sciences* 2011, 32.

[60] Review, n. 1 above, at 20; S. Entrekin *et al.*, 'Rapid Expansion of Natural Gas Development Poses a Threat to Surface Waters', 9:9 *Frontiers in Ecology and Environment* 2011, 503.

'completion'[61] may require up to three million gallons (roughly 11,000 cubic metres) of water.[62] A British report states that five million gallons (roughly 19,000 cubic metres) is the amount needed to operate a hydraulically-fractured shale well for a decade,[63] although no source is cited for that estimate. In general, between 2 and 10 million gallons will be needed just for the fracturing of each well.[64]

The injection of such amounts of water below ground and the expected flow back of waste waters raise a number of regulatory issues, within the complete reorganization of European water law and policy instituted by the Water Framework Directive.[65] The regulatory framework for water protection and management thus instituted asks Member States to aim to achieve a 'good water status' in relation to both surface and ground waters.[66] This integrated approach in principle requires the EA - as the competent authority for the implementation of this directive - to regulate the whole spectrum of water uses and impacts of shale gas extraction. In addition to water supply as described above, others areas of concern are the injection of the water - turned into fracturing fluid - into the shale formation due to the possibility of its migration and contamination of groundwater aquifers and the waste created by hydraulic fracturing due to the same reasons, as well as the additional possibility of surface water pollution through surface leaks. In practice however, there are some gaps in the process as currently conceived.

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[61] I.e. drilling and casing *only*, excluding subsequent fracturing stages and eventual operation, see Review, n.1 above, at 9.

[62] J. A. Harper, 'The Marcellus Shale – An Old "New" Gas Reservoir in Pennsylvania', 38:1 *Pennsylvania Geology* 2008, 2, at 11-12.

[63] S. Moore, n. 57 above, at 49.

[64] D.M. Kargbo, R.G. Wilhelm and D.J. Campbell, n.2 above, at 5861.

[65] Directive 2000/60/EC of 23 October 2000 Establishing a Framework for Community Action in the Field of Water Policy, [2000] OJ L 327.

[66] Ibid., Art. 4(1)(a)(ii) & 4 (2)(a)(ii). The term 'good status' is composed of the terms 'good chemical status' and 'good ecological status'.

In terms of the treatment of water prior to its injection into the shale, the typical composition of the fracturing fluid is over 94% water, sand added as a propping agent or 'proppant' to keep the created fractures open, as well as crucially a number of chemicals to assist in the fracturing process.[67] These added chemicals may include scale inhibitors, acids, biocides, friction reducers and surfactants to assist the process at various stages. Contrary to the US, where the precise nature of these chemical additives is protected as a trade secret,[68] the disclosure of the chemicals included in the fracking fluid may be requested by the EA already under the Water Resources Act 1991,[69] which predates the Water Framework Directive. This may affect both the planning permission and the permits required for the site to operate. Knowledge of the exact composition of the fracking fluid of course also assists in the correct treatment and disposal of the created wastewater after the completion of hydraulic fracturing, which is further discussed below.

In addition to EA disclosure, there are further constraints on the type of chemical additives that can be used in the fracturing fluid. Before they are used, any substances used in fracturing fluid must be registered with the European Chemicals and Health Agency, along with their requisite chemical safety assessment, under the relevant European-wide REACH regulation.[70] This is an obligation to register of the operator as a 'downstream user' of these chemicals.[71] Coupled with the disclosure requirement, the Environmental Agency can then presumably check that the safety reports of the disclosed chemicals for extractive use. However, a recent examination of the registered chemical safety reports of substances likely

[67] For a full breakdown of a typical composition see Review, n. 1 above, at 19.
[68] R.B. Jackson *et al.*, *Research and Policy Recommendations for Hydraulic Fracturing and Shale-Gas Extraction* (Centre on Global Change, Duke University, 2011), at 9.
[69] Water Resources Act 1991, n. 49 above, Sec. 92.
[70] Regulation (EC) 1907/2006 of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), [2006] OJ L396/1, as implemented by The REACH Regulations 2008 S.I. 2008/2852.
[71] Ibid., Chap. 1, Art. 3 & Chap. 2, Art. 3. Downstream user means 'any natural or legal person established within the Community, other than the manufacturer or the importer, who uses a substance, either on its own or in a preparation, in the course of his industrial or professional activities.'

to be used in hydraulic fracturing indicated that they contain no explicit references to shale gas.[72] Therefore, compliance of shale gas operators with chemicals regulation is incomplete, if not lacking. Nevertheless, from the above it is clear that regulatory safeguards against the unrestrained use of chemicals in hydraulic fracturing do exist.

Moving on to the actual injection of the fracturing fluid into the shale formation, this practice is regulated by the Water Framework Directive. Article 11(3)(j) of the Directive allows Member States to 'authorize, specifying the conditions for, the injection of water containing substances resulting from the operations for exploration and extraction of hydrocarbons or mining activities'.[73] Under the Environmental Permitting Regulations 2010, it falls to the Environment Agency to consider whether this injection constitutes 'groundwater activity' requiring an environmental permit,[74] taking into account the quality criteria established in the new Groundwater Directive.[75]

Presently in the UK, hydraulic fracturing is flatly not permitted below freshwater aquifers used for drinking water supply.[76] However, if that blanket ban is set aside, the level of protection afforded other types of groundwater by the EA drops off significantly. Since, during the 'normal operation' of the shale gas well there would be no actual injection or risk of leakage of the fracturing fluid into the groundwater[77], so therefore no environmental permit would be required. This was the decision reached by the EA in relation to Cuadrilla's exploratory activities.[78] It has been noted however that this finding is based solely on the risk

[72] J. Broderick *et al.,* n. 13 above, at 102.
[73] This is an exception that is carried across relevant EU legislation. E.g. see Groundwater Directive, n. 74 below, Art. 6(3)(a).
[74] Environmental Permitting Regulations 2010, Reg. 12.
[75] Directive 2006/118/EC of 12 December 2006 on the Protection of Groundwater against Pollution and Deterioration, [2006] OJ L372/19, Art. 3 and 4.
[76] Review, n. 1 above, at 34.
[77] This refers to operation only. The permit requirement regarding discharge/injection of wastewater produced by the operation of the well is discussed further below.
[78] Review, n. 1 above, at 34.

associated with the normal operation of the gas well and is based on the assumption that the existing controls over design, construction and operation of wells guarantee this 'normality'.[79] Ideally, best practice guidelines for well construction, and in particular the various casings of the wellbores required, are sufficient to protect general well integrity and prevent any environmental risk of groundwater leakage.[80] However, such comprehensive guidelines 'across the lifecycle of shale gas extraction' do not yet exist in the UK.[81] In addition, as already underlined in the licensing section of this article, since that aspect of the process is regulated by the HSE, environmental risks are not actually considered, and the emphasis is on the health and safety of persons.

Therefore, the trust that the EA places on the well examination scheme and the HSE appears misplaced, as environmental risks are the purview of the EA. It seems odd that the EA would expect other regulators to usurp its authority on environmental matters. On a more serious note, there is little doubt that this decision to waive the permit is favourable to the shale gas operator, while at the same time possibly increasing the adverse environmental impact of shale gas extraction in the case of well failure. This is indicative of a broader legislative and policy trend to create exceptions in water regulation in favour of allowing hydraulic fracturing; a trend initiated by the US Energy Act 2005 that explicitly excluded hydraulic fracturing from the definition of 'underground injection' for the purposes of the Safe Drinking Water Act.[82]

Experience from the US has taught us that a permissive regulatory environment built on exceptions in relation to the impact of shale gas extraction on groundwater can have

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[79] J. Broderick *et al.*, n. 13 above, at 98.
[80] Review, n. 1 above, at 24-26.
[81] Ibid.
[82] L. Reins, n. 16 above, at 302-303; H. Wiseman, 'Regulatory Adaptation on Fractured Appalachia', 21(11) *Villanova Environmental Law Journal* (2010), 229, at 243.

catastrophic results. As shale gas consists predominantly of methane, any migration of formation or produced water[83] into shallow freshwater aquifers due to poor well design and construction can result in significant contamination of drinking water. Although it has been claimed that methane does not affect the 'potability' of water,[84] this form of groundwater contamination has galvanised opposition to shale gas extraction, driven by images of local residents setting their tap water on fire with a lighter.[85] The US National Academy of sciences has provided evidence of methane contamination of drinking water at the Marcellus and Utica shale formations in Pennsylvania and New York.[86] This risk is particularly augmented in areas of the US where households rely on private water supplies, but less immediate so in the UK under the Water Framework Directive and the provisions outlined in the preceding paragraphs. Nevertheless, the difference of course remains that the UK does not have a fully developed shale gas industry. If the development of such a UK industry is followed by a similar trend towards relaxation of regulatory controls, there is already ample knowledge of the impacts on groundwater sources.

As if the issues with hydraulic fracturing and water resources were not sufficiently serious, there are some alternative options to water-based fracturing fluids currently being advertised. Gelled liquid petroleum can be used as fracturing fluid,[87] allowing for quicker recovery of the fluid itself and less toxic waste, as these fluids do not dissolve salts, heavy metals, and radioactive material in the shale formation.[88] The 'DryFrac' technique, developed in Canada, uses liquid CO_2 as the carrier fluid and sand as proppant, but not any water or additional

[83] I.e. mixture of fracturing fluid and saline water with minerals from the shale formation. See discussion about wastewaters below.
[84] Jackson et al., n. 67 above, at 3.
[85] As shown in the 2010 documentary 'Gasland'.
[86] S.G. Osborn et al., 'Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing', 108(20) *Proceedings of the National Academy of Sciences* (2011), 8172.
[87] Review, n. 1 above, at 20.
[88] Wastewater management is discussed in the following paragraphs.

chemicals except N_2 gas to prevent ice formulation.[89] The result of this fracturing method is liquid and chemical residue-free propped fractures in the well, as the CO_2 turns into gas form within the well, and an increase in production, particularly for wells that do not respond well to hydraulic fracturing due to characteristics of the shale formation or the presence of tectonic faults. Greatly reducing the strain on water resources, this technique would obviate the need for water abstraction licenses or arrangements with water companies, but may also have the unintended effect (from the operator's perspective) of forcing the EA's hand into considering additional environmental permits for chemical-based fracturing methods, as the volume of chemicals injected into the ground would increase exponentially. Additional compliance with REACH regulations in terms of chemical registration may also be required. Furthermore, the use of these innovative non-water based fracturing methods requires additional infrastructure to transport those liquids on site, which aside from the cost will add to already outlined oppositions (local traffic, noise etc.) associated with shale gas extraction.

Finally, the regulation of wastewaters produced from shale gas extraction through hydraulic fracturing is also an important component of the regulatory framework. The management of these 'wastewaters' requires both short term and long term systems, since the term refers both to 'flowback' water, i.e. the injected fracturing fluid returning to the surface along with saline water and minerals from the shale, as well as 'produced' water, i.e. the formation water that returns to the surface over the productive lifecycle of the gas well.[90] In addition to the chemicals added to the fracturing fluid, salt, methane, heavy metals, other organic and inorganic compounds from within the shale formation can also be present. There is also a possibility that this produced water will also contain naturally occurring radioactive materials

[89] D.M. Kargbo, R.G. Wilhelm and D.J. Campbell, n. 2 above, at 5682.
[90] Review, n. 1 above, at 9.

(NORM) due to the fact that shale rock contains uranium deposits. [91] Consequently, these wastewaters constitute a significant risk to surface waters near the site, in the event of a major spill or leakage. For this reason, the installation of impermeable site lining ('bunding') is required by the MPA in order for planning permission to be granted. The wastewaters are initially stored onsite in closed tanks, before being treated using a variety of methods, depending on whether they are going to be reused or disposed.

These wastewaters are considered extractive under the Mining Waste Directive,[92] which requires the operator to have a waste management plan that addresses the identification, reduction, recycling and safe disposal of the waste produced by the extractive activities.[93] The ideal scenario from an environmental perspective for shale gas extraction employing hydraulic fracturing would be a zero-waste, closed-loop system, where the produced water is continuously treated on site and reused as fracturing fluid, obviating the need for disposing any wastewater. However, technological and cost limitations mean that in practice some wastewater recycling takes place on site, while excess volume is transported to a treatment facility off site and then disposed by underground injection into a disposal well constructed for that specific purpose.[94] This type of injection would constitute 'groundwater activity' requiring an additional environmental permit under the Water Framework and Groundwater directives mentioned earlier. If NORM are also present in the wastewater above certain concentration levels, additional environmental permits are required for disposal, based on existing radioactive substances legislation.[95]

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[91] For more details on the composition of produced water see National Petroleum Council, *Management of Produced Water from Oil and Gas Wells* (Working Document of the NPC North American Resource Development Study Group, 2011).

[92] Directive 2006/21/EC of 15 March 2006 on the Management of Waste from Extractive Industries, [2006] OJ L 102/15.

[93] Ibid., Art. 5.

[94] Under the Borehole Sites and Operations Regulations 1995. Alternatively, abandoned wells can also be used.

[95] Radioactive Substances Act 1993 (c.2).

INDUCED SEISMICITY

A well-constructed shale gas well with excellent quality casings coupled with a closed-loop storage, treatment and recycling system for the wastewater would completely separate shale gas extraction from both groundwater and surfacewater, and thus significantly reduce the environmental risks associated with such activities. Aside from the fact that such a utopian scenario is not technically or financially possible, it still would not address all the environmental issues raised regarding such activities, and in particular the technology of hydraulic fracturing. An additional emerging concern is the possibility of induced seismicity.

In April and May 2011, two small earthquakes were reported near Blackpool, after hydraulic fracturing was employed at the Cuadrilla exploratory site at Preese Hall, in Lancashire's Bowland Shale formation. Operations were suspended pending a report on the relationship between these earthquakes and operations at the Preese Hall exploratory site. The studies commissioned by Cuadrilla concluded that 'earthquake activity was caused by direct fluid injection into an adjacent fault zone during the treatments, but that the probability if further earthquake activity is low.'[96] While the first claim that the earthquakes were caused by hydraulic fracturing is accepted, the experts asked by the British government to review these studies were not convinced about the latter claim regarding the low probability of further induced seismicity. The expert findings confirm that this remains an area of concern, because induced seismicity is not as well as understood as the impact of shale gas extraction on water resources.

[96] C. A. Green, P. Styles and B. J. Baptie, *Preese Hall Shale Gas Fracturing: Review & Recommendations for Induced Seismicity Mitigation* (2012), at ii.

A certain level of (micro) seismicity is expected during the hydraulic fracturing process, as the engineered fractures propagate throughout the formation. 'Larger seismic events are rare but can be induced by hydraulic fracturing in the presence of a pre-stressed fault'.[97]

This was exhibited in the case of the Blackpool earthquakes, where the fracking fluid probably migrated into a nearby unidentified pre-stressed fault, causing it to reactivate and release its energy, which was 'several orders of magnitude greater than the microseismic energy associated with routine hydraulic fracturing'.[98] However, the expert findings 'failed to identify a causative fault'[99] and their rejection of the Cuadrilla-commissioned report findings as regards the probability of further earthquakes is underpinned by the same concern stressed by the overall government review of shale gas extraction, i.e. the lack of detailed geological surveys of faults in the area; 'in the present state of knowledge it is entirely possible that there are critically stressed faults elsewhere in the basin'.[100] Although the risk of direct structural damage from induced earthquakes in the UK is minimal because of its very low natural seismicity, such seismic events can cause significant environmental harm by damaging well casings,[101] thus possibly affecting well integrity and leading to contamination of groundwater.

At the moment, there is a gap in the regulatory framework regarding induced seismicity. The government experts concurred with the Cuadrilla-commissioned report that the issue of induced seismicity can be addressed through self-regulation, namely via a real-time 'traffic light' monitoring system that stops the fracturing when induced seismicity exceeds a certain

[97] Review, n. 1 above, at 41.
[98] Ibid.
[99] C. A. Green, P. Styles and B. J. Baptie, n. 97 above, at ii.
[100] Ibid.
[101] This in fact has occurred at the Meese Hall exploratory site. C.J. de Pater and S. Baisch, *Geomechanical Study of Bowland Shale Seismicity: Synthesis Report* (Cuadrilla Resources Ltd, 2011).

threshold.[102] In terms of additional regulatory controls, widening the scope of the Environmental Impact Assessment by adding a 'seismic risk assessment' has also been proposed.[103]

CONCLUSIONS

Many of the factors that drive local and national opposition to shale gas extraction, such as non-disclosure of fracking fluids or groundwater contamination due to poor well design and construction, drilling close to public water aquifers, lack of monitoring are in fact solely a product of the very lax and fragmented – between federal and state level - regulatory framework of the US. As shale-gas regulation in the EU and the UK develops in response to the possible development of a shale gas industry, it is important to not pick up 'bad habits' or import worrying deregulatory trends from the US, such as the numerous exceptions granted to the industry, but to adopt best practices and adapt them to the European and UK context. The analysis of the UK context suggests that additional legislative steps will have to be taken at the European level in the coming years in the event that a full-scale shale gas industry develops in Europe.

The Royal Society and the Royal Academy of Engineering stressed throughout their commissioned review of shale gas extraction and hydraulic fracturing that the existing UK regulatory framework is adequate at this point in time for exploratory activities to proceed. However, and in view of the lack of knowledge of the environmental and health effects of these activities, this article has discovered a number of surprizing gaps that contradict the aims and objectives of the relevant EU directives.

[102] C. A. Green, P. Styles and B. J. Baptie, n. 96 above, at iii. Also discussed in S. Moore, n. 57 above, at 51.
[103] Review, n. 1 above, at 46-47.

Authorizing shale gas extraction without requiring an EIA, a well examination scheme that does not monitor gas wells for specific environmental impacts, waiving environmental permits (and thus not imposing any conditions) for the injection of fracturing fluid into the groundwater, completely effacing the risk of induced seismicity from the procedure until seismic events actually occurred all point towards a business-friendly regulatory environment bewitched by the shale gas revolution, further indicating a trend towards adopting US-style regulation. Such measures may even be sufficient for conventional oil and gas exploration. Proponents of shale gas take pains to emphasize its many similarities with other gas sources. However, since shale gas is classified as an unconventional source and comes with its own particular challenges, maybe a business as usual approach is not the best way forward? At least, the review also contains numerous proposals on how to improve the regulatory framework, along with an explicit acknowledgement that a regulatory framework sufficient for licensing and monitoring a dozen sites nationally may indeed prove inadequate when production increases to commercial levels.[104]

Before new regulation is instituted however, it is worthwhile to take a broader view of a debate that has tended to focus excessively on the technical, environmental and public health aspects. First, the hype of the shale gas revolution can obfuscate the understanding of shale gas as a 'transition' fuel, turning it into a replacement fuel. While the UK does not appear to possess significant reserves for this misunderstanding to flourish, other European countries, such as Poland, are planning to change their energy policy due to abundant shale gas reserves. In turn, this national policy change may affect the delicate balance of shared competency struck in the energy chapter of the Treaty of Lisbon and the overall direction of a potential EU energy policy. Secondly, the shale gas revolution has the potential to affect not only energy policy, but also climate policy, as methane is a greenhouse gas. The climate

[104] Review, n.1 above, at 55-56.

impact of a global shale gas industry is poorly understood. Thirdly, in an era dominated by the concept of sustainable development, and an environmental law increasingly framed in governance terms,[105] it would be remiss to ignore the economic and social impacts of shale gas extraction, and particularly in relation to the local communities in close proximity to the proposed long term production wells, or the low level of public acceptance of such extractive activities, which is dependent on public perceptions of risk associated with hydraulic fracturing. Finally, the lack of attention to the risk of induced seismicity further betrays an odd unfamiliarity with the functioning of the precautionary principle, particularly given its relative success in the European context. However, this may be an indirect result of the lack of EIA to be rectified later. Existing knowledge of shale gas extraction through hydraulic fracturing suggests that the risk of induced seismicity will have to be included in any form assessment of the impact of such extractive activities.

From the above, it becomes clear that there is a significant amount of research and decision-making still pending at both European and member-State level. It can be argued that a shale gas-specific regulatory framework is presently on the edge of being formulated. It remains to be seen whether this edge is in fact the edge of a dangerous cliff of environmental degradation or an opportunity to benefit from the discovery of a sustainable energy source.

[105] N. Gunningham, 'Environmental Law, Regulation and Governance: Shifting Architectures', 21(2) *Journal of Environmental Law* [2009], 179.