Hydraulic Fracturing and Water Conservation in Alberta: Policy Recommendations to Encourage Water Reduction

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Abstract
Hydraulic fracturing is a water-intensive method of oil and gas extraction, with a growing presence in Alberta, specifically in the Montney Formation. Many existing water management policies and regulations for the oil and gas industry were developed for conventional production methods, and have been applied to hydraulic fracturing. This can be problematic since conventional methods use freshwater in different ways and in different quantities than hydraulic fracturing. Alternative fracturing fluids that can eliminate or reduce water in hydraulic fracturing exist, but are not widely used. We analyzed the hydraulic fracturing fluids used in 598 hydraulic fracturing wells in the Montney Formation. The hydraulic fracturing fluids used in the wells were divided into 4 categories- Water-Based, Oil Based, Energized Gas, and Energized Cryogenic. Results from our analysis shows that Energized Cryogenic hydraulic fracturing fluids are ~20% more efficient in barrel of oil equivalent produced than water-based fluids, and energized fluids reduce water up to 80%. Here, we examine freshwater-use in hydraulic fracturing in Alberta and relevant policy that could be introduced to support alternate technologies for the reduction of fresh water use in fracking.

Introduction
Freshwater is used in different extraction methods of oil and gas resources, making the oil and gas industry the second largest consumer of freshwater in Alberta (Alberta 2010; AER n.d; Alberta WaterPortal n.d). Due to recent advances in hydraulic fracturing, a water-intensive resource extraction method, there has been an increase in these projects and a growing demand for freshwater by hydraulic fracking operators in Alberta (Alberta 2017).

Water used for oil and gas resource development generally becomes contaminated and is not returned to the water cycle (AER 2012; NRCAN 2013; AER 2017). The extraction of large amounts of freshwater from their sources for resource development projects can affect the health of aquifers and of aquatic ecosystems (NRCAN 2013; Horner et al. 2016). Additionally, communities have expressed concerns that an increased use of freshwater is negatively impacting the quality and availability of potable water sources (Alberta 2003; NRCAN 2013; O'Connor and Fredericks 2018).

As demand for freshwater in hydraulic fracking projects increases, so will negative impacts to the water cycle, aquatic ecosystems, and communities. Alternative technologies that reduce the necessity for freshwater in hydraulic fracturing must be pursued to reduce those impacts. For this paper we analyzed hydraulic fracturing in the Montney Formation in Alberta, specifically the fluids used, as well as provincial policy and regulation guiding these projects. Using our analysis we propose policy that could be introduced to incentivize the reduction of freshwater intensity in hydraulic fracturing projects.

Background

What is Fracking?

Unconventional hydrocarbon resources, such as tight oil, are resources that are trapped in a low-permeability rock, and are not easily accessible (Scanlon et al. 2014; Reeves 2019). Hydraulic fracturing, also known as "fracking," has been practiced in Alberta since the 1950s (NEB et al 2013). Originally used as a method to extract conventional hydrocarbon resources, it was later advanced as a method to extract unconventional resources (AER n.d). As shown in Figure 1, the process of hydraulic fracturing involves the injection of a special hydraulic fracturing fluid (HFF) into the low-permeability rock, as a means to fracture the rock, which allows the resources to flow out of it (Horner 2016; CAPP 2017). The composition of the fluid normally includes large quantities of freshwater (AER 2017; CAPP 2017; Horner 2016).

In 2017, 24 million cubic meters of water were used in fracking operations in the province, most of which cannot recovered to be recycled (AER 2017). As such, hydraulic fracturing is considered a water-intensive method; in 2017, on average it took 0.59 barrels of water to produce 1 barrel of oil equivalent, which was an increase of 250% between 2013-2017 (AER n.d; AER 2017). The Alberta Energy Regulator (AER) notes that as economic conditions improve there will likely be an increase in the number of wells drilled and, therefore, the amount of water used in this process (AER 2017).

The Montney Formation: Geology & Geography

The Montney Formation is a subsurface geologic formation of low-permeability siltstones that stretches from North Eastern British Columbia into North West Alberta (NEB et al 2013). Resource development has occurred in the Montney since the 1950s and has increased in recent years due to major technological advancements in unconventional resource development, including hydraulic fracturing, in the early-2000s (NEB et al 2013). The formation is estimated to contain millions of barrels of natural gas and oil that can be economically extracted (NEB et al 2013).

The Montney Formation: Community

As shown in Figure 2, in Alberta, the Montney formation lies under towns such as Grand Prairie, Fox Creek, and Peace River. This area is also home to the traditional territories of the people of

Treaty 8 and Treaty 6, several Indigenous Reserves, and the Metis Nation of Alberta Regions 4, 5 and 6.

In Canada and the US, communities adjacent to fracking operations have expressed concern about the risks of fracking to their way of life, especially impacts to water quality and water quantity used in operations (Garvie and Shaw 2016; Sangaramoorthy 2016; Moore et al. 2017). Indigenous communities can have unique concerns related to impacts on their traditional practices and territorial issues around water governance (Garvie and Shaw 2016; Moore et al. 2017). It is important to understand and incorporate the diversity of cultures and land uses in the area otherwise, community perception can negatively impact fracking operations through protests and disruptions (Cham and Stone 2013; Sangaramoorthy et al. 2016).

Relevant Policy and Regulation

Water management decisions rest with the provincial government (Alberta 2003). Specifically, Alberta Environment and Parks oversees water-related conservation and management, with the Alberta Energy Regulator responsible for management and conservation of water use in energy resource development (Alberta 2014). The *Water Act* grants both agencies their authority (Alberta 1999).

Alberta Environment and Parks: Water Strategies and Directives

As part of the *Water for Life* strategy, the Government of Alberta implemented the *Water Conservation and Allocation Policy for Oilfield Injection* in 2006 (Alberta 2006). This policy and accompanying guidelines provide objectives and regulatory measures for conservation and reduction of freshwater use in in-situ oil sands production, including a mandate for water recycling and exploration of freshwater alternatives (Alberta 2006 n.d). While this policy is not directly applicable to hydraulic fracturing it provides an example of what water conservation policy could look like for hydraulic fracturing.

In 2018, Alberta Environment and Parks implemented the *Directive for Water Licensing of Hydraulic Fracturing Projects-Area of Use Approach* in order to address the unique necessities of hydraulic fracturing projects as it relates to licensing of water (Alberta 2018). This directive allows for some flexibility when issuing licenses for hydraulic fracturing projects. Therefore, instead of requiring a temporary diversion license for each well, the directive allows for a temporary diversion licence to be granted for a specified area- the “area of use”- as defined by the sub-surface mineral rights held by the hydraulic fracturing company(Alberta 2018). This is supposed to lead to better long-term water management planning over the life of the project, since the total water allocation will be roughly calculated based on the number of wells expected to be drilled (Alberta 2018).

Albert Energy Regulator: Directives and Regulations

The Alberta Energy Regulator (AER) provides regulations and directives that guide technical requirements, processes, and reporting obligations that oil and gas companies must follow. Relevant to hydraulic fracturing are directives and orders related to: subsurface integrity, water use reporting, and drilling and completions reporting (AER n.d). Included in these directives are general statements that require fracking companies to take all precautions necessary to protect ground water and other freshwater sources by conducting risk planning to mitigate contamination of freshwater with fracturing fluids (AER 2013). Companies must also identify the chemical components used in fracturing fluids and report quantities used, but there is no directive that prohibits the use of alternate fracking fluids below the baseline water table (AER 2013).

Analysis: Water Alternatives

Water-based fracturing fluids are used in the majority of projects, but there are alternate fluids that use no, or reduced, amounts of water such as oil-based fluids, liquified gases such as carbon dioxide and nitrogen, brackish water, and energized foams (Donaldson et al. 2013; Zhang et al. 2018). The AER's *Directive 059: Well Drilling and Completion Data Filing Requirements* requires companies to submit summaries of their drilling data within 30 days of an operation ending, which is then made public via FracFocus (AER 2018). Using this data we analyzed 598 hydraulic fracturing wells in the Montney Formation (Figure 3) to determine what hydraulic fracturing fluids (HFF) are being used in Alberta, the volume of water required, and the production efficiency.

We found that various hydraulic fracturing fluids (HFF) are used in hydraulic fracturing operations in Alberta. We classified these HFF into 4 categories: Oil-based, energized-cryogenic, energized-gas, and water-based. The classifications were determined based on the listed primary carrier fluids and energizing components, which give the HFF certain properties to impact production efficiency. Oil-Based fluids have oil, kerosene, base oil, frac oil, distillates, or hydrocarbon listed as the primary carrier fluid, making up >65% of the concentration by mass in the HFF. Energized-Cryogenic fluids have water as the primary carrier fluid, making up 30-60% of the concentration by mass in the HFF, and N2 or CO2 are used as the energizing fluid in liquid form. Energized-Gas fluids have water as the primary carrier fluid making up 35-75% of the concentration by mass of the HFF, and a gas form of N2 is used as the energizing component. Water-Based fluids have water as the primary carrier fluid making up >75% of the concentration by mass in the HFF.

We found that when Energized-Cryogenic or Energized-Gas HFF were being utilized, water consumption was reduced by more than 80% and completely eliminated when Oil-based fluids injected to wells. Our analysis also found that the production efficiency, determined by the barrel of oil equivalent produced, of wells utilizing energized-cryogenic HFF were ~20% better than wells utilizing water-based HFF (Figure 3).

Analyzing by the date the wells came on production, we found a trend where alternate HFF were more widely used between 2012-2016 (Figure 4). However, water-based HFF have become the dominant HFF between 2016-2018, even though the efficiency of each well decreased with. Freshwater remains one of the cheaper fluids to use in fracking operations due to simpler accessibility and transportation (Horner et al. 2016; Zhang et al. 2018). As a result, until other alternatives are incentivized or become more viable, it is likely that water will continue to be used as the largest component of fracturing fluids.

Policy Recommendation

There are few regulations that are specific to fracking. Many existing water management policies and regulations for the oil and gas industry are in place for conventional and in-situ oil sands production methods (AER n.d). These regulations have guided hydraulic fracturing projects too, which can be problematic since conventional and in-situ methods use freshwater in differently and in different quantities than hydraulic fracturing. There are approaches the province can take to fill this policy gap.

Community Engagement

As hydraulic fracturing in Alberta becomes more widespread, policies and regulations to encourage a reduction and improved efficiency of freshwater consumption will need to be implemented in order to mitigate negative environmental impacts. It is important to incorporate community and Indigenous voices in the discussions when creating policies to address water consumption in fracking, including addressing perceived risks and communicating risk management plans (Cham and Stone 2013). Additionally, as the technologies used change and develop, it will be important to keep all communities updated of the changes and the impacts they may have (Cham and Stone 2013). Due to differences in technical knowledge between the public and operators, it is important to communicate the information in jargon-free language that is accessible to all (Cham and Stone 2013). Developing relationships, and keeping the community informed and engaged helps build trust around projects.

Recommendation: Update the Water Conservation and Allocation Policy for Oilfield Injection

As a water-intensive method for unconventional hydrocarbon resource development, there is room to encourage water conservation in hydraulic fracturing. Existing policies set out a vision for water conservation in the oil and gas industry, but minimal incentives exist to encourage hydraulic fracturing companies to explore alternatives to water. To promote water conservation through alternate fracking fluids, policies should be strengthened to incentivize their use and ensure the integrity of operations using the alternative fluids. As such, the *Water Conservation and Allocation Policy for Oilfield Injection* should be updated to include provisions for hydraulic fracturing and strengthen water conservation incentives.

The *Water Conservation and Allocation Policy for Oilfield Injection* and the accompanying *Water Conservation and Allocation Guideline for Oilfield Injection* were introduced by Alberta Environment and Parks in 2006 (Alberta 2006 ; Alberta 2006). The policy was introduced as a part of the *Water for Life* strategy to guide the operators of conventional oil and gas projects and enhanced recovery to reduce their water consumption (Alberta 2006; Alberta 2006). The policy provides measures for conservation and reduction of fresh water use in in-situ oil sands production by encouraging in-situ operators to use alternatives to freshwater where possible and mandates that they maximize water recycling (Alberta 2006). The guideline provides the incentive of easier water license renewals if companies prove success in achieving the water reduction targets outlined in their license (Alberta 2006; Alberta 2006). As a result of this policy, water use in in-situ oil sands projects had fallen by 30% over 4 years.

The policy was introduced prior to the widespread practice of fracking in the province and so does not apply to the projects. This gap in policy and regulation should be closed through the updating of the *Water Conservation and Allocation Policy for Oilfield Injection* to reflect the changes in the energy landscape since 2006.

Alberta Environment and Parks' directive for Water Licensing of Hydraulic Fracturing Projects and Subsurface Integrity, include requirements for hydraulic fracturing project proponents to show that they have conducted an assessment exploring alternatives to freshwater, and to prove that no other economically and environmentally feasible water source is available for the project (Alberta 2018; AER 2013). However, neither provide the incentives that the *Water Conservation and Allocation Policy for Oilfield Injection* does to encourage the use of alternatives to water. By providing similar incentives for hydraulic fracturing projects, similar water reductions would occur in this area.

Conclusion

As the number of hydraulic fracking projects increases in Alberta, so will the demand on freshwater for use in hydraulic fracturing fluids. Increased use of fresh water will have negative impacts to the water cycle, aquatic ecosystems, and communities. Alternative technologies that reduce the necessity for freshwater in hydraulic fracturing must be pursued to reduce those impacts**.** Our analysis shows that alternative hydraulic fracturing fluids result in less water consumption and increased resource production. However, barriers, such as cost, limit the use of these alternative fluids.

The *Water Conservation and Allocation Policy for Oilfield Injection* should be updated to apply to hydraulic fracturing projects to bind and incentivized the mandates in the policy. The *Policy for Oilfield Injection* was successful in encouraging high rates of water recycling and reduction for in-situ oil sands projects, as well as new technologies, and it is likely similar results would occur in hydraulic fracturing projects.

Figures and Tables

Figure 1: Steps of hydraulic fracturing (CAPP 2017)

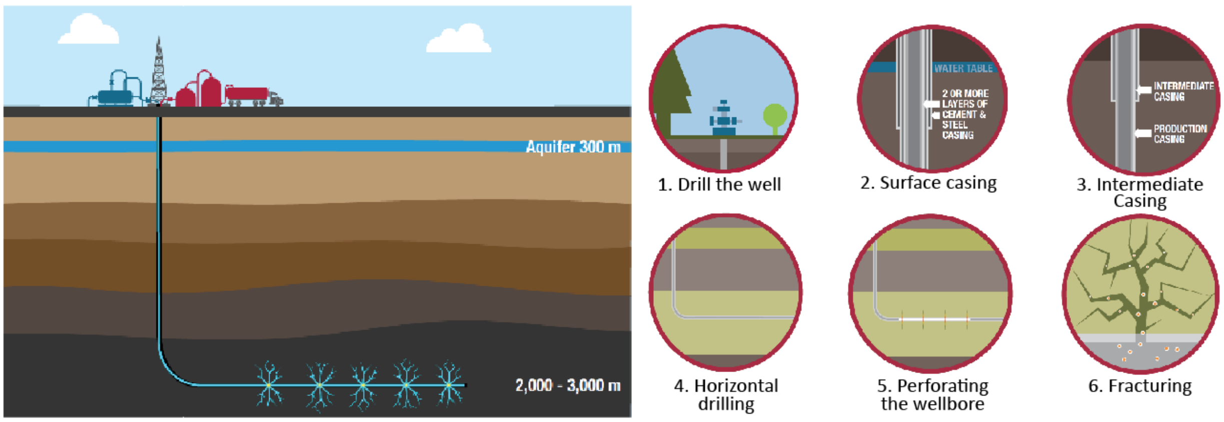


Figure 2: The Montney Formation in Alberta: Geography and Community

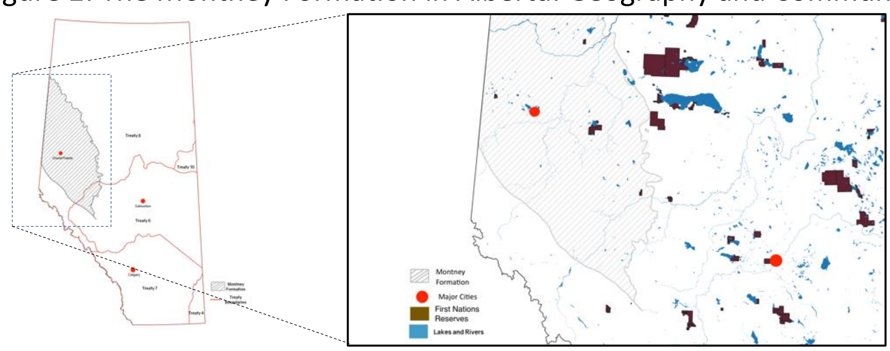


Figure 3: Hydraulic fracturing wells analyzed in the Montney Formation

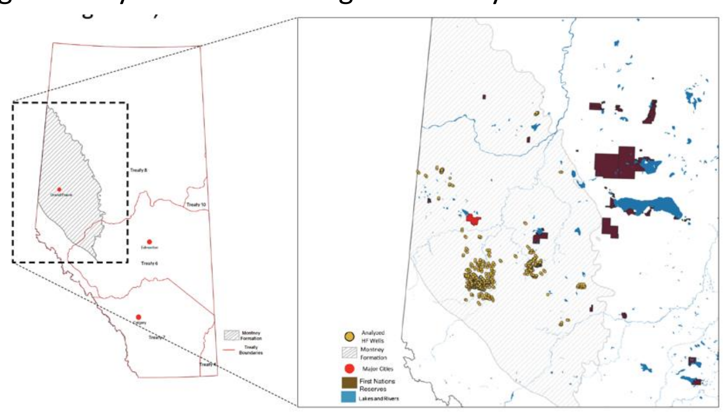


Figure 4: Comparison of resulted BOE and amount of water used. Triangles represent average normalized BOE and water use. In this study only BOE production within first 12 months was analyzed. (Data from FracFocus.ca and GeoSCOUT)

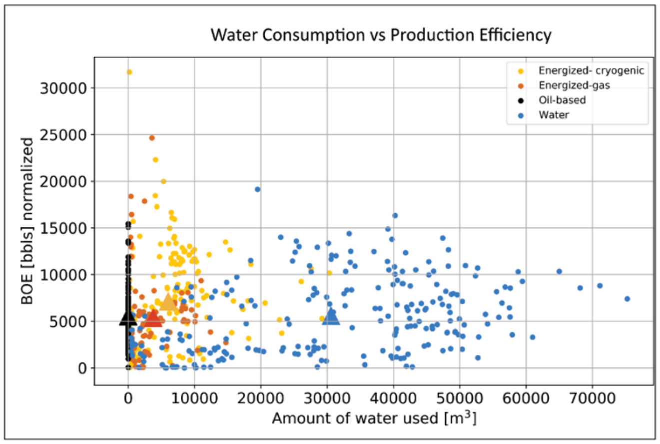
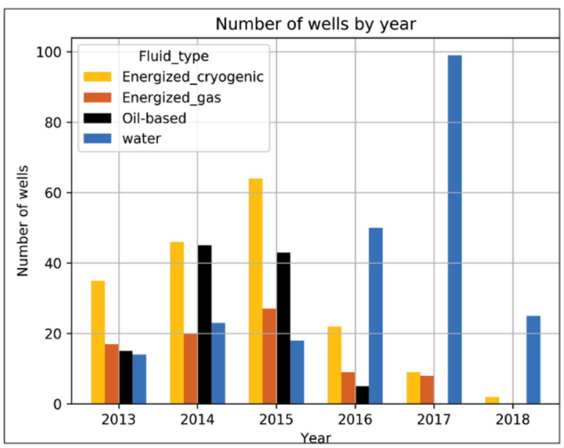


Figure 5: Number of wells for fluid types by year. (Data from FracFocus.ca and GeoSCOUT)



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