SPECIMEN
MATERIAL

Level 3 Certificate and Extended Certificate in Applied Science

SCIENCE IN THE MODERN WORLD

Unit Number: ASC3

Pre-released material

SPECIMEN 2017

Time allowed: 1 hour 30 minutes

- This pre-released material should be opened and issued to learners on or after 31st March or 1st November.
- **A clean copy of the pre-released material will be provided at the start of the examination**

Information

This pre-released material is to be issued to learners for use during preparation for this examination. The pre-released material consists of four sources (**A**–**D**) on the subject of Fracking.

This material is being given to you in advance of this examination to enable you to study each source in preparation for questions based on the material in **Section A** of the examination.

A wider understanding of the topics and issues raised in the sources would be beneficial for the assessment. You are not required to understand any detailed scientific explanations beyond those outlined in Sources A–D and those in the Applied Science specification.

You may write notes on this copy of the pre-released material, but you will not be allowed to bring this copy, or any other notes you may have made, into the examination room. You will be provided with a clean copy of this pre-released material at the start of the examination.

It is suggested that a minimum of three hours detailed study is spent on this pre-released material.

Source A Extract from BBC News website first published on13.12.12

Fracking: Untangling fact from fiction

By Matt McGrath Environment correspondent, BBC News

The government has announced that it will remove a temporary ban on hydraulic fracturing across the UK.

Fracking, as it is known, is a controversial technique for recovering gas and oil from shale rock. But how concerned should people be about the environmental impacts?

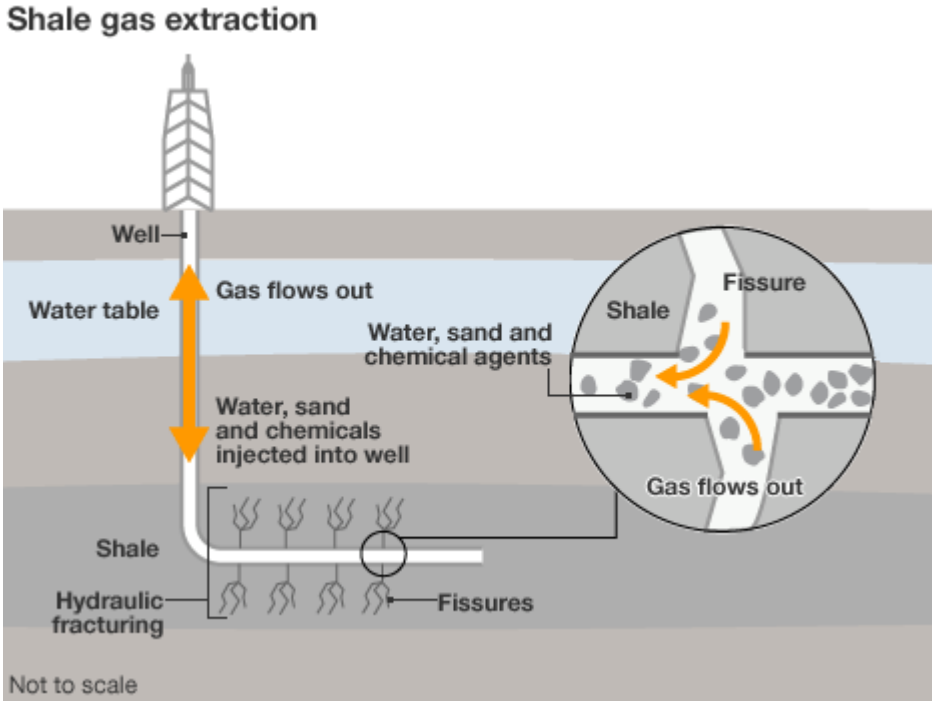
Hydraulic fracturing is widely used across the US to exploit reserves of oil and gas that were once believed to be inaccessible.

But in the UK, the use of fracking was halted in 2011 after some minor earthquakes near Blackpool, in north-west England, were attributed to test wells being drilled by the energy company Cuadrilla.

The company carried out its own report into the incident and found that it was "most likely" that the seismic events were caused by the direct injection of fluid into the fault zone.

The Department for Energy and Climate Change (DECC) then asked three experts to make an independent assessment. Their report indicated that future earthquakes as a result of fracking could not be ruled out - but the risk from these tremors was low and structural damage extremely unlikely. The experts also made recommendations on how to minimise these risks.

Another review, carried out by the Royal Society and the Royal Academy of Engineering, also gave fracking the green light - provided that strong regulations were in place.



Earthquake issues have also been attributed to fracking in British Columbia, Canada, and in some parts of the United States.

But according to the Francis Egan, chief executive of Cuadrilla, there needs to be a sense of proportion about the risk of earthquakes from fracking.

"If you look at the British Geological Survey website, in the last two months alone there were nine events of the same magnitude," he told BBC News.

"We have a host of measures in place to ensure there is no recurrence."

It is expected that if fracking resumes in the UK, the government will insist on constant monitoring and a threshold of seismic activity.

If fracking causes a tremor above the limit, it could lead to a suspension of drilling.

Fluid situation

Many people have concerns about the fluid used in fracking. It is normally a mixture of water, sand and some chemicals that is pumped into the well under high pressure to force the gas from the rock.

There have been worries that the fluid is dangerous - suspicions that were fuelled by the reluctance of many companies in the US to disclose what's exactly in the mixture. Democrats in the US Congress released a report that detailed some 750 different chemicals and other components used in fracking fluid.

In the UK, Cuadrilla has been open about what is in its fracking mixture.

But the liquid going down into the well isn't the whole story.

Fracking requires tens of millions of litres of fluid - much of what goes down the well comes back up as "produced water".

It can contain a mixture of organic hydrocarbons, and naturally occurring radioactive material.

In the US, this water is often stored in open pits before it is processed but in the UK the pits will have to be covered.

In many locations where the facilities don't exist on site, the water has to be trucked away to be cleaned.

Prof Richard Davies, director of the Durham Energy Institute, says that this would also be the likely scenario in the UK if fracking becomes more widespread.

"It'll be a bit like Pennsylvania, where a whole industry has grown up to deal with waste-water," he said. "We'll have to clean the water if we want to re-use it."

The International Energy Agency (IEA) has suggested ways of cleaning up the water that is used in shale gas exploitation. The IEA says that the technologies to address these issues exist or are in development and if they are adopted, fracking might be more widely accepted.

The other water issue associated with fracking is the potential of the technology to contaminate existing drinking supplies. In the US, the Environmental Protection Agency (EPA) investigated complaints from residents in Pavillion, Wyoming, who complained that fracking was affecting their drinking water.

The EPA's initial report concluded that there was a link with the waste-water produced by drilling for gas. Further investigations into this incident haven't yet conclusively shown the sources of contamination.

There have been many other reports of a similar impact on drinking water from people living near fracking operations across the US.

Prof Davies says that when water has been contaminated in the US it has not been the fault of fracking. It has been as a result of cracks in the wells or surface spillages.

"We have been distracted by hydraulic fracturing," he told BBC News. "It is really at the bottom of the list when it comes to contaminating water supplies. Drilling wells properly and cementing them are the critical things."

In a report published in the journal Marine and Petroleum Geology, Prof Davies found that in the UK the possibility of fracking causing rogue fractures that would allow methane gas to contaminate water was a fraction of 1%.

The study recommended a minimum vertical separation distance between fracking wells and water supplies of 600m (2,000ft).

Some scientists have proposed adding chemical tracers to fracking fluids as a way of confirming that any contamination of drinking water comes from the drilling process.

Environmental disruption

Horizontal drilling can offer many advantages to the gas extraction process, allowing wells to be drilled in several directions from one pad. But there are downsides as well. Horizontal drilling means companies can extract oil and gas from locations that were once inaccessible, and these may be under built-up areas as they are in several cities in the US.

The disruption that this can cause is considerable. Road traffic, drilling noise, and the danger of accidental fuel spillages are all associated with the process.

Mark Boling, executive vice president with Southwestern Energy, a US oil and gas exploration company that uses fracking technology, says the fracking industry needs to be more honest about the real impacts.

"We need to think more innovatively above the ground," he told BBC News. "We need to figure how to do better on surface impacts, water supply, water transfer and disposal, drilling locations - we really didn't come out and say, 'yes, these are risks, and there are obstacles'."

Mr Boling says that in many parts of the US, people have accepted the technology because they have seen a direct financial benefit from selling mineral rights. That's not something that pertains in the UK.

"You are going to have even more difficulty where the minerals are owned by the Crown - if you don't have something that is going to put money in the pockets of people that are suffering through all the trucks, road damage the compressor noise all these sorts of things."

Source B- article from Parliamentary Office of Science and Technology postbox- published in July 2013

HOUSES OF PARLIAMENT
PARLIAMENTARY OFFICE OF SCIENCE & TECHNOLOGY

POSTBOX

UK Shale Gas Potential

Shale Gas Resource and Reserve Estimates

Estimates of UK shale gas potential are at an early stage of development. Variations in shale thickness and gas content are known to occur across the UK, so reliable estimates require significant geographical coverage of data, from rock layer imaging and drilled wells. However, currently only a few exploration wells have been drilled into UK shales and properties from individual wells are extrapolated across large regions, leading to uncertainty in resource estimates. There are no official reserve estimates, which are needed to forecast the commercial scale of shale gas extraction.

Resource and Reserve Terminology

Several terms are used to describe the volume of gas available.

- **Total Resources**: the estimated total volume of gas.
- **Potentially (or Technically) Recoverable Resources**: the estimated volume of gas that it is possible to extract from the total resource. The proportion of the total resource that is potentially recoverable is known as the **Recovery Factor.**
- **Reserves**: the fraction of the potentially recoverable resources that are deemed to be commercially recoverable.

Estimation Methodologies

Total resource is estimated by multiplying three factors:

- geographical extent of shale layers
- thickness of shale layers
- gas content per unit volume of shale.

These will vary depending upon many factors including the local geology. At this early stage of development a number of pieces of work could be undertaken to refine resource estimates. Seismic imaging of the subsurface may be undertaken or more legacy imaging data analysed to improve thickness data[1]. More wells could be drilled to allow direct measurement of the subsurface gas content. As no data have been available in the UK, these wells could be used to test the production of shale gas to help estimate recovery factors. Currently estimates are based on limited data and international comparisons. US experience indicates that recovery factors are less transferable for shale gas than conventional gas and as the UK has a different geology to the US, comparisons are speculative.

UK Resource Estimates

The potentially recoverable resources of shale gas in the UK are uncertain. in 2010, the British Geological Survey (BGS) published an indication of the potential of some 150 billion cubic metres (bcm).[2] A study for the US Energy Information Administration (EIA) puts it at 740 bcm.[3]

These estimates used analogies for the shale thickness, gas content and recovery factor. The BGS estimate assumed the same shale gas production per square kilometre as the US Barnett Shale gas basin. The EIA estimated a shale gas production based on the UK geology. These productivities were applied to UK shale areas to provide speculative early estimates.

In 2011, the company Cuadrilla estimated a total resource of 6,000 bcm in their licensed portion of the Bowland Shale, a layer of shale located under northern England that is considered to have the UK's best shale gas potentiai.[4] Assuming a North American recovery factor of around 8-20%[5] would indicate potentially recoverable resources of 500-1,100 bcm. The thickness and gas content used for the estimates were informed by data from three wells drilled by Cuadrilla in 2011 along with three wells drilled in the 1980s. Estimates of shale thickness were also supported by subsurface imaging; however, the accuracy of both recovery factors and extrapolating gas content across the Bowland shale based on well information remains uncertain.

In 2013 the BGS released an estimate of the total resources of the entire Bowland Shale layer of 23,000-65,000bcm[6]. The approach involved mapping the layer to provide information on its thickness. Assuming a North American recovery factor of around 8-20% would indicate potentially recoverable resources of 1,800-13,000bcrn.

To put these estimates in context, the UK's remaining potentially recoverable conventional gas resources are 1,466 bcm (of which 493 bcm are reserves)[7] and annual UK gas consumption is 77 bcm.[8]

UK Reserve Estimates

There are currently no official reserve estimates. The UK reserves could be anywhere from zero to substantial. To determine reliable estimates of shale gas reserves, flow rates must be analysed for a number of shale gas wells over a couple of years. Further, estimates will be determined by many non-geological factors including costs, engineering, supply chain and access restrictions due to environmental and planning issues. Without reserve estimates the commercial scale of shale gas extraction cannot be forecast.

Endnotes

1 HC 785-1 ECC Committee, Session 2012-13, Corrected oral evidence, 012
2 DECC, 2010, The Unconventional Hydrocarbon Resources of Britain's Onshore Basins – Shale Gas
3 EtA, 2013, http://www.eja.govlanalysisfstudjestwoddshaleaas/
4 Cuadrilla 2011.htto://I'MW.cuadrillaresources.comlwhat-we-do/about-nalural-aas/
5 Curtis, 2002, Non-conventional gas, volume 3, Encyclopaedia of Hydrocarbons.
6 DECC, 2013 *httpsifvMrw.aov.uklaovemmenVoubljcations/bowland-shale-aas-study*
7 DECC UK oil and gas reserves lwww.qoy.uk/oil-and-aas-uk-oil-portal)
8 DECC Digest of UK Energy Statistics and website (www.goy.uk/decc)

The Parliamentary Office of Science and Technology, 7 Millbank, London SW1P 3JA; Tel: 020 7219 2840; email: post@parliament.uk www.parliament.uk/post
For further information on th1s subject, please contact the author, Dr Aaron Goater.

Source C Article from touchstoneblog.org.uk first published on 22.9.15

Balancing the Costs and Benefits of Shale Gas Fracking

22 Sep 2015, by Geoffrey Hammond Guest in Environment

Should the Government call on an independent body, such as the former Royal Commission on Environmental Pollution, to undertake an independent evaluation of the costs and benefits of shale gas fracking? The new Conservative Government has picked up where the Coalition left off in the race to exploit shale gas resources across the country. Amber Rudd, now Secretary of State for Energy and Climate Change, has loosened the planning regulatory framework in order to speed industrial development.

But there is clearly a need to carefully weigh the upsides and downsides of this new energy resource – evaluate the credit and debit 'columns' of the shale gas hydraulic fracturing (or 'fracking') balance sheet – so as to better inform all the disparate stakeholders.

Commercial extraction of shale gas in the UK might improve our fuel security, as well as enhance jobs and growth. However, it is uncertain whether job creation would be any greater than for equivalent programmes aimed at reducing energy demand or encouraging the take-up of small-scale low carbon energy options. Similarly, the UK balance of payments could benefit, although it is unlikely that gas bills for household and industrial consumers would fall dramatically as they have done in North America. This is because the UK gas price is determined by supply and demand factors in the wider European natural gas market.

The socio-economic benefits and costs of shale gas extraction are not evenly distributed between various communities and income groups. Thus, the nation might benefit from improved energy security and reduced balance of payments deficits, whilst it will be local communities that bear the adverse environmental or health risks of fracking. Local environmental impacts are critical to communities near the wellhead. Public resistance has been focused around increased traffic and vehicle exhaust emissions and noise, such as those emanating from heavy road transport vehicles.

In terms of the key global issue of climate change, the carbon footprint of shale gas is lower than that of coal-fired power generators, providing stringent regulation is implemented to minimise emissions. On the other hand, carbon emissions from shale gas are slightly higher than conventional gas, and considerably higher than nuclear power and renewables. Shale gas could therefore form part of a transitional UK energy strategy, but this might ultimately prohibit the attainment of a low (near zero) carbon transition pathway by 2050.

Governments ideally need independent and objective advice in order to rigorously evaluate the fracking 'balance sheet', or that of other emerging technologies. However, the UK Government (perhaps most governments) appear in reality to want 'policy-based evidence', i.e., evidence that supports their pre-existing policies. Independent advice might best be secured by establishing something like an Office or standing Royal Commission for Technology Assessment to undertake impartial evaluations. That may take some of the 'heat' out of debates over new technologies, and leave politicians ultimately still free to make choices based on the evidence. It could draw on, and interact with, national and local stakeholders through community engagement in a genuinely participative process. Obviously, that would only work if the government was prepared to change course in response to the evidence and public opinion.

There are a number of examples of parliamentary offices for technology assessment across Europe. One model might be the Office of Technology Assessment at the German Bundestag (TAB), or the equivalent bodies in the Scandinavian countries. In the UK, earlier bodies like the Royal Commission on Environmental Pollution and the Sustainable Development Commission (both effectively abolished by the Coalition Government during their 'bonfire of the QUANGOS' when coming to office in 2010) also utilised something like this 'whole systems' assessment proposed here.

A body of this type could be reasonably modest in size, provided that it draws on specialist advice from organisations like the Committee on Climate Change, the Environment Agency, and the Health and Safety Executive, as well as external stakeholders such as the communities most affected.

Source D -News article from edie.net, first published on 15.8.16

Could public support for renewables derail UK fracking and nuclear projects?

Amid a wave of discontent over the controversial fracking and Hinkley Point nuclear plant projects, recent developments suggest the general public are vying for low-carbon technologies to form the focal point of the UK Government's clean energy mix.

A YouGov poll published today (15 August) revealed that only 33% of the 1,704 people surveyed would support shale gas exploration in their local area even if efforts were made to incentivise communities through payments.

The Government's recent plans to pay up to £10,000 for households affected by the practice has seemingly failed to capture the mood of the public, with today's poll showing that 43% remain 'strongly' opposed to fracking.

Commenting on the survey findings, Friends of the Earth senior political strategist Liz Hutchins said: "The Government are desperate to show support for shale gas exploration, and recent headlines that offered cash payments were meant to bolster, not diminish, support.

"But when you look at the details of the scheme, any cash for households would only be *after* shale exploration, and would be derived from taxation on profits. It all seems a pretty unlikely and distant proposition.

"What we do know is that the more people learn about fracking and what it could mean for their health and environment, the more opposed they could be. And it's clear from this survey that they haven't been fooled by the Government's latest bribe."

'Mature solution'

Public backlash to the Government's fracking proposals comes amid continued political and business opposition to another contentious energy project, the Hinkley Point C nuclear plant.

As Theresa May's administration re-examines the case for nuclear reactors at the Somerset plant, the Crown Estate's energy, minerals and infrastructure director has put forward a strong case for offshore wind to act as an alternative, affordable provider of clean and reliable energy.

Speaking to the Guardian at the weekend, Huub den Rooijen commented on the sector's ability to deliver "on time and to budget".

"In the Netherlands, there has been an even bigger step change," Rooijen said. "Although there are differences in terms of regulation, most would agree that after a recent offshore wind tender the Dutch are now going to be paying the equivalent of about £80 per MWh for their 700MW wind farm. That is significantly lower than Hinkley Point C at £92.50 per MWh.

"We have an inexhaustible supply of reliable and clean power right on our doorstep and competitively priced offshore wind now offers a mature part of the solution for the UK's energy mix."

Green alternative

These recent developments reflect a growing consensus among industry experts that renewable alternatives to the Hinkley and fracking projects would be both environmentally beneficial and financially cost-effective for the UK's long-term supply of reliable energy.

Last week, the Shale Wealth Fund publication revealed that payments of up to £10m during a site's lifetime will not be provided for communities until a new fracking well is up and running – at least five years after initial exploration.
Research at the start of this month also found that installing energy efficiency measures could be £12 billion cheaper than the construction of Hinkley.

Earlier this year, think-tank analysis revealed that scrapping plans for new nuclear reactors at Hinkley Point in Somerset and building huge amounts of renewable power instead would save the UK tens of billions of pounds.
George Ogleby

END OF SOURCES A, B, C and D