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ENVIRONMENTAL IMPACT OF HYDRAULIC FRACTURING TREATMENT PERFORMED ON THE ŁEBIEŃ LE-2H WELL

Report summary[1]

Shale gas is natural gas entrapped in rock (shale) layer occurring at large depth. Resources of shale gas are related to shale parent rock that is impervious so the gas cannot flow through the rock as in other formations.

At the core of shale gas development at commercial scale are advances in development of two key technologies: hydraulic fracturing (used mainly for enhancing production of conventional gas till the end of the 1990s) and horizontal drilling

Main goal of studies

The major aim of works of a consortium led by the PGI-NRI was to assess environmental impact of hydraulic fracturing carried out in August 2011 on the Łebień LE-2H exploratory well operated by the Lane Energy Poland company of the 3Legs Resources Group.

The works were ordered by the Ministry of Environment in agreement with the operator.

The studies comprised seismic monitoring, measurements of gaseous emissions and noise and analyses of soil gas, hydraulic fracturing fluid and surface and ground water.

In that well, the hydraulic fracturing of a horizontal section has been performed for the first time in Poland. The authority to drill that well was granted in the license no. 16/2007p for prospecting and exploration of unconventional gas resources. The hydraulic fracturing operations were conducted in accordance with Annex no.1 to the Work Plan approved by the Director of the Regional Mining Authority in Poznań.

Location and parameters of the well

The Łebień LE-2H well is localized at Rekowo, Nowa Wieś Lęborska commune (Pomeranian Voivodeship). The well site area is 3.74 hectares in size, situated by the road from Łebień to Rekowo Lęborskie. The drilling rig has its own water intake to cover needs for cooling and hydro-fracturing operations. The site is situated far from any areas under legal protection.

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Within the frame of exploratory works, a vertical well named LE-1 was made down to 3.5 km depth and hydraulic fracturing treatment was performed on a small scale. Drilling of the second well with a horizontal section was completed in June 2011. Total depth of the well is 4,075 m and the horizontal section is 1,000 m long.

The hydraulic fracturing was performed in the horizontal section of that well on August 19-28, 2011.

Results of studies

The hydraulic fracturing treatment did not generate any air pollution. Some increases of noise level were noted in time of hydraulic fracturing. The studies did not show any impact of the treatment on quality of surface and ground water nor decrease in ground water resources in the well site which would result from water consumption for the needs of the operation. The treatment also did not result in any ground vibrations or shaking which could create risk of damage for buildings or infrastructure.

[1] Full report is available at the **www.pgi.gov.pl**

Air

The hydraulic fracturing treatment did not generate any air pollution. The released gas was neutralized at well flare stack by oxidation of hydrocarbons and accompanying gases.

Diesel engines used to run the operation were found to be an effective source of air pollution. However, measurements taken in windward, potential stream of exhaust gas showed that permissible levels were not exceeded.

Noise

Work of high power diesel engines was the major source of noise. Temporary increases in noise levels as measured at the fencing on the well site were equal 77.5 dB. Taking into account the background values and time of work of engines, the balanced noise level was estimated at 76 dB. Along with distance from the sources, the noise level was decreasing down to about 53.8 dB in proximity of village houses, that is values not exceeding permissible levels for daytime hours (56dB).

Soil gas

The hydraulic fracturing treatment did not generate any noticeable changes in composition of soil gas, especially in concentration of methane and radioactive radon. The presence of methane was also not in aeration zone of water intake in the well site area. It follows that the hydraulic fracturing treatment did not open routes for migration of gas from deep-seated horizons in the well area and even in direct proximity of the drilling rig.

Landscape

The Łebień LE-2H well became an element of landscape of the Nowa Wieś Lęborska commune for several months. In opinion of the local community, the well was not blemishing the beauty of the landscape in any significant way whereas flame rising over flare stack turned to be some kind of tourist attraction.

At present the well site is set in order and all the unnecessary equipment such as well derrick and mobile reservoirs removed. Wellheads of the two wells are secured and under protection for 24 hours.

The impact of the operations on land surface was mainly due to load of the whole drilling equipment and materials brought to the well site. The loading was temporary and it seems that it did result in any larger changes.

Ground vibrations

The hydraulic fracturing treatment did not result in any ground vibrations or shaking which could create risk of damage for buildings or infrastructure.

Waste

The treatment resulted in origin of small amount of solid waste which were disposed at the recultivated communal waste landfill. In large part the solid waste consists of unused quartz sand.

Used fracturing fluids that return to the surface appeared to be changeable in properties but generally characterized by significant content of chemicals and toxicity. These flowback fluids were under strict control which precluded any leaks to the environment. The recycling of flowback fluids made possible reuse of their large part in other hydraulic fracturing jobs and, in this way, saving water. Some liquid waste was sent to be subjected to specialized treatment methods.

Surface water

The studies did not show any impact of the treatment on quality of surface water. The hydraulic fracturing did not influence hydrological conditions in areas adjacent to the well site. There were no complains which would concern fluid waste discharge

Ground water

Large quantities of water for technical purposes were stored in surface reservoirs. Therefore, despite of the use of almost 18,000 m^3 from the water-bearing horizon, the hydraulic treatment did not resulted in decrease in ground water resources in the well site area. This was due to the fact that water was gathered for several months in quantities consistent with the water rights permit.

The results of studies and measurements made till the second half of October 2011 did not show any adverse effects of the operations on ground water. Quality-control results for ground water in intake located in the well site area, that is at the point closest to the well, did not show an deterioration. All the operations carried in the well site area in that period (recycling of flowback fluids, storage of waste in leak-proof reservoirs, protection of land surface with concrete plates and liners made of plastic film) were conducted in a way minimizing risk of negative impact on ground water. No failures or breakdowns were reported possibilities to take place in the course of hydraulic fracturing operations.

Taking into account hydrogeological conditions in the Łebień area, it is recommended to continue control measurements of selected physico-chemical indices at points localized along direction of ground water flow.

Hydraulic fracturing – description of technology used by the operator

The hydraulic fracturing operations on horizontal section of the well were carried out on August 19-28, 2011. The treatment comprised 13 intervals 45–50 m long. Each interval was subjected to treatment involving clean-up of what was left of the damaging material near well bore area, intensification of flow and sealing. The hydraulic fracturing of individual intervals was performed in 14 steps differing in length of time, quantity of injected fluid and type and proportions of addition of proppants, in accordance with the accepted program. The operations were carried out using 17,322 m^3 of water, 462 m^3 of a variety of other fluid additives and 1,271 tonnes of proppants.

After drilling through and removal of all the well bore plugs, pressure gradient started to be reduced in order to initiate gas flow. About 248 633 nm^3 of nitrogen were pumped into the borehole, resulting in flowback of fluids and inflow of gas. All the operations gave 2781 m^3 flowback fluid which was subjected to treatment in separators, settling tanks and filter stations installed in the well site area and subsequently stored in leak-proof basins used earlier to gather reserves of technological water. After the end of the operations the fluid was transported to another well site area for use in hydraulic fracturing treatments.

Methodology of studies of environmental impact

In order to assess environmental impact of hydraulic fracturing, all the stages of that treatment were analysed – from preparatory works through the hydraulic fracturing stage to mounting the well head.

Seismic monitoring

Seismic monitoring was conducted by the Institute of Geophysics of the Polish Academy of Sciences. Measurements were taken from July 15 to September 30, 2011 which made it possible to determine the level of of intensity of seismic disturbances before and during the hydraulic fracturing and record seismic events which could take place with some delay. The studies were carried out using 10 mobile seismic stations spaced in distances from 1 to 25 km from the well site.

Gaseous emissions

Measurements of concentrations of gaseous pollutants in air and noise level were made by the Voivodeship Inspectorate for Environmental Protection in Gdańsk. .

The indicators selected for assessing potential pollution included: sulfur dioxide, nitrogen oxides, benzene, methane, carbon oxide and hydrogen sulfide. Measurements were taken using Draeger CMS mobile analyser. The measurements were taken three times: on July 19, August 19 and September 30, 2011, and at different places.

The measurements were supplemented with those made using the passive measurement method which makes possible determination of much lower concentrations of selected indicators of air pollution. That method is connected with continuous sorption of pollutants from air throughout one month exposition. Indicators selected for these studies included sulfur dioxide, nitrogen dioxide and benzene.

Measurements of noise level

Measurements of noise level were made at three measurement points in order to trace changes related to emission and propagation of sound waves in the studied area.

Soil gas – radon

In order to check hypothesis of potential health risk due to migration of radon from the shale formations, the PGI-NRI team measured concentrations of radon (^{222}Rn) in soil gases on July 19 and 20, that is before the start of the hydraulic fracturing treatment. The measurements were taken again at randomly selected points on October 13. Gas samples were taken using drive samplers pushed into the soil down to 0.8 m depth. The collected samples of soil gas were analysed using Radon Detector LUK-3B mobile device.

Soil gas – methane

In order to get background values from before the start of the hydraulic fracturing, the PGI-NRI team took measurements of of methane concentration in soil gas. The measurements were taken using Seitron mobile methane gauge.

Directly after completion of the hydraulic fracturing, specialists from the Oil and Gas Institute in Cracow sampled the same points for laboratory analyses of chemical composition and isotopic ratios of carbon from soil gases. They also took gas samples from the well to compare characteristics of original shale gas and organic compounds from soil gas. The analyses were carried out to identify eventual presence of shale gas in the soil gas after the treatment and to give the basis for such identifications in the future.

Fluids and waste

In the course of hydraulic fracturing treatments and gas tests, the team studied these technological processes and gathered data on quantities of water used in the treatments and monitored quantities and quality of water stored in technological reservoirs. Moreover, samples of the injected fluids (hydrochloric acid and hydraulic fracturing fluid) were taken for chemical and toxicological analyses.

Chemical analyses of the fluid samples were made in the PGI-NRI Central Chemical Laboratory in Warsaw and ecotoxicity analyses – in the Biology Division of the Faculty of Environment Engineering, the Warsaw University of Technology.

Surface water

Quality analyses of surface water were carried out by the Voivodeship Inspectorate for Environmental Protection in Gdańsk. The measurement point was located at Kisewska Struga Creek, downstream of Brzeźna Lęborskie. The pollution indicators selected for the study and determined in the Inspectorate Laboratory in Gdańsk included: pH, dissolved oxygen, $B.O.D._5$, chlorides, sulfates, sodium, potassium, sum of nitrate and nitrite nitrogen, Kjeldahl nitrogen, total nitrogen, Total Organic Carbon (TOC), sum of hydrocarbons $C_{10} – C_{40}$, boron, detergents anion and non-ionic detergents and sulfides.

Ground water

The studies on impact of hydraulic fracturing operations on ground water were carried out by the staff from Warsaw headquarters of the PGI-NRI. The analyses covered 17 drilled water wells and dug wells. The information from the PGI-NRI data base and results of field studies made it possible to developed a ground water flow model model for the Łebień well area. The studies made it possible to simulate the ground water flow and determine directions and velocities.

Translation Wojciech Brochwicz-Lewiński