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A Review

Is Hydraulic Fracturing a Threat for Drinking Water Resources?

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Abstract

The aim of this paper is to briefly emphasize the shale gas technology of extraction and because the important role of water within this process, the imperious need to preserve the water quality. If rigorous geological prospects indicate the presence of gas in shale, it is extracted using the hydraulic fracturing technology. The water delivered by tank trucks mixed with sand and additives is injected into a well, at near 1,500 m, under high pressure, from a pumper truck, through a probe (lined with several layers of steel and cements for protecting the groundwater of the fluids that are pumped through the probe and also of the natural gas that is released and collected inside the well). For obtaining gas from shale, holes are horizontally made in stainless steel and cement casing of the probe up to shale, and gas is extracted from the fractures with steel pipes. The reflux water is conducted to depuration stations in order to be cleaned and reused (about 10 – 30% is recycled). The residues (wastewater and solids) resulted from depuration process are stored in special facilities designed and built with aim of waste storage. Usually, such a well is productive for several decades. Complete exploitation of such facility needs about 10,000 – 20,000 m^3 water. By comparison with other types of fuels, the ratio water volume used/unit of energy, is the lowest for shale gas production. The negative experiences worldwide, concerning environmental protection, with accent on water issue, must be taken into consideration if Romania would implement hydraulic fracturing technology in order to obtain shale gas, especially focused on total accomplishment of exploitation standards and regulations.

Keywords: well, drill, groundwater, additives, depuration.

1. Introduction

The problem of energetic security is already a common place for discussions at highest levels worldwide. It is well known that the process of originating of one of the most important energetic resources, natural gas, respectively, consists in burying organic matter inside Earth's surface, under genuine conditions of heat, and pressure.

The final product results after bacteria action that turns organic matter first into oil, then under severe thermic conditions from underground, the oil in natural gas [2].

It is, practically, a mixture made up of different components, function of the region where reservoir is placed.

About 85% is methane, 4% alkanes (e.g. ethane, propane, butane, propane, etc.) and inert gases as vapors of condensed gases (also called wet gases), sulphured hydrogen, or carbon dioxide that diminishes gaze quality [2, 3].

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Even Romania has important conventional natural gas resources, the share of export dependence is about 30%, ourdays, and future perspectives are not optimistic. For this reason, finding new, unconventional, natural gas sources is an imperative for Romania, too [7]. Such a source seems to be the shale gas. Apart from conventional gas sources (where gas is held in a pocket beneath rock layer), the shale gas is trapped in the pores of shale rocks. In this way, the extraction of the shale gas is a more difficult process. Because geological estimations, previously performed, emphasize that Romania has important shale gas resources, the national authorities granted Chevron (an important American company) to make further prospects in the future five years in East and South – East Romania (Moldavia and Dobrogea) in order to exploit the targeted sites [7]. But taking into account the American experience, serious concerns arise from this type of exploitation, and one of the most important is the water quality [1].

The technology of the shale gas extraction

The extraction of shale gas is performed using technologies already practices, directional drilling and hydraulic fracturing, respectively.

Even hydraulic fracturing was discovered in the first years of the former century, it is a technology commercially applied for the first time only in the end of the 40's.

It was initially developed for improving the oil and gas extraction, but it was also used for other aims as: improving drinking water drilling, waste disposal, or valuation of geothermal sources for obtaining electricity [2, 3, 6, 7].

Process description

The water needed for the fracturing process is delivered by tank trucks. Water with sand and additives is injected into the well, under high pressure, from a pumper truck, through a probe drilled vertically from a few thousand meters deep. High pressure is used with the aim of producing fissures in shale [8].

The probe is lined with several layers of steel and cements that isolates it of water resources and geological formations.

These layers act as a barrier protecting the groundwater of the fluids that are pumped through the probe and also of the natural gas that is released and collected inside the well.

At the time the probe is drilled to the needed depth, horizontal drilling is performed over a distance of nearly 1,500 m [1, 3, 8]. In order to obtain deployed gas from shale, small perforations (holes) are horizontally made in stainless steel and cement casing of the probe up to shale, using an electric pistol, and gas is extracted from the fractures with steel pipes introduced in wells with this aim (fig. 1).

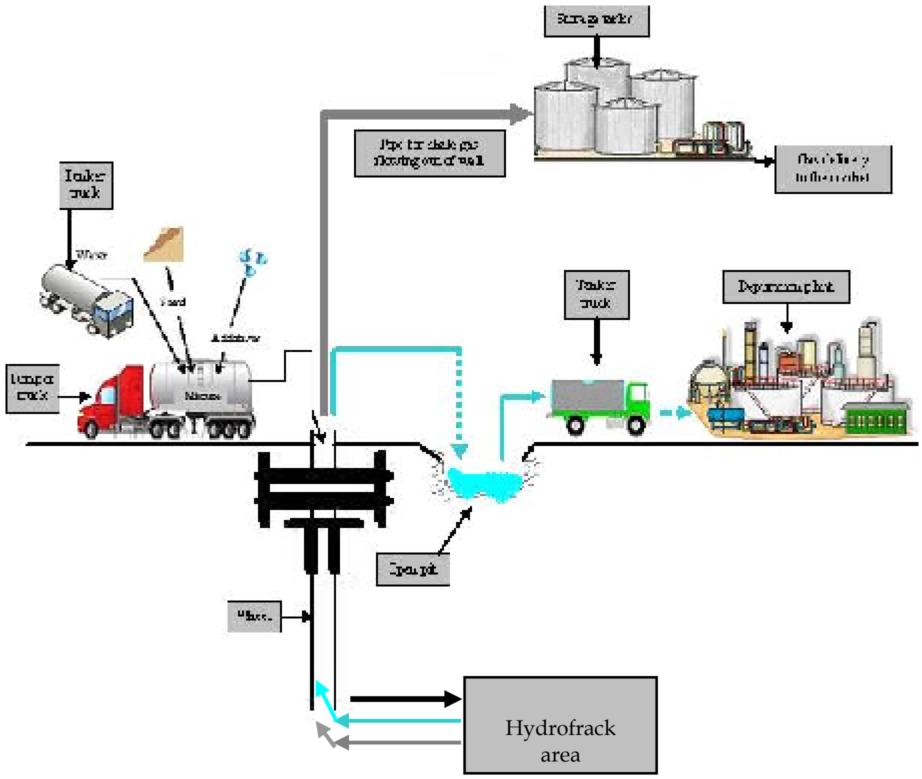


Figure 1. The technological flow of a shale gas extraction process

When the drilling ends, the steel casing is insert in the horizontal section of the probe [2, 8]. Then, around the probe length cement is introduced, in order to supply permanent cover. Thus, any leakage of gas or liquid is prevented when they are brought to the surface [1, 8]. The reflux water is conducted to depuration stations in order to be cleaned and reused (about 10 – 30% is recycled). The residues (wastewater and solids) resulted from depuration process are stored in special facilities designed and built with aim of waste storage [4, 5]. The facility is considered completed when gas is collected to the surface. All operations needed for making functional such exploitation may last about five years. Then, a series of measures are taken in order to reduce to minimize the process impact upon the environment. Majority of initial area is rearranged in similar manner to its initial shape [1, 6, 8]. Usually, the well is productive for several decades, and all this time, about one hectare remains occupied by the exploitation (water tanks, probes, and pipes).

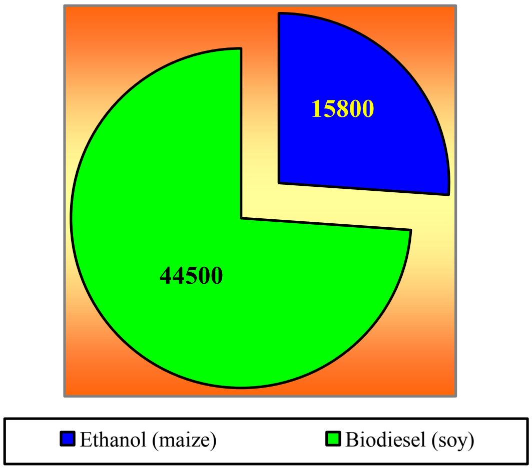
The water issue

The technology of the shale gas exploitation confronts with a special issue, water, respectively. Here we deal with important environmental standards and imperious need of professional management of the water resources. The water is used in two technological steps, drilling and hydraulic fracturing. The last step is the essential step of the technology, because is generates the end product, the shale gas, respectively [8].

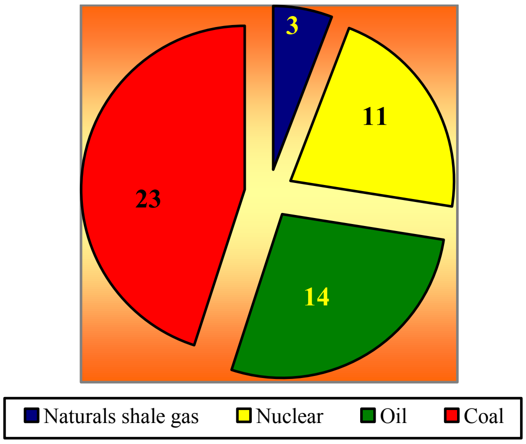
Complete exploitation of such facility needs about 10,000 – 20,000 m^3 water (facility construction, and use - about several decades -). By comparison with other types of fuels, the ratio water volume used/unit of energy, is much lower for shale gas production (fig. 2). A series of possible water resources are taken into consideration when shale is used as gas resource. Among these, we mention: surface waters (rivers and lakes), treated residual water, depth aquifers with salt water, recycled water resulted from previous fracturing operations, or even water resulted from special drilling performed with aim of supplying resources for shale gas exploitation [1, 4, 5].

Usually the selection of water resources depends on water quality, availability, and geological traits of region to be fractured [1, 3].

The fluid used by the technology of hydraulic fracturing is pumped at high pressure in order to allow gas to get into the probe well and from there to the surface as consequence of fractures produced by the liquid pressure in the rock [2, 4]. The fluid is made up of water, sand – 99.50%, and additives – 0.50% (fig. 3), designed for different purposes. The role of the sand is to maintain the fractures open in order to allow gas leakage, while additives have several roles (e.g. to facilitate sand penetration) [4, 5, 7].



a. The ratio water volume (L)/ unit of energy (kWh) for ethanol obtained from maize, and biodiesel from soy



b. The ratio water volume (L)/ unit of energy (kWh) for natural shale gas, coal, oil, and nuclear sources

Figure 2. The ratio water volume (L)/ unit of energy (kWh) for fuels obtained from different sources

The water used for the extraction process is recycled, but a total recycling is not yet possible. In order to solve the important problem of resulted wastewater, a series of solutions are available: injection in authorized pits located at long depth inside earth rock layers, transportation towards authorized storage devices – wastewater tanks (fig. 1) [1, 4, 5, 7]. Usually, the hydraulic fracturing is a process developed at several kilometers depth, so fracturing processes are developed at a distance of thousands meters of rock from groundwater pools. Even though, the fracturing process could have important consequences upon water quality, while additive presence in fracturing water may have unwanted effects upon water resources. For these reasons, the complex implications of fracturing water composition are a continuous challenge for preservation of groundwater quality in fracturing area and surroundings [3, 5]. In order to minimize the contamination risk several methods must be taken into consideration: correct concept of probes design, casing the probes and well with several layers of stainless steel and cement (for preventing gas deployment through the well into groundwater), performing periodic pressure tests upon well cases during all exploitation period [1, 4, 5, 7, 8].

Figure 2. The composition of fracturing fluid (water, sand, additives), according to EPA data concerning energy [5]

A special attention is focused on improving the fracturing recycled water yield [4, 6].

Conclusion

In this way the need of fresh water in fracturing process could be reduced, in the same time with reducing the wastewater volumes.
Experience emphasizes that the problem of shale gas impact upon environment still is an open one, even shale gas exploitation has important social benefits, as creation of work places well remunerated, increased income for equipment producers, etc. Much more, the water issue, as special component of the fracturing technology remains most vulnerable. Even theoretically all measures are taken - from design, construction solutions to official regulations, procedures and standards – the practice is not always in compliance to them, and harmful effects upon environment are the consequences [3, 8]. Thus, the negative American experiences in the field, with accent on water issue, must be taken into consideration if Romania would implement this technology, especially focused on total accomplishment of exploitation standards and regulations.

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