CIWEM Chartered Institution of Water and Environmental Management

Policy Position Statement

Hydraulic Fracturing (Fracking) of Shale in the UK

Purpose

This Policy Position Statement outlines the potential environmental impacts of the use of hydraulic fracturing, known as 'fracking' to access natural gas reserves in shale rock and discusses whether it is an acceptable method to produce gas in the UK. An in depth report *Shale Gas and Water*[1] is also available from CIWEM.

CIWEM considers that:

1. Before an industry has developed, hydraulic fracturing for shale gas has become highly contentious. Government departments and agencies should actively promote informed understanding among stakeholders using clear scientific evidence, transparency and consistent messages, across a range of media and forums. Government Ministers should ensure that their messages on shale gas are consistent with those of the Government departments.
2. Pursuing a more carbon based fuel strategy will make it more difficult to reach our climate change commitments and potentially our renewable energy targets. The development of shale gas must not undermine the necessary drive for energy efficiency and clean renewable energy within UK energy policy.
3. Gas will continue to play a part in our energy mix, especially for its role in space heating, in the medium term; but we will need global climate policies to avoid an increase in cumulative greenhouse gas emissions and the risk of climate change. Sustained investment in renewable energy sources and carbon capture and storage is needed to decarbonise the electricity sector.
4. It is important that the UK Government continues its commitment to a tightly controlled industry and must ensure that the regulators are properly resourced to undertake their duties.
5. Public opposition during the planning process could present a major barrier. The industry should ensure it complies with the UK Onshore Operators Group community engagement charter so that the public are involved within the planning process with adequate notice and information.
6. Local Planning Authorities must take into account the potential cumulative impacts of pollution on health, the natural environment, general amenity, and the sensitivity of the area to adverse effects from pollution. Local Planning Authorities who are considering

1 CIWEM. 2016. Shale Gas and Water http://www.ciwem.org/shalegas

planning applications will need to take great care to ensure that their planning decisions are very robust.

7. Water supply issues are likely to be local and early engagement by shale gas companies with the Environment Agency and water companies is essential to establish the nature of any risks and manage them accordingly. Water and sewerage companies should become statutory consultees in the shale gas planning process regardless of whether they continue to provide and treat water for the industry.

8. If shale gas is to be developed safely, ensuring due regard for protection of the wider environment, exploration should not be permitted in areas where there is a genuine risk to valuable drinking water resources located in groundwater. CIWEM is supportive of the Environment Agency's precautionary approach.

9. Seismic monitoring should be used to assess any potential impact on well integrity, in line with UK Onshore Operators Group guidelines. Wells must be shut down if induced seismicity, groundwater contamination or an uncontrolled release of gas to the atmosphere is likely. The HSE must undertake an active role in visiting sites for verification inspections of monitoring operations and take enforcement action where it is found to be inadequate.

10. The nature of the substances in the returned waters may not be of an appropriate chemical composition to be sent to a typical public wastewater treatment works and may require specialist industrial treatment or pre-treatment in order to enable this. If the industry grows, and wastewater volumes increase, water treatment capacity will certainly need to expand to support it.

11. The industry must follow UK Onshore Operators Group guidance to ensure returned waters are appropriately contained, managed, and treated prior to eventual disposal. Best practice for fluid storage (above ground tanks that meet industry standards) is needed to ensure no risk of fluid leaks or spillages.

12. It is important that before shale gas activities commence, baseline data for appropriate contaminants is obtained for potentially affected ground and surface waters and receptors. Following the production of a baseline, the long-term monitoring of relative conditions will be required. This should be carried out throughout the lifetime of development, production and post-production.

13. If hydraulic fracturing operations are managed properly the risk from induced seismic events is low, and structural damage is extremely unlikely. The new system for reviewing seismic risks and monitoring operations should help to improve public confidence.

14. The potential public health impacts of exposures to chemical and radioactive pollutants as a result of the shale gas extraction are low if operations are properly run and regulated.

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Context

Hydraulic fracturing or 'fracking' began in the 1940s in the United States. It is a process not solely associated with extracting gas from shales but routinely used in 'conventional' oil and gas fields and hydrothermal wells to extract hydrocarbons using pressurised fluids to create fractures in rocks.

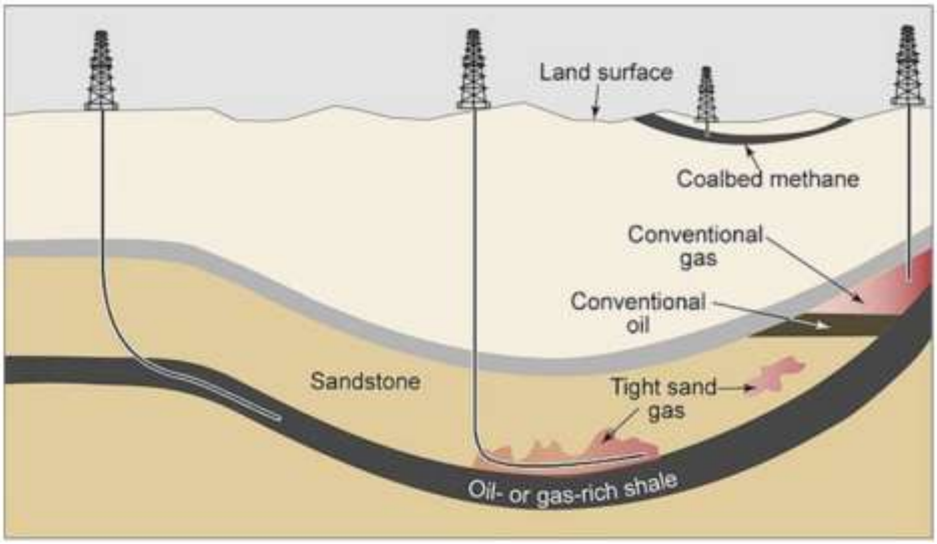

Figure 1 – Schematic geology of natural gas resources,

US Energy Information Administration

Unconventional hydrocarbons such as shale gas, coal bed methane, underground coal gasification etc. are called such because they are found under conditions that do not allow them to flow and be easily captured (fig 1). Coalbed methane is methane formed through the geological process of coal generation. It is present in varying quantities in all coal and can be extracted using hydraulic fracturing techniques. 'Tight gas' refers to gas which is trapped in unusually impermeable hard rock or in a sandstone or limestone formation that is unusually impermeable and non-porous (known as tight sand).

The extraction of shale gas from rocks with low permeability at economically viable flow rates relies on the use of two technologies; horizontal drilling and hydraulic fracturing. Drilling rigs bore into the rock and the well bore is lined with a steel pipe and backfilled with cement. Water and fracturing fluids are pumped at high pressure into the well to create a zone of narrow fractures; water pressure and proppants keep the fractures open and allow hydrocarbons to flow freely from the rock pores into the well bore to be captured. Horizontal wells are fractured in stages with a lateral drilled, perforated and then fractured; a mechanical plug is put in place to stop the gas from flowing back up the well whilst the next section is perforated and fractured. This process continues until the whole lateral has been fractured, the plugs are then drilled through to allow the fracturing fluid and gas to flow up the well.

What makes hydraulic fracturing in shale gas extraction different from other hydrocarbon extraction techniques is that it is on a greater scale; the wells are often drilled deeper than conventional wells and a greater number of wells (including lateral wells) are needed to access the resource. Shale also requires higher volumes of water and chemicals and higher water pressures[2] due to the depth of the well and because there are very few natural fissures in the rock. This can present engineering challenges.

Shale Gas in the UK

Whilst the US and Australia have been producing shale gas via hydraulic fracturing for years, exploration in the UK is still in the early stages with only a modest level of exploration activity.

The UK has abundant shales at depth, although their distribution is not well known. The British Geological Survey (BGS) have been working to establish shale gas *resources* (the estimated total volume of gas (gas-in-place (GIP)). Technically Recoverable Resources (TRR) can then be estimated as those that are extractable from the total resource. Shale gas *reserves* are the fraction of the TRR that is deemed to be commercially recoverable using today's technologies[i].

In 2013 DECC commissioned the BGS to undertake a detailed GIP analysis for part of central Britain in an area underlain by the Bowland Shale which extends across a significant area of England from the Midlands northwards[ii]. The Bowland Shale is believed to be the rock type with the greatest potential for shale gas in the UK as it occurs at both depth and at outcrop and it is known from previous studies and investigations to be an excellent hydrocarbon source rock. The central estimate of GIP was 37.6 trillion cubic metres (tcm $1x10^{12}$). Using similar recovery factors to the US (8-29 per cent) gives a TRR estimate between 1.8 – 13 trillion cubic metres (UK annual gas consumption is 77 billion cubic metres (bcm $1x10^{9}$))[iii]. These studies are not able to accurately to predict reserves (i.e. that will be technically and commercially produced); these can only be established by allowing exploration drilling and testing.

It is not surprising then that the Government[iv] desires indigenous gas production as this will allow the UK to reduce our reliance on energy imports which are expected to increase from 50 per cent to 76 per cent by 2030, and provides considerable tax benefits to the Treasury. A misunderstanding of the nature of resource estimates has fuelled speculation of an energy revolution with lower gas prices and self sufficiency in the medium term. This has brought much conjecture over both the size of the potential industry and how quickly it will be able to establish itself in the UK.

Further studies are being undertaken across the UK, but it may require a period of around two years of exploratory drilling in order to establish the viability of shale gas in the UK[v]. Until that point, very low levels of certainty can realistically be attached to claims on either side of the discussion. This uncertainty is of greater relevance in the case of unconventional oil and gas than for more conventional sources, which are easier to assess and predict.

Key Issues

Sourcing gas utilising hydraulic fracturing generally poses greater environmental challenges than conventional developments and a robust regulatory regime is required to mitigate risks and to improve general public confidence[vi].

The key issues discussed in this PPS are:

[2] Environment Agency. 2012. Monitoring and control of fugitive methane from unconventional gas operations.

- Climate change and fugitive emissions
- Regulations
- Planning, amenity and public opposition
- Water use
- Water pollution
- Earthquakes - induced seismicity
- Air pollution and health

Gas as an energy source – climate change considerations

'Natural gas' is used to generate electricity, is a key feedstock to the chemicals industry and is the gas used in domestic heating and cooking in homes. Since the early 1990s, investment in gas electricity generation infrastructure has been a key component of investment in the energy sector, accounting for nearly 70 per cent of new capacity coming online between 2000 and 2011. Currently 80 per cent of our domestic heat comes from gas[vii].

The extraction of shale gas in the UK may not necessarily mean that it will be consumed in greater volumes on our shores and this is really a question of wider energy policy. However given that it would reduce our dependence on imports (the prices of which are likely to rise) and help to meet the UK's continued gas demand in industry and for heat in buildings it is likely that it would play a contributing role. Gas is important in maintaining energy security, affordability and being 'cleaner' than coal for the same energy output. As such it is being touted by many as a bridging fuel that can be used whilst renewable energy sources are developed to achieve grid parity.

Shale gas, like other forms of gas, cannot be regarded as a low-carbon fuel source. Pursuing a more carbon based fuel strategy will make it more difficult to reach our climate change commitments and potentially our renewable energy targets. In the longer term any electricity generation infrastructure for gas will have to have Carbon Capture and Storage (CCS) technology if it is to provide significant amounts of generation as part of a low-carbon energy mix. This has not yet proven to be technically or commercially viable.

CIWEM considers gas will continue to play a part in our energy mix, especially for its role in heating, in the medium term, but measures to minimise lifecycle emissions will be needed. We will also need commitment to global climate policies to avoid an increase in cumulative GHG emissions and the risk of climate change. Sustained investment in renewables is needed to decarbonise the electricity sector; developing gas generation infrastructure must not detract from energy efficiency, local combined heat and power and clean renewable energy investment in sources such as solar, wind, biomass, wave and tidal power.

Fugitive emissions

The greenhouse gas footprint of shale gas consists of the direct emissions of carbon dioxide (CO_2) from end use consumption, indirect emissions of CO_2 from fossil fuels used to extract, develop, and transport the gas, and methane (CH_4) fugitive emissions and venting. The independent Committee on Climate Change's (CCC) view is that shale gas can have lower lifecycle emissions than imported liquefied natural gas (LNG), if it is transported by pipeline and if there are appropriate measures to manage methane released during production[viii].

Methane can be emitted from unconventional gas extraction during several steps of the gas production process. These fugitive emissions are a concern because methane has a very high global warming potential (25 times more than CO_2 over a 100 year time [periodix]). Due to conflicting reports on fugitive emissions, a government commissioned study[x] reviewed all the available evidence and found that if adequately regulated, local greenhouse gas emissions from shale gas operations should represent only a small proportion of the total carbon footprint of shale gas.

The industry must adopt the UK Onshore Operators Group (UKOOG) guidelines commitment to eliminating all unnecessary flaring and venting of gas and implement best practices such as 'green' completions. Monitoring must commence prior to drilling to establish background levels of methane, during drilling operations for leak detection and fenceline measurements to evaluate the performance of an individual installation and also as part of aftercare and maintenance of capped wells. CIWEM considers landfill permits offer a suitable model in terms of aftercare.

Regulatory regime

The conventional oil and gas industry is mature in the UK and is already tightly regulated both onshore and offshore. Unconventional oil and gas exploration and exploitation is regulated by appropriate sections of DECC, the Environment Agency (EA) and the Health and Safety Executive (HSE). It is also subject to planning requirements through the Department for Communities and Local Government (DCLG) and local authorities (figure 1.8). Elsewhere in the UK the Scottish Environmental Protection Agency (SEPA), Natural Resources Wales (NRW) and the Northern Ireland Environment Agency (NIEA) fulfil the role of the environmental regulator. These bodies ensure compliance with European Directives and legislation and also that which is in place at the national level. (Further details of the process can be found in CIWEM's report *Shale Gas and Water)*.

Within DECC, the Office of Unconventional Gas and Oil (OUGO) has been set up to co-ordinate the activity of the regulatory bodies and Departments and to deliver a streamlined planning and regulation system. In addition to the regulatory framework an industry code of practice has been developed by UKOOG.

Many apprehensions over hydraulic fracturing in the UK are a result of the experience of regulation in the US. There each State regulates separately and to varying levels of stringency. A further key difference is that in some states land owners own the mineral rights and these circumstances have led to a rapidly expanding industry with limited environmental controls.

The UK Government has committed to a tightly controlled industry and this must continue. Guidance to the regulatory regime currently only applies to the exploration phase and may need to be modified for production to reflect the more intensive conditions associated with it. The European Commission is also evaluating its own role and has produced a communication[xi] on minimum principles for shale gas (with which the UK's regime currently complies). The Environment Agency's final guidance is due for consultation in summer 2014 and it is currently developing Standard Permits to help speed up the permitting process.

Regulation must clearly distinguish between the different impacts associated with exploration and that of production. There will be different requirements for regulation, control, monitoring and local issues for both contexts, i.e. whether there are one or two wells or several hundred. Further regulations associated to specific environmental impacts are discussed below.

Planning, amenity and public opposition

The National Planning Policy Framework and the government's planning practice guidance for onshore oil and gas[xii] detail what constitutes a material planning consideration. This includes ensuring that new development is appropriate for its location "taking account of the effects (including cumulative effects) of pollution on health, the natural environment or general amenity, and the potential sensitivity of the area or proposed development to adverse effects from pollution".

Shale gas formations typically cover a much wider lateral extent than conventional gas reservoirs and will require multiple surface entry points. Surface installations require an area of approximately 3.6 hectares per pad for high volume hydraulic fracturing during the fracturing and completion phases, compared to 1.9 hectares per pad for conventional drilling[xiii]. This opens the possibility of more extensive gas fields. Following the completion or abandonment of a well it may not be possible to fully restore sites particularly in areas of high agricultural, natural or cultural value. Over a wider area, with multiple installations, this could result in a significant loss or fragmentation of valuable farmland or natural habitats, which must be considered during the planning process.

The difference in the UK compared to Australia and the United States is that shale gas extraction may be nearer to greater densities of populations creating a much more noticeable impact on the community and the local environment. The industry requires considerable industrial activity such as trucking, moving rigs and fluids; all of which can have an impact on local amenity, landscape value, aesthetics and noise. Amenity is important for leisure and tourism in the UK and this sector generates considerable economic benefits that should not be compromised by fossil fuel development.

Public opposition during the planning process could present a major barrier. UKOOG and the Government[3] have sought to counter the already vociferous public opposition to possible future widespread construction of well pads in parts of the country with an incentive package for local communities, comprising £100,000 for communities sited in the vicinity of exploratory wells and one per cent of revenues from production. With mineral rights in the UK being vested by the Crown Estate and licensed by DECC the incentive package has to come from the industry. This is a different situation to that which prevails in the US, where in some states property owners have mineral rights and up to 20 per cent of production revenues may be paid to individual land owners[xiv].

Local authorities are also able to keep 100 per cent of the business rates they collect from shale gas sites, double the previous 50 per cent figure[xv]. Local authorities who are considering planning applications will need to take great care to ensure that their planning decisions are very robust in light of this potential conflict of interest.

[3] Initially proposed by UKOOG and adopted by the Government

There have been criticisms[xvi] that the public consultation process has been poorly implemented in areas of shale gas exploration to date so it is important that the industry improves upon this. It will need to be transparent about the risks and the management measures they are putting in place. UKOOG has established a binding community engagement industry charter[4] for its members that cover how operators will communicate and engage and also makes specific commitments with respect to logistics, health and safety, environmental compliance and local needs. It is important that as the industry develops these are adhered to.

Water use

The processes of drilling and hydraulic fracturing both require water. This is carried out in stages to progressively fracture the shale along the horizontal wellbore (lateral). This may take a few weeks with each stage taking around a day. Once the well has been drilled and fractured a significant amount of fracturing fluid (up to 80 per cent) returns to the surface as flowback fluid.

Estimates of water use in the literature have ranged from 250 - 4000m^3 for drilling and 7000 – 23,000m^3 for hydraulic fracturing[xvii] per well. This large variation in estimates of water use reflects the complexity of drilling, geological conditions, borehole depth, pressure, thickness of the gas reservoir and other factors. The water volume that the energy company Cuadrilla have stated for its UK operation at the Preese Hall borehole is around 9000m^3.

To put it into perspective, to meet ten per cent of the UK gas demand from shale gas over 20 years (9bn m^3 gas) would require 25 – 33 million m^3 of water, or 1.2-1.6 million m^3 per year[xviii]. Although this may sound a large amount, when compared to licensed water abstraction per year in England and Wales (12.6 x 10^3 million m^3) it equates to less than 1/10th of one per cent of total abstraction[xix]. Water use is therefore low in national terms, but there could be local or regional consequences should a large industry develop which will have to compete against different users. A production scenario for a region with 1000 wells shows the estimated peak demand is 2.2 Ml/d. This is still a fraction of regional water use per day but some catchments are already overabstracted so there may not be any spare headroom.

Compared to other fossil fuels, experience from the US has shown that the water intensity is relatively low: (0.6 – 1.8 gal/MMBtu (million British Thermal Units) for shale gas, 1 to 8 gal/MMBtu for coal mining and washing, and 1 to 62 gal/MMBtu for onshore oil production[xx]). The difference being with shale gas is that the water consumption is front loaded, used in the drilling and fracturing stage, so there is a large upfront water usage over a few days or weeks, after which the natural gas is produced over many months or years. This allows for flexibility with the timing of operations should any supply restrictions be in place.

Shale gas operators have the option to source water directly from the environment via abstraction under licence from the Environment Agency or purchase it from a water company and receive it via the mains or from tankers. There may be scope for larger companies to recycle their water for future fracturing which would reduce the water demand.

4 UKOOG. 2013. Community Engagement Charter Oil and Gas from Unconventional Reservoirs

Should an industry become established in the 2020s, when there will be greater pressures on the water environment, there could be local issues with water sourcing, especially in the water stressed South East. Essentially it will be for the water company or the environment agency (depending on where the water is sourced) to determine if there is enough to go round. Where there are water stressed catchments however, operators will need to be aware of the risk that there may be smaller volumes available in the future. CIWEM believes water and sewerage companies should become statutory consultees in the shale gas planning process to establish the nature of any risks and manage them accordingly regardless of whether they continue to provide and treat water for the industry.

Water pollution

A frequently expressed concern associated with shale gas operations is that contamination of groundwater could occur. This may result from a catastrophic failure or loss of integrity of the wellbore, or if methane or contaminants can travel from the target fracture through subsurface pathways[xxi]. There is also the potential for pollution of the local land and water environment if the returned water from the hydraulic fracturing process is not appropriately contained, managed, and treated prior to eventual disposal.

The fracturing process entails pumping a large quantity of hydraulic fracturing fluid (composed of approximately 98.5% water, 1% sand (used as a proppant to keep fissures open) and 0.5% chemical additives). In the US there has been much controversy over the chemical additives used in the fluid not being disclosed. The UK is keen to avoid such controversy; using information from the shale gas operator the EA will assess whether an additive is hazardous or a non-hazardous pollutant using a methodology that follows the requirements of the Groundwater Daughter Directive and under the EA technical guidance WM2[xxii]. The Directive requires that no hazardous substances are allowed to enter groundwater and that non-hazardous pollutants do not cause pollution. To date in the UK, the Environment Agency has set out that the only additives that will be permitted are polycrylamide, hydrochloric acid and a biocide.

The most likely pathway of contamination to groundwater is from failure of the cement or casing surrounding the wellbore. However a 'failure' does not necessarily represent a leakage of contaminants to the environment, rather a failure within a multibarrier system. The Offshore Installations and Wells (Design and Construction, etc) Regulations 1996[xxiii] apply to all wells drilled with a view to the extraction of petroleum regardless of whether it is onshore or offshore. These specify that the operator should ensure that there can be no unplanned escape of fluids from the well. Seismic monitoring should be used to assess any potential impact on well integrity, in line with UKOOG guidelines. CIWEM considers the HSE must undertake an active role in visiting sites for verification inspections of monitoring operations and take enforcement action where it is found to be inadequate.

Contamination of aquifers from mobilisation of solutes and methane is unlikely where shale plays exist at depth in the UK. The BGS believes such contamination is unlikely to occur if shale gas exploitation is restricted to depths greater than 1500m[5]. Where the source rocks are shallower there could be a greater risk and companies will have to ensure that fracture

[5] Stuart, M.E. 2012. Potential groundwater impact from exploitation of shale gas in the UK. BGS

sequences are monitored using performance standards. Fracturing operations should be examined as part of the well examination arrangements.

One way to protect groundwater is to ensure that shale gas operations do not take place in the nearby area. The EA's groundwater guidance[xxiv], states that it will object to shale gas extraction infrastructure or activity within Source Protection Zone 1[6] (SPZ1) through planning or permitting controls. Outside of SPZ1, the EA will also object where the activity would have an unacceptable effect on groundwater, or if it is close to sensitive receptors it will adopt the precautionary principle. Groundwater including any local aquifers should be carefully delineated by the operator as part of the well design and fracturing risk assessment process. CIWEM believes that if shale gas is to be developed safely, ensuring due regard for protection of the wider environment, exploration should not be permitted in areas where there is a genuine risk to valuable drinking water resources located in groundwater and is supportive of the Environment Agency's precautionary approach.

Accurate baseline environmental monitoring is essential to assess the impact of shale gas extraction on the environment and any implications for public health and should obtained for potentially affected ground and surface waters and receptors. Following the production of a baseline, the long-term monitoring of relative conditions will be required. This should be carried out throughout the lifetime of development, production and post-production.

Waste and wastewater treatment

The industry must follow UKOOG guidance to ensure returned waters are appropriately contained, managed, and treated prior to eventual disposal. Best practice for fluid storage (above ground tanks that meet industry standards) is needed to ensure no risk of fluid leaks or spillages.

The returned waters from the hydraulic fracturing process require treatment as they may be highly saline and include naturally occurring radioactive materials. This presents further financial and regulatory risk to meet compliance with the UK's robust water regulation regime. The nature of the substances concerned mean that the water may not be of an appropriate chemical composition to be sent to a typical public wastewater treatment works and may require specialist industrial treatment or pre-treatment in order to enable this.

At the exploration stage there seems to be enough capacity to treat returned waters as public treatment works are able to cope with a range of contaminants and there are a number of industrial wastewater treatment works in the UK. However returned waters are likely to be highly saline and to be able to treat by dilution a public treatment plant that serves a population of 50,000[xxv] or one that discharges to an estuary may be needed. There are other technologies available but these entail greater energy consumption and cost. It is certain that if the industry grows, and wastewater volumes increase, water treatment capacity will need to

6 SPZs are used to identify areas close to drinking water sources where the risk associated with contamination is greatest. SPZ1 is the inner source protection zone defined by 50-day travel time of groundwater from the borehole and a minimum 50 metre radius. SPZ2 is the outer protection zone defined by a 400-day travel time from a point below the water table. SPZ3 is the source catchment protection zone defined as the area around a source within which all groundwater recharge is presumed to be discharged at the abstraction source.

expand to support it. There also needs to be further consideration given to disposal of the solid residues from some treatment options.

Reuse of flow back and produced water arguably represents the most sustainable process and the regulatory systems should aim to encourage this. The development of onsite treatment processes will also reduce the risks associated with transporting waste.

Earthquakes – induced seismicity

Earthquakes caused by hydraulic fracturing are usually too small to be noticed above the ground. The magnitude 2.4 earthquake felt in Blackpool in 2011 was a result of a perturbation of pre-existing stress at Cuadrilla's Preese Hall site. A DECC commissioned review[xxvi] of the incident concluded that further small earthquakes cannot be ruled out, however the risk from these earthquakes is low, and structural damage is extremely unlikely.

The UK experiences a magnitude 4 earthquake or greater every 3-4 years and a magnitude 5 earthquake roughly every 20 years[xxvii]. Hydraulic fracturing of granite for hydrothermal purposes can cause much larger earthquakes due to the tensile strength of the rock. Shale by contrast is inherently weak and fractures at much lower pressures, storing less energy and therefore smaller earthquakes result.

If hydraulic fracturing operations are managed properly the risk of accidents should be small[xxviii]. A prior review of information on seismic risks and the existence of faults is required and seismic monitoring will have to be carried before, during and after the fracturing process. DECC will provide consent to drill after scrutinising fracture plans and once any controls to mitigate seismic risks are put in place. Operators will also have to implement a traffic light system, so if there is any unusual seismic activity, operations would have to stop.

Air pollution and human health

During the drilling and operation of shale gas wells air emissions can come directly from the well, as well as from the large number of on-site diesel powered engines on site[xxix]. These emissions combined with other natural (biogenic) and anthropogenic emissions in the region can together form ozone, other photochemical oxidants, and particles in the atmosphere. High concentrations of ozone and other oxidants in the atmosphere near the ground are of concern because of the adverse effects on human health and damage to vegetation, while particles impact on human health.

Public Health England has produced a draft review[xxx] of the potential public health impacts of exposures to chemical and radioactive pollutants as a result of the shale gas extraction and concludes the risks to public health are low if operations are properly run and regulated.

There are few studies on the quantities of volatile organic compounds (VOCs) produced from hydraulic fracturing which have the ability to create photochemical smog under certain conditions. Also, if these are later flared then this will increase the emission of oxides of nitrogen. Further research is needed here.

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Note: CIWEM Policy Position Statements (PPS) represents the Institution's views on issues at a particular point in time. It is accepted that situations change as research provides new evidence. It should be understood, therefore, that CIWEM PPS's are under constant review, that previously held views may alter and lead to revised PPS's. PPSs are produced as a consensus report and do not represent the view of individual members of CIWEM.

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