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Hydraulic Fracturing and Wellbore Integrity Risks

Implications for Québec Legislation

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Preamble

In the development, formalization, and enforcement of Regulatory Statutes governing possible future development of oil and gas in the Province of Québec, a broad awareness of issues is needed to avoid issuing too restrictive rules, suppressing positive aspects of development, or too lax rules, leading to social or environmental outcomes that have genuinely negative impacts. Furthermore, because of rapidly evolving technology, as well as progressive knowledge acquisition during the resource development process, it is important to strike a balance between proscriptive regulations that may inhibit technology implementation and regulations that are too liberal and could lead to abuse. These are important challenges that the Committee clearly recognizes. They are core aspects of the legislative goals of the Act that the Quebec Parliament seeks to implement.

In this discussion, the following definitions are followed:

Drilling and **Completing** a well refers to the process of drilling a borehole, and cementing appropriate steel casings into place as required by the regulations to protect surface waters and the resource at depth.

Hydraulic Fracturing is the process of forcing a fluid into the rock at high pressure to open fissures in the rock which can promote the flow of fluids (generally oil and gas) to the wellbore.

Decommissioning is the process of permanently shutting down and plugging a well in a manner required by the regulatory agency, generally involving the placement of a series of cement plugs within the steel casing and guaranteeing that there are no detectable leaks.

What is Risk in Resource Development?

The concept of risk is understood differently by engineers and by the public.

To an engineer, risk is the combination of probability and consequence. The 1663 Charlevoix earthquake, estimated at 7.3 to 7.9 Richter magnitude, caused extensive damage. This was a RARE EVENT, but with SEVERE CONSEQUENCES. Engineers consider the Charlevoix region to be a region of high earthquake risk, even though events are rare. In contrast, for well-understood scientific reasons, earthquakes accompany all hydraulic fracturing operations, but they are small in magnitude; rarely can they be felt at the surface. Thus, despite a certainty of earthquakes during fracturing operations, engineers consider risks to be minimal because the consequences are extremely low.

It is important to include both probability and consequence in any risk assessment. Once these are estimated for the subject being studied, more rational decisions can be made.

All industrial developments carry risks, and the role of the government and the regulatory agencies is to balance the risks with the rewards, and establish a clear regulatory framework to reduce the risks while allowing development to occur for the economic and social benefits it brings. In some cases, risks may remain too large for the benefits that will accrue; in other cases, careful regulations can reduce risks to an acceptable level by reducing event probability, reducing its consequences, or both.

Because it is impossible to quantify all risks in advance of a resource development project that will unfold over decades, the Adaptive Management approach (*Gestion Adaptative*) is commonly adopted.

> *« …un processus systématique d'amélioration constante des politiques et pratiques de gestion qui se base sur les leçons tirées des résultats de politiques et pratiques antérieures.*[1] »

Maximizing the value of Adaptive Management for the citizens of Québec to reduce negative social and environmental impacts means that there must be a continuous constructive dialogue between the companies doing resource development and the agencies that are regulating them. This dynamic interaction must allow for flexibility as technologies change and as data become available.

Hydraulic Fracturing (HF) Risks

A great deal of exaggeration of the risks of HF has taken place in the non-scientific literature and social media in the last ten years. Collection of scientific information and the evolution of fracturing methodologies shows that the process as currently executed is a low-risk activity, not significantly different from other industrial activities, and is achieving even lower risks with time. The following points can be verified by examining widely available refereed scientific literature and by accessing the many reports written by independent expert panels in many countries (USA, Germany, Canada, United Kingdom, Australia).

- HF at depth (at least 200 m below the base of fresh groundwater) in a standard wellbore does not lead to fluids rising to the surface or to the groundwater table except if there is another wellbore nearby (within 100-200 m). Regulatory procedures require the identification and monitoring of adjacent wellbores during HF to avoid such events.
- HF takes place at high pressures; once HF stimulation is completed, pressures return to normal, so the potential for HF fluids to continue to propagate is removed.
- The chemicals in HF fluids are generally benign or of low toxicity. In the rock mass, much of the chemicals in the HF fluid are permanently absorbed within the rock matrix or adsorbed on the surfaces of the clay and siliceous minerals in the rock. Furthermore, acids are neutralized by carbonate minerals in the rock.
- During production, the pressure in the reservoir that was subjected to HF is reduced massively over a large volume; residual HF fluids can only flow toward the production wellbores.
- The real environmental risk associated with HF is in surface spills during transportation and storage; these risks are well understood, exhaustively quantified, and easily managed.
- Under pressure from environmental groups and governments, corporations performing HF operations are moving toward chemicals that are of lower potential environmental impact; this means that the consequences of a surface accident or leak are being reduced over time.

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[1] http://www.greenfacts.org/fr/glossaire/ghi/gestion-adaptative.htm

- More and more jurisdictions require that HF operators publish the chemicals used in the HF treatment. Volumes and rates are provided to the regulatory agencies, and limits can be placed on these in various cases (e.g. shallower HF, or HF near a fault) to further reduce risk.
- Given that there are some risks associated with HF, mainly surface risks, and given that the surface and subsurface are public goods, industry transparency and accountability are needed to inform citizens of actions and methods to manage risk.

Recently, earthquakes in England, Alberta and British Columbia during HF treatments have attracted a great deal of attention and are used as examples of unknown and potentially serious risk.

- The maximum magnitude of the earthquakes that might be feasible in the Province of Québec during HF stimulation is lower than in AB or BC because of the shallower depths to the target formations in Québec, and the knowledge that smaller volumes will be used for HF stimulation (the strata are thinner, so lower volumes would be used).
- Several HF earthquake events were clearly felt at the surface in AB and BC; the consequences have nonetheless been negligible because the surface shaking is small, and the infrastructure is not affected by small earthquakes. This will also be the case in Québec and this conclusion can be validated through monitoring during exploration, trial HF and development.
- If there is a concern about the level of earthquakes that might be associated with HF, rules can be promulgated to limit HF proximity to known faults (such as the Jupiter Fault in Anticosti Island), and to collect data so that Adaptive Management principles can be used to improve HF practices and outcomes.
- Although the probability of a damaging earthquake being triggered by HF appear to be vanishingly small, data collection in the public domain is advised as a means of gaining valuable information about the process at depth, and providing reassurance to the public.

All major international reports on HF risk that have been undertaken by expert panels comprised of scientists and engineers familiar with HF practices and geomechanics have reported that, in a properly regulated industry, risks are low, and are associated mainly with surface activities, not subsurface effects. These reports also suggested that, to manage and reduce risks, it is necessary to have appropriate regulations, properly enforced, and some form of Adaptive Management.

Wellbore Integrity

A number of Canadian expert panels – Canadian Council of Academies (2014), Nova Scotia HF Review Panel (2014), Newfoundland and Labrador HF Review Panel (2016) – conclude that environmental issues related to long-term wellbore integrity are of greater concern than those related to subsurface HF issues. The following points summarize the current view of wellbore integrity issues and environmental impact.

- Natural gas seepage to the surface is common in sedimentary basins where there is gas in the strata at depth. Seepage gas is commonly >95% methane, partly biogenic gas from vegetation buried to depths less than 1000 m, and partly thermogenic gas formed during oil generation at greater depths.
- Gas in water wells and other gas seepages are observed in the St Lawrence Lowlands, Anticosti Island, and under the sea in the St Lawrence Estuary. Home water wells in these regions often

have methane dissolved in the water, and occasionally as free gas. In the St Lawrence Lowlands of Québec, perhaps thousands of country wells naturally have methane present.

- The health impacts of methane in groundwater are apparently very low, as can be deduced from the large number of water supply wells across North America with endemic methane and an absence of reports of poor health outcomes.
- Despite drilling and completion practice improvements over the decades, a small percentage of oil and gas wells will display evidence of slow leakage, almost exclusively of methane, alongside the exterior of the casing, and exiting at the surface, or into shallow groundwater zones.
- The source of the seepage methane in leaking wells apparently is dominated by shallow biogenic gas and by thermogenic gas from intermediate-depth beds, found between the bottom of the surface casing and the deep target formation. This methane migrates slowly toward the surface in a thin annulus outside the exterior casing.
- Many shale gas exploration wells in Québec show evidence of gas seepage, although the sources (shallow or deep) remain unquantified.
- The amount of gas seeping to the surface per leaky well in Alberta is estimated to be about 100 kg per year. Even if as many as 10% of 470,000 wells in Alberta leak, this is a minor contribution to worldwide methane emissions in the context of other larger sources of methane (landfills, cattle, gas distribution systems in cities and towns, coal mining, vegetation decomposition, etc.).
- Although there are cases where oil and gas activity has definitely led to methane seepage into water wells, these cases are rare. In the context of widespread natural gas seepage in the same areas, the impact of the oil and gas industry on water well methane appears to be minor.
- There is a deficiency of quantitative information on gas migration around oil and gas wellbores, and it is advisable to pursue high quality data in order to develop a better base on which to make regulatory decisions and evolve best practice guidelines.

The conclusion from these points is that natural gas seepage, while not desirable and to be avoided, occurs naturally, has only minor consequences, and is therefore not a major risk. Promotion of best practices and quality control in well completion and decommissioning, along with improvements in well intervention approaches to arrest observed cases of leakage, will be effective in further reducing risk.

Summary

Given good regulations, enforcement, and a commitment to Adaptive Management, it appears that the risks associated with HF and well integrity can be easily managed so that environmental impacts are low. Drilling and producing oil and gas is not a particularly risky endeavor compared to other industries. Based on extensive activity in Alberta, Pennsylvania, Ohio and other jurisdictions, and backed up by the conclusions of many expert panels, the environmental impacts of HF and wellbore integrity for shale gas well development are small and can be reduced further. Québec has an excellent opportunity to base regulatory guidance on a broad experience base, and thereby to further reduce risks.

Maurice B Dusseault August 15 2016