A RAPID EVIDENCE ASSESSMENT OF REGULATION AND REGULATORY PRACTICES INVOLVED IN FRACKING AND ITS PUBLIC HEALTH IMPLICATIONS

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Summary

This review explores the existing evidence base on regulation and industry practice from a public health perspective in relation to unconventional gas extraction (UGE) and fracking. The review focuses on the subject with regard to potential and likely public health impacts in the UK. A rapid evidence assessment approach was used. Although several reports and papers, including some from the UK government and its agencies, state fracking would be safe assuming there is or will be industry best practice and 'robust' regulation, the evidence base for such statements is remarkably sparse. We find very little support for this position in the relevant peer-reviewed scientific literature. Some government and agency reports fail to reference any evidence at all to support their regulatory and industry practice assessments.

The key case study publications reviewed include scientific and academic papers, professional reports, government agency reports, industry and industry funded reports, and an NGO report. Each case study is structured to address the strengths and weaknesses of the publication in relation to the review research questions. We make no judgement on any other aspects of the papers reviewed. Large-scale commercial onshore UGE and fracking is not currently underway in the UK, so much of the existing literature comes from the USA. The USA and UK have different regulatory regimes, as well as different geological and geographical constraints, including drinking water sources. Nevertheless, there are many similarities typical of any global industry and its transnational companies. Several fracking governance reports indicate many of the key principles mooted will have international application. The evidence suggests that there is both good and bad practice relating to fracking and UGE in the USA. Notably, the conventional wisdom that the USA has weak regulations across all its states and federal agencies is inaccurate. In relation to public health we have identified some comparatively high regulatory standards in OSHA, NIOSH and EPA, yet UK reports often fail to note these. However, compliance with existing regulations, and relatedly, monitoring and enforcement of regulatory standards remains variable in the US. This is a key challenge from a public health perspective.

Several reviewed papers and reports concluded fracking could not be conducted safely. These assessments emphasise the inherent dangers the industry presents over the short, medium and long term to public health directly, and through global climate change impacts. These risks and dangers cannot simply be mitigated so that no significant damage to public health would be done. A number of case study publications supporting fracking fail to acknowledge or cite peer reviewed work contesting their position, thus leading to skewed assessments. It is notable that discussions about the industry and its regulation – particularly in the non-peer reviewed literature – often ignore critical peer reviewed studies, are overly reliant on sources that are not peer-reviewed, including industry sources or industry-funded research. These reports frequently fail to draw on independent expertise in public health, fail to adequately explore different regulatory systems and their drivers, and do not deal with evidence of industry malpractice. These are all areas that should be essential to any rigorous assessment of past and future fracking activity.

Key lessons from regulation and industry practice lessons suggest a much more cautious approach is required. This is so particularly against the background of major past failures in the capacity of regulators and industry to protect public health from known or suspect carcinogens or known air pollutants. The WHO International Agency for Research on Cancer estimates 7-19% of cancers world-wide are due to environmental exposures causing thousands of UK deaths each year and air pollution is now estimated to cause 40,000 deaths each year in the UK. UGE will be an additional source of exposures to such environmental and workplace pollutants.

The review conclusions are as follows:

(1) the evidence base for robust regulation and good industry practice is currently absent. There are multiple serious challenges surrounding location, scale, monitoring and data deficits facing regulators overseeing onshore UGE and fracking in the UK;

(2) the evidence from peer-reviewed papers suggests fracking in the UK will not be effectively regulated. It is highly likely that regulatory agencies may lack the staffing and resources necessary to monitor and enforce effective regulation of the industry;

(3) US and UK peer-reviewed analyses and EU law identify both the precautionary principle and prevention as keys to dealing with fracking. This is underpinned by findings from the peer-reviewed public health literature that already identifies significant hazards and major potential risks from the industry.

Introduction

The health and environmental impacts of fracking, and the regulation and enforcement of the unconventional gas industry, are being debated globally as different countries and regions consider the costs and benefits of onshore UGE. Not all of these debates and the issues raised regarding regulation are addressed in key UK reports assessing the viability and desirability of fracking and UGE development across the UK. The UK Government and the fracking industry often argue the problems associated with fracking in the US are not applicable to the UK context. The acknowledged concerns are linked to past bad practice and partly due to different geology and geography, especially connected to groundwater. Past bad practice it is argued, was largely a product of inadequate regulation and poor enforcement in the USA. A number of problems emerge with such analysis. Firstly, regulations and their enforcement vary markedly from state to state. Secondly, US agencies such as EPA, NIOSH and OSHA have set some of the best global health, safety and environmental standards. Thirdly, the fracking industry in the USA has created problems in very recent years that cannot simply be explained away by recourse to arguments about lax regulation and poor industry practice as an historical exception. These problems merit full discussion when examining the future of fracking in the UK.

The US focus is often on mitigating risks in an industry that already exists. In the UK, and in Scotland where there is currently a moratorium on UGE, a more fundamental question could be put: 'can the industry be regulated effectively and in a healthy and safe manner'?

Three key questions were posed in the review as follows.

Research Questions

1. What is the evidence that effective UK fracking regulations currently exist or can be produced?
2. What is the evidence that such regulations can and will be enforced to protect public health?
3. What are the major regulatory and enforcement problems relating to fracking?

Methods

'Rapid evidence assessments provide a more structured and rigorous search and quality assessment of the evidence than a literature review but are not as exhaustive as a systematic review. They can be used to gain an overview of the density and quality of evidence on a particular issue; to support programming decisions by providing evidence on key topics and; to support the commissioning of further research by identifying evidence gaps'. [1]

A Rapid Evidence Assessment (REA) has been adopted here because of limited time and resources linked to a pressing policy timetable. REAs are often circumscribed because of limited time and resources, but these two reasons also explain their adoption. Problems with REAs include possible bias due to truncating the usual systematic review process, such as excluding unpublished material; being less comprehensive than a systematic review; and generating inconclusive results that may not fully answer questions posed at the outset.[2]

The search terms and results from the search strategy are provided in Table 1 below. The literature search used key words and terms and was not restricted by language, country or time.

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[1] https://www.gov.uk/government/collections/rapid-evidence-assessments. 28 July 2015. Accessed July 1 2016

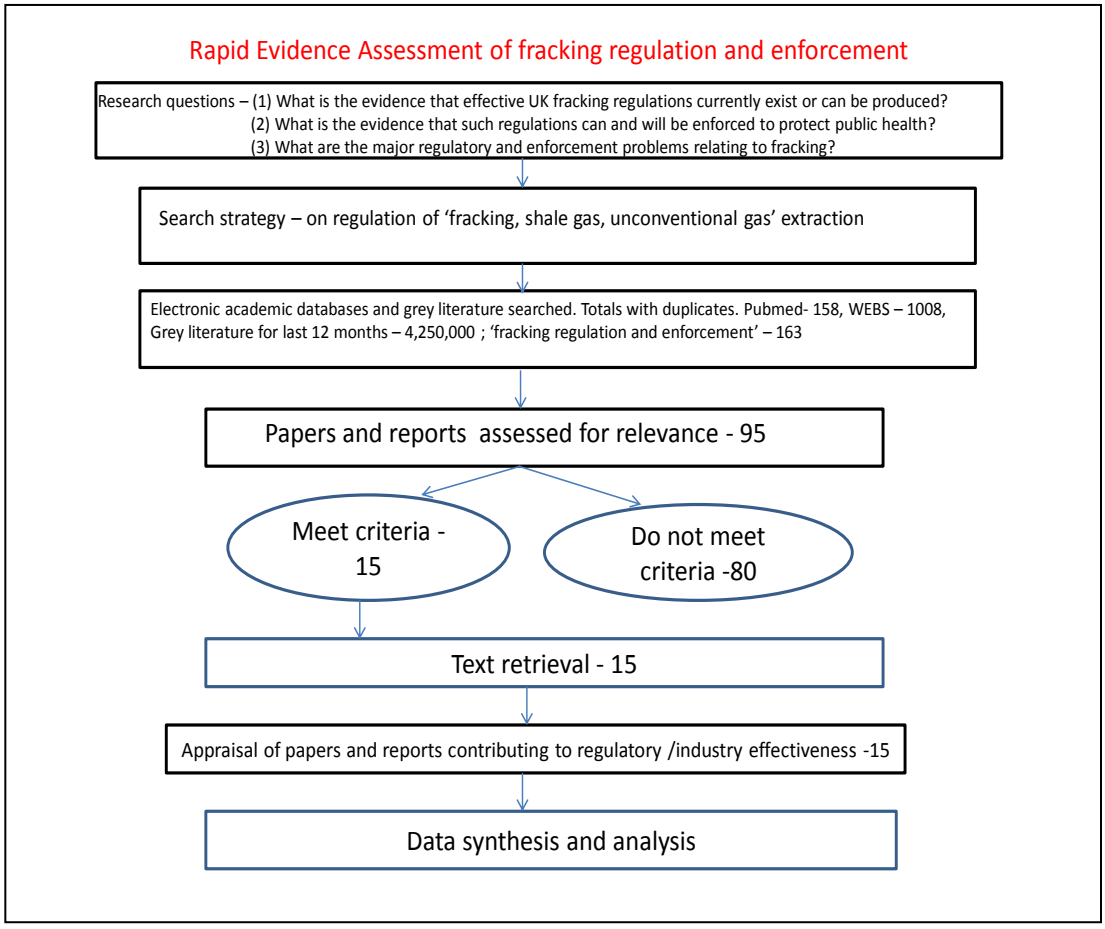
[2] http://webarchive.nationalarchives.gov.uk/20140305122816/http://www.civilservice.gov.uk/networks/gsr/resources-and-guidance/rapid-evidence-assessment/what-is Accessed July 1 2016

Table 1.

	Regulation		
Pubmed	regulating fracking – 0 regulation fracking – 0 regulating shale gas-0 regulating UGE-0 regulation UGE -24 shale gas regulation – 35 fracking regulation 13 hydraulic fracking regulation – 25 unconventional gas regulation – 24 control of fracking – 14 shale gas controls – 10 fracking legislation – 14 shale gas legislation – 15 unconventional gas legislation - 8		
WEBS (1960-2016)	Regulating fracking – 14 Regulation fracking – 42 Regulating shale gas – 106 Regulating unconventional gas extraction – 6 Regulation UG – 75 Shale gas regulation -134 Fracking regulation- 42 hydraulic fracking regulation – 23 unconventional gas regulation – 75 control of fracking – 113 shale gas controls – 280 (including 278 on public health and 8 in UK) fracking legislation – 23 shale gas legislation – 48 unconventional gas legislation – 27		
Grey literature – accessed through Google Searches 12/05/2016 Last 12 months scanned	regulating fracking – 204,000	UK – 489,000	Scotland – 245,000
	regulation fracking – 541,000	UK - 434,000	Scotland – 307,000
	regulating shale gas-871,000	UK – 744,000	Scotland - 345,000
	regulating UGE- 373,000	UK – 361,000	Scotland – 132,000
	regulation UG - 259,000	UK – 283,000	Scotland – 106,000
	shale gas regulation – 546,000	UK – 653,000	Scotland - 400,000
	fracking regulation – 548,000	UK – 408,000	Scotland – 303,000
	hydraulic fracking regulation – 295,000	UK - 295000	Scotland – 210,000
	unconventional gas regulation – 261,000	UK – 261,000	Scotland – 106,000
	control of fracking – 4,250,000	UK – 520,000	Scotland -384,000
	shale gas controls – 689,000	UK – 801,000	Scotland – 2 million+
	fracking legislation – 538,00	UK – 418,000	Scotland – 248,000
	shale gas legislation – 485,000	UK – 525,000	Scotland – 282,000
	unconventional gas legislation - 136,000	UK – 154,000	Scotland – 219,000

The papers were then each reviewed independently by both authors using the standard approach for REAs and the results are provided in Table 2 below.

Table 2



Papers were assessed for relevance using abstracts and summaries available and then retrieved. They fell into the following categories listed below in Table 3

Table 3 Papers assessed for relevance on fracking regulation

Category for search	Numbers
Academics	21
Consultants	3
EU	3
Regulation	2
International	17
Lawyers	7
NGOs	3
Scottish Government and SEPA	4
UK Government and HSE	4
General	31
Total	**95**

15 papers were selected for the review, based on the first appraisal. These appeared to be the most important in terms of immediate relevance to the key questions and are noted in Table 4 below

Table 4.Key papers selected for the review case studies

Category for search	Numbers
Academics (UK and international)	6
Consultants	
Professional bodies	1
Regulation	1
International	
industry	2
NGOs	1
Scottish Government	1
UK and US Government and agencies	3
General	
Total	**15**

The case studies included in this evidence assessment are listed below.

1. Royal Society/ Royal Academy of Engineering**.** Shale Gas Extraction in the UK: A Review of Hydraulic Fracturing. June 2012

2. Public Health England. Review of the Potential Public Health Impacts of Exposures to Chemical and Radioactive Pollutants as a Result of the Shale Gas Extraction Process. June 2014

3. Shale Gas Task Force. 1st Interim Report. Planning, Regulation & Local Engagement. 2015

4. Scottish Government Independent Expert Scientific Panel. Report on Unconventional Oil and Gas. Edinburgh 2014

5. Hawkins, J. Fracking: Minding The Gaps. Environmental Law Review 2015, Vol. 17(1) 8–21

6. American Public Health Association (APHA). Policy Statement on the Environmental and Occupational Health Impacts of High-Volume Hydraulic Fracturing of Unconventional Gas Reserves. 2012

7. Environment America Research & Policy Center. Fracking Failures: Oil and Gas Industry Environmental Violations in Pennsylvania and what they mean for the U.S. January 2015

8. New York State Department Of Health. Public Health Review of High Volume Hydraulic Fracturing for Shale Gas Development. December 2014

9. Wiseman, H.J. The Capacity of States to Govern Shale Gas Development Risks. Environ. Sci. Technol., 2014, 48 (15), pp. 8376–8387

10. Small, M. et al. Risks And Risk Governance in Unconventional Shale Gas. Environ. Sci. Technol., July 2014, 48 (15), pp. 8289–8297

11. UKOOG. Guidelines for Addressing Public Health in Environmental Impact Assessment for Onshore Oil and Gas. United Kingdom Onshore Oil and Gas. 2015

12. Cook, J.J. Who's Regulating Who? Fracking Policy in Colorado, Wyoming, and Louisiana. Environmental Practice. June 2014, 16 (2), pp. 102-112.

13. Bomberg, E. Shale Governance in the European Union. Issues in Energy and Environmental Policy. (15) October 2014

14. Centner, T. J. Oversight of Shale Gas Production in the United States and the Disclosure of Toxic Substances.. Resources Policy. 2013, pp. 233-240

15. Centner, T. J. and O'Connell, L.K. Unfinished Business in the Regulation of Shale Gas Production in the United States. Science of the Total Environment (476–477) 2014 p. 359–367

It is evident that those reports produced by UK regulators – HSE, EA and SEPA – are generally written for policy users, politicians and civil servants. These documents largely fail to engage with independent literature dealing with assessments of fracking industry practice, regulation and enforcement.

They are mainly descriptions of the agencies regulatory and enforcement responsibilities, structures, practices now and in the future. They all therefore fall out with the review framework because they provide information about application of the laws. Although some indicate the need to expand or revise legislation to deal with fracking they do not evaluate their own practices, staffing and resources. They often fail to reference and rarely document the sources used beyond official ones.

The credibility of any self-assessment by these agencies, or assessments by those they commission, is clearly open to challenge. This presents a dilemma because all the agencies claim they are capable of regulating fracking. At present this remains an opinion and assertion lacking in evidence and independent scrutiny. There are also problems with the 'better regulation' approaches recently adopted by several UK agencies. For some agencies there may be perceived conflicts of interest with regard to regulatory practices. For example one agency has used a former chemical industry executive, from a company that makes fracking fluids, to train hundreds of its staff on how to regulate for sustainability and economic growth.

No publicly available and independent assessments of what the regulators now do, or propose to do, with regard to fracking were identified in this REA beyond those already included as case studies in the assessment. There is much literature on regulation and regulatory philosophies that provide an invaluable backcloth for the REA. This literature contains both positive and negative analyses of the UK regulation. There are also critiques of the monitoring and enforcement policies and practices adopted by various regulatory agencies. Information on some of the debates on regulation and industry practice that have relevance to the terrain in which UGE and fracking regulation is available[3] in the critical analyses done by independent researchers such as Tombs and Whyte (2016a, 2016b, 2014, 2013).

There may be in-house agency assessments of the challenges presented by fracking (what many but not all now view as a new technology with new materials for the UK) in terms of staff expertise, staffing levels and resourcing. However, these do not appear to be publicly available at present. The problem for the agencies that may be responsible for monitoring and enforcing fracking regulation is further compounded by the fact that there is currently no experience of dealing with the onshore fracking industry at scale. Moreover, the cuts in resources and staffing that many agencies have experienced over the last decade or more raises pressing concerns about regulatory capacity. If UGE or fracking entails the sinking of thousands of wells, the public and communities in areas where fracking is most likely to occur may be sceptical of statements from regulators that they can effectively oversee such large developments with existing staff, resources and expertise.

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[3] http://www.regulatingscotland.org/report/

Regulatory assessment? What UK regulators have stated about fracking

It has not been possible to assess, from the regulators own documentation, their capacity to effectively regulate fracking. Regulators in-house publications are not independently assessed. The position is further complicated by conflicting analyses of the role and function of such agencies generally. One end of the spectrum argues that agencies are independent of government and free to make their own judgements on whether fracking is safe or presents a risk to public health, and, if so, how to regulate it and allocate staff and resources accordingly. A more critical perspective suggests many agencies lack autonomy. They can be captured by those they oversee or must increasingly align regulation with government preferences (see Tombs 2016). There are also a number of positions between these poles. The debate about whether precaution or prevention informs regulators dealing with fracking has been explored in recent years in the context of legal and other drivers (Fleming and Reins 2016). Several critiques are considered below. However, a brief commentary is offered here on the past documentation provided by the regulators themselves.

Environment Agency (EA)

The EA operates under DBEIS (formerly DECC). DECC had oversight of UGE and in April 2015 gave up some of its functions to the Oil and Gas Authority. The Environment Agency still deals with 'appropriate permits or authorisation' for exploratory and production phases. The Environment Agency's environmental permitting regulations pertain to water resources, and they assess the use of chemicals in hydraulic fracturing fluids. The Environment Agency also have a function in respect of treatment and disposal of wastes produced during borehole drilling and hydraulic fracturing processes and is a statutory consultee in the planning process and advises local government on the potential risks to the environment from individual gas exploration and extraction sites.[4] 'If an environmental regulator finds that an operator is in breach of an authorisation or permit, it will take action to stop any activity, prevent further impacts and remedy those that have happened' (DECC 2014). DECC relied heavily on the Royal Society/Royal Academy of Engineering 2012 report and the PHE 2013 report to support its assessment that fracking is safe if well regulated. They assert: 'Before any shale operation can begin in the UK, operators must pass rigorous health and safety, environmental and planning permission processes' (DBEIS 2016).

The official guidance does not test if the existing regulations and permitting processes are adequate and will be effectively enforced by an agency with sufficient staff, resources and expertise to ensure proper regulation.

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[4] https://www.gov.uk/government/publications/about-shale-gas-and-hydraulic-fracturing-fracking/developing-shale-oil-and-gas-in-the-uk

Health and Safety Executive (HSE)

The HSE locus in relation to UGE and fracking centres on well design, construction, operation and decommissioning and borehole regulation. Occupational health and safety is a reserved matter and so the HSE has responsibility across Great Britain but not the UK for worker health and safety, and related risks to the public from workplace hazards. It did require operators to 'notify HSE, at least 21 days before drilling is planned, of the well design and operation plans to ensure that major accident hazard risks to people from well and well related activities are properly controlled' (HSE nd). To what extent HSE could have guaranteed the necessary scrutiny within the specified 21-day period is unclear. How 'joined up working' with other agencies can be ensured and be effective remains untested. While a memorandum of understanding between HSE and the Environment Agency (HSE/EA 2012) has existed for a few years there is currently no large-scale shale gas production from fracking anywhere in the UK. No one knows if these agencies will work well together in joint initial inspections, review inspections and other regulatory activities. For example, there is considerable uncertainty about how to ensure effective oversight of fracking chemicals. Currently the EU's REACH directive applies in the UK, but with Brexit uncertainty, and numerous data gaps regarding fracking fluid toxicity, the challenge facing these regulators on this aspect of fracking regulation alone is considerable.

Much is made by HSE of its established regulatory regime on health and safety but there is widespread agreement from independent assessors (and even within the HSE itself) that it has failed to address the longstanding issues with occupational disease in the UK. There are legitimate concerns at the moment that such failures will be replicated in the fracking sector. The position is further compounded by declining HSE inspections, limited enforcement and court penalties, and the use of 'independent' well examiners who 'can be an employee of the operating company or a contractor' according to the HSE. Staffing and resources are key concerns. HSE itself notes they believe they have 'sufficient 'if undefined 'wells expertise' but 'would need to reassess the situation if it [fracking] moved into large scale production' (HSE nd). When considered against their existing national health and safety record, resources and staff, there are clear grounds for concern surrounding the capacity of HSE to fulfil its regulatory obligations vis-a-vis worker and public health should fracking develop even at modest scale across the UK.

The HSE produced an Onshore Gas and pipelines sector strategy for 2014-2017 in which it stated its main concern was to eliminate 'the risk of major hazard incidents in which many workers and/or members of the public might be killed or injured' through fire and explosion risks. Nowhere in the document does it refer to the need to regulate the occupational disease threats to workers and the public that might be posed by the onshore gas industry. The operational regulatory regime is largely business-friendly. 'Our regulation is undertaken within a wider context. Whilst we will always take the protection of the safety and health of onshore gas and pipelines industry workers and members of the public as an overriding priority, we also recognise that the industry operates within a complex environment. This strategy looks to encourage industry cooperation and leadership in a context that supports all aspects of good business practice' (HSE nd Strategy).

The HSE Delivery document linked to this states 'in general, the industry has a good record regarding the management of conventional health and safety issues' (HSE nd Delivery). The use of regulation specifically to reduce occupational ill-health does not feature as something the HSE seeks to deliver. Occupational health is mentioned only once in the Aims and Objectives document that focuses again on catastrophes, rightly a major issue. 'Personal health and safety' is seen as separate and the HSE does not set aims and objectives for the industry because it regards it as having a relatively good record. (HSE nd Aims).

Such an approach downgrades the population and epidemiological approach to sectoral occupational ill-health. This is reflected in HSE's historic inability, or neglect over recent decades, to take national regulatory and enforcement action on occupational diseases. Identified onshore gas and oil pipeline issues are confined for example to concerns about hand arm vibration whereas it is clear that onshore gas presents many more occupational health challenges. If onshore fracking develops on a large scale the range of occupational health concerns will likely mirror those reported and documented in places where the industry is already operating.

Scottish Environment Protection Agency (SEPA)

SEPA has similar responsibilities and powers in Scotland to the Environment Agency in England with regard to fracking and other forms of unconventional gas extraction and has identified in the recent past a range of duties and functions relevant to UGE regulation. It is a statutory consultee in the local authority planning permission process and in this sphere has an authorisation role with regard to exploration wells. Along with HSE and what was DECC, it issues well consents. Health Protection Scotland may have a role to advise government, industry and planning authorities on the public health impacts of UGE.

In terms of well operations, SEPA will be responsible for: the Water Environment (Controlled Activities) Scotland Regulations 2011, and related licenses that deal with water abstraction, treatment and possible pollution issues; the Management of Extractive Waste (Scotland) Regulations 2010; the Radioactive Substances Act 1993; the Pollution Prevention and Control (Scotland) Regulations 2012 (SEPA nd). SEPA also has a regulatory role under the Control of Major Accident Hazards Regulations 199 (COMAH) and the Environmental Liability (Scotland) Regulations 2009 and has 'a duty to consider how Scotland can reduce the greenhouse gas emissions from regulated industry and businesses, under the Climate Change (Scotland) Act 2009'. As well as contributing to climate change, fugitive emissions have the potential to impact on human health and the environment.

The regulatory challenges for SEPA relate to resources, staffing and data gaps in key areas related to UGE that currently exist both globally and within Scotland. Whilst not as savagely cut as the Environment Agency or HSE, the impacts of Westminster economic retrenchment policies on Scottish environmental regulation and enforcement are very real. In terms of assessing the likelihood that fracking can or will be effectively regulated in Scotland, there are no independent judgements available. SEPA has repeated its commitment to deliver 'robust and proportionate regulation' of UGE (SEPA 2014) but exactly what this means in terms of overseeing potentially thousands of wells in the densely populated central belt for example is not clear.

SEPA has indicated it believes existing staff can deal with any regulatory challenges they face. However, others outside the agency may not share this confidence in SEPA's enforcement activity and practices. There is also potential for perceptions of conflict of interests. For example the agency has used a former chemical industry senior executive who worked for a company that produces fracking fluids, to train hundreds of its staff on how to regulate for sustainability and economic growth (SEPA 2015; PR Newswire 2015).

An analysis of key findings

The analysis that follows below seeks to summarise some of the inter-connected key themes and key findings of our rapid evidence assessment.

1. What is the evidence that effective UK fracking regulations currently exist or can be produced?

Although several reports and papers, including some from the UK government and its agencies, state fracking would be safe assuming there is or will be industry best practice and 'robust' regulation (Case Studies 1,2,3,4,10,11), the evidence base for such statements is remarkably sparse (Case Study 5). Government and agency reports and other papers fail to reference any evidence at all to support their regulatory and industry practice assessments and no substantial evidence was available to support such a conclusion. The fact that effective regulation does not yet exist is clearly recognised in some case studies, as is the necessity of ongoing monitoring of air/ health risks to 'inform regulation of each phase of operation' (Case Study 2). There is some recognition of the impact of political and industry influence on existing regulatory structures and enforcement environments (Case Studies 5, 7, 12, 13)

Other case studies failed to examine the question of effective enforcement of regulations in a soft regulatory regime where regulatory agencies would inspect and oversee what could be thousands of fracked wells (Case Study 4). So effective regulation by necessity is simply speculative and prompted public health experts on fracking in the USA to observe: 'a focus on mostly hypothetical regulatory and engineering solutions may mistake best practices for actual practices, and supplants the empirical with the theoretical' (BMJ 2014; 348). Yet other researchers in the USA were clear that: 'the sheer number and severity of risks posed by fracking operations make constructing an adequate regulatory regime – much less enforcing it at thousands of wells and other sites – implausible' (Case Study 7). This conclusion on the public health threat from fracking is echoed by UK researchers (for example Reap 2015). It would also be wrong to automatically assume that the UK has across the board a better regulatory structure, proposed better laws and created better agencies with more resources than for example EPA and NIOSH in the USA. Yet even with an improved regulatory system and supposedly improved industry practice, the most detailed well-informed and lengthy study on the health impacts of fracking concluded the industry should not be permitted (Case Study 8).

There is confusion in several UK reports about the technology underpinning shale gas extraction, which is new and may be conducted in new areas, not always coal mining districts.

Some case studies highlighted the lack of knowledge about gas and groundwater contaminants and the need for more surveys (Case Study 1). These pollution problems exist for older extractive industries and practices, and have done so for centuries. Yet one case study was clear that 'Fracking must be recognised and regulated as a new and uncertain technology' (Case Study 5). The capacity of regulators to deal with the new UGE industry over similar periods of time is inevitably speculative. An industry-funded report has cast doubt on the capacity of the various agencies now responsible for on shore gas development to work together to ensure effective regulation (Case Study 3). Other case studies noted the lack of clarity that exists with regard to waste disposal (Case Study 1). One trenchant analysis written by a legal scholar indicated significant problems with current regulations: 'The very way in which the risks have been assessed assumes that a 'robust' regulatory system will be in place; this has fed the justification for significant instances of regulatory inaction. Clearly the current regulation is not 'robust', and the framing of such risks as 'low' based on this assumption highlights the deficiencies in this cyclic determination' and 'maintenance of the current approach is beneficial in that it requires minimal effort and expenditure, whilst allowing the shale gas industry to develop. However, it risks allowing regulatory gaps to remain until problems materialise' (Case Study 5).

Some case studies did not have terms of reference tied directly to regulation although they commented on regulatory suitability. Other case studies did not consider all the issues raised by fracking that require regulation: for example climate change and greenhouse gas emissions, sustainable use of water resources, nuisance issues, traffic (apart from vehicle exhaust emissions), occupational health, visual impact and the socioeconomic benefits and impacts of shale gas extraction (Case Study 2). One case study identifies a range of failings with the existing regulatory and monitoring and self-monitoring systems (Case Study 3). These would indicate that it is impossible to guarantee the current regulatory system can deal effectively with the health, safety and environmental challenges posed by fracking. Reconciling this assessment with another case study that states 'considerable legislative safeguards' already existed to prevent adverse UGE impacts but noted 'confusion has been expressed about the regulatory framework and a lack of confidence in the regulatory regime' (Case Study 4) may be problematic.

2. What is the evidence that such regulations can and will be enforced to protect public health?

Several case studies sometimes contained either no public health experts, no legal specialist, no members who had independent research expertise in assessing regulation or no independent members with research expertise in assessing this industry's health, safety and environmental performance (Case Study 1, 3, 4, 11).

The budgets, resources, and staffing of all the key central and local governmental agencies and departments dealing with fracking-related issues have been cut – a trend that in some instances predates the latest economic crisis. Some case studies stressed the need for increased regulatory capacity and regulator co-operation, highlighting the potential problems with well inspection and the need for more independent verification (Case Study 1).

Other case studies draw out the important and complex settings within which regulation will be made (Case Study 13), a matter arguably likely to be exacerbated with Brexit.

There is therefore a regulatory deficit in the UK relating to the infrastructure needed to ensure effective oversight of existing industrial activities. If fracking is permitted across the UK, then there will be potentially tens of thousands of wells developed with all that entails. Planning staff and local environmental health professionals who may play key roles in approving or monitoring large numbers of fracked wells and the communities around them are already fully stretched, under substantial pressure and lack resources and staff. The inspection and enforcement issue is compounded further by the 'better regulation' agenda. This has overtly and covertly damaged both inspection and enforcement regimes and appears to be geared towards making regulation better for business, rather than those social groups who may carry the burdens of business externalities not protected by regulation. Some case studies did not necessarily look to more regulation on all aspects of UGE but called for specific guidelines to ensure effective 'goal-based' risk assessments were prepared and submitted to regulators for both scrutiny and enforcement with compulsory reporting of well failures (Case Study 1).

One case study found that not only were base line environmental monitoring studies lacking but consideration of wider socio-economic impacts was missing and, although the problem of cumulative impacts of many wells in relatively small areas was recognised, it was not possible to establish how this played into low potential risk assessments (Case Study 2).

Evidence from the US has revealed the continued failures in fracking industry practice despite the creation of an industry-led Centre for Sustainable Shale Development. This points to the ongoing problem of enforcement in several states and the dangers of over-reliance on industry initiatives and in-house industry surveillance (Case study 7). There are salutary lessons here for the UK.

There is also evidence about wider failures of regulators to identify, prevent or reduce exposures to a range of past pollutants that now present major public health problems. Fracking will add to this pollution burden: a fact that highlights the urgent need for cumulative environmental health impacts and the development of metrics to inform exposomes (a measure of all the exposures of an individual in a lifetime from birth to old age and how those exposures relate to health). The WHO International Agency for Research on Cancer estimates 7-19% of cancers world-wide are due to environmental exposures causing thousands of UK deaths each year (Straif 2008; WHO 2009). Air pollution is now estimated to cause 40,000 deaths each year in the UK (SPICE 2016). UGE will be an additional source of exposures to such environmental and workplace pollutants.

3. What are the major regulatory and enforcement problems relating to fracking and public health?

There are important lessons to be learned in relation to securing public health. Regulation, experience and practice elsewhere should inform policy making on fracking and other UGE in the UK. Also it is clear that good regulation without effective enforcement is meaningless (Case Study 15). These lessons suggest a much more cautious approach is required, and that the regulatory frameworks and capacity must be established well in advance of operations. For example one case study found that after two decades of fracking in the USA, in a complex regulatory environment, there was still a lack of understanding about some risks. Moreover, there were still regulatory gaps and problems with information and training needed for enforcement (Case Study 9). Another case study based on US experience highlighted 'current practices and regulations often do not adequately consider long-term and compounding health effects' (Case Study 15).

The economic value of effective controls reducing public health threats from air pollution were flagged in one case study, but the difficulty of making similar calculations for water pollution was noted due to lack of information on costs and risks. Research has noted the failure of some US state regulators to consider the cumulative externalities generated by fracking through air, soil and water pollution, loss of water resources and added health service costs (Case Study 14). The solution to the problems of estimating the economic costs of fracking in the UK is even further away than in the USA.

Some case studies neglected to flag or discuss how particular groups need to be protected in both regulations and enforcement practice if fracking occurs. For example the issue of exposure of vulnerable groups, and very low-level exposure to endocrine disruptors, is not addressed in several case studies (Case Study 11). Crucially, for public health, to protect vulnerable groups as well as local populations, baseline monitoring and data-gathering must be first undertaken. This appears to be severely lacking or limited and fragmented in many areas with regard to environmental and health data (Case Studies 1,2,4,6). This evidence gathering should then be used to inform any subsequent decision-making around permitting or licensing extraction. Monitoring and data-gathering to fill gaps are considered vital to best regulatory practice (Case Studies 6, 14). Some case studies recognised the many public health uncertainties of fracking, the lack of peer-reviewed studies in certain subjects (Case Study 1-2) that cannot preclude major public health problems with the industry in future.

There is a view in some case studies that a community's right to know about the hazardous substances used in fracking, including detailed toxicity information, is vital (Case Study 14). Disclosure of information on fracking fluids for example with regard to laws rather than agreements has exercised industry, regulators and academics and has not yet been fully resolved either in the UK or USA (Case Studies 11,14).

Proper recognition of many public health related problems is not achieved, partly because of the absence or limited input of public health and regulatory expertise in several British case studies (Case Studies 1, 3, 4, 11). Yet resources may be constrained.

One solution offered to a lack of regulatory resources is that industry might fund regulation through fees and levies drawn from operators (Case Study 3). Such an approach is in itself problematic as has been shown with a similar HSE scheme now running, creating tension with industry, workers and communities alike. The approach could also imply regulation would lag behind industry practice. Would industry be first expected to fund regulation and then begin operations? This seems an unstable and unsatisfactory regulatory solution, as the independence of a regulator dependent on industry for its survival would be extremely difficult to establish in the eyes of other stakeholders.

A number of studies advocated or noted a precautionary or preventative approach to future shale gas development (Case Studies 5,6,8,13) but the detail on how exactly such approaches could be implemented were often lacking. These studies largely focus on US or EU cases (Case Studies 5, 8, 13). It is notable that the precautionary principle is one that has not been adopted readily in the UK. A House of Commons Library Briefing Paper on fracking prepared for MPs in October 2015 touched on and described the existing regulatory regime, reiterating statements from HSE, DECC and DCLG. No detailed analysis was offered on regulation and the merits of a precautionary approach were not considered. The briefing re-iterated the conclusions of what it described as 'a short review' of fracking risks produced by the Royal Society and Royal Society of Engineering in 2012 (White el al 2105: 24). The briefing document did explore pollution incidents and cited sources that made it clear regulation of fracking in the USA varied in levels of stringency. This is a point frequently forgotten by several UK commentators who simply categorised US regulation as universally poor when it was not.

The Commons briefing also drew on the Tyndall assessment of shale gas with regard to environmental and climate change impacts. The Tyndall researchers highlighted some issues that are not mentioned in the Commons briefing note: for example on data gaps and regulatory problems; they considered at that time in 2011 'Concerns remain about the adequacy of current UK regulation of groundwater and surface water contamination and the assessment of environmental impact' (Broderick 2011:5). Even with stringent regulatory controls, the Tyndall report recognised contamination risks could not be 'fully eliminated' and their key conclusion was 'Evidence from the US suggests shale gas extraction brings a significant risk of ground and surface water contamination and until the evidence base is developed a precautionary approach to development in the UK and Europe is the only responsible action' (Broderick 2011:5).

Conclusions to the REA

The 15 case studies within the REA, with a variety of strengths and weaknesses, provide some answers for our 3 main research questions.

(1) the evidence base for robust regulation and good industry practice is currently absent. There are multiple serious challenges surrounding location, scale, monitoring and data deficits facing regulators overseeing onshore UGE and fracking in the UK.

(2) the evidence from peer-reviewed papers suggests fracking in the UK will not be effectively regulated. It is highly likely that regulatory agencies may lack the staffing and resources necessary to monitor and enforce effective regulation of the industry.

(3) US and UK peer-reviewed analyses and EU law identify both the precautionary principle and prevention as keys to dealing with fracking. This is underpinned by findings from the peer-reviewed public health literature that already identifies significant hazards and major potential risks from the industry. In the UK there appears to be an absence of evidence of both effective prevention and precautionary thinking in unconventional gas extraction laws, guidance and policies advocated for fracking.

There is undoubtedly a great deal of debate about what may work and what may not in regulations, inspection and enforcement. Much of the focus has been on regulating the well construction. Relatively less attention has been devoted to what goes into the wells, comes out of the wells and is disposed of, or sealed in, when wells are decommissioned. Figures on well failures and orphaned wells in the USA and UK vary. In the three year period 2010 to 2012, in the US 6-7% of Pennsylvania's 100,000 fracked well casings failed (Ingraffea 2013). Without any fracking underway in the UK, existing data relates to other hydrocarbon wells and boreholes which do not involve the same risks as fracked shale wells. Of the 2152 UK hydrocarbon wells drilled onshore between 1902 and 2013 there was in 2013/14 no visible evidence of 65.2% of well sites and no monitoring was conducted. The ownership of perhaps 53% of wells in the UK is unclear and researchers estimated between 50 and 100 were orphaned and one of 143 active UK wells producing at the end of 2000 had evidence of well integrity failure (Davies et al 2014). Such surveys and several reviewed case studies raise significant and as yet unanswered questions about how wells and their related inputs and outputs can be effectively regulated and monitored during production and decades afterwards.

However some of the primary drivers for UK fracking policy relate not to scientific or legal evidence but to ideology and to precedence for economic growth and profit. This is revealed in a number of reports and position papers published at the request of the Westminster government. This is a highly contested approach in the fields of environmental and public health protection, and critics view the current policy trajectory as highly speculative and risky. For example the UK Government's Business and Industry Ministry, along with its Better Regulation Executive Task Force, has been keen to curtail EU regulation (Business Task Force 2013). Whilst mention is made of the need to protect the environment and public from shale gas hazards, the Task Force opinions were clear. There were unnecessary proposals in the EU to regulate shale gas extraction, and 'New European legislation could

increase costs to business and threaten the exploitation of this valuable source of energy, without offering any additional environmental protection'. (Business Task Force 2013:9) They advised 'A new (Shale Gas) Directive would bring years of uncertainty, deterring investors. Instead, guidance should be produced to clarify how existing EU environmental regulation applies to the new possibilities of shale gas exploitation. This would minimise scope for differences in interpretation, and enable safe and sustainable exploitation of shale gas' (Business Task Force 2013:9). So despite evidence that shale gas regulation in Europe and fracking industry practice are currently inadequate, the UK Government was advised by the Task Force to oppose strengthening regulation, preferring to rely on guidance. Post-Brexit that deregulatory position may become more entrenched.

This is against the background of growing concerns in the European Parliament in 2013 that 'existing (European) treatment plants are ill-equipped to treat hydraulic fracturing waste water and may be discharging pollutants into rivers and streams' at a time when the exact impacts of fracking were uncertain (Reins 2017: 197). Reins recognises there are still real challenges with 'the regulatory requirements applicable to shale gas development prior to operation, the regulation of surface water issues, the framework applicable to underground injection and groundwater, and wastewater management.' (2017: 197) And there is a high level of uncertainty about fracking and water regulation in the EU with a possible race to the bottom on regulation from member states faced with minimum standards (Reins 2017:210).

Our case study assessments also confirm earlier research on the subject. In 2015, some of the failures on fracking risk assessment and control came from either poor or inadequate regulation or problems with well construction. However others relate to the intrinsic nature of the industry. These factors were carefully and rigorously analysed by an environmental scientist including well construction and failures (Reap 2015). The author criticised the assumption by Public Health England that 'all reported health risks from fracking could simply be overcome by regulation and engineering'. She commented: 'Exposure to harmful chemicals due to fracking activity cannot be eliminated through regulation as there are technological and economic limitations to the treatment of emissions into the air, into groundwater and from waste; thus fracking is an inherently risky process in terms of human health' (Reap 2015:2). Moreover 'UK regulations claim to minimise the risks derived from fracking; however, in England and Wales there is no set minimum distance between industrial activity and populated areas. This ignores evidence that geographical distance is a key variable affecting cancerous and non-cancerous health effects in residents near fracking sites' (Reap 2015:3). In terms of policy conclusions linked to the application of cautious approaches, Reap considered " … the safest approach with regard to public health would be to dismiss fracking as a viable option and promote energy technologies that are known to have less of an impact on human health' (Reap 2015:4).

It is this kind of salutary and precautionary analysis that is largely missing from official and industry commissioned reports on UGE and fracking in the UK. Based on our reading of the available evidence we believe a much more precautionary policy stance is necessary to protect public health. Caution, with significant margins of error built in, should underpin all rigorous evaluations of what can and cannot be done with regard to assessing the viability and credibility of effectively regulating, monitoring and inspecting the UK fracking industry.

It may be that the public health risks and challenges presented by the industry outweigh any benefits and are beyond effective regulation in which case prevention becomes a major policy option.

Case Study 1. Royal Society/ Royal Academy of Engineering. Shale Gas Extraction in the UK: A Review of Hydraulic Fracturing. June 2012

The terms of reference of this review were firstly to examine 'the major risks associated with hydraulic fracturing as a means to extract shale gas in the UK, including geological risks, such as seismicity, and environmental risks, such as groundwater contamination' and secondly to find out if those 'risks can be effectively managed and, if so, how' (p.8). It did not look at climate risks to public health.

The report declared that the health, safety and environmental risks from fracking 'can be managed effectively in the UK as long as operational best practices are implemented and enforced through regulation' (p.4). It concluded that fracking was an established technology and the UK had 60 years of experience in regulating onshore and offshore oil and gas and aquifer contamination risks were 'very low' as long as there was deep extraction.

It further concluded 'more likely causes of possible environmental contamination include faulty wells, and leaks and spills associated with surface operations. Neither cause is unique to shale gas. Both are common to all oil and gas wells and extractive activities' (p.4). Hence the report follows but did not precede earlier pronouncements by the UK government that fracking for shale should be developed provided industry practice was good and regulation effective.

At a time when the global health, safety and environmental record of both the offshore oil and gas industry and the onshore oil and gas industry in the USA and Australia was open to serious question, the need for rigorous independent scrutiny of the shale gas industry's practices and regulation was clear. The question is whether this report achieved that scrutiny.

Strengths

The working group and review panel has considerable expertise in the fields of engineering, geology, geography (although some of their conclusions about geological risks were strongly contested). The panel contained members experienced in some wider environmental policy matters as well as some industry background. However, the panel was unbalanced and lacked members able to critically assess the shale gas industry from independent public health, regulatory and industry good practice perspectives. These issues are addressed below. The report does devote two chapters to matters relating to regulation.

The report provides a succinct account of various aspects of good, bad and missing regulation and practice relating to UGE and fracking in the USA, the EU and UK. The report identifies a number of problems and challenges the industry presents along with recommendations for improving regulation, enforcement and industry practice. The report also correctly identifies that whilst some states in the US had deficient regulations on fracking, others did not. The report did not explore these differences in detail in terms of the intrinsic problems with fracking, not just in terms of regulation and operation. The need to collect data to improve risk management is highlighted.

The changes in RIDDOR and breaking of data set continuity, not fully addressed, would suggest the report in some respects was overly optimistic on this subject. The goal-based and prescriptive approaches to risk management are briefly described and discussed although there are no references provided to critiques in the US and elsewhere of this approach in the offshore oil and gas industry.

The report notes the current lack of knowledge about existing methane and other groundwater contaminants and the need for surveys to rectify this (p.6). Baseline health data are also missing. The report recommended that 'options for treating and disposing of wastes should be planned from the outset. The construction, regulation and siting of any future onshore disposal wells need further investigation' (p.6). Again, this begs the question that neither the regulators nor the industry were in a position to estimate accurately what waste water disposal requirements there would be, how to regulate these and who would deal with it. The Cuadrilla Lancashire public enquiry in 2016 highlights the fact that the answer to this question is still lacking.

The report called for specific guidelines rather than new regulation on fracking to ensure effective 'goal-based' risk assessments were prepared and submitted to regulators for both scrutiny and enforcement with compulsory reporting of well failures (p.5). The report further advocated the application perhaps through guidelines of risk assessment (in Environmental Risk Assessment) along the 'entire lifecycle of shale gas extraction' including waste disposal and well abandonment and noted 'regulatory capacity may need to be increased' (p.5). Poor industry operational fracking practices in the US are discussed (p.12).

The report also noted the need for increased regulatory capacity and regulator co-operation. The potential problems with well inspection were recognised along with concerns that the well inspector's role not sufficiently independent (p.26).

A lack of knowledge of various areas and uncertainty were flagged as issues by the report authors, especially in terms of uncertainty about large-scale production activities. Rather surprisingly they appear to consider the environmental, health and safety risks of fracking were addressed in the report (p.57).

Weaknesses

The report states it has 'analysed environmental and health and safety risks' but it is difficult to argue that it has done so effectively on health risks. Public health is mentioned only once in the body of the report. This undermines the assumption that this report adequately considers all the necessary regulations, guidelines and enforcement practices needed to deal effectively with the industry should it start UK-wide commercial activity. To some readers, the report may be viewed as skewed by not just downplaying but simply not considering the health literature on shale gas available at the time. Mackenzie's work on air pollution published in 2012 is the principal public health research mentioned but prior to the report being published in June 2012, papers by Witter were available in 2008 and 2010, by Finkel in 2011, Goldstein in 2011 and by Colborn in 2011.

The report praises the UK's goal based approach to regulation and managing health and safety (p.48). It fails to point out, however, that the UKs record on occupational health is dismal with millions of occupational diseases and thousands of occupational disease deaths happening each year. This does not indicate either effective national regulation or enforcement and a set-up within which fracking activity can be safely conducted. WHO and UK assessments of deaths from air pollution in the country also indicate significant failures in public health regulation and enforcement.

Resources and staffing issues are not addressed in detail by the report at a time when attacks on 'red tape' and public sector cuts were being absorbed across enforcement agencies. The wider political context of deregulation and the pushing of business-friendly 'better regulation' policies and practices appear not to have been factored into the analysis.

It is quite clear that if thousands of fracked wells were sunk by the new shale gas industry in the UK, then there would need to be a very significant increase in regulatory resources and staff in agencies like the HSE, the Environment Agency, SEPA and what was DECC just to deal with existing regulations. Such staff would be needed to deal with even light touch scrutiny of the risk assessment documents proposed by the report, monitoring and enforcement and either enhanced inter-agency working or the creation of a new dedicated agency for fracking as suggested by the Smith Task Force. This does not sit well with a Government committed to deregulation and must raise serious questions about achieving 'robust' regulation and enforcement and the ability of regulators to ensure best industry practice. Self-regulation and the use of 'independent' well examiners will not be sufficient.

No full life cycle analysis (LCA) of the fracking industry from health, safety and environmental perspectives was available to the report authors. Limiting the call simply to environmental risk assessments across the life cycle as the report does (p.5) meant the report missed the opportunity to look at fuller industry regulation, practice and outcomes in for example the USA. The USA was identified as a priority partner (p.56) to learn from regulatory practice and failure. This report published in 2012 points to then forthcoming EPA reviews in the USA on environmental impact.

Well construction in the US is seen to be much more robust and reliable post 2000, after development of more stringent regulation (p. 26). The report calls for more research and notes the lack of clarity for example about what regulations might be needed to deal with waste disposal (p.22). This would suggest it was premature to advocate the development of the new industry at least until regulatory frameworks, responsibilities, base line data and resources are in place. There is also an assumption regulators would know where all the freshwater aquifers were prior to issuing environmental permits, if needed, and ensure fracking did not occur below them (p.34). The evidence to support such an assumption when many thousands of wells may be drilled does not appear to be available or fully documented.

The balance and expertise of the review panel in certain areas has also been challenged. The review panel contained no public health or medical specialists and no independent expert on scrutinising industry practice in the oil and gas sectors.

The balance issue is important and relates to proper scrutiny of regulation and industry practice.

For example the report drew on some fracking regulation publications by a researcher in Texas with reference to the view that spills of fracking fluid could pose a greater contamination risk than hydraulic fracturing itself (p.16). That researcher also produced reports favourable to the industry and had financial interests in natural gas. That researcher was discredited and resigned from his University post. His university then produced a new and tougher conflict of interests' code because of the case.[5]

There is no discussion at all of the precautionary principle – strengths and weaknesses - in the whole report in terms of an approach firstly to permitting fracking and secondly to controlling it. Indeed the word 'precaution' is mentioned only once with regard to seismic activity.

The document is already dated and much more research is now available for example on fracking contaminants and exposures of populations near fracking sites, as well as issues surrounding well viability and failures and the public health consequences of extracting fracked gas linked to global and national climate change. Further gaps have been identified with regard to the capacity of researchers and regulators to monitor fracking additives' movements. New analyses are also available on the limit of our regulatory system to effectively control fracking.

Evidence of implementation

Unclear. An independent engineer identified a series of recommendations made in the report not actioned in the UK by the Government in 2013 (Hill 2013). These included actions on environmental risk assessment, well inspections, well integrity and independent well examiners, and inter-agency collaboration.

Role of political, commercial and industry groups

Yes. The review panel chair had worked in the energy industry and has since had a range of private and public sector roles. Perceived conflicts of interests exist. The Working Group contained eight members: one had worked for BP, one member ran a commercial consultancy, one worked as an advisor for an engineering company, one chaired a company with interests in underground gas storage, one had acted as a consultant on shale gas via an Energy company, one had acted as a consultant for several companies including Cluff with interests in underground coal gasification, and one was a director of Cluff.

The report itself also notes that review panel members from the Royal Academy of Engineering and the Royal Society were asked to declare any potential conflicts of interest. The Royal Society and the Royal Academy of Engineering acknowledged they 'invest their portfolios in a range of companies and funds, including equity holdings in oil'.

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[5] http://inhabitat.com/university-of-texas-fracking-study-discredited-over-researchers-financial-interests-in-natural-gas/

The report itself does not contain details of each review panel member's known or potential conflicts of interests in terms of consultancies and financial interests if any.

Involvement of public health professionals and researchers and specialists in regulatory and industry scrutiny

Not clear

Generalisability

Not clear

Key Lessons

The report failed to address public health issues fully and at the time did not include key literature on hazards and risks. It is now quite dated. The conclusions are not, in a number of key areas, borne out by the evidence or sometimes the lack of evidence provided within the report.

Case Study 2. Public Health England. Review of the Potential Public Health Impacts of Exposures to Chemical and Radioactive Pollutants as a Result of the Shale Gas Extraction Process. June 2014 – Final version.

The review was conducted partly because various national and local agencies requested advice on the matter and appeared in draft form in 2013. The final version was published in 2014 but with the basically the same findings. This analysis relates to the 2014 version. The 2013 draft version was produced following statements by UK government ministers that supported fracking when properly regulated and with industry good practice. The report stated Public Health England provided 'advice on the potential public health impacts of exposures to chemical and radioactive pollutants as a result of shale gas extraction'. The report deals with regulation in chapter 3 and part of chapter 4 but has no sections specifically devoted to industry practice.

The review did not examine climate change and greenhouse gas emissions, sustainable use of water resources, nuisance issues, traffic (apart from vehicle exhaust emissions), occupational health, visual impact and the socioeconomic benefits and impacts of shale gas extraction.

The review concludes 'the potential risks to public health from exposure to the emissions associated with shale gas extraction will be low if the operations are properly run and regulated' (p.iii). The validity of this statement is explored under the weaknesses section below.

Strengths

The review was accepted by many to be a sound assessment of some of the existing scientific literature at the time addressing some, but certainly not all, of the public health implications of extracting shale gas. Air and water quality problems associated with fracking were covered and the review recognised many public health uncertainties of fracking.

For every section dealing with air quality, radon, naturally occurring radioactive materials, water and waste water and hydraulic fluids, the review identifies gaps in knowledge and recommendations for further work. The review also notes the absence of peer reviewed papers on UGE dealing with UK data on fracking and controlled water, on groundwater and surface water impacts, on likely composition and use of fracking fluids and on epidemiological data on health risks and fracking. In the public health context it should be noted that absence of evidence is not evidence of absence. An external reader cannot view these gaps as evidence that fracking can be done safely and will be properly regulated.

The review acknowledged that 'baseline environmental monitoring is needed to facilitate the assessment of the impact of shale gas extraction on the environment and public health' (p.iv). The review also recommended broader public health and socio-economic impacts should be considered (p.iv). The review flags the problem of cumulative impacts of many wells in relatively small areas (p.iv) but does not appear to have factored in or tried to factor in what those impacts might be and how they might affect the PHE estimate of the industry presenting 'low potential risks'.

There is a recognition that regulatory systems are not yet in place, and of the need for ongoing monitoring of air/ health risks to 'inform regulation of each phase of operation' (p. 22). The impact of fracking on water not seen as a problem for 99% of water supply, though there is a recognition that the 1% of population that receive supplies from private sources are potentially vulnerable (p.36) given gaps in knowledge (p.38)

Weaknesses

Many public health professionals and researchers would view assessment of several or all of the excluded topics listed in the introduction as linked to the direct or indirect effects of fracking, as important to public health and mental health and so requiring both scrutiny and regulation.

PHE reviewers considered that the literature on fracking revealed the reported problems were typically a result of operational failure and a poor regulatory environment. It is unclear who made that judgement, who reviewed it and what independent evidence exists to test and/or support it.

The final PHE review was published in June 2014 but a critical peer-reviewed BMJ article which commented on the 2013 draft review appeared in April 20014. The critique contained several pertinent points about the capacity to regulate the fracking industry and the inevitability of its production failures anywhere in the world leading to potential public health problems. As Law and his colleagues pointed out 'a focus on mostly hypothetical regulatory and engineering solutions may mistake best practices for actual practices, and supplants the empirical with the theoretical' (2014). What is of even greater concern is that the review fails to acknowledge that debate and fails to cite any of the fracking publications of these critics who have a different analysis to PHE of the industry risks and public health threats.

It is difficult to see how the risk assessments of the industry by PHE can be so low when baseline environmental monitoring data does not exist and when there is also a lack of relevant baseline health data. The review additionally fails to specifically flag either 'mental health' or well-being as public health concerns that should be assessed, considered and controlled in any health impact assessments of the industry. However, it does report on the Colorado Health Impact Assessment (p.43-44) that identified the potential risks of psychological impacts such as stress and depression when fracking is proposed or occurs.

The question of cumulative impacts of many wells in relatively small areas is mentioned in the review. However, there does not appear to have been any consideration of the need for cumulative health impact assessments or the use of methods such as the exposome to inform not just regulation and monitoring of industry practice, but also the wider question of the introduction of fracking at all in areas of high population concentration, previously high industrial pollution levels, currently high industrial pollution levels, vulnerable populations and environmental justice challenges.

Whilst the review recommends fracking fluid chemicals should be publicly disclosed (p.iv) it does not explicitly call for a regulation to require this to happen– a topic flagged by the Smith Task Force. The review was not apparently subject to independent external peer review through a journal.

Evidence of implementation

The report is widely cited by the UK government, its agencies and by the unconventional gas extraction industry. It is heavily critiqued by some scientists, public health researchers and some elected representatives.

Role of political, commercial and industry groups

PHE is itself a government executive agency of the Department of Health and although it states it has operational autonomy in 2015 it was criticised in the British Medical Journal as being 'nominally independent, (but) appeared to be serving the policy agenda of a government promoting the potential of fracking…to provide the UK with greater energy security, growth and jobs' (Gornall 2015).

Involvement of public health professionals and researchers and specialists in regulatory and industry scrutiny

Public health staff prepared the report but it is unclear what expertise the various authors had in research on regulation or on industry practice and malpractice linked to corporate governance. The report assumes that consultation is sufficient involvement for public health professionals, and the recommendations shy from giving public health officials a significant regulatory role.

A number of commentators in the US and Canada have expressed concern that public health agencies are not engaged with industry and policy makers over the regulation of shale gas extraction/exploitation (Goldstein et al, 2012; New York Health Professionals, 2011). This should not be an issue in the UK as public health bodies play an important role in planning and permitting of industry by acting as independent consultees in both these processes… at present, public health professionals are consulted on bespoke environmental permit applications. Similarly, local public health professionals would be expected to play an active role during planning applications. Both processes will help ensure public health agencies participate in, and contribute to, initiatives around the regulation of shale gas (p10).'

The report concludes optimistically that 'The UK's planning and regulatory approaches are intended to allow for public consultation during the development process and public health agencies including PHE are consulted on environmental permit applications, enabling assessments of the potential risks to health to be undertaken. It is essential that they are applied robustly to the shale gas extraction process and that health impacts of operations are therefore assessed. Operators and developers will also be required to use best available techniques and good industry practices to prevent, manage and reduce the impacts and risks associated with shale gas exploration and production projects and the industry should be transparent in its operations and constantly improve technologies and operating practices.' (p. 46)

Generalisability

Debated

Key Lessons

The fracking report was addressed in the BMJ editorial which concluded 'rigorous in its presentation of the evidence, there were "problems with its conclusions … Unfortunately, the conclusion that shale gas operations present a low risk to public health is not substantiated by the literature' (Law et al., 2014) As the BMJ article further noted 'the report incorrectly assumes that many of the reported problems experienced in the US are the result of a poor regulatory environment. This position ignores many of the inherent risks of the industry that no amount of regulation can sufficiently remedy, such as well casing, cement failures, and accidental spillage of waste water. There is no reason to believe that these problems would be different in the UK, and the report provides little evidence to the contrary, despite repeated assertions that regulations will ensure the safe development of shale gas extraction'.

The review's belief that the potential risks from the industry will be low if properly run and regulated raises the very significant issue about the lack of any detailed analysis of regulation and industry practice in the review itself, and associated reviews elsewhere. Similar questions exist about what exactly 'low' risk means, what are 'properly run' companies and what are 'effective' regulations and, equally important, enforcement? PHE will have been aware in 2013 and 2014 of the cuts in a range of agencies responsible for public health but still appeared remarkably sanguine about the state of the public health profession in England and Wales and its capacity to take on new work in the fracking field and fill all the gaps identified in the review.

A full 'regulatory impact assessment' of the cuts in these agencies in relation to monitoring the practices in the industry and the checks, inspections and enforcement of fracking regulations would at least have provided an evidence base to support the PHE assessments, which look more like opinion and assertion than fact. These elements all affect the capacity of the industry to ensure 'good on-site management' and for agencies to ensure 'appropriate regulation' (p.iii) but PHE appears to take their existence for granted almost as an act of faith. This is not born out by evidence elsewhere.

Case Study 3. Shale Gas Task Force. 1st Interim Report. Planning, Regulation & Local Engagement. 2015

This very brief report noted 'a consensus on whether or not a shale gas industry will benefit or harm the United Kingdom will not be found' but acknowledges that the UK government was committed to developing the shale gas industry. This included government funds to 'provide independent evidence on the robustness of the existing regulatory regime'. The task force found 'the current regulatory oversight for any potential shale gas industry at national level does not command the public confidence that is necessary.

Strengths

Sections of the report offer solutions, in the English and Welsh context, to problems identified in the report with the current regulatory system that would apply if fracking was introduced now. The report suggested one bespoke regulatory agency to oversee all aspects of UK fracking. The proposal has supporters and critics but the details provided in the report were sparse. The Task Force observation on enforcement noted that when monitoring was being carried out, it was important 'not to rely solely on self-monitoring and self-reporting by the operator' but there must be regular (and sometimes random) visits and inspections by regulators. The Task Force had found this did not happen in 2015 but should be more actively pursued in future. This would indicate significant failures in the existing regulatory system. The Task Force also recommended the statutory regulator needed to be proactive in inspections and monitoring of fracking sites and community representatives should be involved alongside the regulator when monitoring occurs. How this would be operationalised across thousands of fracking sites, by whom, and with what resource implications was not detailed.

There is mention in the report of the potential for integrating UK regulation within the EU and working with the European Commission to develop bespoke regulation for shale (p. 15) but events surrounding Brexit may delay or prevent such developments.

Weaknesses

The Task Force is funded by businesses involved in the shale gas but it argues it 'operates independently from its funders and the funders have no influence over its research, recommendations or publications'.

The report was prepared by a small panel of three with limited time available to examine a complex subject. This is demonstrated for instance by limited discussion on the drivers of regulation in Europe such as 'better regulation' and 'smart regulation' linked to deregulatory trends and substantial cuts in budgets of UK regulatory bodies. At UK level, the Regulators Code which applies to the EA and HSE has both overtly and covertly weakened regulatory activity through application of the 'growth duty'. The report recommends ERAs instead of EIAs – this in itself reduces the regulatory burden on business, but it is framed as a solution to the communicative problem of the public not understanding EIAs, or industry more generally. Communication is positioned as the solution to controversy and concern

surrounding fracking. Arguably this downplays the inherent problems associated with the industry (p. 14)

The literature cited in the review is minimal with regard to critical analyses of regulatory systems, procedures and practices. The report is very poorly referenced and claims and statements are not systematically linked to the evidence that underpins them. There are only three specific peer-reviewed papers mentioned on regulation and these relate to fracking in the USA. One solution that is offered to a lack of regulatory resources relates to the possible funding of increased regulatory capacity and monitoring by the industry through fees and levies drawn from the operators. (p.15). Such an approach is in itself problematic as has been shown with a similar scheme now running for, creating tension with industry, workers and communities alike. The approach could also imply regulation would lag behind industry practice.

Much of the literature relied on comes from UK government bodies that cannot be viewed as neutral or independent assessors of their own policies and practices on regulation, and from industry or industry consultants (Watterson and Dinan 2015). Where literature on public health impacts of fracking is cited, this does not appear to clearly inform consideration of the failings of the regulatory system nor support a view that fracking can be done safely. A good deal of that literature from the USA and Germany indicates intrinsic public health threats whatever the regulatory system adopted. For example in 2012, in Germany, in a risk assessment study of fracking funded by Exxon-Mobil, scientists identified what they viewed as new risks associated with UGE including the proximity of gas reserves to usable groundwater reserves and proximity to ecosystems depending on groundwater. The research also suggests new risk dimensions are associated with the high number of wells required, greater land usage, and more people affected by necessary infrastructure developments: “more people and in particular agriculture, tourism, and nature conservation are directly affected in a given region.” Fracking in tight spaces, greater water usage, and greater energy use in drilling were also identified in the overall risk profile of fracking. The study discussed the need for precaution in risk assessment (Ewen 2012)

One of the biggest failures on regulation linked to the oil and gas industry that involved both HSE and the EA came with the Buncefield explosion in 2004 at a major oil storage terminal. The incident is not mentioned in the Task Force report on planning and regulation. The later Buncefield investigations and legal cases found, among other things, that the two agencies tended to undermine the regulatory effectiveness of each other (Black 2014).

Evidence of implementation

Not applicable

Role of political, commercial and industry groups

Yes.

Involvement of public health professionals and researchers and specialists in regulatory and industry scrutiny

It is unclear exactly what involvement there was, if any, in all these areas and with whom.

Generalisability

Some

Key Lessons

The report is superficial. Nevertheless the Task Force calls for a simplification of the regulatory structure and consolidation of agencies responsible for fracking with the creation of a bespoke regulator. This would suggest that the existing regulatory set-up is not fit for purpose. The report also identifies a range of failings with the existing regulatory, monitoring and self-monitoring systems. These would indicate that it is impossible to state the current regulatory system can deal effectively with the health, safety and environmental challenges posed by fracking.

As referenced above, the Buncefield incident exposed significant regulatory weaknesses along the existing oil and gas supply chain. The industry-funded task force also produced a separate Second Interim Report (2015) on the local environment and health. This report offered additional opinions that again in parts appear to be based on assumptions and assertions about the regulatory landscape possible if fracking was introduced across the UK.

It noted 'in the Task Force's opinion, current regulations in the UK do serve this purpose [effective regulation and enforcement it is assumed] and on the whole are more rigorous and robust than those in operation in the US' (p.17). This assessment related primarily to well integrity and construction but fracking presents a much wider range of health hazards and risks along the life cycle chain that are not fully addressed. The Task Force statement is not substantiated, and US agencies such as OSHA and NIOSH have better provisions, resources and practices. In the UK regulatory resources do not compare with those in the USA and budgetary cuts have forced UK agencies along the route of undertaking commercial contracts which must take them away from key monitoring and enforcement work.

The report cites the PHE review with regard to both operational and regulatory failures that have occurred in the fracking industry and the consequences when large numbers of wells are being commercially exploited rather than small numbers of exploratory wells. This report further adds the caveat that 'strong regulations in this area should be acceptable to responsible operators because they should prevent 'cowboy' operators from entering the UK shale market if an industry develops' (p.17).

Yet the first report on regulation failed to explore the whole area of global industry practice and assumed there would always be responsible operators. Contemporaneous evidence from Australia, other parts of Europe as well as the USA indicated failings at that time on health, safety and environmental matters by multi-national oil companies. In this context it may be of concern that regulatory agencies in the UK have used consultants who came from

multi-national companies with fracking interests to advise staff about 'better regulation' policies.

The Task Force's Final Conclusions and Recommendations (2015) rest partly on the superficial report dealing with regulation that failed to provide robust and rigorous analysis of either regulatory regimes or global industry practice. It does so against a background of 'better regulation' approaches to industry, on changed mission statements to accommodate businesses and downplay health, safety and environmental priorities now working through as 'growth duty' and agency commercialisation . The task force view that shale gas 'can be produced safely and usefully in the UK provided that the Government insists on industry-leading standards' (p.1) is therefore an assertion and an opinion that is currently neither fully evidence-based nor evidence -informed. It relies on highly optimistic assumptions about industry best practice and regulatory oversight. It does recognise that US fracking industry practice has improved but neglects to examine the continuing fracking problems in that country, Australia and elsewhere in the world and the health risks that remain.

Case Study 4. Scottish Government Independent Expert Scientific Panel. Report on Unconventional Oil and Gas. Edinburgh 2014

The panel's remit was to deliver a 'robust, well researched evidence base relating to unconventional oil and gas upon which the Scottish Government can reliably base future policy in this area; a well-developed narrative on the environmental and regulatory issues associated with the potential development of unconventional oil & gas in Scotland; an assessment of the potential resources available to Scotland' (p.iv).

With regard to regulation, the panel concluded that 'the regulatory framework is largely in place to control the potential environmental impacts of the production of unconventional oil and gas in Scotland, although there may be gaps to address' (p.v). The panel believed 'considerable legislative safeguards' already existed to prevent adverse UGE impacts but noted 'confusion has been expressed about the regulatory framework and a lack of confidence in the regulatory regime' (p.v).

The paper explores mitigation and generally appears confident that regulatory structures could deal with UGE in Scotland. However, important caveats are noted and there is a more nuanced recognition than in comparable UK wide official reports that regulation was not yet satisfactory. For example: 'mitigating a potential or realised impact depends on strong and visionary environmental, and health and safety, regulators to enforce legislation and identify and respond rapidly to gaps that may emerge.' (p.50)

Strengths

The panel members included engineers, geologists, chemists and environmental scientists as well as former environmental regulators with high levels of experience. This meant that aspects of extraction and production of shale gas were well covered although the impacts of UGE are the subject of debate and disagreement among engineers, geologists and environmental scientists.

The panel makes an important call for 'genuine public engagement on unconventional gas needs to include a consideration of social, political and ethical aspects of developments, both within the community and as a nation' (p.63).

The panel recognised the gaps that existed in terms of UGE in the central belt with its 'high population density' and also noted the complexity of identifying its negative and positive impacts.

The panel also state that "none of the required technologies are particularly new, albeit they have yet to be applied at full-scale onshore in Scotland for these particular purposes. To date, there has been preliminary, exploratory drilling, for coal bed methane only, at only two sites (with a third under consideration), and pilot production at only one site (Airth). No full scale commercial operations are yet underway in the UK, or globally" (p.18). The language about controls was often conditional indicating processes 'could' be controlled, not that they would be. This is both a strength and weakness in the report.

Weaknesses

The report is couched in regulatory language and implicitly assumes the problems with UGE can be mitigated or resolved because that is the regulators role and that is what regulators must do. Even so, problems are identified. Injecting fracking chemicals in Scotland is a new process although the panel appeared to think it was not (p.18).

The panel had no members from the public health field, no legal specialist, no members who had independent research expertise in assessing regulation and no independent members with research expertise in assessing this industry's health, safety and environmental performance. Whilst in some fields the panel sought advice from other specialists, including those acting as commercial consultants for the oil industry, it apparently sought no specialists in the areas identified above. If it had done so, the panel's conclusions would have had greater weight and credibility. Some of the panel had interests in underground coal gasification and had worked as consultants for the oil industry. Whether other members of the panel had worked for the oil and gas industry or had shares in such companies is not always clear from the report itself.

The policy analysis is underdeveloped and the report failed to acknowledge the scientific debate and indeed controversy about 'better/smart/responsive regulation' and questions surrounding capacity to regulate fracking.

The report does not examine the question of effective enforcement of regulations in a soft regulatory regime, nor does it adequately cover the issue of resources and staffing needed by regulatory agencies to inspect and oversee fracked wells in Scotland. There are relatively sparse references to monitoring too with open source monitoring as a solution mentioned fleetingly (p.67). Both these topics are particularly critical for 'robust' and effective regulatory regimes. The report makes several references to 'industry best practice' which the panel considers vital for safe UGE including fracking and refers to the need for 'rapid, expert, and rigorous licensing and regulation'. No mention is made of enforcement and no detailed and rigorous analysis of industry practice is provided (p.8).

The literature reviewed by the report includes very little if any independent peer reviewed or grey literature specifically focussing on either regulation and enforcement or industry practice. The report relies heavily on government material from DECC and SEPA and from the oil and gas industry which is highly likely to skew some of the analysis and conclusions provided.

In parts, the report appears to undermine the scientific credibility of arguments of those opposed to fracking regardless of their merits, and creates a false dichotomy where those not opposed to fracking are presented as impartial arbiters but those opposed are 'anecdotal' and so affected by scientific bias (see p.48 and p.63). The case for such a view has not been made convincingly or evidenced in the panel report. Reference is made to the role of the media in representing the pros and cons of the fracking debate. The panel mentions 'cherry picking of data and anecdotal evidence to support either position making it a harder proposition to use the wider body of robust evidence to have a balanced debate on the subject. Arguably, this only leads to further confusion among the public.'

It is difficult to view the statements made about effective regulation and industry-practice in parts of the report as anything other than equally anecdotal.

The report has not apparently gone through independent external peer review in a scientific journal.

Evidence of implementation

Not currently applicable

Role of political, commercial and industry groups

Yes. Members of the public are unlikely to be convinced by reports that do not scrutinise industry and industry-funded research and will often perceive publications produced by or with industry consultants and advisors as biased. This is especially so if reports do not include rigorous and robust examinations of industry practices and independent assessments of regulatory agency practice, resources, staffing and performance.

Involvement of public health professionals

Directly on the panel, apparently none.

Generalisability

Limited in terms of the gaps in the report discussed above

Key Lessons

The report notes: "Robust, scientific evidence around the safety and regulation of unconventional oil & gas is becoming available. However, as in any emerging field of research, evidence is sometimes conflicting or appears to be contradictory. In addition, outcomes from research that is either untested, or has not been subject to peer-review has been cited in the media and circulated on the web" (p.62).

This was debatable then and is still debatable. It is difficult to find detailed proper discussion of regulatory principles and practice. There also appear to be strong inferences in the report that the public did not understand UGE risks and this could be addressed by better consultation. However, in the report itself there is confusion about which sources cited are or are not peer reviewed and have or have not been tested.

Case Study 5. Hawkins, J. Fracking: Minding The Gaps. Environmental Law Review 2015, Vol. 17(1) 8–21

The paper noted that at the time the underpinning research was conducted little attention had been paid and sparse literature existed on current regulations relevant to fracking in the UK. The author queries the argument that fracking is not a new technology and notes fracking debates occur in a political context. She examined various regulatory, practical and enforcement elements (p.18) including the key issues of fracking with regard to water, air quality and seismic activity linked to old regulations used to address a new technology. She found 'inappropriate thresholds, failure of controls to apply (or lack of clarity as to whether to apply) and the absence of required guidance documents' along with gaps (p.15). In addition, 'the lack of relevant experience and knowledge' of regulators in the UK to address fracking specifically was flagged at local authority and national level as were possibly conflicting interests in terms of economic benefits to councils from fracking (p.16).

On the basis of her analysis Hawkins concluded: 'Under the current regulatory system, the uncertainty and risk associated with fracking is not justifiable. The very way in which the risks have been assessed assumes that a 'robust' regulatory system will be in place; this has fed the justification for significant instances of regulatory inaction. Clearly the current regulation is not 'robust', and the framing of such risks as 'low' based on this assumption highlights the deficiencies in this cyclic determination' and 'maintenance of the current approach is beneficial in that it requires minimal effort and expenditure, whilst allowing the shale gas industry to develop. However, it risks allowing regulatory gaps to remain until problems materialise' (p.18).

Strengths

This is the only completely independent and dedicated paper dealing with regulatory issues relating to fracking primarily in England. The research considers explicitly the political context, noting 'the government insists that current regulation for conventional oil and gas extraction is adequate to control fracking' (p.11) which echoes both the PHE and Royal Society reports that argue fracking risks could be reduced and controlled with a 'robust' regulatory system. Nevertheless her analysis found gaps in the application of that system 'which may risk harm to human health and/or damage to the environment' (p.11). She further found that simply borrowing an existing regulatory regime for fracking was inadequate. Evidence cited elsewhere in our REA would support such a view.

This research describes a regulatory mismatch in the field and potential regulatory problems and gaps arising from the following: activity escaping permitting relating to boreholes, fracking chemicals, waste prior to well suspension or abandonment, best available techniques on industrial emissions, classification of sites, emissions, thresholds for triggering storage of hydrocarbon products under major accident regulations, exploratory sites, remediation linked to fault/negligence burdens.

The paper also highlights the implications of fracking and fracking regulations for the UK's climate change targets and recognised the importance of precaution in regulatory reform.

Weaknesses

The author acknowledged that the study focuses on England and was not designed to be comparative but still found EU regulation on fracking was also underdeveloped. The paper looked at regulation and its purpose but was not designed to decide firstly if fracking can ever be effectively regulated or if it should not proceed. It legitimately explored the legal issues surrounding regulation and regulatory gaps.

There is some useful discussion of the regulators and their resources and knowledge but this is not detailed. More generic bespoke studies of some of the regulators exist in peer reviewed papers and publications and present a less optimistic view of performance, staffing and resources.

Reference is made to industry practice and voluntary industry guidance on fracking. Hawkins considers that an industry umbrella group encouraged monitoring and transparency but noted such an approach and information would still fail to guarantee 'adequate environmental and health protection unless there were 'enforceability mechanisms and supporting legislation' (p.18). Other studies have presented a less Panglossian view of the oil and gas industry globally and its practices and governance, including later US practices by companies associated with a centre for sustainable fracking.

Evidence of implementation

Not applicable

Role of political, commercial and industry groups

None. The project was funded by a UK Research Council. The author declared no competing interests

Involvement of public health professionals and researchers and specialists in regulatory and industry scrutiny

Not applicable. The author is an academic law lecturer

Generalisability

Yes in the UK context.

Key Lessons

The analysis demonstrates that in 2014 the regulatory structure the UK government had in place was clearly not fit for purpose in dealing with fracking. It further indicated the hopes of 'robust 'regulation on fracking that reports from bodies such as PHE and Royal Society/ Royal Academy of Engineering mentioned simply did not exist then and still do not. Further evidence currently available in 2016, from peer reviewed scientific papers and examination of fracking industry practice globally, show that health risks and regulatory gaps remain.

‘Maintenance of the current approach is beneficial to industry and government in that it requires minimal effort and expenditure, whilst allowing the shale gas industry to develop. However, it risks allowing regulatory gaps to remain until problems materialise’ (p. 18). ‘Fracking must be recognised and regulated as a new and uncertain technology.’ (p. 19)

Hawkins advocated the precautionary approach as the preferred response to the problems and shortcomings she identified and considered ‘a temporary moratorium must be imposed’ (p.19) whilst deficiencies were addressed and changes introduced.

Case Study 6. American Public Health Association (APHA). Policy Statement on the Environmental and Occupational Health Impacts of High-Volume Hydraulic Fracturing of Unconventional Gas Reserves. 2012

The APHA looked at the benefits (including economic and energy security aspects) and risks associated with fracking which, unlike the UK, was already underway in many US states. It noted fracking posed potential risks to public health and the environment, including groundwater and surface water contamination, climate change, air pollution, and worker health. The statement notes the highly varied emissions from fracking related not just to drilling practices but also geography and cumulative impacts.

Strengths

The document considers the benefits as well as costs of High-Volume Hydraulic Fracturing (HVHF) development and recognises that economic development can have indirect public health benefits – but this is largely dependent on (a) private welfare gains of those employed in the industry and (b) an assumption that taxes are spent on health and monitoring services, notwithstanding concerns regarding boom & bust extractive industry patterns.

The statement covered the whole fracking process including site preparation, drilling and casing, well completion, climate change, production, transportation, storage and disposal of wastewater and chemicals, and site remediation. Other papers often only focus on well construction and immediate production. The statement also notes that natural gas extraction was historically dangerous industry for workers and that the occupational health implications were not properly understood. It identified a wide range of short, medium and long term risks to a range of populations.

To quote from the report: 'Policies that anticipate potential public health threats require greater transparency and use of a precautionary approach in the face of uncertainty'. Uncertainty remains over potential environmental benefits. The report notes that 'complete evidence regarding health impacts of gas drilling cannot be obtained due to incomplete testing and disclosure of chemicals…and nondisclosure agreements. Vulnerable populations, particularly children and low-income rural populations, are most likely to be negatively affected by fracking and it has the potential to affect large numbers of people.'

The list of public health problems associated with HVHF is extensive and the statement does not make assumptions regarding how policy might be organised – i.e. it is rooted in available & emerging evidence base regarding population health and industry practice. However the report is clear that evidence base now only emerging. The APHA statement specifically addresses the evidence base that might inform policy: 'Research gaps due to the limited number of years fracking has been in use and to challenges in studying health impacts - the lack of identified unique health indicators, latency of effects, limited baseline and monitoring data, low population densities in many affected areas, and, in some cases, industry practices and nondisclosure agreements. These challenges to research are unlikely to be overcome in the immediate future.

However, an increasing number of case reports, agency documents, and environmental models suggest that this process presents unique and significant health concerns'.

Weaknesses

The policy statement was specifically prepared for a US audience although many of the problems and recommendations would be equally applicable globally. It does not elaborate on what a precautionary approach might look like in practice and offers broad guidance on the kinds of issues to be considered if regulating on a precautionary basis

Evidence of implementation

Not applicable

Role of political, commercial and industry groups

Independent of industry

Involvement of public health professionals and researchers and specialists in regulatory and industry scrutiny

Yes

Generalisability

Yes

Key Lessons

The report looks at the process and identifies key principles and the need for high levels of public health input and good quality base line health data. Only 1 of the 8 APHA recommendations was concerned with regulation and related to a call for precautionary approaches on chemical use, endocrine disruptors, monitoring and health impact assessments. The importance of cumulative health impacts and involvement of public health professionals in regulatory decision making are highlighted

Case Study 7. Environment America Research & Policy Center. Fracking Failures: Oil and Gas Industry Environmental Violations in Pennsylvania and what they mean for the U.S. January 2015

Note

To address the research questions raised by the rapid evidence evaluation, it is necessary to look at both regulation and industry practice, as robust regulation and industry good practice are viewed by UK government and various UK bodies as the guarantee that fracking can be conducted safely. Unfortunately there are no in depth academic analyses available exploring fracking industry practice and the peer reviewed literature on the subject is generally remarkably slight. The only accessible accounts are from the industry and from its critics which are both openly partial. In this report, industry publications are also examined. The Task Force was funded by industry. The case study below comes from an NGO so both sides of the debate are represented.

This case study looks at an NGO report from Environment America Research & Policy Center[6] on industry practice in one state and includes discussion on the fracking industry's Center for Sustainable Shale Development (CSSD) which describes itself as "an independent 501(c)(3) non-profit organization whose mission is to support continuous improvement and innovative practices through performance standards and third-party certification….. the Center provides a forum for a diverse group of stakeholders to share expertise with the common objective of developing solutions and serving as a center of excellence for shale gas development. Funded by philanthropic foundations and participating energy companies…" Its Board of Directors in 2016 included several oil industry executives, academics and others and the Environmental Defense Fund was one of its 'strategic partners'. The Centre began as a partnership between 11 fracking companies and NGOs and floated 15 voluntary standards for fracking and certifying drillers.

Introduction

The Environment America Research & Policy Center is part of Environment America, an NGO federation of American state-based citizen-funded environmental advocacy organisations. The Center describes itself as 'dedicated to protecting America's air, water and open spaces. We investigate problems, craft solutions, educate the public and decision makers, and help Americans make their voices heard in local, state and national debates over the quality of our environment and our lives'.

Their report found that in Pennsylvania, where CSSD is active, fracking companies including international ones regularly broke rules and regulations. Between January 1, 2011, and August 31, 2014, the top 20 offending fracking companies committed an average of 1.5 violations per day.

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6 http://www.environmentamericacenter.org/

The violations included 'allowing toxic chemicals to flow off drilling sites and into local soil and water', 'endangering drinking water through improper well construction', 'dumping industrial waste into local waterways and 'otherwise disposing of waste improperly'.(p.4). Large and small companies broke the law. The report is largely based on a secondary analysis of official data on fracking violations, and this is likely to underestimate infractions.

The Center noted: 'oil and gas industry spokespeople routinely maintain that the risks of fracking can be minimized by best practices and appropriate state regulation. Not only is this false – fracking is harmful even when drillers follow all the rules – but drillers also regularly violate essential environmental and public health protections, undermining their own claims' (p.4 and p.14).

Strengths

The report is detailed and well documented on violations and looks at regulatory offences often ignored in other reports and covers a period up to 2014 which goes beyond what might be termed as the 'cowboy' period of fracking in the USA.

The report examined enforcement as well as regulatory structures and addressed the issue of under-reporting of legal breaches. It observed: 'Pennsylvania's consistent pattern of conducting fewer inspections than state rules require, and because inspectors regularly decline to issue violation notices when companies voluntarily agree to fix problems' (p.6).

The report looked at the recent meta-review of fracking (Bushkin-Bedient 2014) which concluded 'regulations are simply not capable of preventing harm' because of the growing number of wells and the many other factors outside human control.

In contrast to the PHE report the Center does include sources and comments from those holding different views – for example from the fracking industry's Chris Faulkner writing in the Wall Street Journal that the misdeeds of a few Companies did not justify fracking bans (p.40).

Weaknesses

The report was produced by an NGO and not subject to external expert peer review. However the interests of the NGO publishing this report are related to human health and the environment, which is significantly different to vested interests related to making money and profits for shareholders from an industrial/commercial activity.

Climate change was not a focus for the report but issues around global climate change are touched upon (p.12).

The report focuses on Pennsylvania as time and resource limitations applied. This focus is both a strength in terms of depth but possibly a weakness in terms of establishing the bigger US picture. However, the report specifically addresses how their findings may have significance for the USA as a whole. The report is extensive and well referenced if not fully comprehensive.

E**vidence of implementation**

Not applicable

Role of political, commercial and industry groups

NGO publishing this report has a well understood political agenda regarding environmental protection.

Involvement of public health professionals and researchers and specialists in regulatory and industry scrutiny

Not clear

Generalisability

Yes

Key Lessons

Many of the key findings may have relevance to Europe and the UK with regard to fracking industry bad practice involving multi-national companies, and the problems of regulation and enforcement that will arise in what will be a new and possibly very extensive UK industry in terms of numbers of wells drilled.

The researchers found: 'the sheer number and severity of risks posed by fracking operations make constructing an adequate regulatory regime – much less enforcing it at thousands of wells and other sites – implausible'. This led to their recommendations for banning fracking and giving every local community the right to reject fracking operations in their area.

Case Study 8. New York State Department Of Health. Public Health Review of High Volume Hydraulic Fracturing for Shale Gas Development. December 2014

The report evaluated emerging scientific information on environmental public health and community health effects. It analysed if such information was sufficient to determine the extent of potential public health impacts of fracking in New York State (NYS) and whether existing mitigation measures implemented in other states are effectively reducing the risk for adverse public health impacts. The report concluded the overall weight of the evidence from the cumulative body of information contained in this Public Health Review showed there were significant uncertainties about various adverse health outcomes that may be associated with fracking, the possibility of adverse health outcomes, and the effectiveness of some mitigation measures in reducing or preventing environmental impacts which could adversely affect public health. These included risks not fully understood and public health impacts over a geographically very broad area. The weight of evidence showed significant uncertainty about adverse health outcomes and the effectiveness of mitigation measures. The fracking process was highly likely to have negative impacts, based on health impact assessments with regard to air quality, occupational health, health care infrastructure and social determinants of health.

Strengths

A detailed and lengthy assessment of the problem was conducted drawing on a wide range staff with extensive expertise in the fields of public health, science and medicine. Its strength lies in the interrogation of research methods and assumptions built in to research designs. Scepticism and rigour are hallmarks of the evaluation of results and the methods that produced those results (including interpretation of secondary data analysis and whether data warrant some of the respective authors' conclusions). Most other studies reviewed here do not display this level of detail.

One argument frequently put in the UK by industry, government and some of their advisors is that US fracking regulations have been weak and the industry and regulators in the UK would not repeat the errors of the global industry in the USA. However, this presumes fracking regulation, enforcement and practice was and is uniform across the country and this is not the case as the New York report demonstrates. It also assumes that the EPA and bodies such as NIOSH are weaker than the UK's EA, SEPA and HSE which is also not necessarily the case. In New York, low-volume hydraulic fracturing has been specifically regulated under the Generic Environmental Impact Statement since 1992 but in California there are no formal fracking regulations. In New York there are specific regulations that require specific 'separation distances' of oil and gas developments from surface water for example. Texas did not have such regulations.

In the UK, a steady stream of reports has asserted mitigation measures will be effective if the commercial fracking industry starts here. There has been no independent evaluation of such claims. The New York report, however, examined this subject and reported on a National Institute of Environmental Health Sciences working group funded study (Penning, 2014).

This found there were data gaps and uncertainties regarding impacts and the effectiveness of fracking mitigation measures.

The group also concluded a potential for water and air pollution existed which might endanger public health, and that the social fabric of communities could be impacted by the rapid emergence of drilling operations (p.48).

New York State also identified European work and specifically the Broomfield report of 2012 from the European Commission which found, specifically in a European setting would entail 'high' cumulative risks of groundwater contamination, surface water contamination, depletion of water resources, releases to air, increased noise, and increased traffic.

Weaknesses

Some limits of time and resources applied. However, the report devoted more time, staff and resources to the review than many other organisations who have prepared similar reports on the subject. Relatively little detail on industry practice.

Evidence of implementation

Yes

Role of political, commercial and industry groups in funding or preparing the report

None

Involvement of public health professionals and researchers and specialists in regulatory and industry scrutiny

Yes

Generalisability

Yes. While there are quite detailed assessments of selected studies, the review is based on the limited available published material on public health and environmental impacts. The evidence base has not changed substantially since this report (as per selection criteria for the rapid review outlined).

Key Lessons

The report was one of the most extensive and detailed on likely impacts and considered the regulatory frameworks across the USA. Its application of the precautionary principle in its recommendations was justified by the evidence collected.

Case Study 9. Wiseman, H.J. The Capacity of States to Govern Shale Gas Development Risks. Environ. Sci. Technol., 2014, 48 (15), pp. 8376–8387

The research explores the successes and failures of fracking extraction governance – laws, stakeholder influences including industry and NGOs, and practice - in the USA. The paper concludes that states were addressing changing development risks although there remain gaps linked to resources, information, training, risk prioritisation, enforcement and monitoring.

Strengths

The paper focused on both regulation and practice and influences on governance. 'The term governance, as used here, encompasses all institutions associated with shale gas development including governmental incentives, guidance and mandates, and private standards. It also encompasses the entities that form, interpret, and implement policies' (p.8376). In the UK many but not all analyses pertinent to regulation have either ignored or played down the role of government incentives either to strengthen or weaken governance. The analysis noted federal and state agencies will deal with the full range of fracking activity including well site erosion, groundwater impacts, water quantity, seismic activity, air pollution, worker and community safety and health, waste and site restoration and remediation.

The paper explored the importance of various factors in effective governance and considered funding enforcement was a critical strand.

Key findings related to: - (i) Improving understanding of risks. The paper noted the work of New York State's extensive public health impact assessment work then underway
(ii) Filling regulatory gaps through for example more testing and monitoring particularly to reflect potentially larger risks. This might require cross-state action.
(iii) Enhancing enforcement through better information, training and enforcement, prioritizing compliance, funding enforcement and enforcing through appropriate penalties and damages. The topic is rarely fully addressed in the UK. The author was clear that 'enforcement also can, if it has sufficiently high penalties, deter future regulatory violations' (p.8383) a subject rarely raised in UK government .

Weaknesses

The paper touched on the voluntary involvement of various 'private' stakeholders in writing fracking guidelines under the regulations and reviewing state regulatory programmes for voluntary compliance with these guidelines.

In this context the work of the Environmental Defence Fund (EDF) and their involvement with the industry's Centre for Sustainable Shale Gas Development was mentioned but neither were examined in depth nor their work critically assessed although the author had consulted for EDF (p.8378).

Evidence of implementation

Not applicable

Role of political, commercial and industry groups

The declared competing financial interests of the author as a consultant for the Environmental Defense Fund (EDF) and consultant on a project for GEC. In this paper the author refers to the EDF.

Involvement of public health professionals and researchers and specialists in regulatory and industry scrutiny

Not applicable

Generalisability

In terms of broad themes, yes

Key Lessons

The paper illustrates both similarities and differences on shale gas governance between the USA and UK. The gaps identified and solutions offered are often germane to the UK position. Much is made by industry and government in the UK of differences between the two countries in respect to UGE and fracking. However, in terms of approaches on what works and what does not, and where gaps in governance still exist, the analysis provided in the paper is highly relevant to the UK. Nor does the paper avoid addressing important issues of regulatory resources and enforcement, all too often neglected in the UK.

The key finding from this research is the complexity and variability of UGE regulation in the USA. Hence there is a need to treat with great care the idea that the UK can easily learn from US regulatory practice. Significant effort still needed to fully map the regulatory complex in US, even without addressing issues like compliance and enforcement

Case Study 10. Small, M. et al. Risks And Risk Governance in Unconventional Shale Gas. Environ. Sci. Technol., July 2014, 48 (15), pp. 8289–8297

The paper has a US focus but also briefly reviews shale gas governance elsewhere in the EU, South America and Australia. It provides a broad assessment of the current state of knowledge regarding the risks associated with shale gas development and their governance. It looks at known and potential hazards and mitigation options including public health and global climate change perspectives (p.8289) along with flagging the perennial problem of global markets leading industries to exploit resources in the least regulated countries (p.8295).

Opportunities and challenges are identified from a decentralised regulatory system in the US. The question of enforcement resources is also touched upon (p.8294) but not explored in depth.

Strengths

The authors judged current research and analysis were 'insufficient to either confirm or preclude important impacts'. Voluntary industry certification was examined, a topic not always scrutinised in other reports on regulation.

The paper noted EU activity on shale gas development and the diverse approaches that may exist. However, it also noted that 'actions thus far suggest EU shale policies are likely to include elements of the precautionary principle, an insistence on transparency, the need for consultation and stakeholder buy-in, and an emphasis on sustainability' (p.8293). These are important elements that may be difficult to square with the introduction and effective regulation of fracking in Europe.

Weaknesses

The paper addressed the problems of an industry already underway in America and looked at existing and new measures needed to mitigate any failures rather than the debates about whether or not to allow the industry to operate in the first place. However, in its assessment it appears to significantly over-estimate how developed and effective regulation is in UK (p.8293)

The discussion of voluntary standards was very brief and although bodies like CSSD were mentioned, there was no critical or rigorous analysis provided of their weaknesses and strengths and indeed failures (see case study 7 above). Such standards and VPPs have been evaluated elsewhere in the US but this literature was not covered. The paper concluded voluntary standards 'could set a floor for state regulations that would also apply to non-volunteering companies. They also might provide a basis for subsequent federal-level solutions designed to reduce industry costs of dealing with a patchwork of state and local regulations and requirements' (p.8293). If such proposals were nested in an EU context, then a detailed consideration of the deregulatory agenda and role of neoliberalism in loosening controls over industry and impacts on public health would be needed.

Evidence of implementation

Not applicable

Role of political, commercial and industry groups in the research

The authors declared no competing interests but stated the paper emerged from a project that received some support from Shell Upstream America for travel and dissemination.

Involvement of public health professionals and researchers and specialists in regulatory and industry scrutiny

Yes

Generalisability

Yes but with numerous caveats and reservations

Key Lessons

The paper provides a useful overview of the US position and governance options and touches on some important issues. However, in terms of the key debates in the UK about regulatory and deregulatory drivers it is silent. The analysis of voluntary programmes lacks critical detail and the observations about global fracking industries moving to the least regulated countries (and the impact for example of trade negotiations) are left hanging.

Case Study 11. UKOOG. Guidelines for Addressing Public Health in Environmental Impact Assessment for Onshore Oil and Gas. United Kingdom Onshore Oil and Gas. 2015

The report looked at health in the EIA process, considered hazard and risk may be confused and believed there was an 'unawareness of mitigation'. The report further argued that the potential hazards identified in the report were not exclusive to the onshore oil and gas industry and 'all are already addressed through design, best practice and the existing UK regulatory assessment process' (p.2). It states 'the current regulatory and planning regime would simply not allow permits or consents to be given without proper review of all hazards and risks, and a series of authoritative, independent experts stating the risks can be managed'.

Strengths

An industry perspective based on their priorities and so giving those outside the industry a view of their key arguments, approaches and priorities to gain approval for fracking developments. The document is supplemented by much related materials and other industry trade group reports obtainable on the web.

Weaknesses

A key purpose of the UKOOG report is communicative, aimed at persuasion, securing consent and assuaging stakeholder concern. It is unclear at present how the health impacts of fracking can be assessed for impact because it is not known for example how many wells may be drilled and where using what substances. No one knows which fracking fluids exactly will be used in the UK because of geological variations and therefore identifying hazards and risks by either the industry or regulator would appear premature. Also, international research indicates there may be inter-actions between fracking fluids, between fracking fluids and other substances used in fracking and between fracking fluids and naturally occurring chemicals. Substances identified as no or low hazard may prove not to be so in the environment and in break-down products in humans. Additionally there is considerable debate about potential pathways and the middle and long term integrity (over decades) of capped wells.

The industry guidelines draw on support from PHE, the Scottish Government Independent Panel and the Royal Society reports to argue the case for low risks to health from fracking. However, all these reports have been heavily critiqued and two had minimal if any public health input in their preparation.

As hydraulic fracturing for shale gas would be a new commercial development in the UK it is difficult to understand why the guidelines indicate the potential hazards associated with it are well understood and can be regulated. Indeed it is even unclear what a 'potential hazard' is in this industry's eyes. For the public, there will be hazards and 'potential risks' and this document appears to confuse the two terms with its use of 'potential hazards'.

There have been no regulations requiring the industry to disclose the fracking fluids that it uses, as the Smith Task Force itself highlighted. The problems with material safety data sheets, additives and commercial confidentiality all remain although the guidelines' view of the subject do not indicate this (p.8)

The question of dose response relationships and total exposures is covered by the guidelines. The argument appears to be that an industry can add to existing levels of carcinogens without concern: yet for benzene, researchers reject the notion of a 'no effect level'. The issue of exposure of vulnerable groups and very low level exposure to, for example, endocrine disruptors is not addressed in the guidelines. This is important in the context of the opinion that there are already 'considerable legislative safeguards' to ensure bad fracking practice and negative impacts like those in the USA do not occur in the UK. This is simply a non-evidence based assertion that draws on at least two reports which had no health experts as authors.

The guidelines choose to ignore the numerous public health experts in the UK and elsewhere who dissent from the industry assessment of risk, hazards and effective regulation. Furthermore the guidelines fail to document the oil, gas and chemical industry's long history of trying to deny evidence on benzene toxicity and to water down regulatory controls of the substance: a story fully documented by the current head of OSHA in the USA (Michaels 2008)

The bibliography, described as references in the index, does not reflect the use of the scientific literature in the document. The guidelines appear to cherry pick only those reports and papers that support its view of hazard, risk and regulation for the public health aspects of an environmental impact assessment.

Evidence of implementation

Not applicable

Role of political, commercial and industry groups

Published by the industry with input from consultants in companies used by the industry

Involvement of public health professionals and researchers and specialists in regulatory and industry scrutiny

Generalisability

In its introduction only supportive regulatory opinion and expert panel reports are cited. The report is written without proper referencing conventions, so that claims with regard to consultation and public health are not explicitly linked to underpinning evidence or research.

Key Lessons

The guidelines present the industry's view on assessing the health hazards and risk of fracking in a UK context and largely neglect the health impacts of having multiple wells at an area and regional level. The guidelines may be perceived by the public and probably by independent researchers as having a clear vested interest in playing down any research that provides a less sanguine view fracking risks, low level exposure impacts and inadequate regulation and enforcement. The evidence for the guidelines' assessment of regulation and enforcement is sparse and often not generated in peer-reviewed scientific journals. No reference is made to potential health impacts of climate change because this is not required but is of growing public and international agency concern.

Case Study 12. Cook, J.J. Who's Regulating Who? Fracking Policy in Colorado, Wyoming, and Louisiana. Environmental Practice. June 2014, 16 (2), pp. 102-112.

The Cook paper explores variations between major American shale gas producing states with regard to fracking regulatory practices because federal activity and interventions have been limited on the subject. The author points out that the Energy Policy Act of 2005 exempted fracking from United States Environmental Protection Agency (USEPA) review but EPA covers waste disposal standards and certain air pollution controls for wells whilst OSHA has a national role and national coverage. The states would then regulate developments because of several federal exemptions and past historical precedents. The researcher found the position of agency staff and privileged stakeholder groups, especially industry-related groups, explained some differences between the states. Wyoming had the most stringent regulations and Louisiana the weakest. The reasons for this are interesting in that a pro-industry governor wished to pre-empt federal regulation, so this state was first to write disclosure rules on fracking fluids.

Strengths

The research develops an analysis of fracking regulation in the selected states that seeks to understand how the political context shapes policy outcomes. Wyoming was the first state to develop fracking regulations and on paper was the best regulated. This may have been an attempt to avoid later more stringent EPA controls (pp. 108-109) but even so it developed disclosure rule on fracking additives and used public meetings to gain input on draft proposals. In other respects the regulations favoured the oil and gas industry. With political change in Colorado after 2006, environmental stakeholders gained greater say in the formulation of fracking policies and controls including stronger groundwater monitoring programmes and the fracking industry's influence although still powerful was reduced (p.106).

Cook argued much of the fracking policy happened at the regulatory level and industry usually had far greater resources than other stakeholders to influence how regulation was formulated. The findings suggest that 'industry remains at a significant advantage in all three states' (p.110) and 'that the governor, agency personnel, and privileged stakeholders have a strong position in determining state-level policies'.

The paper was peer reviewed.

Weaknesses

All the US states involved in the study have a major stake in the industry with politicians who support fracking and either influence or possibly determine fracking controls. In the UK, there are differences between regulatory agencies in England, Wales, Scotland and Northern Ireland and some of the regulations that might apply in one country would not be applicable in the other three countries

Evidence of implementation

Yes

Role of political, commercial and industry groups in the research

None

Involvement of public health professionals and researchers and specialists in regulatory and industry scrutiny

Not applicable

Generalisability

No

Key Lessons

The paper highlights the significant influence industry may have as a key stakeholder in debates about fracking regulation and fracking policy. Industry resources are far greater than those of most environmental groups. This should be considered more carefully in the UK when using industry or industry-funded research or relying on such research to make judgements about the health hazards and risks of fracking and what will constitute effective regulation.

Case Study 13. Bomberg, E. Shale Governance in the European Union. Issues in Energy and Environmental Policy. (15) October 2014

The paper examined guiding principles in treaties, rules, policies, practices for EU policy makers on shale gas governance and the range of benefits and risks linked to fracking. The EU has no binding regulations on fracking for member states but does have treaties on secure and sustainable energy and regulations on use of chemicals and air and water pollution. In 2014, the EU issued a recommendation on minimum principles for safe and secure shale gas extraction. The paper noted several fundamental differences between policy approaches in the US and EU.

Strengths

The paper identified the precautionary principle, transparency, consultation/stakeholder engagement and environmental sustainability as key elements to consider, all involving considerable complexity. Action under the precautionary principle for the EU can be triggered where risks could be high and scientific data are insufficient, inconclusive or uncertain. However, all these components for action can be interpreted in many ways and may be contested. Various parts of the European Commission and the European Parliament have adopted a cautious approach to fracking. The role of environmental groups, industry and the relevance of risk assessments – variously interpreted and possibly subjective- and public perceptions of risk is highlighted. Transparency, consultation, environmental sustainability and public engagement in their varied applications have also been open to multiple interpretations and tensions by the different sides in the fracking debate

Weaknesses

The paper assumes shale gas will be developed and looked at means to re-assure the public should developments take place, but also flags the fact that definitive and unanimous scientific assessments of fracking may not be possible. The paper is mildly critical of the use of the 'reassurance frame' (p.8) to justify decisions already taken. But it does not apply the EU principles and policies to the question of whether shale gas development should occur. Already there are differences across the EU on this basic first question. Agencies such as EFSA and ECHA (through REACH) might recommend banning specific chemicals.

The focus in this research is on principles and governance. So there is understandably no detailed discussion on the regulations that do or might apply to shale gas in each EU country or their enforcement. Nor is there any significant discussion and analysis of the better regulation agenda advocated by some European leaders and adopted by some EU countries although the paper does touch on industry and environmental influence especially on consultation.

Evidence of implementation

Not applicable

Role of political, commercial and industry groups in the paper's production

None

Involvement of public health professionals and researchers and specialists in regulatory and industry scrutiny

Not applicable

Generalisability

Yes

Key Lessons

A useful analysis of some key principles and practices that may underpin shale gas regulation and enforcement and flag, as the author describes, the challenge of 'how to govern risk in a contested, multi-level and fragmented democracy'.

Case Study 14. Centner, T. J. Oversight of Shale Gas Production in the United States and the Disclosure of Toxic Substances. Resources Policy. 2013, pp. 233-240

The author noted the increase in drilling sites with more people at risk from 'accidents and exposure to harmful substances used in fracked wells'. The researcher concludes 'to provide for meaningful health and safety protection, governments may need to re-evaluate legal provisions offering trade secret protection for toxic substances used in fracturing' (p.233).

Strengths

The paper noted the problem of proving groundwater contamination would be very difficult but dangers from spill, blowouts and other incidents could be significant. With risks to water supplies, government action would be needed.

The problem of lack of enforcement of existing regulations was flagged and not simply problems with regulations. The future risks from fracking were emphasised, and linked to law suits currently underway in the US. The economic value of effective controls to reducing public health threats for example to air pollution was flagged but the difficulty of making similar calculations for water pollution was noted due to lack of information on costs and risks. The failure of some state regulators to consider the cumulative externalities generated by fracking through air, soil and water pollution, loss of water resources and added health service costs (p.236).

The gaps in federal regulation of surface water pollution were highlighted as was the fact that although the fracking industry had taken care to prevent fracking fluids from contaminating aquifers, nevertheless such problems could still arise (p.235).

The need for transparency and access to detailed as opposed to general information on fracking fluids, based on regulation, is stressed along with the rights of the citizen and those living or working near wells and others to know about dangerous substances in their communities. Such information was also considered important for medical staff and first responders.

Weaknesses

The evidence cited for safe fracking is weak and based only on a short report in New Scientist in 2011 (p.233). These sources do not adequately inform assessments of regulatory practices.

Evidence of implementation

Not applicable

Role of political, commercial and industry groups in the research

None declared

Involvement of public health professionals and researchers and specialists in regulatory and industry scrutiny

Not applicable

Generalisability

Yes

Key Lessons

The author considered there was 'a significant probability that science will show a relationship between a toxic chemical used in fracturing and a plaintiff's injuries that allows a trier of fact to award damages' (p.234). He noted the controversies around fracking risks had challenged regulators and state oversight of fracking had increased.

The lack of data about the externalised costs of fracking and the concerns that governments and regulators may be unwilling or unable to factor in such costs and consequences when looking at proposals to introduce or expand fracking are sure to apply in parts of the UK.

The need for community's right to know on the hazardous substances used in fracking including detailed toxicity information was viewed as vital. As the author concluded 'While balancing the secrecy of proprietary information, economic performance, injuries to humans, and environmental damages is difficult, legislators charged with promoting public welfare may be neglecting their duties by supporting non-disclosure exceptions that increase uses of toxic chemicals and sacrifice public health'. In the UK there are still no tight regulations on fracking fluid information disclosure to citizens that exist and would over-ride trade secrecy issues: only 'gentlemen's agreements' by the industry.

Case Study 15. Centner, T. J. and O'Connell, L.K. Unfinished Business in the Regulation of Shale Gas Production in the United States. Science of the Total Environment (476–477) 2014 p. 359–367

The paper sets the scene by describing how the oil industry was able to influence Congress not simply to soften but to abandon environmental regulations of the industry.

Strengths

The authors identified weaknesses and uncertainties in establishing any cause and effect relationships between fracking chemical exposures and illnesses. For them: 'American jurisprudence generally is not structured to recognize that causal exposure to toxic chemicals resulting in the aggravation of a health condition or a premature death should be compensated' (p.360). Related to this the paper highlights the important fact that 'current practices and regulations often do not adequately consider long-term and compounding health effects' (p.360).

The efficacy of regulations is linked directly to enforcement. The referenced analysis reveals that: '… if governments decline to meaningfully address violations, operational requirements may not achieve their objectives' and again 'the success of restrictions is connected to governmental enforcement practices. In the absence of inspections and prosecutions of violators, restrictions may fail to protect public health and the environment' (p.360).

The study found 'an evaluation of the literature on the regulation of activities involved in drilling and fracturing shale gas wells suggests that governments are failing as people and properties are being damaged due to insufficient oversight" (p.364).

Weaknesses

The primary focus of the paper is on aspects of fracking regulation. The literature on industry failings, based on studies in 2011, 2012 and 2013 is cited but this is not the major thrust of the paper.

Evidence of implementation

The paper does review different state regulatory approaches and how they have sometimes changed

Role of political, commercial and industry groups in the research

None cited or identified

Involvement of public health professionals and researchers and specialists in regulatory and industry scrutiny

Not applicable

Generalisability

Yes in terms of broad policy areas

Key Lessons

The influence of industry in terms of ensuring the non-regulation of fracking is often ignored in the UK and there are assumptions that such corporate influence are unrelated to weak regulation and enforcement. Awareness of such potential influences is critical for regulators and others who may simply accept statements from industry and their advocates that practices, standards and enforcement are high when there is no evidence to support such assertions.

The problems with identifying environmental illnesses discussed in this paper indicate the best route in terms of illness prevention will be good regulation and effective enforcement. In the UK, the capacity of regulators and health services to identify and record either environmental or occupational ill-health has proved limited and very difficult especially with regard to any diseases that may develop decades after exposure. Indeed many regulators acknowledge that the scale of occupational and environmental ill-health in the UK is huge but many cases remain unrecorded, unreported and uncompensated.

The UK currently has a 'soft', 'better regulation' environment and a commitment to cutting red tape that has been synonymous with weakening environmental and occupational health regulations de facto if not de jure. It is difficult to envisage fracking regulations will be strong and rigorously enforced in such a climate and hence the UK could go down the path described by Cantner and O'Connell with weak controls affecting workers, communities and householders.

References

Black J. (2014) Learning from Regulatory Disasters. LSE Legal Studies Working Paper No. 24. http://www.lse.ac.uk/collections/law/wps/wps.htm

Broderick. J, Anderson K, Wood R, Gilbert P, Sharmina M. (2011) Shale gas: an updated assessment of environmental and climate change impacts. Tyndall centre for Climate Change. http://www.tyndall.ac.uk/sites/default/files/coop_shale_gas_report_update_v3.10.pdf (accessed October 4 2016)

Broomfield M (2012) Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe. Report from AEA to European Commission. AEA/R/ED57281 Issue Number 11 Date 28/05/2012

Bushkin-Bedient S (2014) Compendium of Scientific, Medical, and Media Findings Demonstrating the Risks and Harms of Fracking. Concerned Health Professionals of New York (Unconventional Gas and Oil Extraction), 2nd edition, 11 December updated April 2016.

Business Task Force 'Cut EU Red Tape' (Oct 2013) 19. Available at: www.gov.uk/government/uploads/system/uploads/attachment_data/file/249969/TaskForce-report-15-October.pdf. (accessed October 10th 2016)

Colborn T, Kwiatkowski C, Schultz K, and Bachran M (2011) Natural gas operations from a public health perspective. Hum Ecol Risk Assess, 17(5):1039-56.

Davies RJ, Almond S, Ward RS, Jackson RB, Adams C, Worrall F, Herringshaw LG, Gluyas JG, Whitehead MA (2014) Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation. Marine and Petroleum Geology. September 56: 239–254

DECC (2014). Fracking UK shale: regulation and monitoring. Guidance on fracking: developing shale oil and gas in the UK. Updated 11April 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/283834/Regulation_v3.pdf (accessed 4th October 2016)

Department for Business, Energy & Industrial Strategy (DBEIS). 2016. https://www.gov.uk/government/publications/about-shale-gas-and-hydraulic-fracturing-fracking/developing-shale-oil-and-gas-in-the-uk (accessed 4th October 2016)

EEA (2013) Late lessons from early warnings: science, precaution, innovation [Internet]. EEA Report No 1/2013. EEA; 2013 [cited 2015 Mar 30]. Available from: http://www.eea.europa.eu/publications/late-lessons-2

Ewen C, Borchardt D, Richter S, Hammerbacher R. (2012) Hydrofracking Risk Assessment. Study concerning the safety and environmental compatibility of hydrofracking for natural gas production from unconventional reservoirs (executive summary) [Internet]. [cited] Available from: http://dialog-erdgasundfrac.de/sites/dialog-erdgasundfrac.de/files/Ex_HydrofrackingRiskAssessment_120611.pdf

Finkel ML, Law A (2011) . The rush to drill for natural gas: a public health cautionary tale. Am J Public Health. 101(5):784–785

Fleming, RC and Reins, L. (2016) Shale gas extraction, precaution and prevention: A conversation on regulatory responses. Energy Research & Social Science. 20:131-141

Goldstein BD (2011). Potential Health Effects of Marcellus Shale Activities: The Need for Public Health Surveillance.http://www.chec.pitt.edu/documents/Marcellus%20Shale/CHEC-Present-Goldstein-5.10.11-HealthMarcellus.pdf (accessed April 25 2014)

Gornall, J. (2015) Public Health England's troubled trail. BMJ. 351. November http://www.bmj.com/content/351/bmj.h5826

HSE (nd) HSE's role in regulating onshore shale gas and hydraulic fracturing (accessed October 3rd 2016)

HSE/EA. Working together to regulate unconventional oil and gas. 2012developmentshttp://www.hse.gov.uk/aboutus/howwework/framework/aa/hse-ea-oil-gas-nov12.pdf

HSE (nd Strategy) Onshore gas and pipelines sector strategy 2014-17 strategic context. pp5 http://www.hse.gov.uk/gas/onshore-strategic-context.pdf (accessed October 4th 2016)

HSE (nd Delivery) Onshore gas and pipelines sector strategy 2014-17: Delivering the strategy http://www.hse.gov.uk/gas/onshore-delivering-the-strategy.pdf (accessed October 4th 2016)

HSE (nd Aims) Onshore gas and pipelines sector strategy 2014-17. Aims and objectives. http://www.hse.gov.uk/gas/onshore-aims-and-objectives.pdf (accessed October 4th 2016)

Hill M. (2013) Brief Review of The Royal Society/ Royal Academy of Engineering Report and the present position of Shale Gas Regulation.

Hill M. (2014) Shale Gas regulation in the UK and the implications of fracking. Lancet; 383:2211-2

Ingraffea AR (2013) Fluid migration mechanisms due to faulty well design and/or construction: an overview and recent experiences in the Pennsylvania Marcellus Play. Physicians, Scientists and Engineers for Healthy Energy, United States

Konschnik KE, Boling MK. (2014) Shale Gas Development: A Smart Regulation Framework. Environ Sci Technol; 48(15):8404–16. doi: 10.1021/es405377u.

Law A, Hays J, Shonkoff SB, Finkel ML. (2014) Public Health England's draft report on shale gas extraction. BMJ; 348:g2728

McKenzie LM, Witter RZ, Newman LS, Adgate JL (2012) . Human health risk assessment of air emissions from development of unconventional natural gas resources. Sci Total Environ. 424:79-87

Michaels, D. (2008) Doubt is their Product. Oxford: Oxford University Press.

Penning T, Breyyse PN, Gray K, Howarth M, Yan B (2014) Environmental Health Research Recommendations from the Inter-Environmental Health Sciences Core Center Working Group on Unconventional Natural Gas Drilling Operations. Environ Health Perspect; DOI:10.1289/ehp.1408207

PR Newswire. Fracking Fluid & Chemicals Market 2015- Global Forecasts to 2020. 2015 http://www.prnewswire.com/news-releases/fracking-fluid--chemicals-market-2015--global-forecasts-to-2020-major-players-in-the-32-billion-industry-are-halliburton-schlumberger-bak

Reap E (2015) The risk of hydraulic fracturing on public health in the UK and the UK's fracking legislation. Environ Sci Eur (2015) 27:27er-hughes-dupont-akzonobel-basf--ashland-300157923.html

Reins L (2017) Water Use for Unconventional Gas Production in the European Union Competition for Water Resources. Chapter 2.2.5 pp 197-21.

SEPA (2013) Regulatory Guidance: coal bed methane and shale gas [Internet]. SEPA [cited 2015 Jul 30]. Available from: http://www.sepa.org.uk/media/139706/unconventional_gas_guidance.pdf.

SEPA (2006) SEPA Position Statement to support the implementation of the Water Environment (Controlled Activities) (Scotland) Regulations 2005: Culverting of Watercourses. SEPA: December.

SEPA (2014). Unconventional gas and 'fracking' – a Scottish perspective. March http://www.sepaview.com/2014/03/unconventional-gas-and-fracking-a-scottish-perspective-2/ (accessed October 4th 2016)

SEPA. Agency Board Meeting. 24 November 2015. SEPA 44/15. http://www.sepa.org.uk/media/163332/sepa-44-15-chief-executives-report.pdf (accessed 4th October 2015)

SEPA (nd) Shale gas and coal bed methane. https://www.sepa.org.uk/environment/energy/non-renewable/shale-gas-and-coal-bed-methane/ (accessed 4th October 2016)

http://www.alliance4usefulevidence.org/rapid-evidence-assessments-a-bright-idea-or-a-false-dawn/

Stirling, A. (2014) Making choices in the face of uncertainty: strengthening innovation democracy. In: Innovation: Managing Risk, Not Avoiding it. Evidence and case studies. Annual Report of the Government Chief Scientific Adviser. London: The Government Office for Science, p.49-63.

Straif, K. (2008) The burden of occupational cancer. Occupational and Environmental Medicine 65:787-788

Task Force on Shale (2015) Assessing the Impact of Shale Gas on the Local Environment and Health. Second Report https://www.taskforceonshalegas.uk/reports/assessing-the-impact-of-shale-gas-on-the-local-environment-and-health (accessed October 1st 2016)

Tombs, S. (2016a) Making Better Regulation, making regulation better? Policy Studies, DOI 10.1080/01442872.2016.1157854

Tombs, S. (2016b) Social Protection After the Crisis: regulation without enforcement, Bristol: Policy Press.

Tombs, S., & Whyte, D. (2014). Toxic Capital Everywhere: mapping the co-ordinates of regulatory tolerance. Social Justice, 42.

Tombs, S. and Whyte, D. (2013) "The Myths and Realities of Deterrence in Workplace Safety Regulation", *British Journal of Criminology*, 53(5), 746-763.

Thomas J, Newman M, Oliver S (2013) Rapid evidence assessments of research to inform social policy: taking stock and moving forward. Evidence and Policy, 9(1): 5-27 - See more at: http://www.alliance4usefulevidence.org/rapid-evidence-assessments-a-bright-idea-or-a-false-dawn/#sthash.MBzMW6XA.dpuf

UNEP. Gas fracking: can we safely squeeze the rocks? [Internet]. UNEP Global Environmental Alert Service; 2012 Nov [cited 2013 May 23]. Available from: http://www.unep.org/pdf/UNEP-GEAS_NOV_2012.pdf.

http://webarchive.nationalarchives.gov.uk/20140305122816/http://www.civilservice.gov.uk/networks/gsr/resources-and-guidance/rapid-evidence-assessment

Watterson A and Dinan W. (2016) Health Impact Assessments, Regulation, and the Unconventional Gas Industry in the UK: Exploiting Resources, Ideology, and Expertise? New Solutions Journal of Environmental and Occupational Health Policy. Feb; 25(4):480-512. doi: 10.1177/1048291115615074. Epub 2015 Nov 3.

Werner AK, Vink S, Watt K, Jagals P. (2015) Environmental health impacts of unconventional natural gas development: a review of the current strength of evidence. Sci Total Environ. 505:1127-141

White E,Fell M and Smith L (2015) Shale Gas and Fracking. House of Commons Library Briefing Paper. Number SN06073, 28 October 2015 www.parliament.uk/commons-library http://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN06073 (accessed October 4th 2016)

Witter R, Stinson K, Sackett H, Putter S, Kinney G, Teitelbaum D, et al (2008) . Potential Exposure-Related Human Health Effects of Oil and Gas Development: A White Paper. Available: http://docs.nrdc.org/health/files/hea_08091702a.pdf (accessed April 25 2014)

Witter R, McKenzie L, Towle M, Stinson K, Scott K, Newman L, Adgate J (2010) Health Impact Assessment for Battlement Mesa, Garfield County Colorado . Colorado School of Public Health, University of Colorado Denver 13001 East 17th Place Aurora, Colorado 80045 roxana.witter@ucdenver.edu

World Health Organization (2009) Global health risks: mortality and burden of disease attributable to selected major risks. WHO, Geneva