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Shale Gas and Fracking in Europe

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Positive and negative experiences of exploiting shale gas in the USA over the past 10 to 15 years have put the spotlight on shale gas as a potentially significant fossil resource across the world. In Europe, sizeable reserves are known to exist in several countries including France, Germany, Poland, Romania, and the UK, although it is not yet known how much of the gas is recoverable. Shale gas might bring benefits to EU member states, but there are also valid concerns and environmental risks. It is important that these are adequately analysed and addressed in the context of overarching political targets, in particular mitigating climate change and providing universal access to sustainable energy.

A shale gas rig in the USA

What is shale gas?

Shale gas is methane gas contained in rocks called shales. It is typically found in underground layers anything from a few meters to tens of meters thick and at maximum depths of 6 to 7 kilometres. Worldwide technically recoverable shale gas reserves are sizeable and estimated to be ~200 trillion cubic metres (tcm), of which ~16 tcm are located in Europe.[1] These numbers are, however, not definitive since there is uncertainty with regard to total reserves.

In terms of its chemical composition, shale gas is the same as the 'conventional' natural gas that has been exploited since the 19th century. But instead of being preserved in 'conventional' permeable sandstones (connected pore spaces within the rock), it is hosted in very fine-grained, impermeable rocks and is confined within the pores or adsorbed on organic remains. This means that shale gas cannot travel naturally within the rock and easily rise to the surface. Hence, different extraction techniques are required, such as hydraulic fracturing ('fracking'), a technology that is not commonly utilised in 'conventional' oil and gas extraction.[2] On account of all these characteristics, shale gas is often referred to as 'unconventional gas'.

What is fracking?

Hydraulic fracturing (or 'stimulation') is a technique performed in stages at different locations along the well in the weeks prior to the production phase. It is tailored to the specific conditions of the rock (e.g. thickness), which vary from well to well, and used in conjunction with horizontal drilling[3] to better follow the geological horizon. After the well drilling and completion phase, large amounts of fracking fluid are pumped downhole at high pressure in order to create or enlarge fractures in the rock.

The gas is then able to escape the rock and travel with the water to the well. Its flow can last for decades after the initial hydraulic stimulation, but decreases steeply (60–80% of total production is normally recovered in the first 3 years).

The fracking fluid is composed primarily of water with some sand (2–3%) and a mix of chemicals (1%). The sand acts as a proppant to keep the cracks open, whereas the chemicals serve different purposes, such as preventing the growth of microorganisms and the corrosion of drilling equipment, as well as enhancing gas solubilisation.

Since the early 2000s, the combination of horizontal drilling and fracking in the USA has led to a rapid increase in natural gas and oil production from shales, with significant impacts on the energy supply. This has sparked a discussion about shale gas in other countries, involving governments, the oil and gas industries, the media and, increasingly, the general public. The fact that the terms 'shale gas' and 'fracking' are often used interchangeably in this discussion sometimes leads to confusion.

A risky technique

The main risks and concerns related to shale gas exploitation are: water contamination, induced seismicity (earthquake risk) and methane emissions. Some of these environmental risks are also encountered in conventional oil and gas production and/or geothermal drilling.

High water usage
Similar to the exploitation of other fossil fuels, shale gas production requires large amounts of water: between 11 and 30 million litres of water are required for a single well. Yet in the case of shale gas, water needs to be delivered to each production site, which results in a high circulation of trucks.

Between 30% and 70% of the fracking fluid pumped into the rock returns to surface during the production phase ('flowback water') and may then be re-used in fracking operations. Innovative technologies are being developed to reduce or eliminate the large water demand, including fracturing with gas or air, which would benefit water-stressed regions in particular.

Contamination of water resources
Groundwater and surface water contamination are one of the principal concerns of local communities. This risk is related to the chemicals added to the fracturing fluid (biocides, acids, friction reducers, etc.), methane itself and other natural contaminants that can be picked up from the shale rocks and flushed up to the surface with the flowback water (e.g. radionuclides). Some companies, especially in Europe, claim that they are replacing these chemicals with environmentally friendly substances. There are several potential pathways for the contamination of ground or surface water:

- **Direct contamination by over-propagation of fractures:** Scientists judge the possibility of fluid travelling through fractures and propagating towards aquifers to be remote. Nevertheless, a thorough geological investigation and the adoption of guidelines regarding the distance between the fracturing horizon and groundwater supply are key to eliminating this risk. Further scientific research is also required in this regard.

- **Leaks from damaged well casings:** The casing consists of multiple concentric steel pipes, which are cemented in the ground to create a barrier between the rocks and the borehole. The correct construction, performance and maintenance of this geometric structure are imperative to preventing any leaks.

- **Spillages at the surface:** Often overlooked, spillages represent the main contamination risk, according to specialists. Trucks are used in fracking operations and for the transport and storage of water, and spillages can happen at any point during these activities, potentially seeping into the ground and entering nearby waterways, as well as possibly contaminating soils.[4]

Water treatment and disposal
Effective treatment solutions are required for the enormous amount of flowback water in order to reduce demand for freshwater and disposal sites. Of all the currently available solutions, filtration and reverse osmosis are the most common. In some instances, purification is so effective that the water can be discharged into local waterways, although costs increase accordingly. In areas in the USA where strict water treatment policies are not in force, these fluids are often disposed of partially treated in deep underground wells (disposal wells) at depths of approximately 4 to 5 km.

Induced seismicity/earthquake risk
The rock fracturing process generates small seismic events of a very low magnitude (microseismicity), which are not generally felt by humans. However, in areas with a seismic history and/or specific geological conditions, the injected fracking fluid can facilitate sliding movements of pre-existing faults and trigger major events. Investigating stress conditions and geological structures and prohibiting hydraulic fracturing in specific areas would lower this risk significantly.

Induced seismic events are common during coal mining, oil and gas activities and geothermal power generation. The traffic light system, a risk mitigation technique originally developed for geothermal, is also being proposed for shale gas.[5] This warning system entails real-time monitoring of seismic events, and operations are stopped if an amber- or red-light event is detected. It is also worth noting that some seismic events recorded in the USA were caused by the injection of flowback water into disposal wells rather than the fracking operations themselves.

Gas emissions
Methane, the main component of shale gas, is a powerful greenhouse gas, which contributes much more than CO_2 to global warming despite its relatively short lifetime (i.e. 84 times as much as CO_2 in a 20-year timeframe). Methane leaks at any point of the gas supply chain (from pre-production to distribution) could therefore have serious environmental implications. These 'fugitive emissions' are an issue for both conventional and unconventional gas exploitation, albeit to different degrees. In the case of shale gas they are estimated to range between 1% and 8% of total production.[6] This issue has not been comprehensively investigated yet, but the knowledge gap is beginning to be closed through cooperation between industry, scientists and governments.[7] Moreover, recent studies have demonstrated the potential release of Volatile Organic Compounds such as ozone and benzene, which are often present in natural gas and represent a serious human health hazard.

Other concerns
Europe's higher population density compared to the USA is also seen as a major obstacle to shale gas development. It is true that to keep production constant, shale gas exploitation requires a larger number of wells to be drilled and, therefore, more land utilisation and disturbances for local communities. Nevertheless, due to technological innovation in horizontal drilling and multi-well pads, the number of rigs is decreasing to levels closer to conventional gas extraction.[8]

What role could shale gas play in the future energy system?

Carbon dioxide emissions and climate policy
Natural gas combustion generates CO_2 emissions that contribute to global warming. However, due to its chemistry, methane produces less CO_2 per unit of energy than other fossil fuels; coal combustion gives rise to about twice as many CO_2 emissions. And unlike the latter, gas combustion does not generate

harmful by-products such as NOx (nitrogen oxides) and SOx (sulphur oxides). For these reasons, some view natural gas – and unconventional reserves like shale gas – as a way to reduce overall emissions through coal substitution. In these scenarios, gas would play the role of a bridging resource towards low-carbon energy sources like renewables, while possibly also complementing the latter with flexible back-up capacity generation.

On the other hand, there are concerns that an increased supply of cheap gas would discourage the further deployment of renewables by diverting subsidies and/or reducing their competitiveness. Furthermore, as explained above, fugitive methane emissions during the gas production lifecycle can potentially offset the net climate benefits of burning gas instead of coal. Recent studies indicate that this could be the case when methane leaks exceed 2–3% of total production.[9]

Energy security and diversification
In Europe, shale gas production is often claimed to be a way to diversify the energy supply and decrease reliance on imports. Domestic production is dropping and European dependency on foreign gas, mostly from Russia, is expected to exceed 70% in the coming years.[10] Indeed, countries like Germany already import 90% of the gas they consume. The current crisis in Eastern Europe might have significant repercussions for energy security. The role of shale gas production in this context is contingent on production amounts, which are still uncertain in Europe, but it may represent a way to at least maintain current levels of domestic gas production. In any case, current analysis indicates that even if Europe were to exploit all of its available shale gas resources, it would still not achieve self-sufficiency.

Economic implications
The potential economic benefits of shale gas exploitation, from job creation to increased revenues for local communities, are still being debated. In the USA, another important consequence has been the significant drop in the gas price (down by 60% in the period from 2008 and 2014), which has benefited energy-intensive industries in particular. Yet, persistently low gas prices have been negatively affecting the profitability of most shale plays, especially where well recovery rates have not met expectations. This has created financial burdens for operators, who are trying to repay loans by launching further drilling activities despite a highly uncertain return on investment. In the short term, this is keeping production levels high, but the tendency is likely to be reversed in the future. Identifying the exact role of shale gas exploitation in US economic performance over the last decade remains a complex task. And any lessons learned from this experience are of limited use in Europe, due to differences between the two regions in terms of geology, gas reserves, infrastructure, markets and legislation. It is highly unlikely that Europe will replicate the US shale gas 'boom'.

Furthermore, the economics of shale gas are also linked to other fossil fuels markets – on a global scale – with implications for energy and climate policy. For instance, the availability of cheap gas in the USA has led to a partial displacement of coal in the electricity mix. Thus, unused coal is being exported elsewhere – and particularly to Europe – bringing down global coal prices. As a result, US domestic reductions in CO_2 emissions through coal-to-gas switches are to some degree offset by these 'exported' emissions, raising issues with regard to the international coordination of climate policies.[11]

Finally, shale projects in the USA also have consequences for oil markets (and vice versa), due notably to shale oil production, which has been a factor in the global fall in oil prices. As such, the shale gas 'boom' contributes in complex ways to the decrease in fossil fuels prices worldwide, a trend that can hinder global warming mitigation strategies (e.g. by reducing the cost competitiveness of renewables). In Europe, the slump in global oil prices has led to lower EU gas prices because most liquefied natural gas is still indexed to oil, like much of the gas pipelined to European countries. Yet here, gas-fired generation is still unable to compete with coal generation. At the same time, depressed gas prices on the EU spot market call into question the future feasibility of shale gas projects, since the break-even price for shale gas would be higher than current gas prices. Therefore, the future competitiveness of EU shale gas projects strongly depends on spot prices in the region, and, in turn, on international oil and gas market dynamics.[12]

What is the current status of shale gas development in Europe?

According to current geological knowledge, shale gas reserves are widespread across Europe, with Gas in Place (GIP) estimates equal to 37.6 tcm for England, 13 tcm for Germany, 2 tcm for Spain, and approximately 5 tcm for Poland. Technically recoverable reserves usually range between 10% and 20% of GIP. Sizeable reserves are also present in France, Ukraine, Bulgaria and Romania, although national studies confirming this potential have not yet been conducted. In some shale reservoirs, shale oil is also present.

- **Poland:** To date, this is the only European country where active exploration has been carried out. About 60 exploratory wells have been drilled in the last 5 years, with only the latest wells offering prospects of success. Although the Polish Government has announced that commercial production could begin soon, the real timescale is likely to be more protracted. In the next few years the true potential of Polish shales will need to be elucidated.

- **United Kingdom:** Shale gas exploitation is strongly supported by the current government, and the legislative framework is in the process of being designed. The results of a licencing round conducted in 2014 for drilling licenses are due to be announced by the end of 2015. Patchy public acceptance coexists with active opposition from environmental NGOs and a call for more environmental controls from opposition parties.

- **Germany:** Currently, there is no regulation dealing specifically with fracking for shale gas, but the relevant authorities do not generally grant licenses. A single exploration well was drilled and fracked by ExxonMobil in Lower Saxony (north-western Germany) in 2008/2009. Public opposition to fracking remains strong and is fuelled in particular by negative environmental experiences in the USA. The German Government recently proposed a bill establishing a regulatory framework for shale gas fracking, which is currently going through the legislative process and should be adopted in late Summer 2015. As it stands, this new law would authorise fracking for pilot tests aimed at assessing environmental implications. Strict conditions (e.g. with regard to fracking fluids or the eligible areas) would have to be respected, while the use of shale gas fracking for commercial purposes would remain prohibited, at least until the results of the pilot studies are examined in 2018. However, criticisms have been raised regarding some points, and amendments might be introduced by parliament.

The next emerging country could be **Romania**, where exploration campaigns were authorised in late 2013. **France** and **Bulgaria** have enacted a moratorium on shale gas exploration, while the political discussion in **Spain** is still at an early stage. In **Ukraine**, shale gas development plans have been shelved due to the crisis with Russia.

The exploitation of shale gas in the USA has often been criticised for lacking adequate procedures and regulations. In European countries, legislation and enforcement is expected to be much stricter, and all risks must be adequately investigated before any exploration takes place. In January 2014, the European Commission recommended minimum principles to ensure climate and environmental safeguards. Member States that wish to explore domestic shale gas reserves would have to legislate for these principles.

[1] As a comparison, global gas consumption currently amounts to 3.4 tcm/year (of which 0.45 tcm for Europe), and is forecasted to rise to 5.4 tcm by 2040.

[2] More precisely, fracking is sometimes used in 'conventional' wells (tight gas, for instance), but in this case a smaller amount of water is required than for shale gas extraction.

[3] Since shale resources often lie in horizontal layers, this technique allows for a wider exploitation than that afforded by vertical wells only.

[4] EASAC, *Shale gas extraction: issues of particular relevance to the European Union*, October 2014.

[5] The Royal Society and the Royal Academy of Engineering, *Shale gas extraction in the UK: a review of hydraulic fracturing*, June 2012.

[6] Howarth et al., A *bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas*, in : Energy Science and Engineering, 2(2): 47–60, 2014.

[7] See, for instance, this project coordinated by the Environmental Defense Fund: http://www.edf.org/methaneleakage

[8] Ibid., 4.

[9] See World Resources Institute, *Clearing the Air: Reducing Upstream Greenhouse Gas Emissions from U.S. Natural Gas Systems*, Working Paper, March 2013, and ibid., 4.

[10] European Commission, *Energy Challenges and Policy*, Commission contribution to the European Council of 22 May 2013.

[11] Broderick, J., Anderson, K., *Has US Shale Gas Reduced CO_2 Emissions?*, Tyndall Centre for Climate Change Research, October 2012.

[12] European Commission, Joint Research Centre: *Unconventional Gas: Potential Energy Market Impacts in the European Union*, 2012.

SUMMARY

■ In the last decade, the hydraulic fracturing technique has been used in North America to commercially exploit shale gas. While proponents of this technique highlight possible benefits in terms of energy security, prices, employment, and revenue, others point to negative experiences and environmental risks.

■ Fracking is associated with a number of environmental hazards, including groundwater contamination, risks arising from flowback water treatment/disposal, and induced seismicity. Adequate regulation and enforcement frameworks can help to mitigate these risks.

■ High levels of uncontrolled methane emissions over the entire shale gas production lifecycle can offset the net climate benefits of methane combustion in comparison to coal.

■ In Europe, shale gas exploration is currently being carried out in Poland only, and the future economic feasibility of these activities has not yet been conclusively demonstrated. In Germany, the parliament is in the process of defining a law regulating fracking, which is likely to be passed in the summer of 2015.

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