Exploitation Of Shale Gas And Hydrogeological Risks Assumed

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Abstract

The shale gas exploitation project has two main stages, exploration and production, taken in five steps: identification of the gas resources, early evaluation drilling, pilot project drilling, pilot production testing and commercial development. A preliminary identification of potential risks for environment and human health arising from a shale gas exploitation focus maximum impact on groundwater, surface water and water resource.

Maximum impact on water is connected almost exclusively hydraulic fracturing technique that allowed commercial shale gas extraction to commence in 2002/2003, in United States. Hydraulic fracturing is also used for vertical wells in conventional oil and gas formations. This technique maximizes the rock area that, once fractured, is in contact with the well bore and so maximizes well production in terms of the flow and volume of gas that may be collected from the well.

To drill and fracture a shale gas well two steps are required:

- *Drill down vertically until reach the shale formation*
- *Drill horizontally or an angle to the vertical to create a lateral or angled well through the shale rock. A typical horizontal section can be expected to be 1200 to 3000 meters in length.*

Risks involved in using hydraulic fracturing are related to the volume of water used and the chemical additives required.

Because of the longer well lengths, higher volumes of water are required for horizontal hydraulic fracturing compared to conventional fracturing. Vertical shale gas wells typically use approximately 2,000 cubic meters water in contrast with horizontal shale gas that use 10,000 to 25,000 cubic meters per well.

High volume hydraulic fracturing requires significantly more water than current hydrocarbon extraction techniques, and could potentially enable the development of extensive shale gas plays in Europe which would not otherwise be commercially or technically viable. Consequently, attention must be focused on high volume of water used in hydraulic fracturing.

Fracturing fluids are produced by mixing into the water propane and other additives. The additives are designed primarily to modify the fluid characteristics to improve the performance of the fracturing fluid and typically includes: water (98% to 99%), friction reducer (0.025%), biocide (0.005% to 0.05%: glutaraldehyde, quaternary amine or tetrakis hydroxymethyl phosphonium sulphate), surfactants used to modify surface or interfacial tension, break or prevent emulsions (0.05% - 0.2% of total volume), scale inhibitors, corrosion inhibitor etc.

The paper presents some details on the impact of hydraulic fracturing on quality of water.

Keywords: shale gas, groundwater, hydraulic fracturing, volume of water, chemical additives.

Introduction

Technology is opening up possibilities for unconventional gas to play a major role in the future global energy mix, a development that would ease concerns about the reliability, affordability and security of energy supply.

The IEA released an analysis in June 2011 whose title asked the question "Are We Entering a Golden Age of Gas?".

The Golden Age of Gas Scenario (GAS Scenario) in 2011 built a positive outlook for the future role of natural gas on four main pillars: more ambitious assumptions about gas use in China; greater use of natural gas in transportation; an assumption of slower growth in global nuclear power capacity; and a more optimistic outlook for gas supply – primarily though the availability of additional unconventional gas supplies at relatively low cost. In the GAS Scenario, as a result, natural gas increased its role in the future global energy mix from 21% to 25% over the period to 2035.

A range of factors will affect the pace of development of this relatively new industry over the coming decades. In our judgment, a key constraint is that unconventional gas does not yet enjoy, in most places, the degree of societal acceptance that it will require in order to flourish. Without a general, sustained and successful effort from both governments and operators to address the environmental and social concerns that have arisen, it may be impossible to convince the public that, despite the undoubted potential benefits the impact and risks of unconventional gas development are acceptably small.

1. What is shale gas?

Shale gas is natural gas contained within a commonly occurring rock classified as shale, formations characterized by low permeability, with more limited ability of gas to flow through the rock. These formations are often rich in organic matter and, unlike most hydrocarbon reservoirs, are typically the original source of the gas.

Shale gas is gas that has remained trapped in, or close to, its source rock, generally at depths greater than 1500 meters (***Fig.1.1***.).

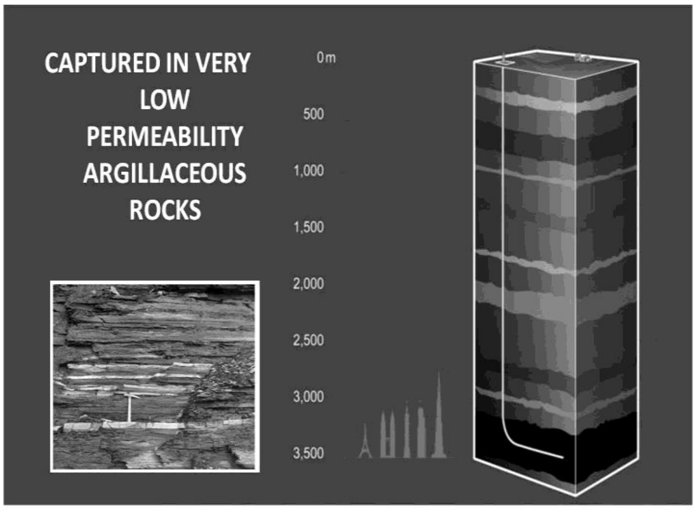

Fig.1.1. *Shale gas is occuring in shale at depths greter than 1500 meters*

As shale gas, unconventional gas resources are considered also coalbed methane and tight gas. Coalbed methane, also known as coal seam gas in Australia, is natural gas contained in coalbeds. Tight gas is a general term for natural gas found in low permeability formations. Generally, we classify as tight gas those low permeability gas reservoirs that cannot produce economically without the use of technologies to stimulate flow of the gas towards the well, such as hydraulic fracturing.

2. Shale gas: resources and production

Initial assessments of 48 shale gas basins in 32 countries suggest that shale gas resources, which have recently provided a major boost to United States natural gas production, are also available in other world regions. A new study of EIA reported initial assessments of 5,760 trillion cubic feet of technically recoverable shale gas resources in 32 foreign countries, compared with 862 Tcf in the United States.

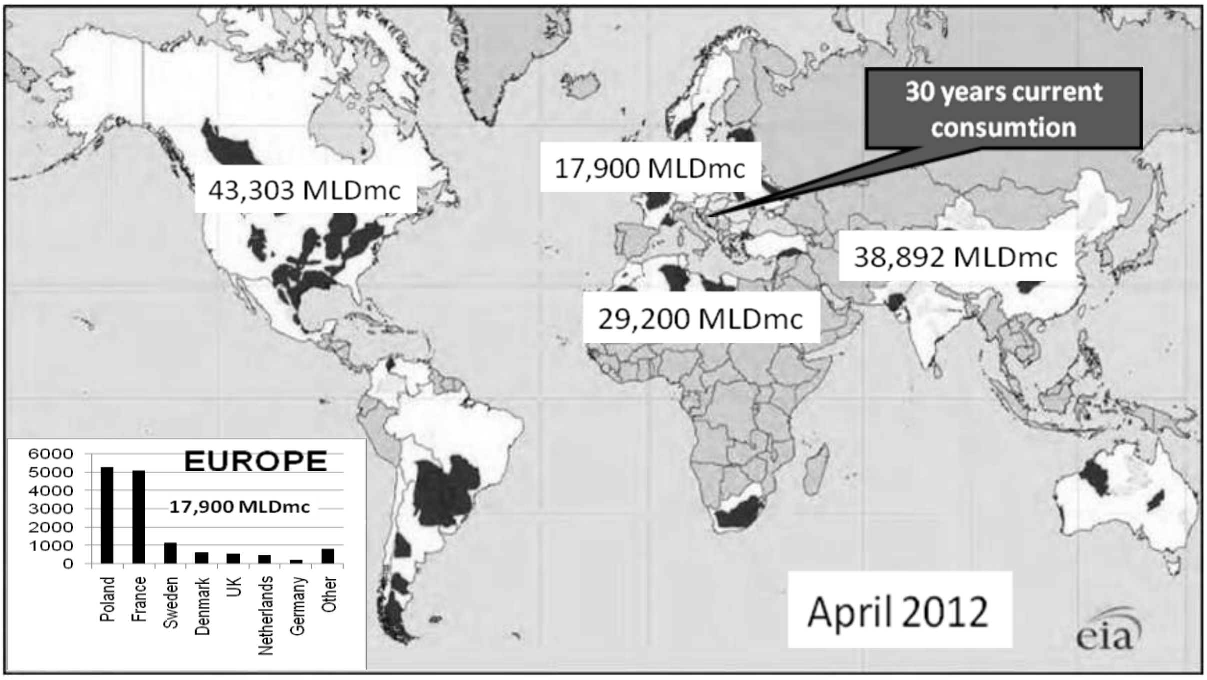

Fig. 2. *Shale gas resources (Source: U.S. Energy Information Administration based on Advanced Resources International, Inc. Data)*

Of the countries covered in the EIA-sponsored study, two groups may find shale gas development most attractive:

- Group 1: France, Poland, Turkey, Ukraine, South Africa, Morocco, and Chile (countries that currently depend heavily on natural gas imports but that also have significant shale gas resources);
- Group 2: United States, this group includes Canada, Mexico, China, Australia, Libya, Algeria, Argentina, and Brazil (countries that already produce substantial amounts of natural gas and also have large shale resources).

The United States and Canada are the only major producers of commercially viable natural gas from shale formations in the world, even though about a dozen other countries have conducted exploratory test wells, according to a study released by E.I.A. in June, China is the only nation outside of North America that has registered commercially viable production of shale gas, although the volumes contribute less than 1% of the total natural gas production in that country. In comparison, shale gas as a share of total natural gas production in 2012 was 39% in the United States and 15% in Canada.

The economic and political significance of these unconventional resources lies not just in their size but also in their wide geographical distribution which is in marked contrast to the concentration of conventional resources. Availability of gas from a diverse range of sources would underpin confidence in gas as a secure and reliable source of energy

3. Environmental risks

The development cycle for shale gas and the technologies used in its production have much in common with those used in other parts of the upstream industry, but shale gas developments do have some special features and requirements from the exploration stage to post stage operation.

The main reason for the potentially larger environmental impact of shale gas operations is the nature of the resources themselves: less concentrated and do not give themselves up easily because they are trapped in very low permeability rock. This means that drilling and production activities are considerably more invasive, involving a generally larger environmental footprint.

3.1. Exploration

One feature of the greater scale of operations required to extract shale gas is the need for ***more wells***: more than one well per square kilometer.

Another important factor is the need for more complex and intensive preparation for production. While ***hydraulic fracturing*** is already used on occasions to stimulate conventional reservoirs, shale gas developments almost always require the use of this technique in order to generate adequate flow rates into the well.

Hydraulic fracturing involves pumping a fluid– known as fracturing fluid– at high pressure into the well and then, far below the surface, into the surrounding target rock. This creates fractures or fissures a few millimeters wide in the rock. These fissures can extend tens or, in some cases, even hundreds of meters away from the well bore. Once the pressure is released, these fractures would tend to close again and not produce any lasting improvement in the flow of hydrocarbons. To keep the fractures open, small particles such as sand or ceramic beads, are added to the pumped fluid to fill the fractures and to keep open the fractures thus allowing the gas to escape into the well.

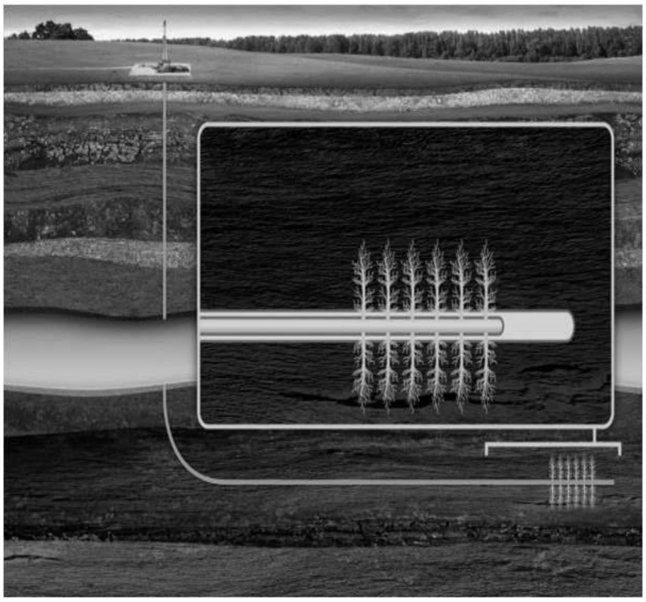

Fig.3. *Hydraulic fracturing*

A drilling for shale gas production use 10,000 to 20, 000 cubic meters of water for operating period of 2-3 months. The water is pumped with sands (99%) and some additives (1%) that promotes shale gas movement. The associated use and release of water gives rise to a number of environmental concerns, including depletion of freshwater resources and possible contamination of surface water and aquifers.

The repeated stresses on the well from multiple high-pressure procedures increase the premium on good well design and construction to ensure that gas bearing formations are completely isolated from other strata penetrated by the well.

Once the hydraulic fracturing has been completed, some of the fluid injected during the process flows back up the well as part of the produced stream, though typically not all of it – some remains trapped in the treated rock. During this flow-back period, typically over days (for a single-stage fracturing) to weeks (for a multi-stage fracturing), the amount of flow back of fracturing fluid decreases, while the hydrocarbon content of the produced stream increases, until the flow from the well is primarily hydrocarbons.

3.2. Production

Production phase begin when wells are connected to processing facilities. During production wells will produce hydrocarbons and waste streams, which have to be managed.

During production the well is less visible and only in some cases, the operator may decide to repeat the hydraulic fracturing procedure at later times in the life of the producing well, a procedure called re-fracturing. This was more frequent in vertical wells but is currently relatively rare in horizontal wells, occurring in less than 10% of the horizontal shale-gas wells drilled in the United States.

The production phase is the longest phase of the lifecycle. For a conventional well, production might last 30 years or more. For an unconventional development, the productive life of a well is expected to be similar, but shale gas wells typically exhibit a burst of initial production and then a steep decline, followed by a long period of relatively low production Output typically declines by between 50% and 75% in the first year of production and most recoverable gas is usually extracted after just a few years.

The production of shale gas also contributes to the atmospheric concentration of greenhouse gases and affects local air quality. Shale gas may contain radioactive elements still being intimately related to the clay that holds the radioactive elements, especially radon.

3.3. Post stage operation

At the end of their economic life, wells need to be safely abandoned, facilities dismantled and land returned to its natural state or put to new appropriate productive use. Long-term prevention of leaks to aquifers or to the surface is particularly important. Since much of the abandonment will not take place until production has ceased, the regulatory framework needs to ensure that the companies concerned make the necessary financial provisions and maintain technical capacity beyond the fields economic life to ensure that abandonment is completed satisfactorily, and well integrity maintained over the long term.

On the other hand, there are potential net benefits from shale gas production to the extent that, having been produced and transported to exacting environmental standards, it leads to greater use of gas instead of more carbon-intensive coal and oil.

4. Water use

The extent of water use and the risk of water contamination are key issues for any unconventional gas development and have generated considerable public concern.

4.1. How much water

In the case of a shale gas development, though some water is required during the drilling phase, the largest volumes of water are used during the hydraulic fracturing process: each well might need anything between a few thousand and 20 000 cubic meters (between 1 million and 5 million gallons). Efficient use of water during fracturing is essential.

Water for fracturing can come from surface water sources (such as rivers, lakes or the sea), or from local boreholes (which may draw from shallow or deep aquifers and which may already have been drilled to support production operations), or from further afield (which generally requires trucking). Transportation of water from its source and to disposal locations can be a large-scale activity. If the hydraulic fracturing of a well requires 15 000 cubic meters, this amounts to 500 truck-loads of water, on the basis that a typical truck can hold around 30 cubic meters of water. Such transportation congests local roads, increases wear and tear to roads and bridges and, if not managed safely, can increase road accidents.

In areas of water-scarcity, the extraction of water for drilling and hydraulic fracturing (or even the production of water, in the case of coal bed methane) can have broad and serious environmental effects. It can lower the water table, affect biodiversity and harm the local ecosystem. It can also reduce the availability of water for use by local communities and in other productive activities such as agriculture.

4.2. Water quality

Environmental concerns have focused on the fluid used for hydraulic fracturing and the risk of water contamination through leaks of this fluid into groundwater. Water itself, together with sand or ceramic beads (the "proppant"), makes up over 99% of a typical fracturing fluid but a mixture of chemical additives is also used to give the fluid the properties that are needed for fracturing.

Until recently, the chemical composition of fracturing fluids was considered a trade secret and was not made public. This position has fallen increasingly out of step with public insistence that the community has the right to know what is being injected into the ground. Since 2010, voluntary disclosure has become the norm in most of the United States. The industry is also looking at ways to achieve the desired results without using potentially harmful chemicals. "Slick-water", made up of water, proppant, simple drag-reducing polymers and biocide, has become increasingly popular as a fracturing fluid in the United States, though it needs to be pumped at high rates and can carry only very fin proppant. Attention is also being focused on reducing accidental surface spills, which most experts regard as a more significant risk of contamination of groundwater.

The treatment and disposal of waste water are critical issues for unconventional gas production– especially in the case of the large amounts of water customarily used for hydraulic fracturing. After being injected into the well, part of the fracturing fluid (which is often almost entirely water) is returned as flow-back in the days and weeks that follow. The total amount of fluid returned depends on the geology; for shale it can run from 20% to 50% of the input, the rest remaining bound to the clays in the shale rock. Flow-back water contains some of the chemicals used in the hydraulic fracturing process, together with metals, minerals and hydrocarbons leached from the reservoir rock. High levels of salinity are quite common and, in some reservoirs, the leached minerals can be weakly radioactive, requiring specific precautions at the surface.

Once separated out, there are different options available for dealing with waste water from hydraulic fracturing:

- recycle it for future use and technologies are available to do this, although they do not always provide water ready for re-use for hydraulic fracturing on a cost-effective basis.
- treat waste water at local industrial waste facilities capable of extracting the water and bringing it to a sufficient standard to enable it to be either discharged into local rivers or used in agriculture. Alternatively, where suitable geology exists, waste water can be injected into deep rock layers.

Conclusion

Central factor in assessing the impact of shale drilling is water on both quantitative and qualitative aspects (Table 1.).

Significant concern has been expressed about the potential for contamination of water supplies, whether surface supplies, such as rivers or shallow freshwater aquifers, or deeper waters, as a result of all types of unconventional gas production. Water supplies can be contaminated from four main sources:

- Accidental spills of fluids or solids (drilling fluids fracturing fluids water and produced water, hydrocarbons and solid waste) at the surface.
- Leakage of fracturing fluids saline water from deeper zones or hydrocarbons into a shallow aquifer through imperfect sealing of the cement column around the casing.
- Leakage of hydrocarbons or chemicals from the producing zone to shallow aquifers through the rock between the two.
- Discharge of insufficiently treated waste water into groundwater or, even, deep underground.

Table 1. *Summary of preliminary risk assessment*

Environmental aspects	EXPLORATION AND PRODUCTION STAGES OF THE SHALE GAS EXPLOITATION PROJECT						
	Site identification	Well drilling, casing and cementing	Fracturing	Well completion	Production	Well abandonment	Overall impact
Groundwater	N/A	LOW	MOD-HIGH	HIGH	MOD-HIGH	N/A	HIGH
Surface water	LOW	MODERATE	MOD-HIGH	HIGH	LOW	N/A	HIGH
WATYER RESOURCE	N/A	ZERO	MODERATE	N/A	MODERATE	N/A	MODERATE
AER	LOW	MODERATE	MODERATE	MODERATE	MODERATE	LOW	MODERATE
SOL	MEDIU	N/A	N/A	N/A	MODERATE	N/A	MODERATE
BIODIVERSITATE	N/A	LOW	LOW	LOW	MODERATE	N/A	MODERATE
TRAFIC	LOW	LOW	MODERATE	LOW	LOW	NUL	MODERATE
PEISAJ	LOW	LOW	LOW	N/A	LOW	LOW	R-MODERATE
ZGOMOT	LOW	MODERATE	MODERATE	N/A	LOW	N/A	R-MODERATE
SEISMICITATE	N/A	N/A	LOW	LOW	N/A	N/A	LOW

BUT NONE of these hazards is specific to unconventional resources; they also exist in conventional developments, with or without hydraulic fracturing.

However, unconventional developments occur at a scale that inevitably increases the risk of incidents occurring.

Exploitation of shale gas can be achieved with existing technology no greater risk than conventional gas or oil if procedures are complied with rigorous execution

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