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Yeovil Innovation Centre
Barracks Close, Copse Road
Yeovil, BA22 8RN
email: info@ypte.org.uk
web: www.ypte.org.uk
Director: Peter Littlewood
Author: Peter Littlewood
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Shale Gas and Fracking

There has been a lot of coverage in the news recently about a controversial technique for extracting gas and oil from underground. Hydraulic fracturing, or 'fracking' is being hailed by the UK government as a means of creating a new boom for our economy, creating thousands of new jobs, lowering our energy bills and giving the UK energy security for decades to come. Yet many people aren't happy about fracking and a lot of environmental campaigners believe that no fracking should take place. In this issue of Conservation Education, we will examine what fracking actually is, its possible benefits and its possible disadvantages.

What is fracking?

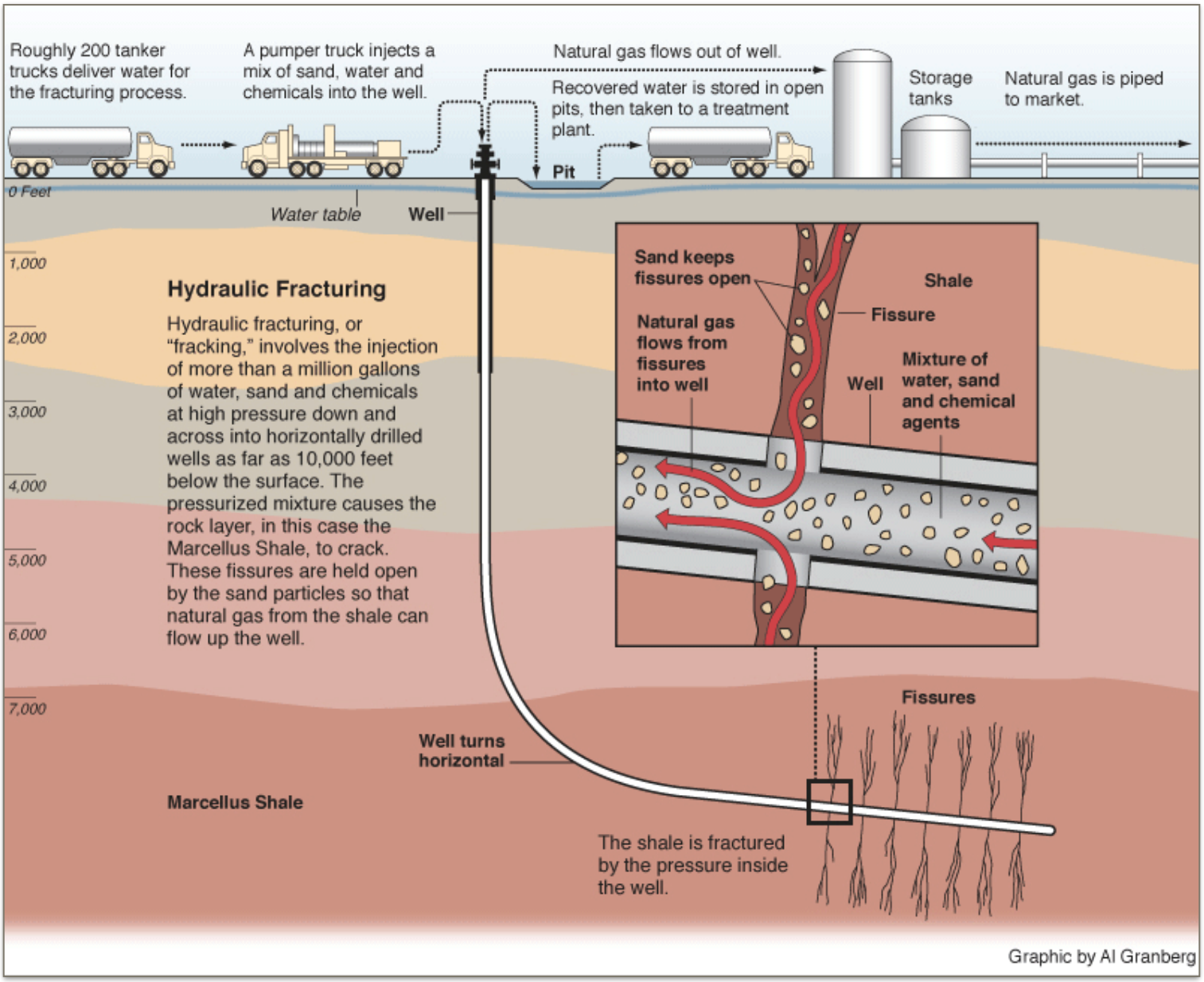
Above: A shale gas drilling rig in countryside. Note the temporary accommodation in the foreground for the workers.

Up until recently, oil and gas has tended to be extracted from huge 'reservoirs' located deep underground. Over time, many of these reservoirs have been used up and are now either of no further use, or have a limited productive lifespan. As a result, geologists and engineers have looked for alternative sources of oil and gas. They have discovered that a clay-rich rock called shale, which is found many thousands of feet below the surface often has bubbles of gas either trapped in the rock itself or located in gaps (pores) in the rock. Shale has very low permeability, which means that it is very difficult for fluids or gases to travel through it. In the past, that has meant that it has been impossible to extract the gas using conventional drilling techniques.

Hydraulic fracturing or fracking is a technique used by drilling engineers to make rocks like shale more permeable and enable trapped gas to be recovered for use. A borehole is drilled until it reaches the desired depth underground, which will be where the target rock is located. The drill is angled almost horizontally and drilling continues outwards, often for a mile or more. Then, a water-rich fluid is pumped into the borehole and the pressure is increased until the rock fractures.

The fluid used for fracking contains small particles, mostly sand, known as proppant to prop open the fractures in the rock. It also contains chemicals such as acid to help create fractures, corrosion and scale inhibitors that help to protect the lining of the borehole and gelling agents to thicken the fluid. After the fracking job, the pressure of the water in the well is reduced and water flows back to the surface, along with the natural gas that has been freed.

Fracking has become a big industry in the USA. The last few years have seen the beginnings of a fracking industry in the United Kingdom, with the establishment of a few test wells, but it is yet to be properly established here and there is still a great deal of doubt being expressed by many people as to whether fracking on a large scale should be allowed here.



As can be seen in the graphic above, shale lies buried very deep underground. Note that the graphic has been simplified and is NOT to scale. The trucks are way too big (note the depth scale on the left in thousands of feet) and the borehole would actually be much smaller at around 21.5 cm in diameter. Extracting shale gas by fracking involves drilling an extremely deep well, at depths of up to 8,000 feet (2,438 metres) below the surface. The well can then extend outwards horizontally for distances of up to a mile. Each 'drilling pad' is likely to contain a number of wells, which whilst relatively small on the surface, can cover wide distances underground. Marcellus shale is a type of shale found in the USA.
Source of graphic: ProPublica, www.propublica.org

What are the advantages of shale gas?

- **It's cleaner than coal.** Between a third and a half of our energy is still produced in power stations that burn coal. Gas emits 57% less carbon dioxide per kilowatt hour than coal, so it could help to reduce our greenhouse gas emissions. A rise in gas prices in 2012 meant that cheaper coal was used to generate more of our energy than in any year since 2006.

- **It will give us greater energy security.** Since 2004, the UK has imported more gas from overseas than it has sold to other countries, becoming a 'net importer' of gas. In 2012 for example, most of our gas came from Norway. Pipelines transport the gas across Europe to 'interconnectors' in Belgium and the Netherlands, which then run under the sea to the UK. Some of our gas came in liquid form in supertankers from Qatar. The rest was produced by our own gas fields in the North Sea. In the same year, most of our coal came from Russia, the USA and Colombia. By finding and producing more 'home-grown' gas, through fracking, the UK would become less dependent on other countries for the fuel we need to heat our homes and to supply our power stations.

- **We need gas.** Some 80% of the UK's population heat their homes using gas. Shale gas could provide us with a ready supply.

- **It is not new technology and has been extensively tested.** Fracking first took place in the 1940s and in the USA, over a million fracks have already taken place. Hydraulic fracturing for shale gas extraction was first carried out in Texas in 2003.

- **It will boost our economy.** The UK government argues that shale gas could be a significant factor in re-shoring businesses (bringing back to the UK businesses that have moved overseas to cut costs). In addition, according to a study by the Institute of Directors (May 2013) shale gas could lead to the creation of up to 74,000 new jobs.

- **It will give financial benefit to communities.** In places where fracking is taking place, companies operating the wells will pay local communities £100,000 for each well that is fracked, along with 1% of all revenues from any resulting shale gas extraction. Figures of up to £10 million over the life of a well have been put forward by some in the fracking industry and cited by the UK's Prime Minister David Cameron.

As can be seen above, shale gas drilling operations often take place near to where people live, or on land used for farming. Here, this drilling rig can be seen above a field of maize in the USA. Shale gas drilling can have a much smaller 'footprint' than other forms of oil and gas extraction.

- **It will deliver benefits to local councils.** Councils will be allowed to retain all of the business rates they collect from companies carrying out fracking operations. This is a special concession from the government, which is also offered as an incentive to councils to encourage renewable energy operations in their area. Normally, councils keep just half of the business rates they collect, with the rest being passed to the government.

- **It will give us cheaper energy.** The situation in the USA is used to back up this claim. Here, widespread adoption of shale gas extraction has led to the gas price for US consumers being greatly reduced to just one third of the price paid by Europeans.

- **The long-term impacts of fracking on the landscape are relatively small.** Preparing a site for shale gas extraction involves ground clearance to create a 'pad', which can be made up of up to ten wells and which covers an area of perhaps 7,000 square metres (roughly the size of a Premiership football pitch). Large and heavy equipment including drilling rigs and large amounts of water, sand and other chemicals need to be transported to the site by lorry. The fluid that comes back out of the well after fracking (the flowback) also has to be either taken away from the site by lorry for treatment or stored onsite in secure ponds. Once the fracturing has taken place, the site is cleared and just the well remains, with the equipment taking up roughly the same amount of space as a two-car garage. Some wells then remain productive for up to 30 years.

- **Renewable energy is not currently able to provide a complete solution.** Whilst new renewable technologies are advancing rapidly and are being adopted more widely in the UK, there are still times when conventional power is required. Wind turbines don't work when it isn't windy, photovoltaics (solar panels that produce electricity) don't work at night etc. In future, renewables may provide all of our energy requirements, but for the present, we still need energy generated conventionally in power stations. These can be fuelled with gas more cleanly than they can with coal.

What are the disadvantages of shale gas?

It's not renewable or sustainable. Whilst there are conflicting estimates as to the precise amount of shale gas available to us in the UK, there is no doubt that however much there is, it will run out at some point in the future if we choose to extract it.

Using gas will not help combat climate change. When gas is burned, carbon dioxide is produced. Although gas gives off less carbon dioxide than coal and is therefore cleaner, it is still causing greenhouse gas emissions when it is burned. Renewable energy like solar power, wind or tidal energy do not create any carbon dioxide when in use.

Many environmentalists would prefer renewable technologies like wind (see wind turbines, above), tidal and solar power to be more widely used.

You need a lot of wells. In the USA, over a million fracks have taken place. Some 82,000 wells have been drilled or permitted since 2005 (Environment America, Oct 2013). The USA has an area roughly 40 times that of the UK. So to get a similar situation here in the UK to that in the USA, we would need around 2,050 wells across the UK. To give some idea of what this might mean, Tesco has 3,146 stores in the UK.

Fracking uses a lot of water. The volume of water required to create a hydraulic fracture varies from well to well, with between 90,000 and 13,500,000 litres required. 1-2 million litres per well seems to be an accepted average. So if we took the figure of 2050 wells, based on the US numbers above and we say that each well needs an average of 2 million litres of water, that's 4.1 billion litres of water. That's a vast amount and is almost incomprehensible. What is possibly even more amazing is that it's equivalent to the amount of water that the UK population uses to flush its toilets for two days! It should be noted that some wells may need up to a further 18 million litres of water during the lifetime of the well to stimulate further fractures (Chesapeake Energy, USA). Up to 40% of the water flows back to the surface and some of this can be recycled for use in further fracking (see below). The rest is left in the shale deposit and is non-recoverable.

Fracking can contaminate groundwater. The fluid used in fracking is mostly made up of water and sand (about 90% water, 9.5% sand), but it also contains other, potentially harmful chemicals. These include ethylene glycol, which is used in household cleaners, borate salts, which are used in cosmetics, sodium carbonate and/or potassium carbonate, which are used in detergents and isopropanol, which is used in deodorant.

It is essential that any companies involved in fracking should provide a detailed analysis of the ingredients used in the fluids they use to carry out hydraulic fracture. This was done by Cuadrilla a firm engaged in fracking, in 2011 in an answer to the UK government's Environment and Climate Change Committee. The fracking fluid used by the company was 99.96% sand and water with polyacrylamide friction reducers at 0.04%.

When the fluid comes back to the surface after fracking, it also contains other chemicals from the rocks below. It contains a lot of salts and sometimes radioactive material as well. For example, Cuadrilla, one of the companies involved in shale gas exploration in the UK has recently withdrawn its applications for permits to frack at sites in Lancashire, because it has found the flowback fluid from the well contained high levels of sodium chloride, bromide and iron, as well as elevated levels of lead, magnesium, zinc chromium and arsenic. The flowback also contained traces of radioactive uranium and thorium, along with radium at a level 90 times the limit for safe drinking water. What to do with this flowback fluid is proving to be a problem and this will have to be adequately addressed before any fracking should be permitted. Much of it could be recycled and used again in further fracking operations. But the remaining water needs treatment and filtration before it can be returned to the environment and afterwards there remains a toxic sludge that needs to be safely stored or disposed of in a way that won't cause environmental damage.

And what if a well cracks? Environmentalists fear that if a well should fracture near to the surface, there is the potential for either the fracking fluid or the flowback fluid to contaminate groundwater and so pollute people's drinking water. There is also the danger that water stored in sealed tanks following a fracking operation could leak out, causing a pollution incident.

Sites could be near where people live. In the USA, some fracking wells have been drilled within a few hundred feet of people's homes, but most wells are drilled in more remote areas, where impacts on people are reduced. The population density in the UK is eight times higher than in the USA, so there is a much greater likelihood of fracking operations taking place near to people's homes, causing lots of additional noise, traffic, unsightly machinery and the possibility of chemical exposure or explosions.

Shale gas won't deliver cheaper energy. The main reason that gas prices have reduced so sharply in the USA is that the shale gas revolution happened so quickly that export terminals required to export the gas had not been planned for or built. The gas stayed in the USA, so as it became more and more abundant, it got cheaper and cheaper. In the UK, we are connected by gas pipelines to the rest of Europe. If gas got cheaper in the UK, producers would sell it to other European countries to maximise their profits and our energy prices would be no lower than they were for the rest of Europe. There may be a small reduction, but it would be nothing like the two-thirds cheaper energy bills seen in the USA. UK Chancellor George Osborne publicly agreed with this in a statement made on 4 February 2014.

Shale gas won't deliver as many new jobs as is claimed. There is no doubt that if shale gas were to be widely adopted in the UK, new jobs would be created. A Strategic Environmental Assessment, undertaken by AMEC and commissioned by the UK government (December 2013) has shown that around 50-60,000 new jobs would be created by widespread adoption of shale gas, not the 74,000 claimed by Ministers. However, even at the lowest end of the range, this is still a significant number of new jobs.

Shale gas won't deliver as much benefit to communities as is claimed. Latest government estimates of benefits to local communities over the life of a shale gas well are £2.4 - 4.8 million, not the £10 million previously claimed.

Above: Shale is a rich source of natural gas.

Fracking can cause earthquakes. When you deliberately cause fractures in rock formations deep underground, there is a risk that tremors and earthquakes can occur. This has already been seen here in UK, when in April and May 2011, two earthquakes, the largest of which measured 2.3 on the Richter Scale were caused by hydraulic fracture operations at Preese Hall, near Blackpool. Cuadrilla, the company drilling at Preese Hall ceased drilling immediately after the earthquakes and a year-long moratorium on fracking was imposed. In December 2013, it announced that it would do no further drilling at Preese Hall.

Fracking can release greenhouse gases. Fracking involves drilling into rock layers deep below the earth's surface, These layers contain natural gas and there is the potential risk of methane leaking from a fracked well. Methane is a much more powerful greenhouse gas than carbon dioxide, so even small amounts of leakage could be significant.

Above: How we will meet our future needs for energy is a real concern for many

The great shale gas debate

At the moment, the UK government has declared itself to be fully in favour of shale gas exploitation in the UK. Prime Minister David Cameron has said that the government is 'going all out for shale gas' and has been strongly championing the benefits that shale gas exploitation could bring to the UK.

However, environmental groups are showing real concern that fracking is being encouraged so actively. The key concerns, shared by many people are that fracking may poison groundwater, that it might happen very close to people's homes and that further investment in gas extraction will divert investment away from the development of greener, renewable energy technologies.

Confusing information

What is clear is that the public needs better information in order to be able to decide whether we are happy to have large-scale shale gas extraction in the UK or not. There is a tendency for exaggeration on both sides, with those in favour overplaying the benefits and downplaying the dangers, while opponents, who have genuine reasons to be concerned often seem to cite inaccurate information to back up their arguments against shale gas.

For example, estimates of the amount of shale gas available in the UK have varied enormously. Currently, the British Geological Survey believes there may be 37 trillion cubic metres of shale gas under the north of England. With our annual gas consumption currently at around 100 billion cubic metres (2009), that would provide us with gas for over 370 years. But most fracking firms believe they would not be able to recover more than 10-20% of the gas trapped in shale. That would reduce shale gas at worst to providing 37 years worth of our current total gas consumption. Back in 2012, a report to Parliament by the British Geological Survey estimated there was about 150 billion cubic metres of shale gas in the UK, or one and a half years of total gas supply, so their current estimate has been increased to over 300 times what it was just two years ago.

Reassurance on safety

Another area which the public needs much greater reassurance on is the safety of fracking as a technique. The UK has already seen minor earthquakes caused by test fracking. There need to be real safeguards in place to ensure that such problems do not arise again in the future.

The danger of serious pollution to drinking water sources is another major concern. People's worries have so far not been allayed by the information made available. Potentially dangerous chemicals could get into the water supply either through a cracked well casing, or by being forced through a previously unknown route back to the surface from the fracking site or through flowback fluid either leaking from a storage pond or being spilled.

Above: Fears over the safety of fracking, together with objections to the use of further fossil fuels has led to protests in parts of the UK near to drilling sites, such as here in Balcombe, West Sussex.

Theoretically, such pollution incidents should be preventable, but ensuring this will require very strict environmental standards to be set by the government, with strict enforcement on operators to ensure that shale gas operations do not result in the poisoning of a drinking water source.

Scare stories and real risks

Burning tap water

There are various films online showing people setting light to tap water that they say has been polluted with methane from nearby fracking operations. However, these mostly originate from areas where the water already contained methane naturally and wells had been dug through coal gas seams. Records exist of Americans setting light to drinking water in certain parts of the United States from the 1600s onwards and there are three separate towns in the US called 'Burning Springs' for this very reason.

Well leaks and pollution

But whilst flammable tap water has been over-sensationalised, the levels of harmful minerals and chemicals contained within the flowback fluid are real and have been scientifically tested. Measures will have to be put in place to give assurance to the public that no such leaks or spillages should occur. A 2011 investigation by the US Environmental Protection Agency (EPA) into whether fracking operations had caused water pollution in Pavilion, Wyoming, USA was called off late in 2013 without conclusions having been drawn. The EPA is currently working on a nationwide study into the effects of fracking on drinking water and will be issuing its report in draft form late in 2014 and continues to support the State of Wyoming in its study of the leak at Pavilion.

Why are we doing it when other countries won't allow it?

Some countries, including Ireland and France, together with some states in the USA like New York have moratoriums in place effectively banning fracking from taking place. Environmentalists here wonder how safe fracking can be, given that other places have already rejected it.

A slow 'dash' for shale gas

The media and politicians have both been guilty of exaggerating the speed at which fracking could take off in the UK. As at August 2013 there were 644 onshore exploration licences in existence in the UK, but it is unclear how many of these are for fracking and how many for conventional oil and gas exploration. However, it is unlikely that more than one or two new wells will have been fracked by the end of 2014 and these will have been for test purposes only. It is only after the suitability of the UK for shale gas extraction has been properly investigated that lots of wells may start springing up.

The UK is not the USA

In many parts of the USA, landowners own the rights to any mineral resources under their land. This has meant that many Americans have welcomed shale gas extraction, as they take a share in the profits from any wells drilled on or extending into their land. In the UK, landowners do not own mineral rights to the resources under their property, but they have to be informed if anyone intends to extract mineral resources under their property and have the right to lodge an objection under planning law. The government is currently exploring ways to make shale gas extraction exempt from planning objections. This is indicative not only of the government's support for shale gas extraction but also of the perception that many people are likely to object to fracking taking place under their homes.

Another way in which the UK and USA differ is in their geology. Most US shale gas fields are found in flat lying, regular beds of rock with few faults, folds or other natural fractures. The majority of shale gas prospects in the UK are in Carboniferous-age rocks, which were folded and faulted by enormous tectonic forces around 350 million years ago. In other words, the layout of the rocks under our feet is much more complicated here in the UK than it is in the USA.

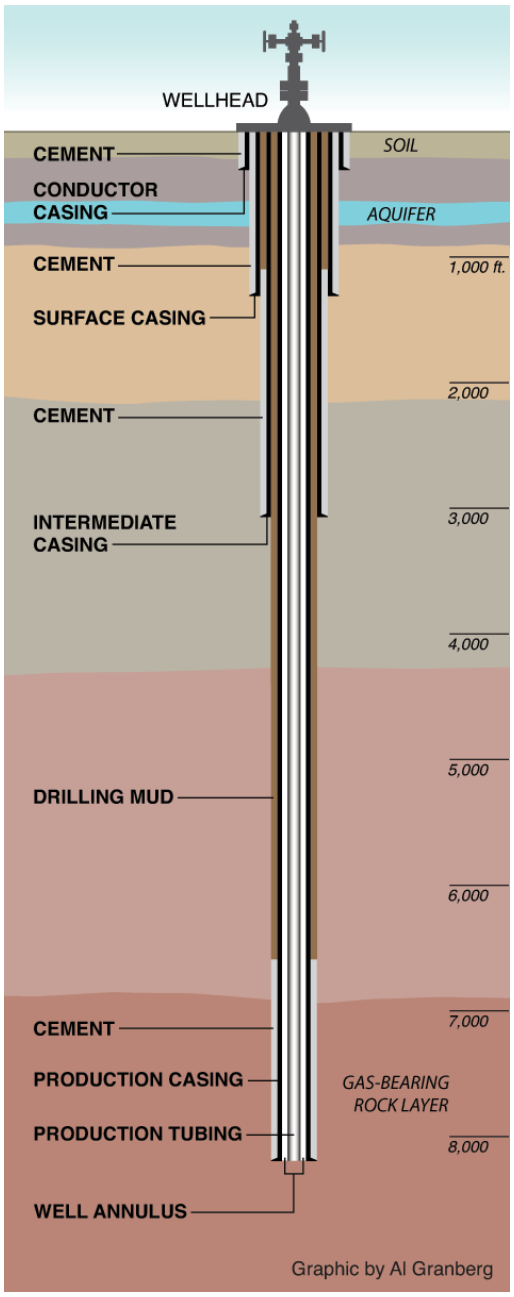


Diagram of a shale gas well (NOT to scale). When drilling, the derrick is 30-40 m high. After about 60 days, this is removed and a wellhead (2-4 m high) is all that remains. The wells typically go down thousands of feet below ground water aquifers, becoming near horizontal when they reach the target layers of shale rock. The strength of the steel casing and the cement surrounding the well are critical for avoiding the contamination of ground water with drilling mud, fracking fluid or released natural gas. Wells drilled in the UK have at least three casings around the bore hole. The bore hole is around 21.5 cm in diameter.
Source: ProPublica, www.propublica.org

It was one such fault, undetected by Cuadrilla's seismic surveys prior to drilling that caused the Blackpool earthquakes of 2011. The fault was reactivated by increased pressure caused by the trial fracking at Preese Hall. The complexity of the UK's geology underlines the need for detailed surveying to take place before companies are allowed to drill. It does not necessarily mean that drilling and fracking should not be allowed in the UK, but to keep us safe and to avoid any danger of further earthquakes, there is a much greater need for detailed seismic surveys. The surveys should take place before any drilling can take place and drilling should only proceed when experts are satisfied with the seismic data.

Why fracking should be safer in the UK than the USA

In the UK, when drilling for oil or gas it is standard practice to have three strings of well casings around the bore hole, with at least two of these casings passing through and protecting any underground water supplies. Recommended practice is to provide cement casings all the way back to the surface. In the USA it is common to have two strings of casings. If these have been installed badly, with the cement casing not reaching back to the surface, the potential for leaks and contamination exists, as had been seen in the case of Pavilion, Wyoming.

Former Energy Minister Charles Hendry said in 2011 'That confirms, if any confirmation were needed, that drilling for shale gas - like drilling for any other oil or gas - is a hazardous operation that requires careful and consistent regulation.' He also said 'there is no evidence that the fracking process itself poses a direct risk to underground water resources, and [the risks]… are not different from those encountered in conventional oil and gas extraction.'The government's view is that if adequate safety procedures are in place and they are properly enforced and adhered to by operators, fracking should therefore be safe. However, the risks exist and they need to be managed properly. Any lapse could result in contamination of groundwater, or another kind of pollution incident.

In conclusion

The subject of shale gas is a highly controversial one, with legitimate arguments to support it and equally good reasons why people are concerned about it. It is possible that shale gas could provide a 'bridge' on the path to renewable energy. There are no easy, quick fixes to our increasing need for energy. Shale gas extraction has the potential to create new jobs and to boost the UK economy. It is by no means a new technology, but the application of the technology to free gas trapped in shale is relatively new. While 80% of us still heat our homes using gas, we have to ask whether fracking for gas in our own country is really a better solution than importing gas from overseas.

Shale gas and fracking could deliver real benefits and provide us with a source of energy for years to come. However, extracting shale gas, as with any other oil or gas is not without risks. Results of fracking done badly can include pollution to ground water, gas leaks and earth tremors. If it is to go ahead in the UK, it should only be with very strict levels of regulation and enforcement in place to protect people and the environment. This is especially important as fracking could happen in places close to where people live.

We should also look to the evidence from other countries where fracking has already taken place to see what lessons can be learned and whether on the basis of this evidence, fracking should be allowed to continue in the UK. We also need to be mindful of the fact that unlike in America, shale gas is unlikely to make our energy cheaper.

Shale gas may help to reduce the UK's carbon footprint, but it may also delay development and adoption of zero-carbon renewable technologies that would be better for the environment. Perhaps if fracking is allowed to take place, a good solution would be for a tax to be levied on shale gas extractors, with the funds raised being used to pay for research and development of renewable technologies. In this way, shale gas could have the potential to speed up the changeover to renewable energy. And ultimately, a society based on sustainable, renewable energy sources should be our goal. This should not be a distant objective, but as something we should be looking to achieve in the next 20-30 years.

A wide range of source materials has been used in preparing this document and is available on request. In particular we would like to thank Dr Dave Healy, Senior Lecturer in Geomechanics at the Universtity of Aberdeen for his assistance.

Young People's Trust for the Environment
Yeovil Innovation Centre
Barracks Close, Copse Road, Yeovil, Somerset, BA22 8RN
t. 01935 385962
e. info@ypte.org.uk
www.ypte.org.uk
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