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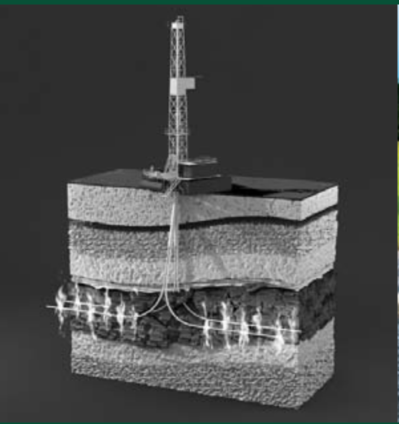
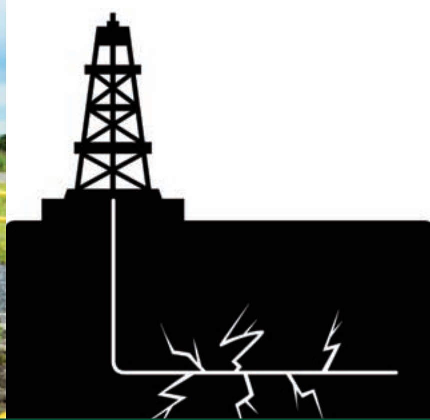
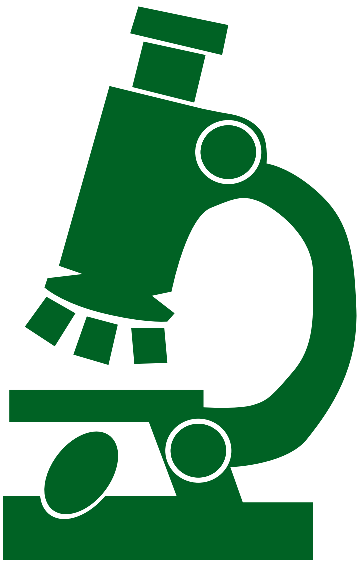




Shale gas and fracking: examining the evidence

Gwen Harrison, Stuart Parkinson
and Gary McFarlane



Shale gas and fracking: examining the evidence

Written by Gwen Harrison, Stuart Parkinson and Gary McFarlane

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SGR is an independent UK-based membership organisation of about 900 natural and social scientists, engineers, IT professionals and architects. We promote science, design and technology that contribute to peace, social justice, and environmental sustainability. Founded in 1992, our work involves research, education, advocacy and providing a support network for ethically concerned science, design and technology professionals. SGR is affiliated to the International Network of Engineers and Scientists for Global Responsibility (INES).

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CIEH is a registered charity and independent professional membership organisation. As a campaigning organisation, we aim to promote improvements in environmental and public health policy through advocacy, research, and education. Our professional members work in a wide range of disciplines across the public, private and not-for-profit sectors and contribute substantially to both health protection and improvement. We are based in the UK with offices in London, Wales and Northern Ireland. We also work closely with the european and international environmental health federations.

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Gwen Harrison is an independent climate change and sustainability consultant, and a member of Scientists for Global Responsibility. She has an MSc in Petroleum Geology from Imperial College London and, more recently, an MSc in Applied Carbon Management. She generally works for public and third sector organisations, helping them tackle the implications of climate change.

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Executive summary

The UK is at an energy cross-roads. Many large power stations are closing, and major policy decisions are being made about replacing energy infrastructure. This is against a background of concern about energy prices, energy security and climate change. Fracking – the hydraulic fracturing technique used to extract natural gas and oil from rocks such as shale – has emerged as a means of opening up a potentially large new UK energy source that some proponents claim will bring down energy bills. Others suggest that, on the contrary, the development or persistence of gas-fired energy infrastructure in the UK locks us into the unpredictable and increasingly expensive international gas market, and threatens the environment. They argue that we should pursue a rapid transition to a low-carbon economy as a much more effective way of improving energy security, reducing bills and tackling climate change.

With fracking for shale gas being relatively new, there are many gaps in the scientific literature regarding its impacts. As a result, the public debate often relies on information from either anecdotal sources or the industry itself, which stands accused of misleading the public. In spring 2013, the Advertising Standards Authority upheld six complaints, and partially upheld another, against oil and gas company Cuadrilla for misleading advertising, exaggeration and/or unsubstantiated claims in its marketing[1]. However, an increasing volume of impartial, evidence-based information now exists. This briefing draws on peer-reviewed literature and independent expert opinion to present an accessible yet robust and fully-referenced overview of the main issues, which readers may then explore in more detail. It challenges some of the commonly-repeated claims that, in many cases, fail to stand up to proper scrutiny. Focusing specifically on the UK situation, this briefing examines:

- the areas under consideration for fracking for shale gas in the UK;
- the potential local environmental and health impacts, including earthquake risk, water and ground contamination, water-use and waste-water, local air quality, and public health risks;
- the regulatory regime intended to deal with local environmental and health risks;
- the implications of widespread shale gas extraction for efforts to tackle climate change;
- socio-economic issues, including energy prices, energy security, jobs and community benefits, and house prices;
- levels of public opposition to fracking; and
- whether we can manage without shale gas.

1. Introduction

1.1 Hydraulic fracturing – the basics

Fracking – or hydraulic fracturing, to give it its full name - involves injecting a mixture of water, sand and synthetic chemicals into a borehole under high pressure to fracture the surrounding rock. This creates pathways along which oil and natural gas can migrate (Figure 1). The sand left behind holds the fractures open[2].

Boreholes are drilled from a well pad, consisting of well heads (above-ground tubes, valves, etc. attached to the underground well), tanks and other equipment. Multiple wells can be drilled from each pad (see Figure 2), which typically covers an area equivalent to about 3 football pitches. Well casing, installed inside the borehole, seals it from the surrounding rock and the groundwater contained within[4].

The technique of fracking is not new. However, it has, until recently, only been used in conventional wells (i.e. those within naturally porous rocks like sandstone, in which fluids can flow freely) to stimulate recovery when extraction becomes more difficult. Fracking for 'unconventional' gas or oil (i.e. that trapped

Figure 1: Shale gas extraction[3]

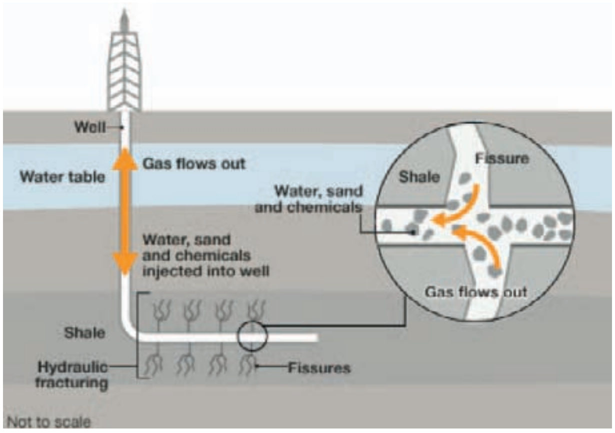

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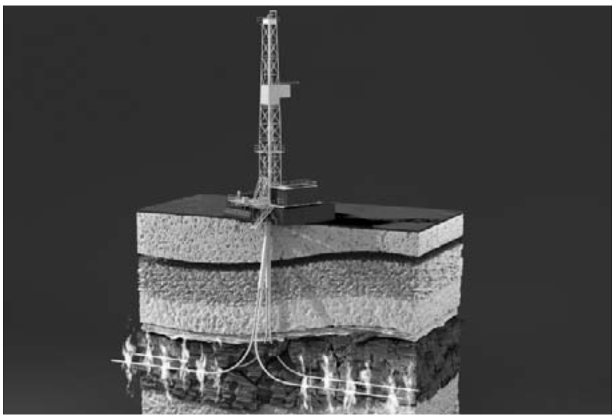
Figure 2: Illustration of a multi-well pad site[5]



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in 'tight', low permeability rocks such as shale) has only taken place on a large scale within the last decade in the USA. To date, only one UK shale gas well has been fracked: Preese Hall in Lancashire.

While shale gas is chemically no different to natural gas extracted in other ways, the process of extracting it is very different. Unlike in conventional wells, fracking in shale requires horizontal drilling (more complicated than vertical drilling), huge numbers of wells (because the gas cannot travel large distances), and millions of gallons of water mixed with synthetic chemicals. The Advertising Standards Authority upheld a claim against Cuadrilla for its misleading suggestion that there were no material differences between fracking in its conventional Elswick well and fracking for shale gas[6].

1.2 The UK situation

There are several areas of interest in the UK, both in Great Britain and Northern Ireland. These include the Bowland Shale, a geological formation stretching across Northern England; the Weald Basin, running through Kent, Sussex and Hampshire; sites in Wales including the Vale of Glamorgan, Rhondda Cynon Taff, and Wrexham; and the Lough Allen Basin in County Fermanagh in Northern Ireland[7].

The British Geological Survey (BGS) estimates that the Bowland Shale contains around 1,300 trillion cubic feet (37 trillion cubic metres) of gas[8]. There is no reliable estimate of recoverable volumes yet (though these are believed to be a small fraction of the total) or, therefore, the number of wells required; AMEC suggests up to 2,880[9].

Over half of Great Britain, and around two thirds of England, is either licensed or under consideration for oil and gas exploration[10], which may include conventional and unconventional sources. In Northern Ireland four petroleum licences have now been issued and a fifth zone is under consideration for South Antrim and North Down. The licenses do not automatically permit exploration or production, which requires subsequent planning consent and other permissions. Cuadrilla has been the UK's main shale operator, having carried out exploratory drilling in Fylde, Lancashire and Balcombe, West Sussex. However, the recent acquisition of Dart Energy by IGAS now makes this the UK's largest shale gas explorer[11]. French oil company Total also recently announced its involvement in a shale gas exploration project in Lincolnshire[12]. Tamboran Resources also have significant interest in the Lough Allen basin in Counties Fermanagh, Sligo and Leitrim, though have not yet begun exploratory drilling.

1.3 Other forms of unconventional gas

Shale gas is just one type of unconventional fossil fuel. Others include Coal Bed Methane (CBM) and methane from Underground Coal Gasification (UCG). The process of extracting CBM is similar to that used for extracting shale gas, and often involves fracking (further information on Department of Energy and Climate Change (DECC) website[13]). UCG involves igniting unmined coal seams in-situ to gasify the coal (see Coal Authority website[14]). While the techniques have common issues, each is different, and this briefing focusses specifically on shale gas.

2. Potential local environmental and health impacts

Among the main concerns over fracking are its impacts on the environment and human health. In this section, we look at local environmental impacts, such as water contamination and earthquake risk, and the regulatory regime under which fracking will take place. We also consider the current evidence on public health and wellbeing risks. We discuss climate change separately in the next section.

2.1 Earthquake risk (Seismicity)

While fracking-induced seismic events are relatively rare in the US, Britain tends to have more complex and fractured geology, and the seismic risk is therefore potentially greater. Professor Mike Stephenson of the British Geological Survey said that to minimise earthquake risk, it is "really very, very important… when you decide that you want to hydraulically fracture… to make sure there are no faults in the area"[15]. The Fylde - home to the UK's only fracked shale gas well - is known to be faulted. Two earthquakes, up to magnitude 2.4, were caused in Lancashire in April and June 2011, when fracking-fluid entered a natural fault[16]. While fracking activities triggered the earthquakes, they may have occurred naturally at a later date[17] and, given their relatively low magnitude, it is unlikely that similar events would cause significant damage to properties and infrastructure. However, the far greater potential risk from such incidents is that of well-integrity failure – the Lancashire earthquakes damaged the well so severely it had to be abandoned. Such incidents risk contamination and methane leakage, and subsequent risks to health, though data on this are currently lacking.

2.2 Water and ground contamination

A report for the European Commission concluded that the cumulative risk of groundwater and surface water pollution and release to air from fracking is high[18]. Contamination can occur from:

- well integrity failure (whereby some part of the well becomes damaged or degrades over time, opening up a potential contaminant pathway);
- spills/leaks of wastewater, synthetic chemicals or gas;
- run-off from well pads;
- poor handling of waste water/chemicals; and/or
- transport.

The widely-used claim that there is no evidence of hydraulic fracturing having caused contamination is misleading, and Cuadrilla was reprimanded by the Advertising Standards Authority for making it[19]. Contamination generally occurs not from the act of hydraulic fracturing itself (which is deep underground), but from subsequent failure of the well or during another part of the process. Evidence is well-reported in the scientific literature. For example, a recent study in Pennsylvania examining gas concentrations close to shale gas wells found methane in 82% of drinking water samples, with average concentrations six times higher for homes within 1km of a well[20]. The isotopic signature of the methane was consistent with a deep shale source, suggesting drinking water contamination resulting from drilling operations. This supports similar previous findings[21]. A more recent study found that 6.3% of the 8,030 wells targeting the Marcellus Shale in Pennsylvania between 2000 and 2013 have been reported for infringements related to well integrity failure[22], while in a seperate study of 3,533 Pennsylvanian wells, 91 suffered some kind of integrity failure between 2008 and 2011[23].

Synthetic chemicals used in drilling fluid depend on the well and the stage of the process. During exploratory drilling, Cuadrilla has only used one chemical – polyacrylamide, a friction reducer that helps reduce pressure-loss. However, if wells go into production more chemicals will be needed to increase flow rates (production generally reduces by 60-90% within a year[24]). It is not yet known what chemicals would be used during production.

UK regulations are more stringent than in the USA, making direct comparison difficult. Local environmental impacts may be less severe here. Nevertheless, it is virtually impossible to eliminate human error, poor well-construction, cement bond failure, etc., especially in such a new, complex and poorly-regulated industry (see Section 2.5). Given the large number of wells proposed, failure of even a fraction could have significant impact. As a comparison, 34% of the UK's North Sea gas wells suffer integrity issues – although it is acknowledged that this is not a perfect analogy[25]. The reality is likely to lie somewhere between what proponents claim, and opponents fear.

2.3 Water use and waste water

Fracking is water-intensive. In the USA, operations on a six-well pad require 54-174 million litres of water and 1,000-3,500 tonnes of chemicals for a first frack[26]. Wells are generally fracked several times over their lifetime, each stage requiring additional water. The UK's only fracked shale gas well used 8.4 million litres of water[27] (equalling 50.4 million litres for six wells).

Water UK, the water trade body, warns that "Where water is in short supply there may not be enough available from public water supplies or the environment to meet the requirements for hydraulic fracturing"[28]. Similarly, the Chartered Institute of Water and Environmental Management stated: "Climate change scenarios predict less water availability in the future so whether this level of water use is appropriate in the long term to source energy requires further research"[29].

Fracking fluid returning to the surface (flowback) ranges from 15 to 80%[30], and is classed as radioactive waste. This is likely to require off-site treatment and disposal, placing a substantial burden on waste-water treatment infrastructure. On-site treatment and re-use could reduce volumes[31] but this may not be possible.

Water and waste-water will require transportation to and from site. During site preparation and production this could range from 14 to 51 daily vehicle movements per well pad for up to 3 years[32].

2.4 Local air quality

There are largely three aspects of fracking operations that may give rise to airborne pollution and subsequently impact on local air quality and therefore public health. Firstly the fracking process within the well itself which may release a range of airborne contaminants. Secondly, the above-ground on-site activities essential to the process involving compressors, generators, and other plant and machinery. And thirdly, transportation of materials both to and from the site. This third aspect is likely to be significant given the vast quantites of water and sand required for the process and also the need to transport shale gas away from the site (assuming that there is no other infrastructure in place, namely a pipeline, to carry it).

In addition to methane, local air pollutants from fracking can include volatile organic compounds (VOCs), particulate matter (PM2.5 and PM10) and nitrogen oxides (NOx). Many of these are associated with site operations and transportation, particularly the combustion of diesel fuel. Action to manage and improve air quality is largely driven by European legislation; The 2008 ambient air quality directive (2008/50/EC) sets legally binding limits for concentrations in outdoor air of major air pollutants that impact public health, such as PM2.5, PM10 and NOx. As well as having direct effects, these pollutants can combine in the atmosphere to form ozone, a harmful air pollutant (and potent greenhouse gas) which can be transported great distances by weather systems.

The 2008 directive replaced most previous EU air quality legislation and was made law in England through the Air Quality Standards Regulations 2010, which also incorporates the 4th air quality daughter directive (2004/107/EC) that sets targets for levels in outdoor air of certain toxic heavy metals and polycyclic aromatic hydrocarbons (PAH). Equivalent regulations exist in Scotland, Wales and Northern Ireland.

It is worth noting that UK MPs are launching a new inquiry into current Government efforts to tackle air pollution, known to contribute to thousands of deaths a year. Earlier this year the European Commission launched legal action against the UK for its failure to reach targets to cut excessive levels of nitrogen dioxide[33].

2.5 Regulatory regime

A number of government bodies have regulatory oversight of shale gas operations, including the Health and Safety Executive (HSE, and HSENI in Northern Ireland), the environment agencies of each UK country (The Environment Agency in England (EA), Natural Resources Wales, Scottish Environmental Protection Agency and Northern Ireland Environment Agency respectively), and local authorities across all regions.

There is widespread concern that the current regulatory regime is inadequate to address the potential impacts of fracking, and the UK Government has rejected many calls for it to be tightened. The Royal Society recommended that industry-specific regulations be developed. Though supported by Lord Browne, Cuadrilla's Chairman[34], the UK Government has rejected this recommendation.

Another key finding of the Royal Society and the Royal Academy of Engineering's report[35] was that "robust monitoring is vital. Monitoring should be carried out before, during and after shale gas operations to detect methane and other contaminants in groundwater and potential leakages of methane and other gases into the atmosphere." Professor Robert Mair of the Royal Society specifically stated a need for an "independent examination and onsite inspection programme"[36]. However, there is currently no legal requirement, or indeed resource, for the regulatory bodies to implement this. Neither are there any provisions within existing frameworks to require specific monitoring of fracking operations, i.e. periodic and regular sampling and analysis. This effectively allows the industry to decide monitoring frequency, scope and, critically, who carries it out. Given the emphasis being placed on robust monitoring this does not seem appropriate in the interests of objectivity, impartiality and public confidence.

Against this backdrop of calls for robust, industry-specific regulation, two of the key regulators – the HSE and the EA – have had large staff reductions. One EA employee recently said: "We've already changed our ways of working so we … rely on operators to self-report problems… how can you guarantee businesses are self-reporting properly if you don't have the staff to check the reports?"[37]. The EA's failure to recognise the need for Cuadrilla to apply for two mining waste permits at Balcombe also calls into question its capacity to regulate the industry effectively[38].

Local authorities, particularly in England and Wales, have also undergone budget cuts, further undermining their ability to provide adequate regulatory oversight. with regard to local air quality, noise, and other public health aspects. Like other regulators therefore, this calls into question the capacity within the system to provide the kind of robust regulation that is being called for as a means of adequate control by commentators such as the Royal Society, DECC, and Public Health England.

Other indications that the Government is failing to provide adequate public protection mechanisms include its recent rejection of a proposed Water Bill amendment requiring fracking companies to insure against pollution damage should they go bankrupt[39]. Any such costs will now therefore fall on the taxpayer. This represents a particular concern given that experts consider well failure, and associated contamination, likely in at least some wells, and have advised that appropriate financial and monitoring processes are in place following abandonment[40].

The UK Government has also lobbied the EU against proposals to adopt legally-binding environmental regulations for shale gas, with David Cameron stating, in a letter to the President of the European Commission, that "It is essential the EU minimise the regulatory burdens and costs on industry and domestic bill payers by not creating uncertainty or introducing new legislation"[41]. In another letter reported in The Guardian, the UK's Permanent Representative to the European Union also allegedly wrote that "seeing off" proposals for tighter regulation would require "continued lobbying at official and ministerial level using the recently agreed core script"[42]. This kind of intervention erodes trust in the Government's commitment to ensuring the UK's regulations are adequate.

Most recently, the Government has created a conflict of interest by announcing its intention to allow councils to keep 100% of business rates from shale gas operations, rather than the 50% that they were entitled to before[43]. Hence, under the current proposals, councils would be financially incentivised to grant planning permission for shale gas operations. This could be worth up to an extra £850,000 for a typical production-stage 12-well site[44] (it is worth noting that the Government has emphasised the total business rate income per site – i.e. up to £1.7m – rather than just the value of the change[45]).

The regulatory shortcomings are particularly relevant given the industry's track record. Cuadrilla "failed to recognise the significance" of earthquake damage caused to its Preese Hall well, and was reprimanded by ministers for not reporting it for six months[46]. It breached planning conditions by drilling two months beyond the time limit and failed to meet a key condition to safeguard bird life from the adjacent SSSI[47]. This serves as a reminder that regulatory mechanisms, even when present, are no guarantee of compliance.

The combination of weak regulation, diminishing resources within regulatory bodies, inexperience of industry and regulators, lack of an appropriate monitoring framework, poor industry compliance and potential conflicts of interests within the planning regime is very disquieting.

2.6 Public health risks

Before commenting on the current body of evidence that considers the risk to public health posed by hydraulic fracturing it is important to define exactly what we mean by public health within the context of this report. The UK Faculty of Public Health defines this as "the science and art of promoting and protecting health and well-being, preventing ill-health and prolonging life through the organised efforts of society"[48]. This definition relates perhaps more to the practice of public health, rather than what public health itself is, although it does include a key phrase, namely "promoting and protecting health and wellbeing".

While health is widely regarded as the absence of debilitating or life-threatening disease or illness, wellbeing is a much broader concept that includes not only physical wellbeing but also mental and emotional wellbeing. Public health as such covers many domains and policy areas including not just health policy but also social, economic and environmental policy.

In the UK, both the Department of Energy and Climate Change (DECC) and Public Health England (PHE) have recently released reports which refer to potential public health risks[49,50]. The PHE report in particular focuses on health impacts from exposure to chemical and radioactive pollutants that might be released as a result of shale gas extraction. It suggests that, while emissions to air have the potential to impact on health, the risk to public health is low. The report states that the only potential implication of fracking is groundwater contamination, which they believe will only be caused by leakage through the vertical borehole or through potential surface spills of fracking fluid or waste water. The report concludes that risk from the extraction process itself is low, but that “good on site management and appropraite regulation of all aspects including exloratory drilling, gas capture, use and storage of fracking fluid, and post operation decomissioning are essential to minimise the risk to the environment and public health”.

The scope of this report is limited to the actual process of extracting shale gas and furthermore to exposures to chemical and radiological pollutants. It excludes “other considerations such as climate change and greenhouse gas emissions, sustainable use of water resources, nuisance issues such as noise and odours, traffic (apart from vehicle exhaust emissions), occupational health and visual impacts”[51]. The report also does not consider socio-economic impacts. It cautions against extrapolating experiences in other countries to the UK since the mode of operation, underlying geology, regulatory environment and spatial distribution (which can impact on public health through socio-economic factors) are likely to be different. However, its findings are nevertheless based largely on evidence from elsewhere – in particular the US – since no substantive data exists for the UK at present.

There are widespread concerns over the lack of evidence on fracking-related health impacts. The Chief Medical Officer for New Brunswick, Canada, Dr Elish Cleary, published a report in 2012[52] within the context of proposed expansion of the shale gas industry within that region. This report considers not only the toxicological risks to public health, but also the social and physical aspects. It highlights the complete absence of any current substantive epidemiological study for populations exposed to shale gas extraction and advocates that this must be addressed; it also advocates Health Impact Asssessment (HIA) for any proposed development. Further recommendations include comprehensive monitoring; adequate licencing/permitting requirements to deal with aspects such as noise, vibration and illumination; and traffic management plans. Finally the report highlights potential social issues that may adversely impact health and welbeing such as the “boomtown effect” which may lead to increased antisocial behaviour, drug-use, and prostitution.

Both the European Union[53] and UNEP (United Nations Environment Programme)[54] have concluded that fracking may result in unavoidable environmental and health impacts even if the gas is extracted properly, and more so if done inadequately. They suggest that even if risk can be reduced theoretically, in practice many accidents from leaky or malfunctioning equipment and bad practices occur regularly[55]. Indeed, a Texas jury recently awarded $3m to a family that filed a law suit against a fracking company for contaminating their air and drinking water, thus harming their health[56].

The EU study[57] found cumulative overall risk to the environment and health from releases to air and from traffic associated with fracking operations to be high. The UK is already facing potential legal proceedings from the EU as a result of its failure to improve air quality (at least 29,000 UK deaths are caused by air pollution each year[58]). Fracking is likely to exacerbate this problem.

3. Climate change

Climate change, often omitted from the fracking debate, is arguably the most important issue. There is international political agreement that a 2°C global average temperature rise (from pre-industrial levels) represents ‘dangerous’ climate change[59] (although scientists increasingly argue that 2°C represents ‘extremely dangerous’ climate change[60]). Climate scientists warn that there is little chance of achieving this without major policy changes[61], many suggesting that we may currently be on-course for 4-6°C of warming by 2100[62,63]. The Intergovernmental Panel on Climate Change (IPCC)[64], the International Energy Agency[65] and Carbon Tracker/the London School of Economics[66] agree that 70-80% of *proven* fossil fuel reserves (i.e. those which are mapped and believed to be recoverable) must remain unexploited to have a reasonable chance of not exceeding the 2°C threshold. Unproven fossil fuel resources, including UK shale gas, have not been included in these assessments.

Also of relevance to this discussion is the Climate Change Act, which commits the UK to an 80% carbon emissions reduction from 1990 levels by 2050. There is now an intermediate target under this Act of 50% by 2025[67].

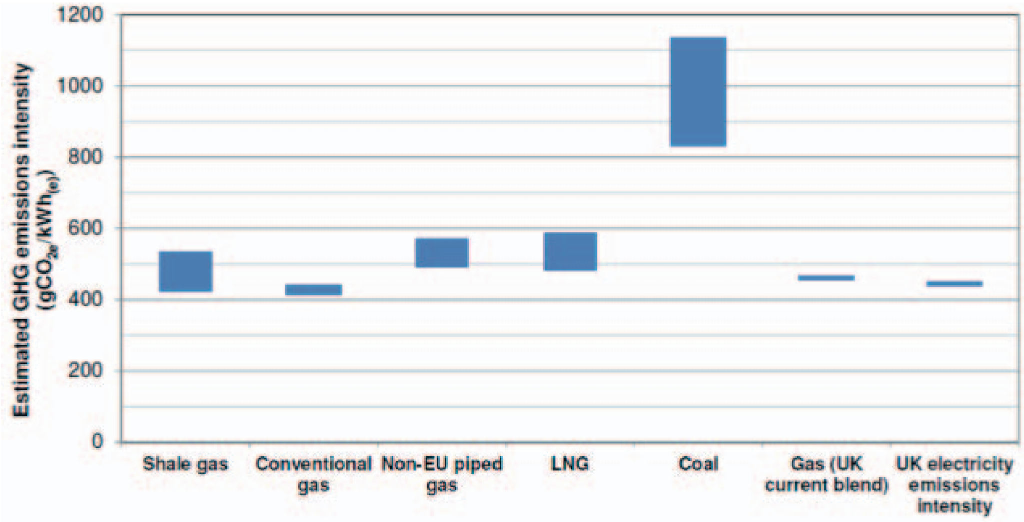
Of the three main fossil fuels, coal and oil generate more emissions per unit of energy produced than natural gas, leading to claims that shale gas represents a relatively low-carbon transition fuel. However, the Committee on Climate Change, the UK government’s statutory advisory body, warns that “unchecked development of gas-fired generation, which the development of shale gas may facilitate, might be incompatible with meeting the UK’s climate change obligations”[68]. A more detailed discussion of the fracking-related climate change issues follows.

While not discussed further in this report, it is important to also note that climate change is now recognised by the World Health Organisation and many other respected organisations as having significant health implications; “Climate change affects the social and environmental determinants of health – clean air, safe drinking water, sufficient food and secure shelter.”[69].

3.1 Comparative emissions

Some researchers have found that shale gas has higher life-cycle emissions (including those during extraction, processing

Figure 3: Comparative life-cycle emissions for electricity production from various sources of gas and coal according to DECC. For shale gas, 90% capture and flaring of methane during completion is assumed[80]



and transport of the fuel, and any additional emissions released post-production) than coal[70], while others suggest they are lower[71,72]. The discrepancy depends largely on fugitive emissions (unintentional methane leakage). While leakage rates of 9%[73,74], 12%[75] and even 17%[76] (two to three orders of magnitude higher than official US Environmental Protection Agency (EPA) estimates) have been found in the US, there is a view that better UK regulation will reduce this percentage.

In a recent review, DECC concluded that emissions from UK shale gas should be comparable with conventional gas and lower than coal (Figure 3). However, it excludes post-production emissions, which may be considerable. For example, a recent academic study found that groundwater methane concentrations increased as shale gas wells aged, indicating significant leakage[77]. The DECC review also assumes methane to be just 25 times more potent a greenhouse gas than CO_2, based on the 100-year timeframe previously recommended by the IPCC[78]. However, the IPCC now estimates methane to be 34 times more potent, or 84-86 times when assessed over a 20-year timeframe (accelerating warming in the short-term)[79], meaning that the figures given by DECC represent a significant underestimate.

To put the fugitive emissions figures into context, it has been suggested that new gas plants reduce climate impacts compared with new coal plants only if leakage rates remain below 3.2%[81]. This is based on methane being 25 times (not the newly recommended 34 times) more potent than CO_2.

3.2 Diversion of investment away from renewables

Bloomberg New Energy Finance suggests that renewables are unlikely to be *directly* affected by shale gas, because their adoption is driven by decarbonisation policy[82]. However, the UK Government's clear support for shale gas and, by contrast, reductions in its support for renewable energy and energy efficiency, may be deterring investment. For example, after the Government's failure to use the Energy Bill to introduce a target for decarbonising the electricity supply by 2030, a group of investors responsible for over £1 trillion called on Chancellor George Osborne to reconsider. They argued that "The UK has the potential to offer a safe harbour for renewable energy investors in Europe, but the delay in delivering a stable policy framework is weakening our prospects and holding back investment"[83].

3.3 Total global emissions

Finally, but most importantly, shale gas exploitation is likely to increase global carbon emissions. Within a given country, coal may be subtituted by shale gas – driven either by relative cost, such as in the USA, or by carbon targets, as may happen in the UK. However, there is little to prevent this unused coal from being sold in international markets, thereby increasing carbon emissions elsewhere. Indeed, as coal use has fallen in the USA following its shale gas boom, the country has simultaneously exported its unwanted coal, including to the UK[84,85], thereby increasing our emissions.

If and when there is an effective global emissions cap, there may be an argument, from a climate change perspective, for reconsidering the possibility of exploiting shale gas in preference to coal. In the absence of such a constraint, however, leading analysts (including those from the Tyndall Centre[86] and DECC[87]) warn that shale gas will be additional to, not instead of, coal, leading to an overall increase in carbon emissions and a consequent acceleration of climate change.

4. Socio-economic issues

A range of assertions has been made by the industry and government for the economic and employment benefits of fracking. Here, we critically assess some of the most high profile claims.

4.1 Energy prices

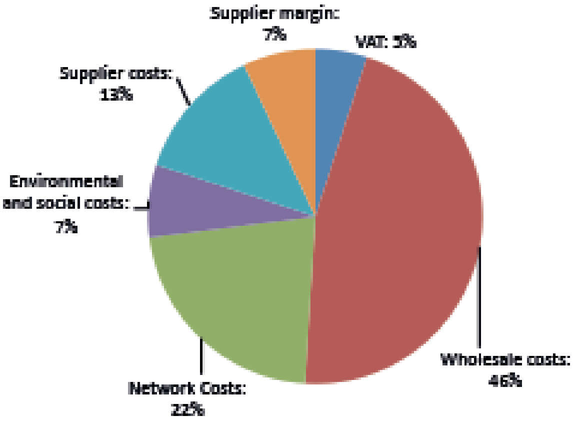
The commonly repeated claim – even made by the Prime Minister[88] - that fracking will bring down energy prices in the UK, as it has done in the USA, has been refuted by Bloomberg[89], Deutsche Bank[90], Lord Stern[91], DECC[92], Ofgem[93], International Energy Agency[94], and even Cuadrilla[95,96]. There are many reasons. Differences in geology, population density, mineral rights laws, environmental regulations, and levels of public opposition will combine to result in higher production costs and a more protracted approval process than in the US. Perhaps most importantly, however, the UK is tied into the international market, where gas is sold to the highest bidder, regardless of its origin. Any increase in domestic gas production will therefore have little impact on the UK price[97].

The principal driver for rising energy bills is the international cost of fossil fuels. Improved energy efficiency and development of renewable energy provides some protection against future rises in wholesale energy costs, which now account for 47% of average household bills[98] (Figure 4 – note that there are some rounding errors). Shale gas, conversely, will not reduce wholesale costs but will tie us into continued reliance on fossil fuels[99].

4.2 Energy security

The House of Commons Energy and Climate Change Committee suggests that, while European (including UK) shale gas development could improve security of supply in the short-term, the future is too uncertain to rely on this[101]. This is echoed by Bloomberg New Energy Finance, who suggest that even under the most favourable scenarios, the UK will not become self-sufficient in gas[102]. The development, or persistence, of gas-fired energy infrastructure in the UK locks us into its continued use, and ties us into an international gas market vulnerable to geopolitical and other disruptions to supply[103].

Figure 4: Breakdown of UK household energy bills[100]



4.3 Jobs and community benefits

An industry-wide study by the Institute of Directors (IoD), sponsored by Cuadrilla, predicted that UK shale gas could generate 74,000 jobs overall[104] (this includes induced jobs through expenditure of employed staff; the number of direct and indirect jobs is lower). The Government's own report, prepared by AMEC and published by DECC, puts the figure at just 16,000-32,000[105] (again including induced jobs. The figure for direct and indirect jobs is 15,900-24,300[106]). AMEC expressed concern over job leakage (only 17% of jobs from the Preese Hall site in Lancashire went to locals) and that jobs are typically short-term (4-9 years). By contrast, the low-carbon energy sector could provide:

- Over 70,000 jobs in wind and marine renewable energy over the next decade (not including induced jobs)[107]
- 35,000 jobs in Anaerobic Digestion[108]
- Numerous jobs in PV, hydro and other forms of renewable energy
- 46,000 jobs in the insulation industry by 2015, according to analysis on government employment estimates[109].

Future jobs in renewables will increasingly be long-term (i.e. operation and maintenance).

Unlike for renewables, there may also be opportunity costs associated with fracking; real and perceived risks from groundwater contamination could have severe consequences in, for example, agriculture and tourism. In many areas these industries represent significant elements of the regional economy.

The industry announced last year that communities will receive £100,000 and a further 1% of revenue from a production site. DECC estimates this 1% to be worth £2.4-4.8 million per site under a high activity scenario (with no estimate provided for low or central scenarios), assuming each well is productive for 20 years[110]. Despite this being an optimistic estimate, the Government, in its recent announcement, quoted a much higher figure still of £5-10 million[111].

4.4 House prices

Concern over groundwater contamination risk from fracking has been found to reduce nearby property values by 24% in the US[112] (except where lease payments are made – rarely applicable here). There are also anecdotal reports of people struggling to sell their houses in affected areas of Lancashire.

5. Public opposition

Public opposition to fracking is strong, and may be growing. In a recent government survey, 27% of people said they support shale gas extraction, while 21% were opposed[113]. Opposition increases when people are asked about fracking near their homes. In Balcombe, where Cuadrilla carried out exploratory drilling, two separate surveys – one by residents and the other by the Town Council – showed 82% and 85% against it. A national ICM survey in August 2013 showed 40% of respondents supported fracking in their area, and 40% opposed it (compared with 68% support for onshore wind, with 67% preferring a wind turbine to a fracking site near their home)[114]. A more recent poll by the Institute of Mechanical Engineers found that 47% of people would be opposed to a fracking site near their home, compared with 14% who would be happy with it[115]. A series of surveys carried out by Nottingham University shows that public support for shale gas has consistently fallen since the Balcombe protests[116].

Given the scale of public opposition, it is necessary to consider policing costs in any assessment of the pros and cons of fracking. Sussex Police estimated the overall cost of its two-month Balcombe operations to be around £4m[117]. Greater Manchester Police have confirmed costs of around £50,000 per week[118] for the ongoing protests at Barton Moss, near Salford. This order of costs could offset any community and council benefits proposed by the government and industry[119].

6. Can we manage without shale gas?

While critics claim that renewables are too unpredictable to replace gas, Fatih Birol (the IEA's chief economist) argues that political unpredictability, rather than technical challenges, are the greatest barrier facing green energy markets[120]. This claim is supported by banking giant, Citi, which suggests that, with more wind farms feeding into a national grid, wind power begins to exhibit more baseload characteristics (i.e. it runs more continuously), and thus becomes a more attractive option, without the risk of low utilisation rates, commodity price risk and carbon costs[121] – all common to fossil fuel suppliers.

The Tyndall Centre estimated the relative cost of electricity generation from shale gas and wind energy. It concluded that the investment required to deliver 7-8GW of electricity generation capacity from shale gas would deliver 21GW or 12GW if invested in onshore or offshore wind, respectively[122]. Bloomberg New Energy Finance calculated that, even after taking account of the typically higher average load factor of gas-fired power stations, under most scenarios electricity from shale gas is more expensive than from onshore wind[123]. Fatih Birol argues that fossil fuel subsidies (which are six times greater than renewables subsidies globally[124]) make oil and gas artificially cheap, and hence renewables are often unable to compete[125]. The UK Government has announced substantial tax breaks for shale gas[126], despite the Environmental Audit Committee advising that "Fracking is not a technology warranting financial support to become viable and competitive, and on that basis it does not warrant subsidy through a favourable tax treatment"[127]. Lord Browne of Cuadrilla also highlighted that "In 2011, the UK spent over four billion pounds supporting the production and consumption of oil and gas, more than is spent to support renewable energy"[128].

Investment in renewables, including in Europe, has paid off, with renewables reaching price parity in many cases. In Germany, RWE recently stated its intention to close fossil fuel power plants because they could no longer compete with renewables[129]. The price of solar photo-voltaic modules fell by nearly 80% between 2008 and 2012[130].

Citi warns that investment in fossil fuels further up the cost curve "entail significantly more risk than is widely recognised"[131], with new projects built facing competition from renewables.

There is not space in this briefing to present a detailed comparison between renewable energy and shale gas, but it is worth noting that there is potential for considerable expansion in the use of renewable resources, especially in tandem with energy conservation[132]. It is also worth noting that, where sufficient sources of hydropower are available, it is possible to generate electricity supplies entirely from this: as of 2008, 46 countries were generating over 60% of their electricity from renewables, of which 18 were managing over 90%, and five achieving 100%[133].

7. Conclusions

In this briefing, we have summarised key evidence concerning the environmental, health and wellbeing, and socio-economic aspects of fracking for shale gas in the UK. In particular, we have critically examined some of the most common industry and government claims, drawing extensively on independent academic and expert literature. We have found several areas of concern.

Regulation of the industry in the UK is currently inadequate, although it is stricter than in the US, thus somewhat reducing the potential for local environmental impact by comparison. With technological advances and an improved regulatory environment, groundwater contamination risks could conceivably be reduced to an acceptable level, although there is much to do to reach that point. Furthermore, the requirement for vast quantities of freshwater (expected to become scarcer under climate change), which require road transportation, is unlikely to be resolved. Confidence in the practice is undermined by a series of disingenuous claims made by both the Government and industry.

Virtually all economic analysts refute the claim that fracking will reduce energy bills in the UK. Instead, it will lock us into continued reliance on fossil fuels and the increasingly volatile and expensive international gas market. Although fracking will generate jobs, job leakage is probable, and it may result in job losses in other industries, for example, agriculture and tourism. The job creation potential has been substantially exaggerated, and is also significantly less than that of the low-carbon energy sector, which itself may suffer from diversion of investment to shale gas. Community benefits have also been exaggerated, while the substantial policing costs do not generally feature in the discussion. There is also some evidence of house prices having fallen near fracking sites.

Given that, even without shale gas, proven global reserves of fossil fuels are five times higher than can be burned without risking a 2°C global temperature rise, the exploitation of shale gas is dangerous and unnecessary. It is true that, assuming minimal methane leakage, shale gas might have a lower carbon footprint than coal. However, in the absence of a global cap on emissions, the use of shale gas will undoubtedly be in addition to, not instead of, coal, and will therefore result in an overall increase in emissions. Until such a constraint on emissions is in place, this problem remains unresolved.

Updates

While every effort has been made to provide the most up-to-date and accurate information, readers are reminded that this is a rapidly developing area, with new policies and new research results being announced on a frequent basis. For example, since the main text of this briefing was agreed, the UK Government has announced proposals to make it easier for fracking to be carried out under private property without the owner's permission.

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