Task Force on Shale Gas

Second Interim Report

Assessing the Impact of Shale Gas on the Local Environment and Health

Letter from The Panel

Thank you for your continued interest in the Task Force on Shale Gas as we consider some of the key issues surrounding the creation of a shale gas industry in the United Kingdom (UK). This is our second interim report, of a planned four, and it looks specifically at local environmental and health concerns that have been associated with shale gas.

We would like to thank our esteemed advisors, whose counsel and guidance continues to be invaluable.

We were pleased to see that there was widespread interest in the publication of our first interim report on Planning, Regulation and Local Engagement. Of course not everyone agreed with all of our recommendations (though many did) – but we felt that we created an opportunity for sensible, reasoned discussion around an issue which has too often been dominated by the loudest voices at either end of the spectrum. It is our hope that this second report continues that conversation.

Everyone has a right to make their own personal decision on the issue of shale gas on the basis of trusted and factual information. As we said in the first report, it is the guiding principle of the Task Force to provide that information.

Producing a report at all would not be possible without the insights of many people in business, academia, local communities, and associations who have given up their time to meet with the Task Force. We very much hope that they recognise the immense contribution that they have made to the Task Force's work.

Finally, we have been clear since taking the helm of this important piece of work that the Task Force will be open and transparent. Around our funding, the people and organisations that we meet, the information and academic literature that we have reviewed and consulted and the timetable that we are working to. Alongside this report, we are simultaneously publishing the detailed analysis of all the academic studies and literature that provides the background to the conclusions we reach here.

All of this information, as well as our first interim report, is available on our website – www.taskforceonshalegas.uk – along with relevant contact details. The Task Force remains keen to hear from anyone who can assist our work.

Lord Chris Smith	Emma Duncan	Professor Ernest Rutter	Professor Nigel Brandon
Chair	Panel Member	Panel Member	Panel Member

Acknowledgements

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Introduction

The Task Force on Shale Gas was launched in September 2014 to provide an impartial, transparent and evidence-based assessment of the potential benefits and risks of shale gas extraction to the UK.

The Task Force's funding comes from businesses involved in the shale gas industry. However the Task Force operates independently of its funders and the funders have no influence over its research, recommendations or publications.

The Task Force recognises that shale gas extraction and its potential benefits and risks to the UK have become a polarising topic in the UK. As such, it is difficult to find a platform for reasoned debate about the issue.

The mission of the Task Force is to create that platform, to provide informed and evidence-based conclusions and recommendations to both industry and Government about the potential of shale gas extraction in the UK, to inform the general public and to promote reasonable discussion about these findings.

To make this possible we decided to deal in detail with clusters of issues over a series of reports, enabling us to publish our conclusions at the earliest possible time.

Our first interim report, published in March, examined the existing planning and regulatory system for shale gas and the need for good public consultation. We made a series of recommendations that we believe would address reasonable concerns raised by the public around potential shale gas extraction.

The first report also contains what is hopefully a useful guide to the current political context around shale gas in the UK and an introductory guide to what shale gas exploration and extraction in the UK would consist of and how this would differ from much publicised shale gas operations in the United States of America (USA). The report is available in full on our website.

This second interim report deals with local environmental impacts. This includes topics such as health impacts, fugitive emissions, earthquakes and water supply and disposal.

Our third report, to be published in September, will examine and assess evidence related to the impacts on climate change.

Our fourth interim report will examine the economics of a shale gas industry in the UK – including community benefits and compensation.

Finally, in the spring of next year we will publish our cumulative report, taking into consideration all of the evidence we have assessed as well as the feedback that we receive from our interim reports.

The conclusions drawn by the Task Force in each report, and the resulting recommendations, reflect the views of the Panel only. They do not necessarily reflect the views of any of the organisations we have met or advisors we have consulted. The Panel has developed its views through its reviews of academic material, discussions with expert advisors, meetings with interested parties and site visits.

Local environment - Our starting point

The first interim report of the Task Force demonstrated that communities living close to potential sites of shale gas exploration and extraction are divided in their support for or opposition to the industry.

Most often those opposed to shale gas point to concerns about the impacts that shale gas extraction might have on the local environment and on the health of the local community, as well as wider environmental impacts like climate change. Those in favour tend to make their argument in terms of economics and opportunity – the employment, skills and industry that will grow up around shale gas – the enhancement of national energy security, as well as direct compensation to the local community.

As mentioned the Task Force will, in its third interim report, examine implications for climate change. In its fourth interim report it will examine the local and national economics of a potential shale gas industry in the UK. This report therefore will specifically examine the claims made around how shale gas exploration and extraction could affect the environment and the communities in which it takes place.

This report considers hydraulic fracturing (fracking) but also recognises that the complete process of shale gas exploration and extraction involves much more than fracking.

Broadly speaking, public concerns around living in the midst of a shale gas industry can be grouped into three 'clusters', each of which will be examined in detail. These are geological concerns, environmental concerns and health concerns.

Put simply, we believe that local communities living near to potential shale gas operations are asking, in addition to traditional planning objections such as noise and traffic, the following broad questions:

- Will fracking cause earthquakes?
- Will shale gas operations contaminate drinking water or release unpleasant and dangerous chemicals and gasses into the air I breathe?
- Will living near a shale gas operation make me or my family sick?

This report will explore each of these questions in detail, drawing conclusions and making recommendations where possible and when appropriate.

Hazard, risk & mitigation

In order to answer these questions effectively it is useful to define three concepts that have informed our approach.

a) Hazard. When we discuss or mention hazards we are referring to a potential source of harm either to the local environment or infrastructure, or to public health as a result of shale gas operations.

b) Risk. When we consider risk we are examining the likelihood (or probability) that the environment or people will suffer as a result of the hazard.

c) Mitigation. In the context of this report we will talk about mitigation in the sense of what can be done to lower or remove the risk associated with a particular hazard.

These definitions are important to consider because there are hazards in almost all walks of life. Being hit by a bus is a hazard associated with crossing a road. This does not necessarily mean that we do not cross roads. Why? Because the risk associated is believed to be acceptably low or can be made to be so. We can mitigate against this risk (reduce the hazard) by installing traffic lights or zebra crossings, and by educating people about how to cross the road safely.

The desirable end result is that, as a society, we accept that we have mitigated the risk associated with crossing the road to an acceptable level and we continue to cross the road.

To answer the questions that we believe the public want answered, therefore, we will identify relevant hazards, examine the risk arising from those hazards and then explore whether or not it is possible to mitigate against that risk to bring it down to an acceptable level in those cases where it is perceived initially to be unacceptable.

Earthquakes

The Task Force's first interim report outlined the much-publicised events that occurred near Blackpool in 2011. Cuadrilla Resources were testing wells at Preese Hall in the area when a series of small tremors, two of which were of magnitude (M) 2.3 and 1.5 on the Richter scale[1] and were felt at the surface, arose following hydraulic fracturing operations at one of these wells, Preese Hall. This led to a temporary suspension of all shale gas operations in the UK while an independent investigation was carried out.

This event, bolstered by numerous reports from the USA, has clearly entered the public consciousness and needs to be examined.

Seismic activity in the UK

Earthquakes are caused when one block of rock moves suddenly (over a few seconds) relative to another driven by natural (tectonic) forces. The boundary between the two blocks across a fault surface is called a fault (a natural discontinuity in the rock). The sudden movement of rock masses causes the radiation of seismic waves or vibrations that can be felt by people when they arrive at the Earth's surface.

The energy released by earthquakes is measured using a magnitude scale, often referred to as the Richter Scale. The Richter Scale is an open-ended scale in which each whole number increase in magnitude corresponds to a release of energy approximately 31 times greater than the preceding whole number value. It is not to be confused with the intensity scale, which is a qualitative measure of how the tremor is felt at the surface.

The amount of energy released increases according to the area of the fault over which slip occurs and the amount of displacement produced. For example a small earthquake might result from 1cm of slip on a fault plane about 100m across. By comparison, the great Indonesian earthquake of Boxing Day 2004 (M9) involved up to 20m of slip on a fault plane that extended 1200km, the length of the UK.

Seismic activity in the UK is low relative to many other countries[2]. Earthquakes measuring M4, for example, take place somewhere in the UK approximately every three to four years. Events of M5 take place around once every 20 years[3]. So larger earthquakes are less frequent. There can be many thousands of M2 tremors in the same time period that one M5 tremor occurs. The magnitude to frequency relationship is well-established for the UK and elsewhere as a result of statistical analysis of large numbers of measurements over a long period.

The British Geological Survey (BGS), which operates and maintains a network of approximately 100 seismic monitoring stations throughout the UK, says that the majority of detected seismic activity in the UK is around M1.5, which is at the lowest magnitude routinely picked up by the current BGS regional network. Such tremors are unlikely to be felt by people at the Earth's surface.

The majority of natural earthquakes occur at around 10km depth. Most people would not notice an M3 tremor or smaller originating at that depth beneath their feet. Depending on local circumstances, anything smaller than M5 would not cause significant damage to local built infrastructure in Britain, although people would probably feel disconcerted by the shaking sensation, which would be unlikely to last more than 5 or 6 seconds. An earthquake in Lincolnshire in 2008, which did cause structural damage to some people's homes, measured M5.2.

Hydraulic fracturing operations, disposal of waste fluids by deep injection, or exploitation of geothermal energy (often involving fluid injection) typically take place at around depths less than 3km underground. Deep mining operations, for example for coal, can take place to a depth of around 2km. Most people would not feel a tremor less than about M2.5 originating from this depth range, and the probability of discernible infrastructure damage is extremely small for events of this magnitude.

> "Seismic activity in the UK is low relative to many other countries. Earthquakes measuring M4, for example, take place somewhere in the UK approximately every three to four years."

Seismic activity in the UK caused by industrial activity

The BGS has identified multiple instances of seismic activity being caused by industrial activities in the UK. Coal mining causes tremors because large volumes of rock are removed from depth in the mining process. This material is often seen as spoil heaps on the surface. The roof of the mined-out area is allowed to collapse as extraction proceeds, leading inevitably to tremors and ground subsidence.

Perhaps the best documented examples are those associated with coal mining in Nottinghamshire. Between mid-December 2013 and April 2014, 93 earthquakes with a maximum magnitude of 1.8 were detected around the area of New Ollerton. The area has a history of seismic activity associated with local coal mining operations. Recent local seismic events are considered to be related to this[4]. Historically, earthquakes associated with coal mining in the UK have not exceeded M3.[5]

Other industrial activities also cause earthquakes, when the activity involves injection of pressurised fluids deep underground. If the fluids penetrate suitably-oriented cracks and faults they act like a hydraulic jack, prising the pre-existing fault surfaces apart slightly, thereby reducing the clamping force (friction) and allowing pre-existing geological forces to cause them to slide by a few centimetres. The slip event causes the shaking that is perceived as an earthquake.

The process of extracting geothermal energy by injecting cold water into the bedrock which is then heated by rocks at depth and extracted is known to have caused earthquakes larger than those caused by coal mining, depending on the type of rock being drilled[6]. In the UK, for example, geothermal energy exploration took place at Rosemanowes Quarry near Penryn in Cornwall between 1978 and 1991. Seismicity in this area was historically low, yet a number of local earthquakes were induced as a result of the fluid injection activities. The largest tremor was M3.5 in 1981, part of a cluster of earthquakes that occurred six kilometres south of the site, near the town of Constantine[7].

There have been no documented instances of induced seismicity onshore in the UK associated with disposal of waste fluids by deep injection into underground formations, or from extensive use of water injection which forms a normal part of safe petroleum production, but there have been many such instances documented elsewhere. An example is the Rocky Mountain Arsenal in the USA where fluid injection activity caused earthquakes in Denver in the mid 1960s.

> "Historically, earthquakes associated with coal mining in the UK have not exceeded M3."

Seismic activity and fracking

Certain industrial activities, then, are known to cause minor earthquakes. But what is the risk to communities of shale gas operations? What is the propensity for shale gas exploitation to cause earth tremors and how does this compare with other industrial activities?

Generally, an industry is accepted as having caused an earthquake if a number of criteria are satisfied (simplified form[8]):

- The seismic events are the first to be recorded in the area
- There is a time correlation between injection of fluid into the rock and the seismic activity
- The epicentres (place on the ground above the earthquake focus) are within 5km of the operation site
- The earthquakes' focal depths are at or around the depth of injection or activity
- If tremors do not occur around the depth of injection, there are geological structures that may allow flow of fluid to the point where the earthquake originated
- The changes in fluid pressure at the base of the well resulting from fluid injection are sufficient to initiate earthquakes

The tremors felt at Preese Hall, mentioned above, for example, are considered to have met these criteria.

Activities involving drilling cannot cause the types of earth tremors associated with mining. Drilling involves the removal of only a tiny volume of rock, not enough to cause any seismicity even if the borehole were to collapse. The strength of nearly all rocks is sufficient to preclude this. Only activities involving fluid injection have the potential to cause seismicity.

As set out in the first interim report of the Task Force, a high-volume fracking operation, as used for the exploitation of shale gas, involves the rapid injection of large amounts of fluid into the earth via a borehole. Two types of induced tremor can be associated with this process[9].

First, small, micro-events are associated with the formation and propagation of new cracks. The detection and location of these tiny events is used to map the progress of a hydraulic fracturing operation. They are far too small to be felt at the Earth's surface.

Second, if fluid is injected into larger, pre-existing fault planes, and if they are suitably oriented with respect to the natural stress field, the clamping force across the fault may be reduced sufficiently to allow pre-existing natural forces to cause movement. The maximum size of such an Earth tremor scales with the amount of fluid injected, so it tends to be self-limiting.

Fracking is thought to have the potential to cause earthquakes up to M3. There is no evidence that earthquakes caused by such activities have ever been large enough to cause structural damage to buildings, neither are there any recorded instances of induced subsidence[10]. The vibration associated with an earthquake measuring M3 and originating at a focal depth of 3km would be experienced on the surface as comparable to a heavy truck driving by.

> "… an earthquake measuring M3… would be experienced on the surface as comparable to a heavy truck driving by."

Seismic activity and waste water disposal

In the USA, where a shale gas industry has emerged, a second process in addition to fracking has been associated with earthquakes. This is to do with the disposal of waste water. Disposal wells are used in several industries but have become particularly associated with shale as a result of recent media coverage.

> "... fracking results in large volumes of waste water (flowback and production) that must be safely disposed."

In a recent US report the Environmental Protection Agency (EPA) concluded that three components are necessary for significant injection-induced seismicity: (1) sufficient pressure build-up from disposal activities, (2) faults of concern and (3) a pathway allowing the increased pressure to communicate with the fault. It noted that no single recommendation addresses all of the complexities related to injection-induced seismicity, which is dependent on a combination of site geology, geophysical and reservoir characteristics.

Later in this report we will consider in more detail the water usage required to operate a shale gas site. For now it is enough to say that fracking results in large volumes of waste water (flowback and production) that must be safely disposed. It may be injected deep into geological formations. Earthquakes measuring up to M5 have been linked to this process.

Waste water injection therefore seems likelier than fracking to cause larger earthquakes. Current guidance from the Department of Energy & Climate Change (DECC) makes no mention of whether this type of waste water disposal would be permitted in the UK[11]. DECC states that the methods employed for water re-use and eventual disposal can be:

- On-site treatment with re-use of water and disposal of remaining liquids and solids to a suitable licensed waste treatment and disposal facility
- Removal off-site to a suitable licensed waste treatment and disposal facility
- Disposal to a special sewer with the permission of the relevant waste water utility company

However it is the Environment Agency which would issue the relevant permit for waste water disposal. It is understood that the agency will not grant a permit for the disposal of waste water by deep injection under its interpretation of the European Union's Water Framework Directive[12].

Operators are tasked with identifying the most appropriate method for water disposal for a particular site.

Seismic activity monitoring

Currently regulations outlined by DECC[13] set out the traffic light monitoring system which would be used if a shale gas operation is licensed in the UK. This was based on the report on the review of seismicity following the Preese Hall borehole hydraulic fracturing experiment[14].

The monitoring system is designed to be extremely cautious and to ensure that operations stop for further investigation if a tremor measuring M0.5 or higher is detected that satisfies the criteria given below (Fig. 1).

This proposed limit is much more conservative than the M1.7 cut-off limit recommended by de Pater and Baisch in their report following induced seismicity at Preese Hall[15].

The monitoring will be carried out by the operator, who is required to submit their results to DECC promptly and to publish up-to-date information on its website.

DECC say that they will keep these rules, including the trigger level, under review as more data becomes available.

GREEN	Less than magnitude 0 on the Richter scale	Injection proceeds as planned.
AMBER	Magnitude 0 to 0.5	Injection proceeds with caution, possibly at reduced rates. Monitoring is intensified.
RED	Magnitude 0.5 or higher	Injection is suspended immediately.

Fig.1 Traffic light monitoring system, DECC, February 2014

Recommendations

The existing academic literature, coupled with the experience elsewhere, particularly in the USA, suggests clearly that shale gas operations have the potential to cause tremors albeit not at a level higher than that expected and considered acceptable across other comparable industries in the UK, nor at a frequency or magnitude significantly higher than natural UK earthquakes.

Nevertheless, local communities are understandably concerned about the possibility of seismic activity. There are a number of measures that we believe can help allay such concerns.

An effective monitoring and detection system must be installed. We believe that this will involve a number of processes:

First, operators must demonstrate in their applications for shale exploration that they have taken every reasonable precaution to select a site where their operations are least likely to induce tremors or earthquakes. We recommend baseline monitoring should be carried out from the earliest practicable point possible, following identification of the site. The Task Force also recommends the use of 3-D seismicity modelling.

Second, the Task Force believes that the principles behind the traffic light system introduced by DECC are sound and should be followed. However our review of the scientific literature suggests that suspending injection at a level of M0.5 may be unfeasibly low. Tremors of M0.5 are relatively common and do not represent a significant hazard to a local community. We believe that in due course this level be might be raised to M1.5. We applaud DECC's commitment to keep the level under review.

Third, we believe that operators have an obligation to the communities in which they operate to choose processes that minimise the risk associated with hazards of particular concern to the public. The disposal of wastewater by deep injection is clearly one process that concerns the public. We recommend that a careful analysis should be made of the geological conditions, together with the amount of water and speed at which the water is pumped, relating to any particular site before a decision is taken to dispose of wastewater by deep injection. The Environment Agency's recent interpretation of the Water Framework Directive[16] as meaning that permits would not be granted for the disposal of wastewater by deep injection takes this cautious approach further, and would of course ensure that no deep injection could take place in England at present.

Notwithstanding the above, the Task Force believes that there may be situations and circumstances – where the geology is suitable – where deep injection is a sensible, cost effective and popular preferred means of waste disposal. This should be decided not by operators, but by the regulatory process led by the Environment Agency – with the aim of setting clear guidelines for operators.

> "... baseline monitoring for seismicity should be carried out from the earliest practicable point possible..."

Contamination of water and air

The second broad area of public concern is the hazard and risk associated with contamination. The process of fracking has been associated with contamination particularly of water and air.

The Task Force has reviewed the available evidence on this and has met and spoken with a large number of experts about the hazards and the risks associated with each hazard.

To study contamination in this way we can follow a simple process:

What is the 'contaminant' and what is the hazard associated with it?

Is the contaminant being used or produced in sufficient quantity or volume potentially to create a significant risk?

Is there a 'pathway' through which the contaminant can come into contact with water or air in sufficient quantity to create a significant risk?

Can all of the above be mitigated to the extent that the risks associated with the contaminant are acceptable?

Water

The process of drilling and fracking consumes significant volumes of water, although as we shall outline, not more than some other industries. For onshore operations some distance from the sea this water must be sourced by the operator either from a local utility company or directly from the local ground or surface water sources.

Before supplying the water, the utility company must be satisfied that its customers' supply will not be adversely impacted[17]. Use of local surface or groundwater will require a permit from the appropriate environmental agency, and will depend on the water supply being available in terms of ensuring other legitimate users and the environment are not adversely affected. Typically, operations will not require a constant supply of water at the same rate, but rather will require large amounts of water at particular times, for example during drilling and fracking[18].

Whilst fracking requires a lot of water, it is not as water-intensive as some other industries[19]. A well needs between 10,000 and 30,000m3 (10,000 to 30,000 tonnes or two to six million gallons) of water over its lifetime[20]. For comparison, this is the same amount of water required to run a coal-fired power station for 12 hours, or to water a golf course for one month - or the amount lost each hour by a large utility company through leakage[21].

During the drilling stage a water-based fluid known as "drilling mud" is permanently circulated through the borehole. This fluid is used to lubricate and cool the drill bit and to loosen and collect fragments of rock caused by the drilling – "cuttings"[22]. The drilling mud brings these cuttings to the surface, allowing the drill bit to function properly and not to become clogged up.

The density of the drilling mud, controlled by adding minerals such as barium sulphate (barite), relative to water in the reservoirs creates a downhole pressure that stabilises the wall rock and ensures that no fluids from the surrounding rock formation reservoir flow into the borehole.

The water used in fracking itself (or fracking fluid) is not drinking water although it is initially most often drawn from the same water supply. For more information on water used for fracking please consider the Task Force's first interim report. We reiterate our recommendation, from that report, that water should wherever possible be piped into a well site, rather than being trucked in with all the associated lorry movements. Shale gas companies should work closely with water companies to ensure demand for water is adapted accordingly during times of potential water stress, such as drought. Neither is fracking fluid the only use of water associated with wider shale gas operations, of which fracking itself is just one part.

> "The water used in fracking itself (or fracking fluid) is not drinking water..."

Potential contaminants in water

The fluid used for fracking is typically 94% water (by volume). About 5% is fine sand or other material used as a proppant. When the sand is injected into the hydraulically-induced fractures it stops them from closing when the hydraulic pressure is reduced. That is, it props open the fracture so that gas can flow.

Chemicals are added to the water for various purposes, for example to reduce friction when creating fractures, to increase viscosity to suspend the proppant and to kill bacteria. The exact composition of these fluids will vary greatly from site to site, determined by the depth of the operation, the length of the well and the geology of the area. As a guideline, however, a report by the Tyndall Centre for Climate Change put the chemical content of the fluid at two weight per cent[23]. This translates to 180 – 580m3 of chemicals injected into a well over its lifetime. However this is significantly higher than the estimate proposed by the Royal Society of 0.17%[24]. The most current US Environmental Protection Agency (EPA) report reviewed actual fracturing jobs and estimated that the additives in 2011 and 2012 totalled 0.43% of the total amount of fluid injected[25].

The chemicals in the fluid must be assessed for their acceptability for use by the appropriate environmental regulator. The details of the chemicals, together with their reason for use and associated hazards, must be fully disclosed to the agency. In the past some companies have not wanted to disclose publicly the chemicals used because of commercial sensitivities of the chemical recipes that are used in their product range. However full chemical disclosure, available to the public, is fast becoming the norm worldwide. The 2013 Agreement entered into by all major companies involved in the UK commits to the principle of disclosure. We recommend however that full chemical disclosure should be a requirement for all UK hydraulic fracturing operations.

Other additives can be used to modify the friction of the fluid against the wellbore, and biocides to inhibit the growth of anaerobic bacteria that feed on the organic components of the wellbore fluids and the hydrocarbons in the rock itself.

A significant proportion of the fracking fluid returns to the surface as flowback water once fracking has taken place. After treatment, it can be re-used for subsequent fracking operations before being disposed of. Approximately 10 to 30% of the fluid introduced into a well will return to the surface as a result of depressurisation following the hydraulic fracturing. The remainder is lost into the rock formation. It is, however, difficult to predict the flowback proportion and it can vary greatly from site to site and can be significantly higher, due to the nature of the rock and the operational conditions[26].

The composition of flowback fluid is modified by contact with the rocks underground. It may contain varying quantities of[27]:

- Chemicals used in the initial fracking fluid
- Gas and volatile organic compounds (VOCs) from the shale
- Shale minerals and heavy metal ions in solution
- Naturally occurring radioactive material (NORM)

Volatile organic compounds (VOCs) are naturally occurring organic compounds that have a high vapour pressure and therefore a low boiling point. Their low boiling point provides a pathway for releasing these chemicals into the atmosphere, where they may become a health hazard. For instance some flowback water has been shown to contain small amounts of carcinogenic Poly-Aromatic Hydrocarbons (PAHs) and benzene.

In terms of risk, the issue here is the extent to which the hazards (for instance PAHs) are released into the environment, the routes by which people and wildlife can be exposed, their atmospheric concentration and toxicity at the point of exposure and whether the resultant risk arising from such exposure is significant. VOCs, it should be said, are found in many everyday products including paints, disinfectants and glues. Later in this report we will look specifically at how the risks arising from VOCs are dealt with and can be reduced by using a process of "green completion".

All rocks comprise minerals and some contain naturally occurring radioactive materials, or NORM. Shale rocks often contain relatively high proportions of these and these may be dissolved by fluids that come into contact with them. An independent research consortium, ReFINE, studied the level of NORM in flowback fluid[28]. They concluded that while the level of some NORM, specifically potassium and radium, was higher than that normally present in shallow groundwater it was below the level of permitted UK exposure limits. The level of radioactivity associated with shale gas production is much lower than that associated with coal power. Their study concluded that, in terms of NORM content, flowback fluid was unlikely to pose a threat to human health if managed properly[29]. Studies have found, for example, that everyday items such as bottled spring water routinely purchased at supermarkets also contain NORM[30].

Pathways to contamination

In the view of the Task Force, there are four pathways by which water could potentially become contaminated through the fracking process and wider shale operations. These are:

- A failure in well integrity during operations
- Leakage following well abandonment (i.e. after a well has finished being used)
- Accidental surface water spillage or leakage
- Failures in wastewater management and disposal

A concern that hydraulic fracturing could allow upwards migration of fluids and gas through the rocks resulting in the potential for groundwater contamination has also been raised.

Recent studies in the US have shown that there is an extremely low likelihood of contamination of aquifers where the separation distances are greater than 1000m[31]. However, we recognise that the risk of aquifer contamination will increase as the separation distance between the frack zone and the aquifer decreases below 1000m. We therefore recommend that a risk assessment of aquifer contamination is carried out where appropriate, with the level of detail increasing as the separation distance decreases. The Task Force further recommends that operators are required to monitor the size of fractures in UK wells so that over time a more complete statistical picture is built up, to assist the ongoing assessment of aquifer contamination.

> "The Task Force further recommends that operators are required to monitor the size of fractures in UK wells..."

Well integrity

A completed well contains a number of barriers designed to isolate the production pathway from the surrounding rocks. The barriers comprise casing, cement, valves and seals[32]. In the UK a well must have at least three layers of concentric steel tubing, called casing. These comprise an outer conductor or surface casing, an intermediate casing that extends below depths where shallow groundwater may be encountered and an inner production casing which runs into the geological formation of interest[33].

Wells often contain more layers of casing than the minimum required. The concentric layers of steel pipe are sealed by injecting cement slurry which hardens along the annuli between the steel pipes, and between the outer steel pipe and the surrounding rocks. Well designs are reviewed and approved by the Health and Safety Executive (HSE) and the Environment Agency (EA).

Well integrity failure involves the failure of one or more barriers, resulting in the formation of a pathway that allows liquids or gases to leak from the well into the surrounding environment[34] or along the outer wall of the well casing. It is worth noting that a single barrier failure will not necessarily lead to an overall failure of well integrity, as a complete pathway to the surrounding environment may not be formed. Well integrity may be evaluated by means of pressure tests or by ultrasonic logging.

Three of the more common results of well integrity failure are:

- blowout caused by the uncontrolled escape of fluid from the well
- leaks where the fluids can move upwards along the outer well casing or within the layers of the well casing and radial leaks, and
- leaks where the well casing itself fails by splitting, through corrosion or at a joint, and the fluid within leaks into the surrounding rocks[35]

As there has been only very limited drilling for shale gas in the UK there is limited evidence of well integrity issues although a study of well deformation was made following the earthquakes associated with the Preese Hall Shale gas exploration well[36]. Failure with onshore shale gas wells in the UK is non-existent because of the limited drilling that has taken place. Therefore it is worth studying conventional, hydrocarbon wells, which are identical or similar in design.

Between 2000 and 2013, the EA recorded nine incidents of pollution within one mile of a well, associated with the release of crude oil[37]. Of these nine incidents, two were associated with well integrity problems, both of which took place at the Singleton Oil Field. The failure was detected by groundwater monitoring. A failure adequately to cement the conductor and intermediate casings led to a leak. No air or land contamination was subsequently detected and only minor water contamination was found[38]. Continued monitoring has since taken place at the site and current levels of contamination are within the acceptable range set out by the EA[39].

Estimates from the Marcellus Shale in Pennsylvania suggest that barrier integrity failure took place in 3.4% of wells (219 of 6466) between 2008 and 2013[40]. Of the 4602 wells drilled between 2010 and 2012, 7% (320) displayed a loss of integrity[41]. The cause of failure was deemed to be a combination of poorly installed, insufficient and defective cement, or casing failure. The fact that well integrity did not improve over time suggested that US operators were not adhering to best operating practices, or that regulations were not being adequately enforced[42].

Clearly it would be unacceptable for a similar situation to occur in the UK. If the increased risk of well integrity failure is significantly the result of error or a failure to follow best operational practice then a framework of regulation and enforcement must be established to ensure this cannot happen in the UK.

It is worth noting that, in the Task Force's opinion, current regulations in the UK do serve this purpose and on the whole are more rigorous and robust than those in operation in the US.

It is also worth noting 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. The prohibition on fracking in "protected groundwater source areas" contained in the Infrastructure Act should also mitigate the risk of pollution of drinking water supplies.

Well abandonment

> "Well abandonment is the term used to describe the stage of operation after all gas production activities have ceased..."

It is likely that the industry regrets the term 'well abandonment' entering the popular lexicon, with its connotations of workers downing tools and leaving. Needless to say this is not the case, but many of the concerns raised over well integrity do apply equally, if not more, to wells once operations have ceased. Well abandonment is the term used to describe the stage of operation after all gas production activities have ceased. Well integrity issues will continue to apply and as time goes on, the public must be reassured that the risk to the environment does not increase, as cement can undergo degradation, with cracking and leaching occurring. The casing might also crack and corrode particularly at the connections between sections of casing[43]. Any degradation of the cement would result in increased permeability, thereby introducing a potential pathway for fluid flow[44].

Once operations at the site have ceased it is the responsibility of the operator to ensure that the site is restored to a state similar to that before drilling[45]. In order for the well to be suitably abandoned it must be securely sealed so that there can be no leakage from within the well bore. In order to seal the well, cement is pumped into the production casing and a steel cap is fitted to the top of the well[46].

Currently in the UK there is little monitoring of abandoned wells[47]. Nor is it clear who is responsible for a well once a licence has been relinquished and passed back to the Government.

Minister of Energy and Climate Change, Andrea Leadsom, recently stated, however:

"The duration of monitoring required after decommissioning/well closure will be assessed on a site-by-site basis by the Environment Agency. The environmental permit requires the operator to have in place a closure and rehabilitation plan, which must be agreed with the Environment Agency before decommissioning begins. The operator will not be allowed to surrender their permit until the Environment Agency is satisfied that there is no-ongoing risk to the environment[48]."

It has been proposed[49] that wells should be inspected two to three months after the concrete plugs have been inserted into the well. Further inspections would then focus on soil monitoring and groundwater monitoring at a suitable recommended interval.

The Task Force believes these recommendations to be sensible, adding that inspections should also occur if there is any a reason to believe that well integrity might be compromised.

We also recommend that the Government should clarify where responsibility for the continued monitoring and documentation of sealed-off sites should lie. We believe that the Coal Authority, who have the much more difficult task of overseeing abandoned coal mines, could take on this additional responsibility.

Surface water storage or leakage

Another pathway by which contaminated water could potentially come into contact with the environment, humans or groundwater comes from accidental spillages or leakages at the surface. Again it is worth noting that surface water spillages – either in the storage, transport or disposal of waste water – are not inherently linked to the process of fracking itself. The hazard of water contamination through accidental spillage is common to many industrial processes. It is again a case of ensuring operational best practice is put into place.

In the US flowback water can be stored in open pits. DECC points out that in some cases these pits have overflowed and caused surface water contamination, or the impermeable lining has become ruptured. Open pits are not allowed in the UK. Rather, DECC requires operators to[50]:

- Make appropriate plans for storing fluid safely, and not in open pits
- Design the site so spills are avoided (and are contained if they do happen)
- Transport and dispose of flowback fluid safely

The fluid itself is defined by DECC as mining waste and so must be disposed of in accordance with the mining regulations put in place by the EA. In addition, a plan for waste management, based on laboratory tests, must be in place before drilling begins. During the operation of the site the relevant authorities must be informed before any movement of waste takes place[51].

> "It is again a case of ensuring operational best practice is put into place."

Wastewater management and disposal

Earlier in this report we described the method for disposing of wastewater by deep injection. While this is a preferred method of disposal in many areas of the USA, the link – outlined above – that has been demonstrated in some places with induced earthquakes means that the public is unlikely to support its use in the UK in populated areas. We believe that in the UK it would be preferable – and essential where the geology might require it – to examine other methods of wastewater disposal[52].

Water reuse

Particularly in the early stages of any shale operation, it is likely that large amounts of flowback water can be collected and reused in the operation. This is attractive as it means that less water is required from elsewhere (although it is still likely that the volumes of flowback will still need to be 'topped up' with other water sources as outlined above).

Flowback water will need to be treated so that it can be reused without affecting the productivity of the well. The level of the treatment required will depend on the 'quality' of the water, which will depend very much on local conditions. In particular, operators will be concerned about the concentration of Total Dissolved Solids (TDS) and the levels of Total Suspended Solids (TSS).

TDS increase the salinity of the water and impact upon the effectiveness of the friction reducers in the water. With each reuse without treatment for TDS the water will become more saline and so less effective. Diluting the flowback water with fresh water can overcome this problem.

TSS – effectively oils and greases in the water - cause scaling and clogging throughout the operation but can be filtered out.

It is important to recognise that a shale operation will produce progressively less flowback water over the life of the well and so water cannot be reused indefinitely as above. At some stage wastewater must be disposed of.

Water treatment

Wastewater can be treated to ensure that the water can be discharged or reused elsewhere, away from the shale gas operation.

It can be treated either to produce clean freshwater or a 'clean' brine.

To create a clean brine, sometimes it is not necessary to reduce the TDS levels. Rather it is necessary to remove other constituents such as certain metal ions. A common method of doing this is to raise the pH, add a coagulant to promote solid formation and then remove the resulting metal-bearing solid precipitates[53].

A more complicated procedure is to convert the wastewater into freshwater. If TDS levels are low it is possible to desalinate the water using a Reverse Osmosis (RO) membrane system. If TDS levels are high, however, this is not effective. To desalinate high-TDS wastewater the only option is thermal distillation.

There are a number of different methods for treating water using thermal distillation – basically, however, the water is heated to form water vapour. This is then distilled to create clean water and concentrated brine. The water can be reused, evaporated or in some areas, crystallised. It is worth noting that these methods require a lot of energy expenditure and will impact adversely on the cost of the gas produced.

Recommendations

The Task Force recommends that the content of the additives being used across the shale gas operation be made public, with an explanation of their use and a comparison with other industries or household uses.

This can be achieved by expanding upon the safeguards introduced by the Infrastructure Act 2015 (which suggest a requirement for an environmental agency permit with a condition that only approved substances are to be used for fracking) by making this mandatory and allowing the public the right to view the relevant application and subsequent permit.

It is recognised that the exact composition of additives can be commercially sensitive. The Task Force is sensitive to this particularly because we believe that innovation is essential for developing new and 'greener' additive compositions. We also recognise, however, that the public needs to be reassured and so recommend that the EA creates a public document of agreed limits of acceptable additives. The EA can then test at regular intervals and reassure the public that additive levels do not exceed limits and that there is, therefore, no risk to public health.

The Task Force welcomes the Infrastructure Act safeguard that requires a period of groundwater monitoring prior to the commencement of fracking as this will provide essential baseline data. We recognise that the UKOOG Code of Practice commits companies to extensive baseline monitoring. However we recommend that baseline monitoring – for ground, air and water – should begin when a site has been identified, before the environmental permitting and planning have been obtained. In some cases this immediate start to monitoring will require a change in the way planning regulations are currently framed. Monitoring of gas, casing pressure and soil should take place for the duration of operations on a well.

In addition, as above, the Task Force believes that monitoring as recommended above once a well has been abandoned should also take place. Our principles of transparency (making the findings public) and engagement (involving the public in an oversight role) apply.

> "...we believe that innovation is essential for developing new and 'greener' additive compositions."

We recommend that operators undertake a specific assessment of the risks to groundwater (and surface water) that is consistent with the principles set out in the Department for Environment, Food and Rural Affairs (Defra) Guidelines for Environmental Risk Assessment and Management – Green Leaves III[54]. It should also take into account the best available data.

Operators must be held to the highest standards in terms of the materials that they use and for the installation of wells. Operators must demonstrate this in advance to relevant authorities. Likewise there are tests that can detect potential well integrity failure. Some of these tests are routinely carried out, but they should be verified independently and implemented across wells at regular intervals.

In addition sites should be monitored for signs of leakage that could point to integrity failure. It is worth noting that mandatory independent inspection of wells was proposed but rejected during the passage of the Infrastructure Act on the basis that the current UK regulatory system covers this under the auspices of the Health and Safety Executive and the EA. We recommend, however, in line with our ongoing recommendations for best practice independent monitoring that there should be community involvement in an oversight role in this monitoring and public disclosure of the results. Independent inspection for well integrity was recommended by the Royal Society and Academy of Engineering more than two years ago; we reiterate their recommendation.

Operator Environmental Impact Assessments (EIAs) should clearly set out the proposed arrangements for the disposal of waste water, clearly identifying the disposal routes for all waste streams, including wastes generated from waste water treatment processes. The EIA should also address any cumulative impacts that may arise from shale gas developments in the area, for instance the disposal of saline waters from multiple well sites.

We also recommend that the Government should clarify where responsibility for the continued monitoring and documentation of sealed-off sites should lie.

Finally, it is a source of concern that it is not clear who is responsible for any issues around an abandoned well if the operator has gone out of business at the time when a leak or contamination has been identified. The Task Force notes that DECC is currently looking into this matter and we would encourage them to publish an approach as early as possible, in order to reassure the public. As outlined above, the Task Force believes that the Coal Authority could take on this important role of overseeing historic wells.

"We also recommend that the Government should clarify where responsibility for the continued monitoring and documentation of sealed-off sites should lie."

Air

Possible contaminants in air

Shale gas operations are also often associated with methane emissions.

Methane is a colourless, tasteless gas and the primary component of natural gas. It is a greenhouse gas, significantly more potent than carbon dioxide, and the Task Force will examine the relationship between shale gas operations and climate change in its third interim report.

For the purposes of the present report we have studied the hazard associated with methane as a contaminant to the local environment and population.

According to the Health Protection Agency, "high levels of methane can displace oxygen in the air and cause oxygen deprivation, which can lead to suffocation. Breathing high levels of the gas can also lead to agitation, slurred speech, nausea, vomiting, flushing and headache. In severe cases breathing and heart complications, coma and death may occur"[55].

However it is worth remembering that methane is used every day in millions of households in the UK, for cooking and heating, and that the dangers associated with methane apply to confined spaces and high levels of methane.

While there is a hazard associated with methane, outlined above, the question becomes whether the quantities are sufficient and the pathways exist, throughout shale operations, to turn this hazard into a risk, and if so, how the risk should be mitigated.

Quantities of methane in shale gas operations

We can compare the quantities of methane associated with shale gas with quantities of methane deemed acceptable elsewhere in the UK.

In the UK there are 23,000 landfills emitting approximately 15 Mt CO2 equivalent per year[56]. Most landfill gas is vented to the atmosphere. However, increasing numbers of landfills are capped, so that the gas can be captured and fixed, burnt or used for local heating or electricity generation. It is of interest to compare the fugitive emissions of methane from landfills with that likely to be produced by shale gas exploitation.

There is generally no agreed leakage rate from shale gas (or indeed conventional natural gas) production, but currently an 'average of averages' of about 2% ± 1.5% of the amount of gas produced can be cited[57]. If we consider the gas used to produce electricity in the UK then, given that around 40% of UK electricity is produced by gas, then a leakage of around 1.75% of the gas used for this purpose would result in around two thirds of the emissions of CO2 equivalent that is currently emitted by UK landfills. Of course it is evident that it would be good to reduce further both these emissions, and steps are being taken to address this from both sources. It is also the case that natural gas is used for many other purposes in the UK, and in particular heating our houses and buildings, with the gas used for electricity generation representing only around one quarter of total UK gas consumption.

Currently the environmental impact assessment, which is now required to be submitted by operators to the EA and planning authority, must contain details about the levels of site emissions expected by the operator. The EA will then review the expected emissions and, if necessary, can enforce monitoring procedures.

Pathways to contamination

In the view of the Task Force, gas emissions from shale gas operations can derive from three main sources:

(i) Emissions resulting from a failure of well integrity or improper storage

(ii) Methane 'disposal' methods: venting and flaring

(iii) Emissions from machinery powered by diesel engines working on-site or vehicles transporting materials to and from the site

Well integrity or lack of containment

The majority of fugitive emissions are released after fracking as the flowback fluid returns to the surface[58]. As detailed above, a proportion of the flowback fluid is made up of hydrocarbons and natural methane gas. To deal with the flowback fluid, a process known as Reduced Emissions Completions, or "green completions" can be used.

This treatment process separates the gas and hydrocarbons from the remaining flowback fluid, allowing the gas and hydrocarbons to be contained and the rest of the fluid to go on to further processing[59]. This process reduces fugitive emissions by 90%[60]. The US has recently mandated the use of green completions.

We recommend that the same policy should be adopted in the UK for production wells. We recognise that green completions may not be feasible for exploratory wells and some flaring may be necessary (see below section on flaring). A third option is also available, in which operators can convert gas to electricity onsite and link it to the grid. This option is generally more acceptable than flaring.

Venting and Flaring

The operator can manage methane loss using two methods:

First the gas can be vented, which involves the controlled release of gas into the atmosphere without burning. By not burning the methane, the output of greenhouse gases from the site increases. As a result, venting can only be carried out when there is a safety risk[61] if it were to be ignited. The Task Force's third interim report will examine this subject in more detail. However it should be noted that there is currently no data regarding the amount of gas vented in the UK[62] from hydrocarbon operations.

The second method involves controlled on-site burning or "flaring". This reduces greenhouse emissions by approximately 80% when compared to venting[63]. In the US there has been pressure to reduce the amount of gas flaring, which has promoted the development of green completions procedures to contain the produced gas and then use the gas rather than flaring it.

Flaring disposes of the gas and removes the release of methane into the atmosphere. However the complete combustion of methane produces carbon dioxide (CO2) as well as water (H2O)[64] and the CO2 has a greenhouse gas effect. It is also possible that some other, potentially harmful materials – such as VOCs or PAHs outlined above – could also enter the atmosphere from inefficient combustion.

Wastewater management and disposal

Finally, gas emissions can result from the trucks and machinery associated with the operations themselves. It is the view of the Task Force that this is no different to any other industrial operation and so should be examined and dealt with under existing planning frameworks. Best practice must be enforced.

It is clearly important, as set out in the first interim report of the Task Force, that operators are transparent about the levels of truck use required for a site and make these representations clearly to both the local planning authority and the local community.

Recommendations

The green completion process is sensible and should be mandated if a UK shale gas operation reaches the production phase. As outlined above, green completions are not necessarily practicable at an exploratory phase.

We believe that DECC needs to challenge operators to set out a clear plan for gas export infrastructure to connect operations to the grid (or set out an alternative use for the gas, for example by generating electricity directly on site, or ensuring local use) when considering long extended well tests. We recognise that this may not be possible for exploration wells but should be carefully considered for appraisal wells where there is a good chance that the field will be developed. This is contingent on the results the operator has to date as to the potential viability of the field and the cost of connecting to the gas grid.

Finally, the Task Force has considered the report produced by DECC on the greenhouse gas emissions associated with shale gas[65]. The authors suggested that, because the shale gas industry in the UK is in its infancy, comprehensive pilot studies aimed at establishing which emissions come from where and how much is produced should be put in place at a small number of sites, in order that the information can be used as a basis for monitoring at future sites. This seems a sensible approach.

"The green completion process is sensible and should be mandated if a UK shale gas operation reaches the production phase."

Health

Allegations that shale gas operations negatively impact on the health of surrounding communities are clearly and understandably a source of concern. Degradation of air quality has become an issue for fracking in the US and was specifically targeted as a major concern in the 90 day Obama SEAB report[66].

There have been two significant reports that have examined and tested evidence regarding the impact of shale gas operations on public health. The first was carried out by Public Health England and the second by the New York State Department of Health.

In addition the Task Force examined closely allegations contained in a report by the health organisation Medact, which is opposed to fracking.

In examining these reports we are particularly interested in the evidence and what it shows and what it does not.

Public Health England Report

Public Health England (PHE), an executive agency of the Department of Health, carried out a review of the potential public health impacts of exposures to chemicals and radioactive pollutants resulting from shale gas operations[67]. The review was carried out, specifically, by the PHE Centre for Radiation, Chemical and Environmental Hazards (CRCE) which examined literature and data from countries where commercial-scale shale gas extraction operations were already underway. The overarching conclusion drawn from the study is that the potential risks to public health from emissions will be minimal and acceptable if the operations are run and regulated properly.

The review highlighted that potential hazards to human health cited in academic literature, such as air emissions and surface spills of hydraulic fracturing fluid, were a result of either poor regulation or an operational failure. The difference in potential human impact between single well exploratory sites and full-scale extraction involving multiple wells, the cumulative impact of which may be more substantial, was also emphasised.

Aside from the main conclusion, the review made eight recommendations:

1. PHE should continue to work with regulators across all aspects of shale gas exploration and extraction in order to ensure that all risks are appropriately assessed.
2. Baseline environmental measurements/monitoring is required in order to assess the impact of shale gas operations on environmental and public health. The development of emission inventories should be considered as part of the regulatory regime.
3. Effective monitoring is required throughout the entire lifetime of the site including the post production abandonment phase.
4. The broader socioeconomic impacts, such as increased traffic and the impact on local infrastructure, should be considered during the planning stage of any operation.
5. The chemicals that are used in the hydraulic fracturing fluid should be publically disclosed and assessed prior to use. The review notes that any potential risk to the public posed by the chemicals will be dependent upon the exposure pathway, together with the total volume, concentration and fate of the chemicals. These risks will normally be assessed during the regulatory environmental permitting process.
6. The type and composition of gas will vary on a site by site basis, and as such, the risk assessment should be carried out on a site-by-site basis.
7. Evidence from the US indicates that well integrity, appropriate storage and management of hydraulic fracturing fluid and waste products are key to ensuring that risks are minimised, therefore, the appropriate regulatory control will need to be put in place. Again, this will be likely to vary from site to site.
8. Characterisation of potentially mobilised natural contaminants, i.e., NORM and dissolved minerals originating from the target formation, is needed.

New York State Review

A similar public health review was carried out by the New York State Department of Health. Like the PHE study, the New York State report covered a range of potential areas that could impact on human health. These were air pollution, climate change impacts, drinking water impacts, soil and water contamination, inadequate treatment of wastewater, earthquakes and socioeconomic impacts.

The review determined that the impact on public health is difficult to assess fully as the hazards and associated risks will vary for each well. The authors considered that, because of the dispersed nature of the potential operation locations in New York state, equipment or process failures were more likely[68]. This, in turn, could lead to an increased cumulative risk of exposure.

The review highlighted the lack of long term studies on the health impacts of shale gas exploration and extraction. The available information and published evaluations were considered to be only exploratory in nature and demonstrated considerable uncertainties in the evaluation of the human health impact of shale gas operations.

The review cited a number of long term studies currently underway in the US. The Marcellus Shale Initiative Study, which began pilot studies in 2013, is one of these. However, the results will not be available for several years. The study aims to assess the impact of shale gas operations on 30,000 asthma patients and 22,000 pregnancies between the years 2006 and 2013, through the use of exposure estimates.

The University of Colorado at Boulder, working in conjunction with the National Science Foundation (NSF), is in the process of carrying out a number of investigations into assessing and mitigating problems posed by shale gas operations. The co-operative is set to extend to 2017 with research being published throughout its lifetime.

The Environmental Protection Agency (EPA) is currently carrying out a study on the potential impact of hydraulic fracturing on drinking water resources and to establish the driving forces that determine the severity and frequency of contamination events. The study began in 2011 and its interim report has just been published. This concluded, broadly, that groundwater contamination was unlikely to occur as a result of shale gas operations. The complete results are expected to be published in 2016.

The New York State review suggests that the results of these studies will reduce the uncertainty associated with assessing the risks and environmental impact of shale gas operations. However, the results may not become available for a number of years.

The Pennsylvania Department of Environmental Protection has carried out a Comprehensive Oil and Gas Development Study. The study, which began in 2013, is analysing the concentration of radioactive isotopes in flowback waters and waste residues produced from shale gas operations together with radon measurements in the natural gas. In addition, the potential exposure of both the public and site workers to radon gas is being investigated. Results from this study have recently been published[69]. It concluded that natural gas extraction poses little threat to the public of increased exposure to radon gas - a similar conclusion to that of Public Health England. It also concluded that there is little or limited potential for radiation exposure of either the general public or workers, either on site or at any stage in the production and supply chain.

The main environmental radiological hazard is that of fluid spills. Wastewater treatment plants should be monitored for elevated levels of radioactive material and, if found, radiological discharge limitations and spill policies should be applied if necessary[70]. It was considered that landfill sites that receive treated waste products present little potential for increased exposure to radioactive material, although it was proposed that the filter cake produced during the treatment of waste products could present an environmental hazard if spilled. The disposal of the filter cake could also present a long term environmental hazard. The study suggested that the protocols governing the disposal of such material contaminated by radioactive material should be reviewed and modified where appropriate.

The New York State Department review concluded that any risk assessment should be supported with scientific information. It was suggested that the currently available scientific information on the risks associated with hydraulic fracturing is insufficient to form a basis for decision making. The authors concluded that until scientific information allows 'accurate' determination of the hazards and associated risks to the general public, or that the hazards and risks can 'adequately' be managed, hydraulic fracturing should not go ahead in New York.

> "… groundwater contamination was unlikely to occur as a result of shale gas operations."

Medact

The Medact report, published in April 2015, also made a number of allegations of health impacts associated with shale gas operations. Specifically it suggests:

"Fracking and its associated activities create multiple actual and potential sources of pollution. Leaks of gas can occur across the entire process of extraction, treatment, storage and transportation. There are also emissions from diesel engines, compressors and heavy transport vehicles; as well as the potential release of silica into the air. Oxides of nitrogen, hydrogen sulphide, formaldehyde, benzene, ethylene, toluene, particulate matter and ground-level ozone are among the more significant airborne health hazards. Surface and ground water can also be contaminated by gas, fracking fluid, or wastewater which consists of original fracking fluid combined with a range of new materials generated from underground (including lead, arsenic, chromium, cadmium; and naturally occurring radioactive material). The health effects of these different hazards vary depending on the type and pattern of human exposure. But they include increased risks of cancer, respiratory disease and birth defects"[71].

The report also alludes to the social impacts of shale – for example societal cohesion and stress. It concludes that the hazards of fracking are significant and the risk is dependent on numerous factors and difficult to quantify. It suggests that significantly more research should be done before shale gas operations are allowed, but that this resource would be better allocated to alternative energy sources. It therefore concludes that shale gas operations be halted.

The Medact report does not produce its own research and, during recent planning discussions in Lancashire, Lancashire County Council's Planning Officer highlighted concerns that the report was not independent:

"Unfortunately, one of the contributors (contributing to three of the report's six chapters – chapters 2, 4 and 5) has led a high profile campaign in the Fylde related to shale gas. Another contributor to the report (chapter 3) has previously expressed firm views on shale gas and has objected to this application. This has led to questions from some quarters about the report's objectivity."

Recommendations

The evidence available suggests a number of things. First, clearly there is a range of hazards potentially associated with shale gas operations. The relevant question is about the specific risks associated with those hazards.

The Task Force is satisfied that the risk levels associated with the public health hazards outlined above are acceptable provided that the well is properly drilled, protected, monitored and regulated. This is an absolutely essential proviso. In this respect, we agree with both the analysis and the conclusions of the PHE report.

However we also recognise that the amount of evidence available is limited and largely based on pre-green completion data. More research needs to be conducted and should continue to be conducted if an industry develops. To oversee and coordinate this effort we recommend that the Government establishes a National Advisory Committee of independent academic experts with a remit to examine, collate and evaluate health impacts associated with shale gas operations in the UK once operations have begun and data from the first wells becomes available.

In addition, to reassure the public further and to ensure early and independent oversight of any shale gas operation, we recommend that Public Health England commits to reassessing and updating its report into health once a number of wells have been drilled and more evidence is available. The timing of this reassessment should be determined by Public Health England.

> "The Task Force is satisfied that the risk levels associated with the public health hazards outlined above are acceptable provided that the well is properly drilled, protected, monitored and regulated."

Conclusion

In studying the impact that a UK shale gas industry could have on the immediate area in which operations would take place, the Task Force believes that there are four essential undertakings for operators and regulators to adopt.

These are:

1) Full disclosure of chemical content and agreement that composition will not exceed levels mandated by the Environment Agency. Local communities have a right to understand what chemicals will be used in industrial activity near to where they live and to be reassured that these are being used in safe quantities. This should not be onerous to operators, indeed a commitment to transparency should help to rebut some myths that have grown up around shale which, as this report has demonstrated, are not backed with evidence. We would expect innovation to produce 'greener' additive compounds as industry develops.

2) Baseline monitoring is essential to reassure local populations. Monitoring of air, land and water should begin as soon as a site has been identified. The current planning stipulation that the drilling of boreholes for groundwater monitoring can only begin once planning permission is granted does not benefit anyone and we welcome the Government's current consultation to remove this barrier to good practice.

3) Operators must be held to the very highest standards for well integrity. A failure of well integrity, evidence suggests, is responsible for many of the problems associated with shale gas operations in other locations, particularly the USA. To ensure this cannot happen in the UK, operators must commit to using only the very best materials and techniques, and to allow independent monitoring of the site, with the community involved in an oversight role, to ensure that any indication of a failure of well integrity can be identified quickly.

4) Finally, the process of "green completions", described above and recently made compulsory in the USA, should also be mandated in the UK for production wells. In the exploratory phases, the Task Force would prefer to see gas converted to electricity on-site with small, time-limited flaring permissions granted only when necessary.

Endnotes

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