

## Opportunity, Risk, and Public Acceptability: The Question of Shale Gas Exploitation in Québec

### Executive Summary

The Canadian province of Québec has the largest reserves of shale gas in Eastern Canada, but Québeckers are in the midst of a heated debate over the desirability of exploiting this resource. At issue is the controversial technique of hydraulic fracturing, or “fracking.” The provincial government has decided to proceed cautiously. In 2011, Québec instituted a temporary moratorium, still in effect, on shale gas development in order to conduct consultations with experts and members of the public that has continued to present day. Recently, the government released the results of the experts’ report, the Strategic Environmental Evaluation. This paper highlights the report’s key findings about the potential economic benefits, environmental risks, and public acceptability of shale gas development. Québec’s balanced approach to the complex, technical issue of shale gas development represents a deliberative approach to governance that emphasizes extensive public engagement.

### Introduction

Since the 1990s, natural gas from shale has risen to the fore of the public debate over energy production. At the core of the discussion lie the main techniques of the exploitation of natural gas from shale (“shale gas”): hydraulic fracturing (“fracking”) and horizontal drilling. Shale gas extraction is efficient and economically viable only when these methods are used in tandem, but the practice has attracted attention for the uncertainty surrounding the long-term consequences of fracking on human health and environmental quality.

As a result of the concern over fracking, many governments around the world are weighing the costs and benefits of allowing shale gas development in their jurisdictions. The Canadian province of Québec has taken this process particularly seriously, banning shale gas development until the completion of a public consultation on the acceptability of the prospective economic and environmental consequences of fracking. This stands in contrast to the governments of Alberta and the American state of Pennsylvania, which are evaluating the impacts of fracking with drilling already well underway, having encouraged development since the mid-2000s.

This paper examines the Canadian province of Québec and the factors in its cost/benefit analysis of shale gas development. It first explores Québec’s culture, history, geophysical situation, and scientific and public engagement on the issue of shale gas to provide context for a discussion of Québec’s evaluation of fracking as a policy issue. The report then turns toward an investigation of the potential economic benefits and environmental risks of shale gas development, including both the substantial natural risks and technological risks related to fracking. Finally, it explores how public opinion on the benefits and risks of shale gas development has evolved over recent years among Québeckers, arriving at a near-consensus that these risks may outweigh the relatively moderate economic gains that may be realized from shale gas exploration in Québec. While Québec’s conclusion regarding the desirability of shale gas development will be the product of a unique combination of Québec’s history, economy, and environment, this experience provides a valuable framework for other jurisdictions considering the impact of fracking.

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## Background

### Québec, the “Rest of Canada,” and the Environment

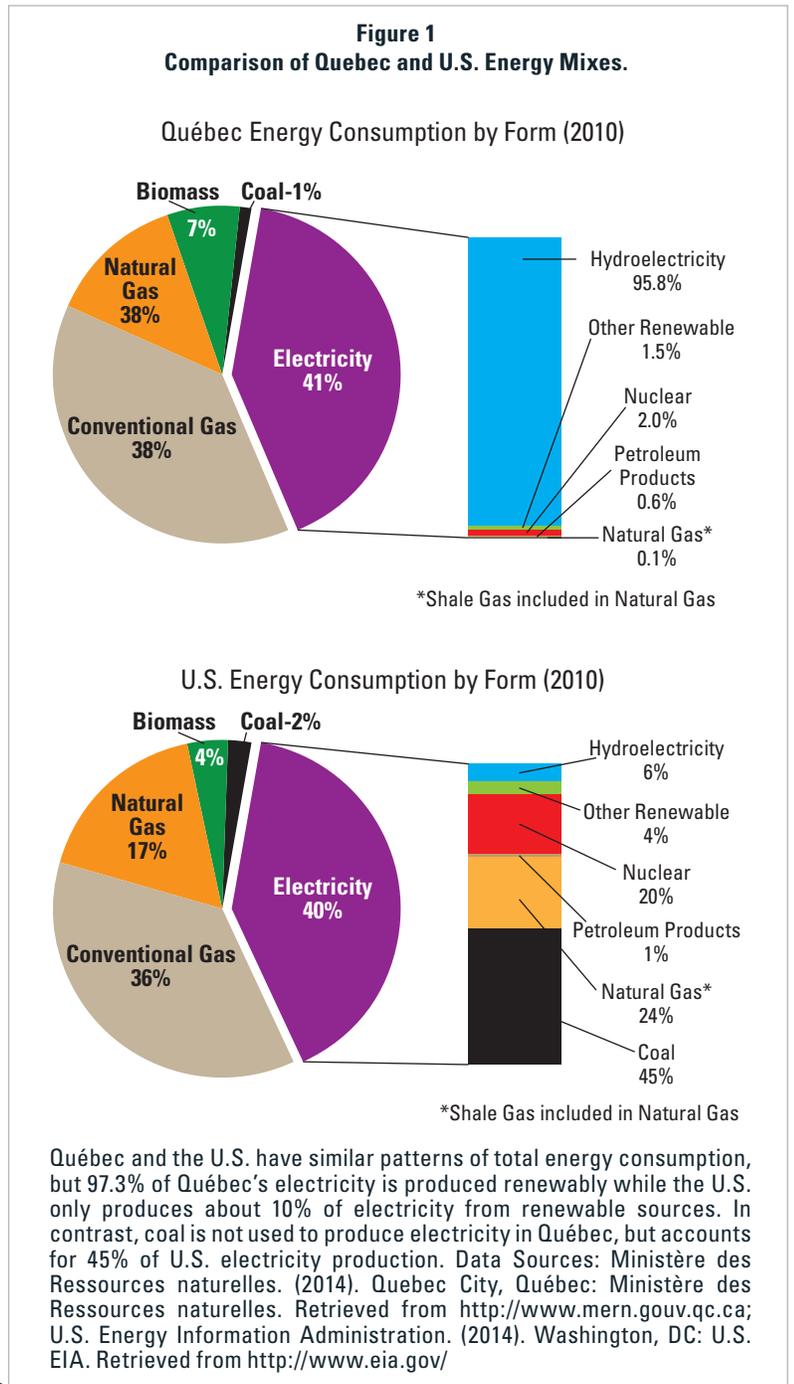
To unfamiliar observers, one of the most striking things about Québec is the degree to which its history infiltrates and influences all aspects of Québec society. Even issues as practical as energy policy are often understood in Québec as just one episode in a long, contentious, and often emotional series of cultural skirmishes running from its colonial era to today. At the center of this struggle lies a fundamental skepticism about the legitimacy of “Canada” as a political unit. For many Québeckers, the concept of “Canada” is fundamentally flawed; yellowed, cracked glue binding two fundamentally different peoples: the Francophones of Québec and the Anglophones of the “Rest of Canada,” or ROC.

Despite federal provisions affording the Québec government greater powers than other provincial governments, the question of autonomy continues to act as the gravitational center of Québec politics. The province voted in 1980 and 1995 on ballot propositions proposing negotiations leading to Québec’s sovereignty from the ROC, but these were rejected by margins of 19.22% and 1.16%, respectively.<sup>1</sup> The Parti Québécois, which led Québec’s government from September 2012 to April 2014, favors a third vote on sovereignty in the near future.<sup>2</sup>

In April 2014, however, the Parti Québécois lost heavily to the Parti libéral du Québec. The Liberals are a centrist party that supports a large degree of autonomy for Québec, but rejects the idea of a sovereign Québec. While a third ballot proposition will not occur under the current government, Québec’s relations with the ROC will continue to be a constant source of tension.

Québec’s history of policy-making with an eye toward autonomy has at times dovetailed with its strong, proactive engagement with the environmental movement. Starting in the 1940s, the province embarked on a series of large investments in hydropower. The underlying purpose of these projects was to take advantage of the province’s formidable water resources to create an independent electricity grid, a necessity for an independent Québec.

An inadvertent, but happy consequence of this effort is that Québec is among the cleanest energy economies in the world today. Hydropower provides over 95% of Québec’s electricity, leaving it more or less independent of hydrocarbon imports.<sup>3</sup> By way of comparison, the United States obtains approximately 10% of electricity from renewable energy sources, and petroleum and natural gas supply 25% of its electricity<sup>4</sup>. These differences are illustrated in *Figure 1*. Other Canadian provinces have also made use of their water resources, with Newfoundland and Labrador, Manitoba, and British Columbia each producing over 80% of their electricity through hydroelectric power.<sup>5</sup>



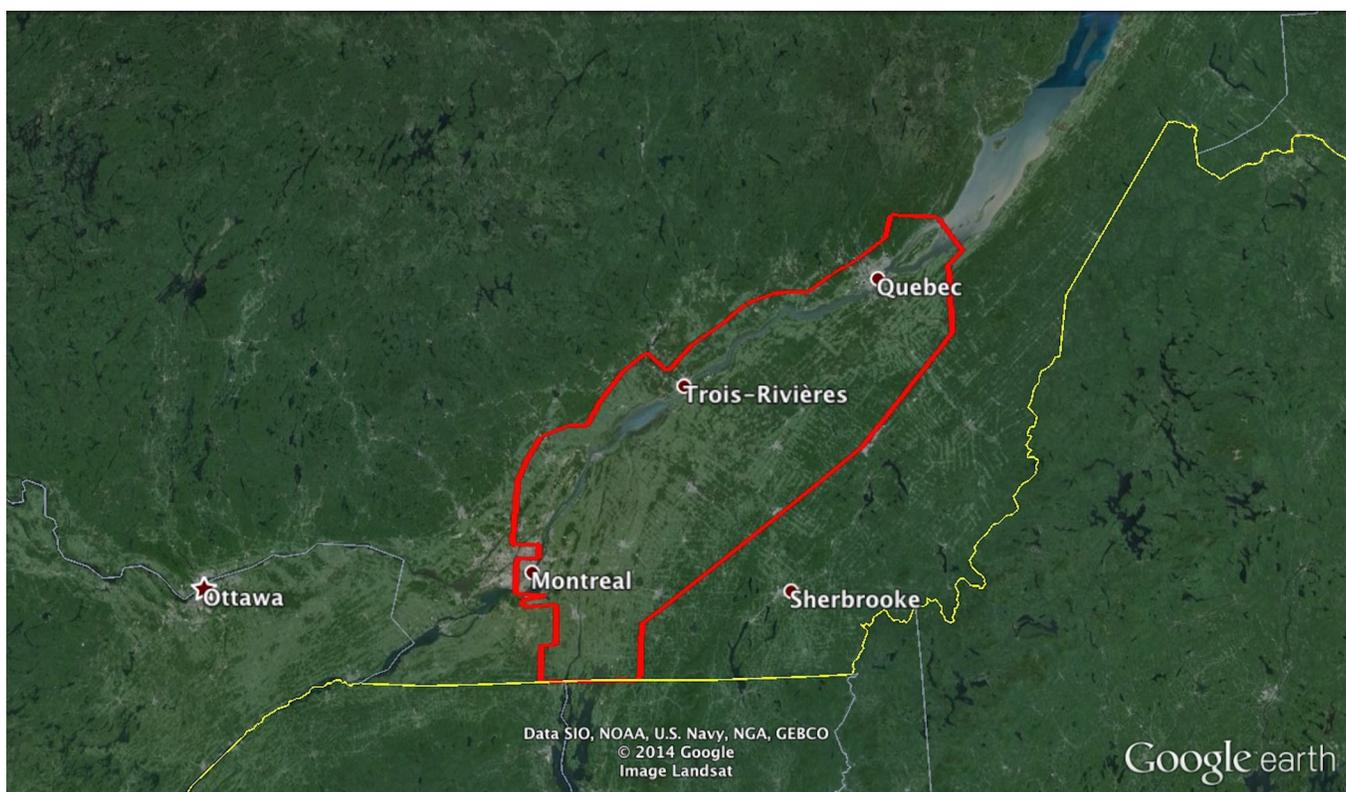


Another example of Québec's efforts to differentiate itself from the ROC aligning with environmental priorities is its cap-and-trade market for carbon emissions, the only one in Canada. Since January 2013, Québec has forced large carbon emitters—those producing 25,000 metric tons of CO<sub>2</sub> or greater per year—to buy emissions allowances at auction. In addition,<sup>6</sup> Québec joined the Western Climate Initiative (WCI) in 2008, a coalition of American states and Canadian provinces with the aim of reducing greenhouse gas emissions.<sup>7</sup> Though the WCI's once substantial membership has suffered through the economic downturn and encountered political backlash in some states, Québec has remained committed to reducing its environmental footprint through its carbon market.

### The Utica Shale

Since 2010, when the discovery of gas reserves in Québec sparked interest among investors and drilling companies, the political debate in Québec has come upon a new issue: shale gas.<sup>8</sup> Though Québeckers have drilled for conventional oil and gas wells since the late 19<sup>th</sup> century, the discovery of substantial reserves of shale gas in the southern half of the St. Lawrence Lowlands, an area spanning approximately 2,900 square miles, has given new impetus to the question of development.<sup>9</sup> As shown in *Figure 2*, the most promising geological formation in the area of interest within the St. Lawrence Lowlands is the Utica Shale, a thin layer of rock topped by a mile-thick layer of quasi-impermeable rock.<sup>10</sup> Exploratory wells drilled in the Utica suggest it contains a total volume of 155 trillion cubic feet of natural gas, of which approximately 31 trillion cubic feet is technically recoverable.<sup>11</sup> This ranks the Utica as the most significant shale gas deposit in Eastern Canada, and Canada's fifth largest overall.

**Figure 2**  
**Area of Interest for Shale Gas Extraction.**

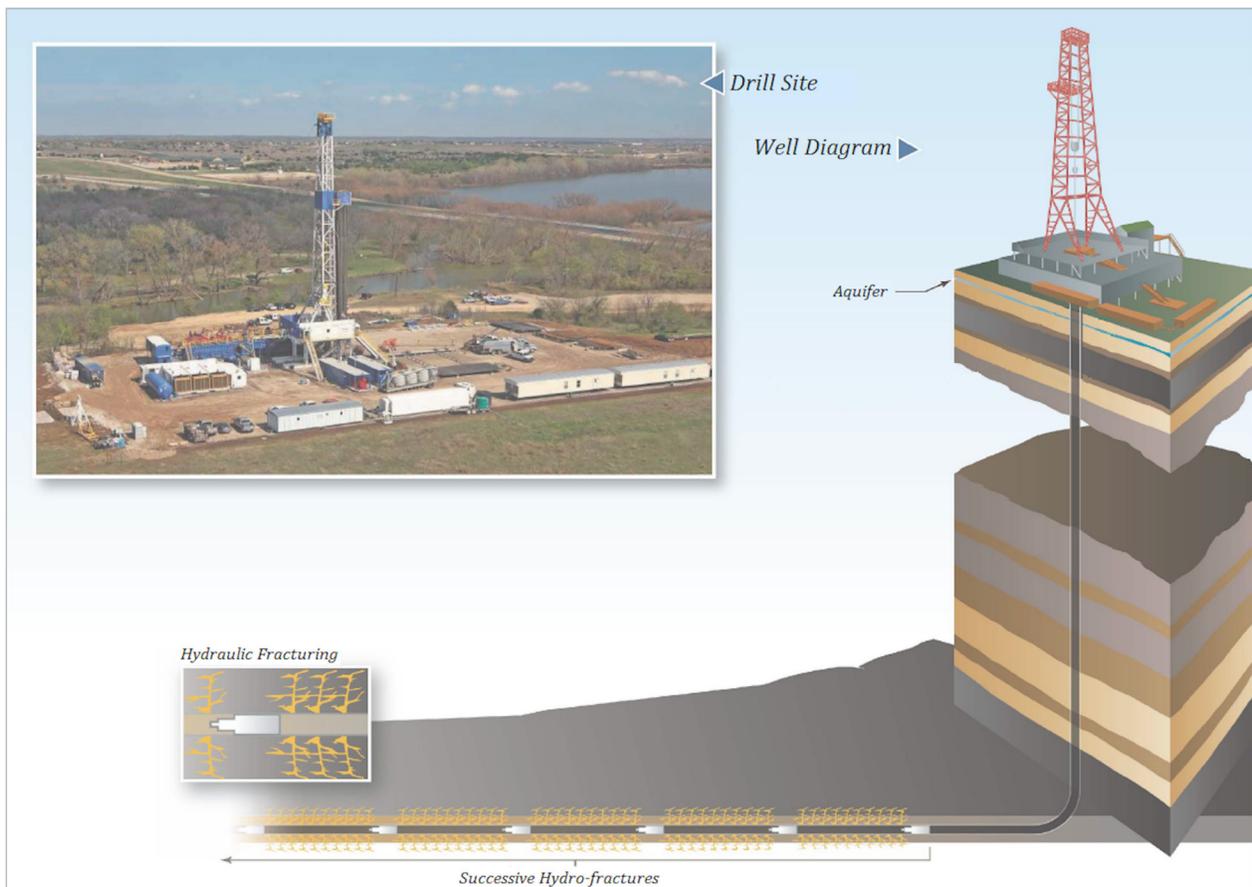


The area outlined represents the area of potential shale gas exploitation in the St. Lawrence Lowlands, Québec. The Utica shale becomes progressively shallower to the north, with the northern edge of the area of interest representing the point where the Utica formation reaches the surface. The greatest reserves of shale gas are located on the southern bank of the St. Lawrence River, which runs southwest-northeast through the area. Source: Google Earth. (Build 7.1.2.2041). [Software]. Mountain View, CA: Google Inc. (2014). Available at <http://earth.google.com>; Semantic Science Integrated Ontology. [Software]. Mountain View, CA: Google, Inc. (2014). Retrieved from <http://semanticscience.org>; National Oceanic and Atmospheric Administration. (2014). Washington, DC: U.S. Department of Commerce. Retrieved from <http://noaa.gov/>; U.S. Navy. (2014). Washington, DC: U.S. Department of Defense. Retrieved from <http://navy.mil/>; U.S. National Geospatial-Intelligence Agency. (2014). Washington, DC: U.S. Department of Defense. Retrieved from <http://nga.mil/>; General Bathymetric Chart of the Oceans. (2014). Liverpool, UK: British Oceanographic Data Centre. Retrieved from <http://gebco.net/>; Image: U.S. Geological Survey Landsat. (Build GEBCO\_08). [Software]. Washington, DC: U.S. Department of the Interior. (2014). Available at <http://landsat.usgs.gov/>

Shale gas is a “tight” gas, meaning the reservoir rock holding the gas is fine-grained, rendering the gas difficult to extract. However, there are two factors that have made the exploitation of the Utica Shale economically attractive. The first is the improved efficiency of exploiting shale gas and other “tight” gases through the combination of horizontal drilling and fracking (see *Figure 3*). Traditional (or “conventional”) wells only drill vertically, limiting the well’s production to the immediate vicinity. Perfected only recently, horizontal drilling increases production per well by creating multiple well shafts extending in different directions from one wellhead.<sup>12</sup> For example, a typical six-well drilling platform using horizontal drilling techniques would have 36 individual well shafts instead of one well shaft per well. Such a set-up would be capable of draining nearly 4 km<sup>2</sup> of rock from just one drilling platform.<sup>13</sup> This leads to substantial efficiency gains, and thus profit margins, over traditional techniques.

The other technological development is the spread of sophisticated fracking techniques. Fracking involves injecting large volumes of “frack fluid,” a mix of water, sand, and chemicals, into a well at high pressure to crack open the rock and free gas deposits. Though the North American oil and gas industry has used this technique for the past few decades, the effectiveness of fracking has dramatically increased recently due to changes in the exact chemical composition of the “frack fluid” mix and its use in combination with horizontal drilling.<sup>14</sup> Due to the low porosity of shale, the exploitation of shale gas and other “tight” gas deposits is only economically viable through the combination of these two techniques.

**Figure 3**  
**Schematic of a Well using horizontal drilling and fracking.**



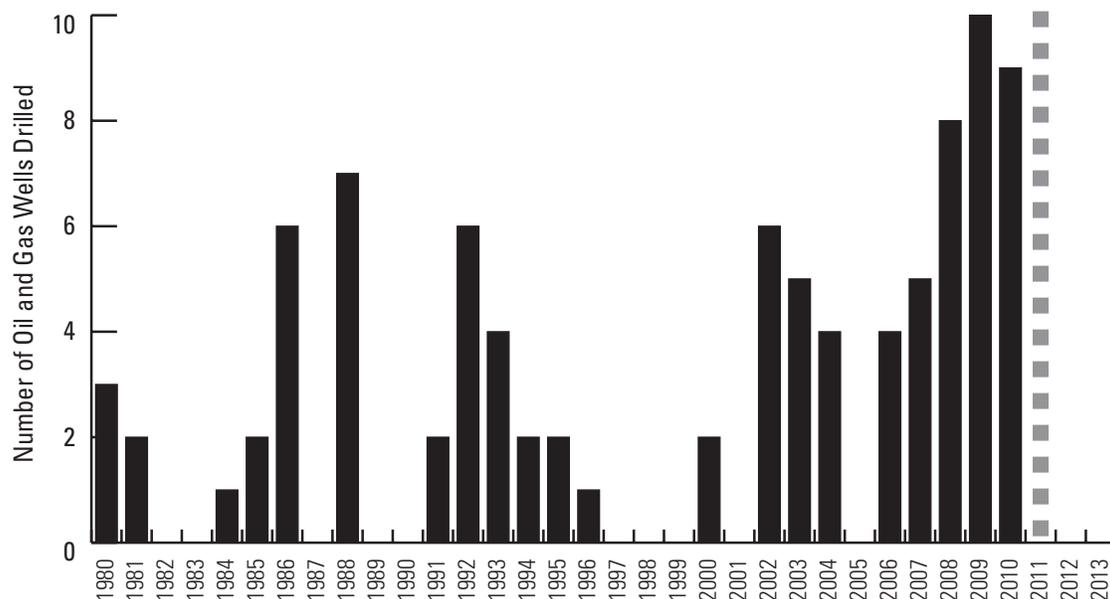
The well shaft descends vertically until it reaches the rock layer containing hydrocarbons. The shaft then turns horizontally and the well operator performs successive hydro-fractures to increase the permeability of the hydrocarbon-laden rock. Figure adapted from Government of Québec. (2011, February). *Sustainable development of the shale gas industry in Québec: Inquiry and public hearing [BAPE] report 273*, p. 31. Québec City: Minister of Natural Resources.



Given these factors, the physical characteristics of the Utica Shale make exploitation particularly cost-effective. The Utica is composed of relatively large, porous grains compared to other shales.<sup>15</sup> This means it is both easier to fracture the Utica and each “frack” frees up more gas than in other geological deposits. The surrounding rock formations are more or less impermeable, meaning the gas formed in the Utica is a concentrated source of natural gas with low rates of migration into neighboring rocks.<sup>16</sup>

Despite these advantages, exploiting the Utica’s natural gas is not cheap. Roughly 15 individual fracks are required to create a well of average yield, three billion cubic feet over a lifetime of 25 years.<sup>17</sup> Each frack requires about 400,000 gallons of water, totaling to just over 5.2 million gallons of water per well.<sup>18</sup> Typically, these millions of gallons of water must be brought in by truck, causing the cost of a fracked exploratory well, created to discover if an area contains accessible hydrocarbon reserves, to reach approximately \$20 million, double that of a conventional exploratory well.<sup>a</sup> This cost difference endures to a smaller degree during the exploitation phase.<sup>19</sup> While only a handful of shale gas wells have been drilled in Québec up to now (see *Figure 4*), hundreds, perhaps thousands more wells stand to be drilled and fracked if Québec allows development of the Utica Shale to proceed.<sup>20</sup>

**Figure 4**  
Oil and Gas Wells Drilled in the St. Lawrence Lowlands, QC (1980-2012).



Since 1980, the number of wells drilled in the St. Lawrence Lowlands of Québec has never exceeded 10 wells per year (solid black lines). The moratorium on new well drilling came into effect in 2011 (grey dashed line). Source: Système d’information géoscientifique pétrolier et gazier. (2014). Québec City: Ministère des Ressources naturelles. Retrieved from <http://sigpeg.mrn.gouv.qc.ca/>

### C. Québec’s Evaluation of Shale Gas and Its Controversy

Following the discovery of Québec’s accessible hydrocarbon reserves in 2010, the Québec government has reacted cautiously to the sudden surge of interest in exploiting shale gas in Québec, seeking out comments and advice from both scientists and the lay public. The provincial government’s first step was to request a public consultation on the sustainable development of shale gas under the auspices of the Bureau of Public Hearings on the Environment (BAPE).<sup>b</sup> This organization is among the most widely known and respected governmental organizations in Québec, with 65% of Québeckers having heard of the BAPE and 93% of those respondents judging the BAPE to be credible.<sup>21</sup> The BAPE, charged with informing and consulting the public on projects liable to have significant impacts on the environment, concluded in early 2011 that it was unable to fully complete its consultation because, “For certain fundamental [scientific] questions, the answers are either incomplete or nonexistent.”<sup>22</sup> The BAPE’s report asked for more time and information.

a All monetary amounts in this paper are in Canadian dollars.

b All translations of titles and quotes in this report are the author’s translations.

The Québec government responded to the BAPE's recommendation, imposing a moratorium on exploratory drilling in the St. Lawrence Lowlands in June 2011. The ban was contingent upon the completion of an environmental impact study, called a Strategic Environmental Evaluation (EES), in order to provide the BAPE with the information necessary to inform and consult the public.<sup>23</sup> This temporary measure, in place to the present day, halted all new oil and gas activities, though the handful of wells in production at that time were allowed to continue to operate.

The EES is similar to the United States' federal and state Environmental Impact Statements, but with a more holistic emphasis. In addition to evaluating the effect of hydraulic fracturing on the environment, the EES has commissioned 78 expert reports over three years evaluating its influence on the economy, human health, and other quality of life concerns. The EES is purely informational, containing no concrete recommendations. Instead, its purpose is to empower the BAPE to perform a more comprehensive public consultation.<sup>24</sup> The EES submitted its final report to the Québec government in December 2013 and the BAPE has begun a second public consultation scheduled to conclude in November 2014, in response to which the National Assembly is due to produce shale gas legislation.

There are two controversial elements in this process. The first is the question of whether the outcome of this process has been predetermined. Québec's National Assembly already adopted a resolution in favor of a ban on gas and oil extraction in Québec before the EES was even submitted.<sup>25</sup> As in the United States, this resolution was an expression of the official will of the legislature, without the binding force of law. The Parti Québécois pushed for the passage of a legally enforceable ban, but this was defeated following Liberal protests that such a bill would moot the years-long evaluation process. Now that the Liberals have taken power in Québec, it seems unlikely that the evaluation process will be short-circuited.

Nevertheless, the Liberals were part of the unanimous approval of the resolution supporting the principle of a ban.<sup>26</sup> In addition, the National Assembly extended the expiry date of the moratorium on drilling in the St. Lawrence Lowlands to 2018, though the BAPE's report is due at the end of 2014.<sup>27</sup> It is unclear why the moratorium lasts well beyond the deadline for the BAPE report. Taken together, these signs suggest that many politicians have already made up their minds. As Martine Ouellet announced in September 2012, less than 24 hours after taking office as Minister of Natural Resources, the Parti Québécois' "position is very clear on shale gas: a complete moratorium on exploration and exploitation."<sup>28</sup>

The second controversial element of this process is that the moratorium did not provide compensation for the lost profits of companies that bought gas exploitation permits from the Québec government.<sup>c</sup> The legal doctrine for compensating the loss of the right to use land, called "regulatory takings," is extremely narrow in Canada. Canadian law explicitly excludes interests in land from individual property rights and Canadian courts have consistently required the loss to be permanent to qualify for compensation.<sup>29</sup> The temporary nature of the ban makes it unlikely Canadian companies could obtain compensation through Canadian courts.

Companies in the United States and Mexico, on the other hand, may have a better chance of obtaining compensation by suing Québec through the North American Free Trade Agreement (NAFTA), which includes strong language requiring compensation for expropriating the property of foreign investors.<sup>30</sup> An oil and gas company incorporated in Delaware, Lone Pine Resources Inc., filed suit through NAFTA's arbitration system in late 2012, arguing the Québec government expropriated the company's permits without compensation despite their multi-million dollar investment.<sup>31</sup> However, the case's future looks bleak for two reasons. The first is that, like Canadian courts, NAFTA arbitration boards also require a permanent transfer of land use rights from the landowner to the government for compensation.<sup>32</sup> Second, the ability of Lone Pine Resources to pursue the lawsuit itself is uncertain following the company's bankruptcy in September 2013.<sup>33</sup>

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c In Canada, surface rights are severed from mineral rights. Private citizens can own the surface rights to land, but the government owns all mineral rights. Private companies can buy leases from the government to extract underground resources.



## Approaches to Fracking Elsewhere

### *In Other Canadian Provinces*

While Québec currently produces very little natural gas, Canada as a whole is the fourth largest producer of natural gas in the world. As shale gas makes up an increasingly large share of Canada's natural gas production, Canadians in other provinces have weighed the cost of accessing this resource and reached varied conclusions.<sup>34</sup> In Western Canada, fracking has become an accepted practice.<sup>35</sup> Alberta, the epicenter of the Canadian fracking industry, gives primacy to industry development but allows municipal governments to regulate the industry. British Columbia created the Oil and Gas Commission to balance industry and local interests, with the possibility of appeal to the Surface Rights Board, a conflict resolution body.

While Canada's western provinces have long been accustomed to living with the excesses and benefits of the oil and gas industry, the industry has historically left a light footprint in the east, specifically in Québec and the Maritime Provinces of Nova Scotia, New Brunswick, Prince Edward Island, and Newfoundland and Labrador. Unsurprisingly, it is in eastern Canada that proposals for shale gas development sparked the greatest furor.

Nova Scotia and Newfoundland and Labrador have both banned fracking to the widespread approval of their residents. New Brunswick gives municipalities complete control over oil and gas development, but limits this authority to urbanized areas. Partly as a result of this distinction and partly due to a controversial court decision allowing companies to drill in less populated areas, rural residents of New Brunswick took to the streets to protest the arrival of the shale gas industry. In one New Brunswicker indigenous community, the Elsipogtog First Nation's protests turned violent, with police cars burned and dozens arrested.<sup>36</sup>

### *Around the World*

Governments all over the world are increasingly skeptical of fracking. France and Bulgaria have explicitly banned fracking and there is a *de facto* ban in Germany. The anti-fracking movement has also gained momentum in the United States, the world's leading producer of shale gas. Vermont is the only U.S. state to explicitly ban fracking, though New York has imposed a *de facto* ban on fracking that, similar to Québec, depends on the publication of a long-awaited evaluation of the impacts of shale gas development.<sup>37</sup> While some states have not followed this trend, such as Pennsylvania, representatives in 19 U.S. states proposed at least 119 bills during the 2012 legislative session alone.<sup>38</sup>

There is an important difference between the approaches to fracking elsewhere and the situation in Québec, however. Since most of the jurisdictions that have acted against fracking contain only marginal shale gas reserves, government officials often have relatively little to lose by banning the practice. Québec, on the other hand, has substantial reserves of shale gas. The next two sections will consider the economic benefits and the environmental risks of developing these shale gas reserves, the largest in Eastern Canada.

## The Benefits of Shale Gas Development

Why develop and exploit shale gas in Québec? One argument often made in the United States in favor of shale gas is its positive environmental impact. Specifically, when burned to produce electricity, natural gas releases only half the CO<sub>2</sub> and one-third the nitrogen oxide compared to coal.<sup>39</sup> Moreover, shorter pipelines from well to furnace would lead to lower greenhouse gas emissions resulting from pipeline leaks relative to shipping natural gas from Western Canada.<sup>40</sup> However, all of these benefits are based on an erroneous comparison. Québec does not use coal to produce electricity, but hydropower. When compared to hydropower, natural gas is clearly not the environmentally-friendly option. Therefore, the only reason to develop and exploit the shale gas contained in the Utica Shale is for economic benefit.<sup>d</sup>

The EES explored three clear economic benefits that stand to be gained by developing shale gas in Québec. The first is reduced prices on natural gas. In 2010, the last data year available, Québec spent approximately \$1.815 billion dollars, or 5.8% of total energy expenditures, importing 195 billion cubic feet of natural gas from Western Canada. While this gas is inexpensive relative to crude

<sup>d</sup> Although the EES did not evaluate the profit potential for private actors, economic benefit would derive from natural gas exports, particularly to nearby provinces dependent upon natural gas for energy, such as Nova Scotia, New Brunswick, and Ontario.

oil, which sells at roughly six times the price, Québec has to pay the extra cost of transporting the fuel roughly 2,000 miles across the greater part of Canada. As a result, the price of natural gas in Québec is more than twice the price in Alberta, where most Canadian natural gas is produced.<sup>41</sup>

By producing natural gas, Québec and its businesses would likely save hundreds of millions of dollars even without selling any gas through exports. If prices fell to those seen in Alberta, the government's savings alone would equal \$900 million per year. Since Québec both has the largest shale gas reserves in Eastern Canada and is one of the few provinces not to ban its exploitation, Québec's neighbors would also hold considerable demand for locally produced, and thus competitively priced, natural gas.

A second economic advantage from the production of shale gas is job creation. Well drilling, preparation, and operation are labor-intensive, with the potential to create thousands of new, well-paid jobs. Estimates of just how many jobs this might entail vary greatly. One report found that a \$1.5 billion investment by the shale gas industry over 10 years would support approximately 11,000 workers.<sup>42</sup> This works out to just over \$135,000 per job. Another report found a \$7 billion investment over 25 years would support approximately 200,000 jobs, an average of \$35,000 per job.<sup>43</sup> What might explain this discrepancy is the former estimate does not consider the three to four low-pay jobs that are indirectly created for every high-pay job directly supported by the industry.<sup>44</sup>

As there are only 330,000 unemployed people in Québec, these new, well-paying jobs will likely attract job-seekers from all over Canada.<sup>45</sup> Unfortunately, this migration can come at the cost of straining the local community. As people flock to the St. Lawrence Lowlands, prices and rents will be vulnerable to large, volatile increases. Individuals on fixed incomes may be squeezed and even forced to leave the area in order to survive.<sup>46</sup> Political tensions may also rise with the arrival of large numbers of non-Francophone workers.<sup>47</sup> It is worth noting that the Québec government's own analysis of the impacts of shale gas gives these concerns greater weight than the industry's job-creation potential.

Finally, shale gas development could lead to a small financial windfall for the provincial government in the form of licensing fees and royalties. A report commissioned by the EES examined three potential development scenarios and their effect on government revenues (see *Figure 5*). The first envisions small-scale development, with only 1000 wells created over 10 years (starting in 2016). Québec's revenues from industry-related fees and royalties would sharply spike over the seven years between 2019 and 2025, reaching a maximum of approximately \$800 million in 2021 and 2022 respectively. By way of comparison, Québec's revenues from forests, mining, and hydropower equaled approximately \$2.2 billion in 2013-2014. Cumulatively, provincial revenues from industry-related fees and royalties would equal roughly \$2.5 billion over 10 years, with an additional \$500 million over the next 20 years.

In the medium-scale scenario, 3350 wells are drilled over 10 years. Québec would see annual revenues rise to a maximum of \$2.7 billion in 2024 within a period of significant collections ranging from 2022 to 2028. Overall, Québec would gain a total of \$10 billion in revenue by 2028, with an additional \$3 billion between 2028 and 2050.

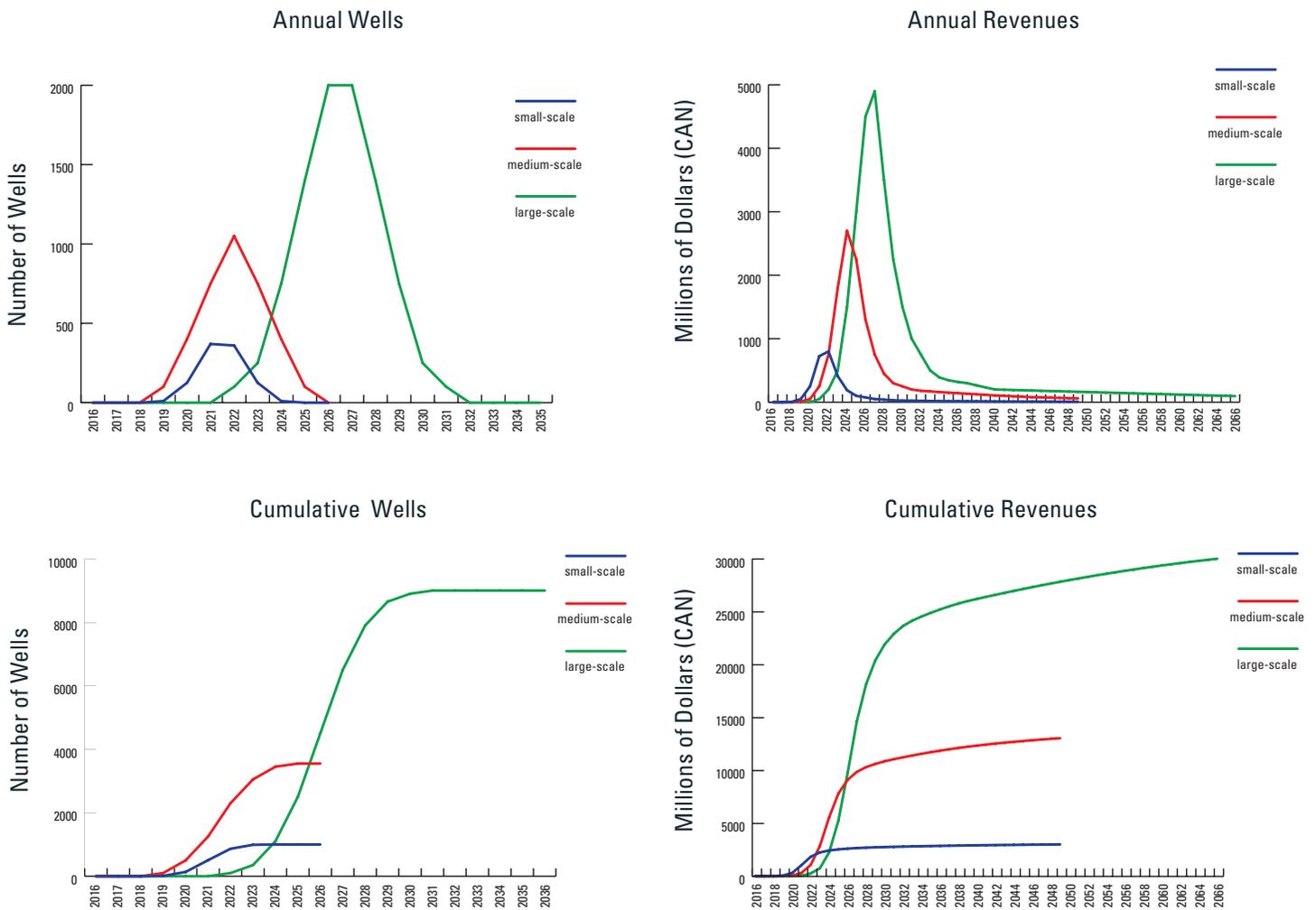
Finally, large-scale development of the Utica Shale would entail the construction of 9,000 wells. Revenues would peak in 2027 at nearly \$5 billion and there would be an eight-year period of revenues greater than \$1 billion between 2024 and 2031. Cumulatively, Québec would receive \$25 billion by 2036 and an additional \$5 billion from 2036-2066.

While these sums appear large, they should be understood in the context of the government's other revenues. Even if annual revenues from fees and royalties were to reach \$5 billion, the peak revenue from the most intensive development scenario, this would equal just 7% of Québec's 2013-2014 budget.<sup>48</sup> Shale gas revenues would make an even smaller contribution to Québec's finances when taking into account the anticipated expansion of Québec's budget between today and 2027, when this peak would occur.

Overall, these estimations suggest that, while shale gas development would lead to lower gas prices, more jobs, and a boost in Québec's revenues, these benefits are not overwhelming and may even destabilize local communities. Given these advantages, limited though they may be, the question of shale gas development now turns to its prospective environmental impacts.



**Figure 5**  
**Graphs of Well Drilling and Provincial Revenues in Three Natural Gas Development Scenarios.**



Clockwise from bottom left: Cumulative number of wells drilled in the small-scale, medium-scale, and large-scale development scenarios. Number of wells drilled per year for each of the three scenarios. Amount of additional provincial revenue from fees and royalties per year resulting from shale gas development for each development scenario. Cumulative amount of additional provincial revenue per year for each of the three development scenarios. Source: Bureau of Public Hearings on the Environment. (2014, April). *L'industrie du gaz de schiste dans les Basses-Terres du Saint Laurent: scénarios de développement* [Strategic Environmental Evaluation report], p. 23, 25, 27. Québec City: Ministère de Développement durable, Environnement, Faune et Parcs.

## The Environmental Risks of Shale Gas Development

Shale gas is certainly present in the St. Lawrence Lowlands. But the risks of accessing and exploiting this resource are not negligible. These risks come in two forms: natural risks and technological risks. Natural risks are inherent to any sort of development, gas or otherwise, in the region. They are events that would happen without any direct human action, though humans may indirectly influence their frequency or severity. Technological risks, on the other hand, are anthropogenic hazards directly related to the techniques and practices of shale gas extraction. These are events that would never occur without human intervention. This section explores each of these in turn.

### Heightened Natural Risks

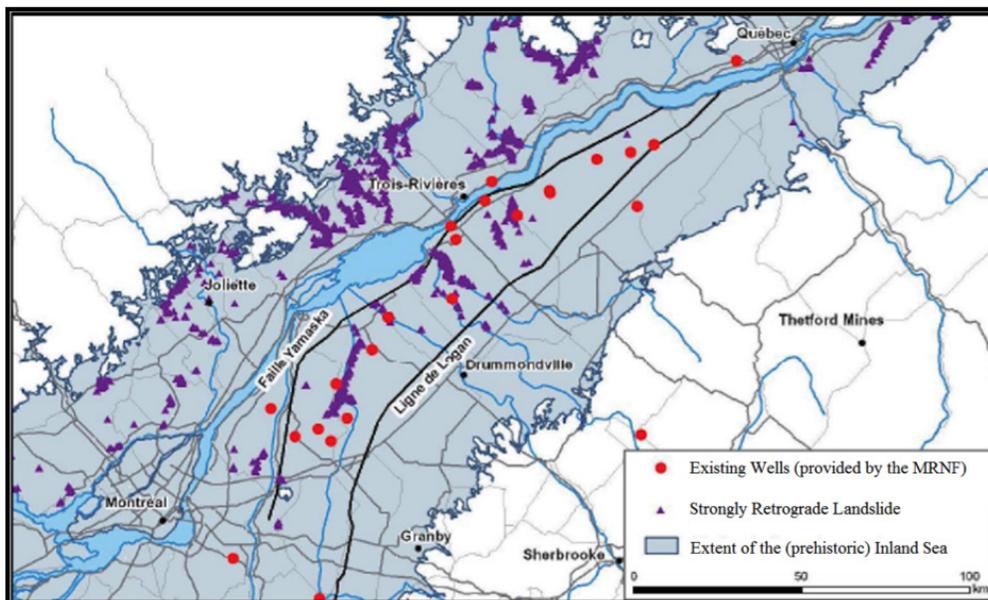
Even without direct human influence upon the terrain, the natural features of Québec introduce “considerable exploration and completion risk” for natural gas extraction in Québec.<sup>49</sup> These include the risks of land subsidence, increased frequency and intensity of earthquakes, and the release of naturally present contaminants.

#### Land Subsidence

Perhaps the most serious of these risks is land subsidence. There are hundreds of landslides every year in Québec, 80% of which occur in clay deposits, such those that exist in the St. Lawrence Lowlands.<sup>50</sup> A very significant proportion of these landslides, some 40%, are indirectly precipitated by human activity.<sup>51</sup> As shown in *Figure 6*, wells are often drilled in areas that have experienced strongly retrograde landslides, a highly destructive form of land subsidence (see *Figure 8*).

In some places, the mere presence of gas activities necessarily results in subterranean pressure shifts following the extraction or migration of gas deposits, overloading of surface water basins, and the erosion of vulnerable slopes.<sup>52</sup> These effects lead to landslides in areas where the soil is extremely sensitive to vibration. As demonstrated in *Figure 7*, this is the case in the St. Lawrence Lowlands.

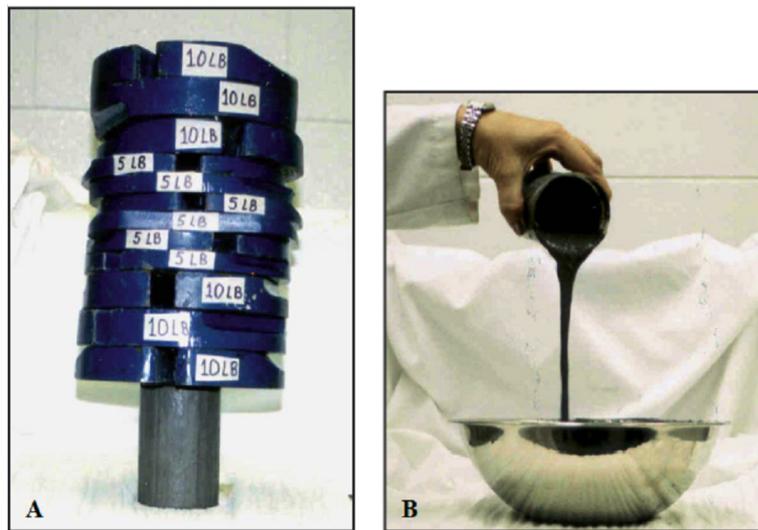
**Figure 6**  
Map of strongly retrograde landslides in relation to existing gas well locations.



Many existing wells are in areas vulnerable to strongly retrograde landslides. Figure adapted from Transports Québec. (2014, April). *Glissements de terrain. Exploration et exploitation des gaz de schiste*, p. 17. Québec City: Government of Québec.



**Figure 7**  
**Photos demonstrating the sensitivity of the St. Lawrence Lowlands' soil to vibration.**



A = intact soil capable of holding 90 lbs without cracking. B = If vibrated, the soil becomes a low-viscosity mud.  
 From Transport Québec's report *Glissements de terrain. Exploration et exploitation des gaz de schiste*, p. 14.

**Figure 8**  
**Photos of strongly retrograde landslides: Saint-Liguori (1989) and Saint-Jude (2010).**



Note the size of the trees in the foreground of the Saint-Liguori photo for a sense of scale. The green roof of a home destroyed on May 5 when it was buried under several meters of mud is visible in the Saint-Jude photo. Pictures from Transports Québec's report *Glissements de terrain. Exploration et exploitation des gaz de schiste*, p. 13.

While the risk of land subsidence is not unique to Québec, few shale plays in North America have a topography and climate comparable to that of the St. Lawrence Lowlands, a mix of steep inclines, substantial precipitation, and a harsh freeze-thaw cycle. This risk is particularly pernicious because it is difficult to generalize the conditions that lead to landslides.

Québec's current regulations attempt to do this, forbidding all construction within 100 meters of a vulnerable slope. Unfortunately, this distance proved to be insufficient when, on May 5, 2010, a family of four was killed when a crevasse one kilometer long and 500 meters wide opened in St. Jude, near St. Hyacinth (see *Figure 8*). The family was watching ice hockey in their basement when mud swept over the house, which was located in an area thought to be beyond the landslide danger zone. The adults and children suffocated to death under several meters of mud.<sup>53</sup> While this incident was unrelated to drilling, it stands to reason that a well would pose considerable risk to the environment under similar circumstances.

### *Earthquakes*

A second, related risk is that of earthquakes. Earthquakes can either directly damage a well or induce damaging landslides. In 1983, an earthquake in Québec measuring M4.1 on the Richter scale occurred six weeks after the injection of fluid into a well lubricated nearby faults.<sup>54</sup> Similarly, scientists believe well exploration was the cause of M4 earthquakes in Wilmington, California that caused damage to several wells.<sup>55</sup> In April 2014, the Ohio Department of Natural Resources explicitly connected fracking in the Ohio section of the Utica Shale with M3 and M4 earthquakes.<sup>56</sup>

Earthquakes in Québec tend to fall between M2 and M4 on the Richter scale, with most between M2 and M3.<sup>57</sup> At this intensity, there is practically no risk of damage. However, the micro earthquakes generated by exploratory drilling and hydraulic fracturing can increase the frequency and intensity of dangerous earthquakes.<sup>58</sup> In order to trigger a landslide, an earthquake has to be above M4.5.<sup>59</sup> While this has not been observed in Québec, the BAPE report notes that “the injection of fluids into the crust can, on occasion, produce seismic events that can reach a magnitude of M5.”<sup>60</sup> In addition, the many inactive faults in the St. Lawrence Lowlands pose a risk of reactivation if widespread fracking occurs. Therefore, increased shale gas development in Québec would introduce increased risk of earthquakes and landslides.

### *Natural Contaminant Release*

Finally, the highly acidic and oxidizing conditions in wells pose a third risk. Fracking may precipitate the release of contaminants naturally residing in the Utica Shale, regardless of the composition of the “frack fluid” used. These potential releases may include significant amounts of dissolved solids, barium, and very high concentrations of chlorides.<sup>61</sup> The resulting contamination of reflux waters would require costly treatment in order to ensure the health of local surface waters.

### *Technological Risks*

Shale extraction involves a number of techniques that involve risks that are generally rare but severe. Of the most recent shale gas development in Québec (2006-2010), 85% has taken place in rural settings (60% agricultural, 25% forest).<sup>62</sup> This means the risks and effects are primarily rural questions, concerning, in order of decreasing exposure: workers on drill sites, residents in direct proximity to drill sites, and communities in which these activities take place. The risks of shale gas exploitation may be inherent to the activity or simply stem from a failure to follow best practices. There is a wide variety of potential impacts on human and environmental health, including explosions, water pollution, air pollution, and nuisances in the form of light, noise, and traffic. This section will discuss each of these effects in order.

### *Explosion*

The most spectacular risk when exploiting shale gas is the violent eruption of flaming gas at the wellhead. This was particularly prevalent around the turn of the 20<sup>th</sup> century, when oil and gas extraction was first introduced to Québec. In 1883, the log of the Cabane Ronde well noted, “A column of liquid, rocks, and gas coming out of the well and rising more than 50 feet could be observed for 48 hours.” Fifty years later, the well log for Lanoraie Oil and Gas Syndicate No. 1 tersely observed, “When drilling reached the gas pocket, a column of mud erupted to a height of 75 meters. Gas flowed for 24 hours before being controlled.”<sup>63</sup>

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e These well logs are accessible on the website of the Système d'information géoscientifique pétrolier et gazier ([sigpeg.mm.gouv.qc.ca](http://sigpeg.mm.gouv.qc.ca)).



Explosions occur when gas surges, leaks, or otherwise escapes containment during drilling or exploitation. These events have become rarer with advances in gas-containment technology. Nevertheless, one gas district in California using fracking experienced explosion rates during exploitation as high as 1:1000 between 1995 and 2005.<sup>63</sup> The 2011 BAPE report concluded that a sizable proportion of recently drilled wells in the St. Lawrence Lowlands experience unexpected leakages of natural gas in volumes large enough to present a risk of explosion.<sup>64</sup>

### Water Pollution

A less dramatic, but similarly concerning risk is the infiltration of contaminants into surface structures and aquifers. This can happen when oil, frack fluid, or reflux sludge spills at the surface or leaks underground. Reflux sludge, the mix of frack fluid, natural contaminants, and mud that returns to the surface after fracking, is particularly difficult to manage safely. Shale gas extraction produces a large volume of reflux sludge, with a single well producing approximately 2000 cubic feet of sludge per day.<sup>65</sup> This liquid can contain heavy metals, certain chemical products,<sup>f</sup> non-biodegradable products, such as suspended polyesters, long-lasting pesticides, and radioactive contaminants.<sup>66</sup>

Reflux sludge requires substantial treatment before it can be released safely back into the environment or reused in other wells. Reuse is the most environmentally-friendly option in terms of minimizing water use and preserving environmental quality, but it is costly to do so. In terms of treatment, it is unclear whether municipal water treatment facilities could adequately purify the liquid, but, in any case, there are not enough of these facilities in the region to treat waste from more than a handful of wells.

While there are alternatives to water use in fracking, such as liquefied natural gas or liquefied carbon dioxide and nitrogen, these gases are dangerous to transport. It is also possible to frack only with water and do without chemical or physical additives. While this liquid would still require treatment, it would be simpler to do so. The main disadvantage is that fracking without additives is less efficient. Nevertheless, some 1200 wells have been drilled in the United States and Canada with these methods.<sup>67</sup> This means it is at least technically feasible to frack with lower-risk methods than those predominantly in use today, albeit with reduced production.

Subterranean seepage of fluids into surface structures and aquifers is a particularly worrisome concern, as this is often not directly observable. In order to isolate the target rock and prevent fluid migration, workers seat a cement casing around a well.<sup>68</sup> If this cement sealant is improperly installed, meaning there are gaps in the cement, or in the casing cracks, methane migration into surface aquifers or nearby structures is possible (see *Figure 9*).<sup>69</sup>

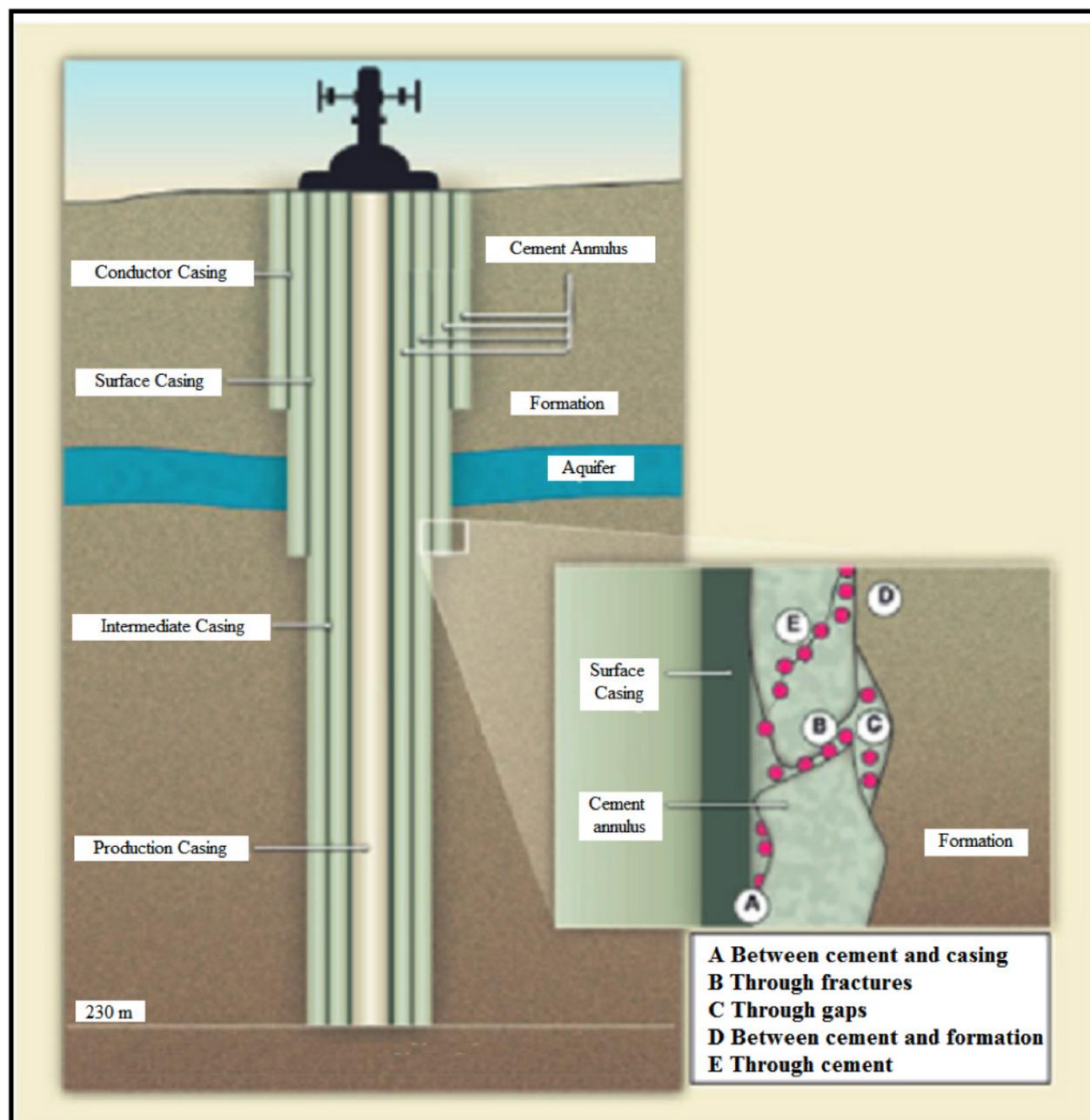
A recent study of the wells in the St. Lawrence Lowlands found that some 15% of wells have unsafe concentrations of methane.<sup>70</sup> The failure of the cement in these wells would pose a material risk to human health, either due to explosion or poisoning. In addition, there is also the possibility of tainted crops, as 80% of the target area is agricultural.<sup>71</sup>

In the worst-case scenario for subterranean fluid migration, as much as 30,000 cubic feet of gas could leak every year into the nearby area after only 10 years of abandonment.<sup>8</sup> Fracking increases the speed and volume of leaks, as the technique involves placing the production tubes under several multiples of pressure. Fracking amplifies weaknesses in the cement.<sup>72</sup> Improperly installed casings made of low-quality cement will break down at an accelerated pace, soon posing a substantial risk to the surrounding environment. In contrast, well-seated casings made of fresh, high-quality cement are unlikely to fail, even after fracking.<sup>73</sup>

<sup>f</sup> Including acetylene alcohol, volatile organic compounds, alkyphenols, ammonium chloride, trimethyl chloride, and quinoxifen.

<sup>g</sup> This is an estimate for a conventional well. This means the effect of fracking is not factored into the calculation.

Figure 9  
Schematic of Well Cementing and Means of Failure.



Gas, natural contaminants, and frack fluid may escape through gaps or fractures (A-D), as well as directly through deteriorated cement (E). Adapted from Vidic, R. D., Brantley, S. L., Vandebossche, J. M., Yoxtheimer, D., & Abad, J. D. (2013). Impact of shale gas development on regional water quality. *Science*, 340(6134), p. 8. Retrieved from <http://dx.doi.org/10.1126/science.1235009>



### *Air Pollution*

A third risk is one that has the potential to affect a larger population: air pollution. Potential sources of air pollution include the use of diesel internal combustion engines, boiler systems, torches and incinerators, and reflux sludge storage basins, as well as fugitive or ventilated gas. A typical shale gas project in Québec releases approximately 250 million pounds of carbon dioxide (CO<sub>2</sub>), 25 million pounds of methane (CH<sub>4</sub>), 6 million pounds of nitrogen oxides (NO<sub>x</sub>), and 5.5 million pounds of carbon monoxide (CO) every year for 25 years.<sup>74</sup> In terms of annual emissions, every three wells drilled are roughly equivalent to opening one new coal-fired power plant.<sup>h</sup>

In a situation wherein a company were to use the least environmentally-friendly practices, local air pollution would likely exceed several norms and air quality standards, particularly for nitrogen dioxide (NO<sub>2</sub>), fine particulate matter (PM<sub>2.5</sub>), and formaldehyde.<sup>75</sup> When water storage basins are left uncovered, there is an additional risk of extreme excesses in terms of concentration and spread of BTEX (benzene, toluene, ethylbenzene, xylene) and hydrogen sulfide (H<sub>2</sub>S). Frack fluid also contains chemicals that can pollute the air, most notably hydrogen chloride (HCl). While most operators use HCl at a 15% concentration, some frack fluid recipes call for HCl in concentrations as high as 28%. HCl is volatile, meaning it may form a toxic gas cloud if spilled, with immediate, dire health consequences for exposed workers, residents, and vegetation. In addition, odors from shale gas operations are emitted regularly, some which may travel as far as five kilometers away.<sup>76</sup>

This is, as mentioned above, the worst-case scenario. There are some basic mitigation measures that can significantly reduce air pollution resulting from shale gas extraction.<sup>77</sup> Equipment should be run on electric power and their chimneys raised several meters above ground level. To eliminate the risk of evaporation and volatilization of reflux sludge and frack fluid, water storage basins should be covered. Other techniques include the use of air capture systems while setting the well casing, burning low-sulfur coal in boilers, treating gas with condensation and thermal oxidation methods, and the installation of micro-leak detection and repair systems. Such measures, when implemented, can reduce the emissions of volatile organic compounds and H<sub>2</sub>S by more than 90% and avoid nearly all excesses of air quality standards. These measures may also limit odors to a 500-meter radius from the drill site during the roughly two-and-a-half months required to frack a well.

### *Nuisances*

As perceived by the public, the most serious problems brought by shale gas development are light, noise, and traffic pollution.<sup>78</sup> The construction of a typical multi-well site requires between 500 and 1180 “noisy” days, when daytime traffic raises sound levels above safe limits.<sup>79</sup> Even if individuals avoid suffering the physical health consequences of these nuisances, constant loud noises and bright lights in residential, commercial, and recreation areas may lead to negative psychological effects.<sup>80</sup> These deleterious effects can be reduced through the creation of buffer zones, the construction of adequate roads, the adherence to strictly defined operating hours, and the application of sound-dampening technology.<sup>81</sup>

It is clear that shale gas extraction threatens to detract from the quality of human life and the environment in Québec. The twin risks of land subsidence and earthquakes pose a serious risk to the physical integrity of wells constructed in the St. Lawrence Lowlands. Shale gas extraction poses an inherent risk of explosion and there is a constant risk of water pollution. The treatment of reflux sludge is complicated by the risk of contaminating surface waters with chemicals naturally residing in the Utica Shale, as well as those included in frack fluid. Sealant failure may lead to the subterranean migration of chemicals threatening aquifers and surface structures. Light, noise, and traffic nuisances pose a danger to human physical and mental health.

Companies that follow best practices may be able to reduce their environmental impact to a large extent. Unfortunately, it is impossible to ensure that these measures are implemented properly. Human error, slipshod work, and, of course, unavoidable natural disasters mean the risk of serious, lasting damage to the environment that cannot be eliminated. With these facts in hand, the question of shale gas development then hinges upon public perceptions of acceptable levels of risk.

### *Public Opinion of Shale Gas Development*

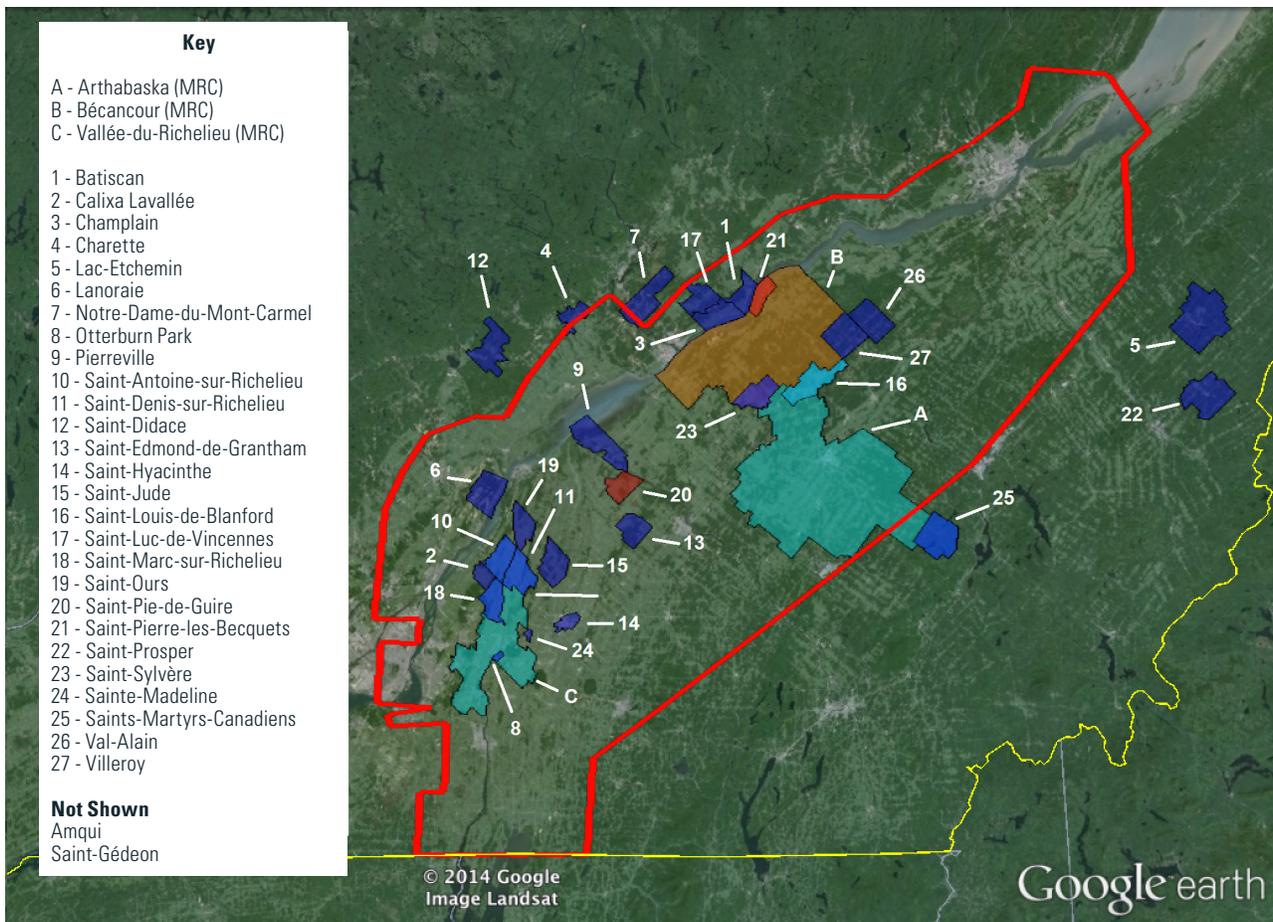
Public perceptions of shale gas are in constant evolution as public awareness grows and new, relevant information becomes available. Since the institution of the moratorium in June 2011, Québeckers have taken an increasingly negative outlook toward fracking. This evolution can be measured in terms of municipal actions, public forums, and surveys.

<sup>h</sup> According to the Environmental Protection Agency's calculator at <http://www.epa.gov/cleanenergy/energy-resources/calculator.html>.

In the first case, the Council of Canadians, a non-partisan civic organization, reports at least three of Québec’s county-level governments (MRCs) and 29 municipal governments have passed motions or submitted official requests to the provincial government calling for a moratorium on fracking (see *Figure 10*).<sup>82</sup> All three MRCs and 23 of the municipalities are located within the zone of interest for shale gas development (see *Figure 2*).

As the EES notes in terms of public input, “The debate on shale gas generally goes beyond local conflicts or factors of proximity. It has taken on national dimensions...”<sup>83</sup> Indeed, more than 50% of the participants in the BAPE’s first round of public consultations came from outside of the area of interest. In addition, over 10,000 Canadians from all parts of the country have signed a petition circulated by the Council of Canadians calling for a moratorium on all fracking in Canada until the federal government completes an environmental impact statement. While this petition became moot with the publication of the Council of Canadian Academies’ report on May 1, 2014,<sup>i</sup> its strong support is notable.

**Figure 10**  
**Map of Municipalities and MRCs That Have Passed Anti-Fracking Resolutions within the Area of Interest.**



This map shows the municipalities (blue) and MRCs, or county-level governments (teal) that have passed motions calling for a moratorium on fracking in their jurisdictions and the municipalities (red) and MRCs (orange) that have sent the Québec government an official request for a moratorium on fracking in Québec. Color variations do not signify qualitative differences between shaded regions of the same colors. Data from Council of Canadians. (n.d.). Fracker tracker. Ottawa: Council of Canadians.

Retrieved from <http://www.canadians.org/fracking/fracker-tracker>; image from Google Earth. (Build 7.1.2.2041). [Software].

Mountain View, CA: Google Inc. (2014). Available at <http://earth.google.com>;  
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<sup>i</sup> The report finds that at present, data is both insufficient and inconclusive about the prospective environmental costs of fracking within the divergent geographical, geological, and ecological contexts of different Areas of Interest for fracking within Canada. See Council of Canadian Academies. (2014, May 1). Environmental impacts of shale gas in Canada: The expert panel on harnessing science and technology to understand the environmental impacts of shale gas extraction. Ottawa: Council of Canadian Academies.  
Retrieved from [http://www.scienceadvice.ca/uploads/eng/assessments%20and%20publications%20and%20news%20releases/shale%20gas/shalegas\\_fullreporten.pdf](http://www.scienceadvice.ca/uploads/eng/assessments%20and%20publications%20and%20news%20releases/shale%20gas/shalegas_fullreporten.pdf)



The BAPE engaged three main actors in its first consultation: business, agriculture, and citizens' collectives. These three groups largely reject the notion of expanded shale gas development in Québec.<sup>84</sup> The promise of economic benefits from development did not appear to significantly influence the various participants' views, as there was no difference between those coming from economically healthy areas and those from economically depressed municipalities.<sup>85</sup> As suggested in *Figure 10*, people in many of the communities in which shale gas has been exploited or may be in the future feel negatively about the industry. This contradicts the idea that familiarity with the industry breeds its acceptance. On the contrary, the strongest condemnations of shale gas development came from areas where the industry was already present.

The results of public opinion surveys echo these findings.<sup>j</sup> Public support of fracking, only tepid at first, slipped quickly over less than a year's time (see *Figure 11.1*). In January 2012, Québec tied Alberta as the province most supportive of fracking, with slightly more than half of Québeckers in favor of a national moratorium on fracking (55%).<sup>86</sup> By November 2012, 72% of Québeckers came out against shale gas extraction of any kind<sup>k</sup>, a 17-point swing.<sup>87</sup>

Montpetit and Lachapelle find that Québeckers are generally hostile to the shale gas industry.<sup>88</sup> The word "fracking" is widely believed to have negative connotations (see *Figure 11.2*), and nearly two-thirds of Québeckers believe the advantages of shale gas development will be outweighed by its costs in the future (see *Figure 11.4*). Even if the highly-respected BAPE were to publish a report showing the risks of shale gas development to be low, the public's risk perception would still be above-average (see *Figure 11.3*).

This skepticism is tied to Québeckers' concern that shale gas development will lead to negative environmental consequences. This is demonstrated by the nearly linear relationship between risk perception and support for development (see *Figure 11.5*). As some three-quarters of respondents strongly or somewhat agree that natural gas drilling represents a major risk to water resources (see *Figure 11.6*), it is unsurprising that Québeckers are largely hostile to the shale gas industry.

Québeckers' take toward the shale gas industry might be explained by their ambivalence toward the desirability of atomistic competition, or that between individuals (see *Figure 11.8*), relative to their clear opposition to private profits from exploitation (73%) and concomitantly overwhelming belief that natural gas reserves are a public resource whose development should benefit citizens, at 92% (see *Figure 11.9*). Québeckers likewise prize environmental protection, with two-thirds in support of restraining economic growth to solve environmental problems (see *Figure 11.7*). For a further investigation into the relation between shale gas development and the values, beliefs, and perceptions of Québeckers, please refer to Montpetit and Lachapelle (2013).

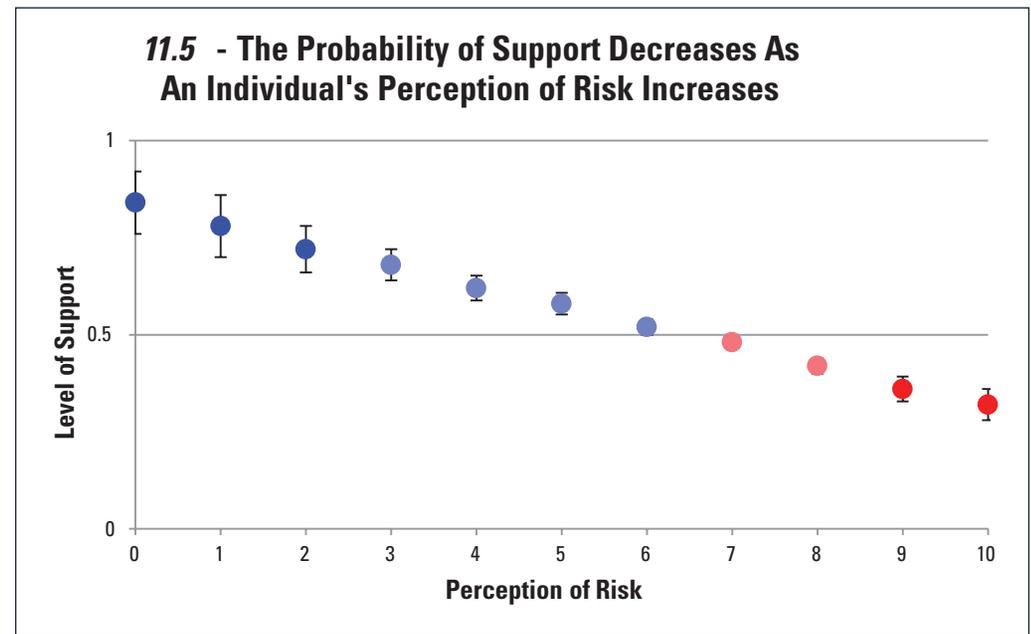
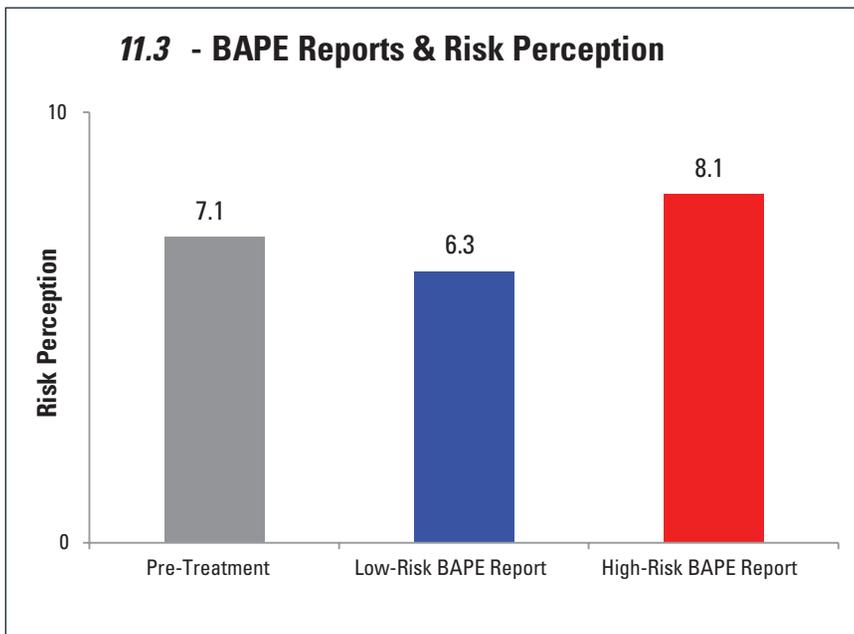
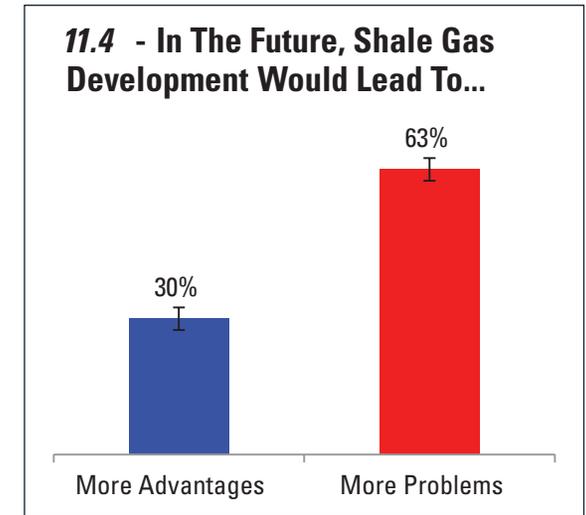
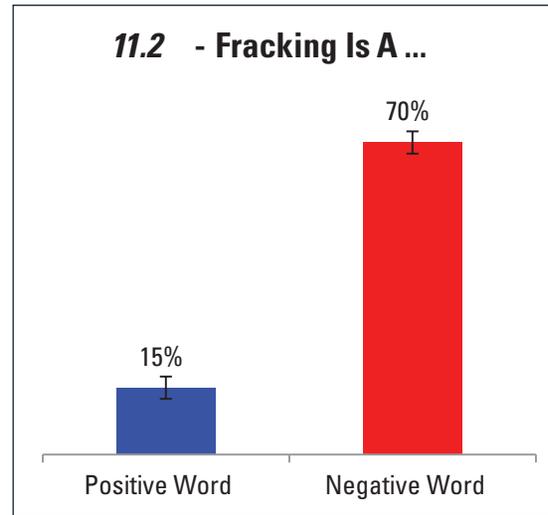
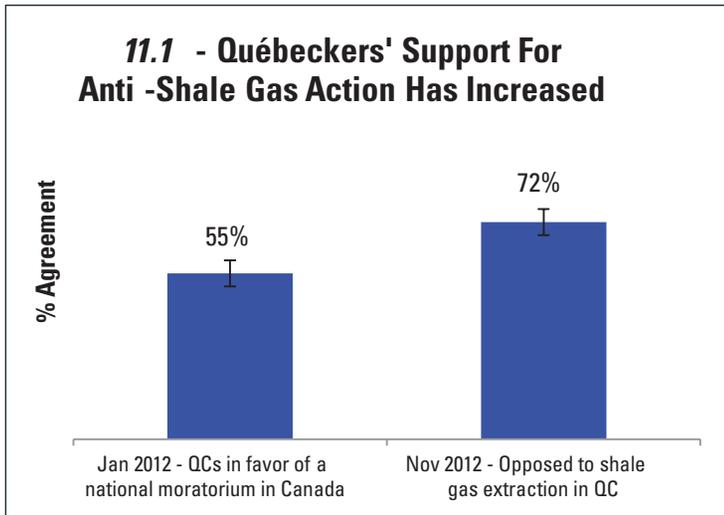
The EES commission considered these three measures of public opinion and concluded that the public acceptability of shale gas development is waning quickly. It is evident that, if development were to proceed in Québec, the industry would be obliged to improve their communication practices to convince the public of the desirability of their industry. As the climate of public opinion stands today, shale gas development is perceived to have little to offer in Québec.

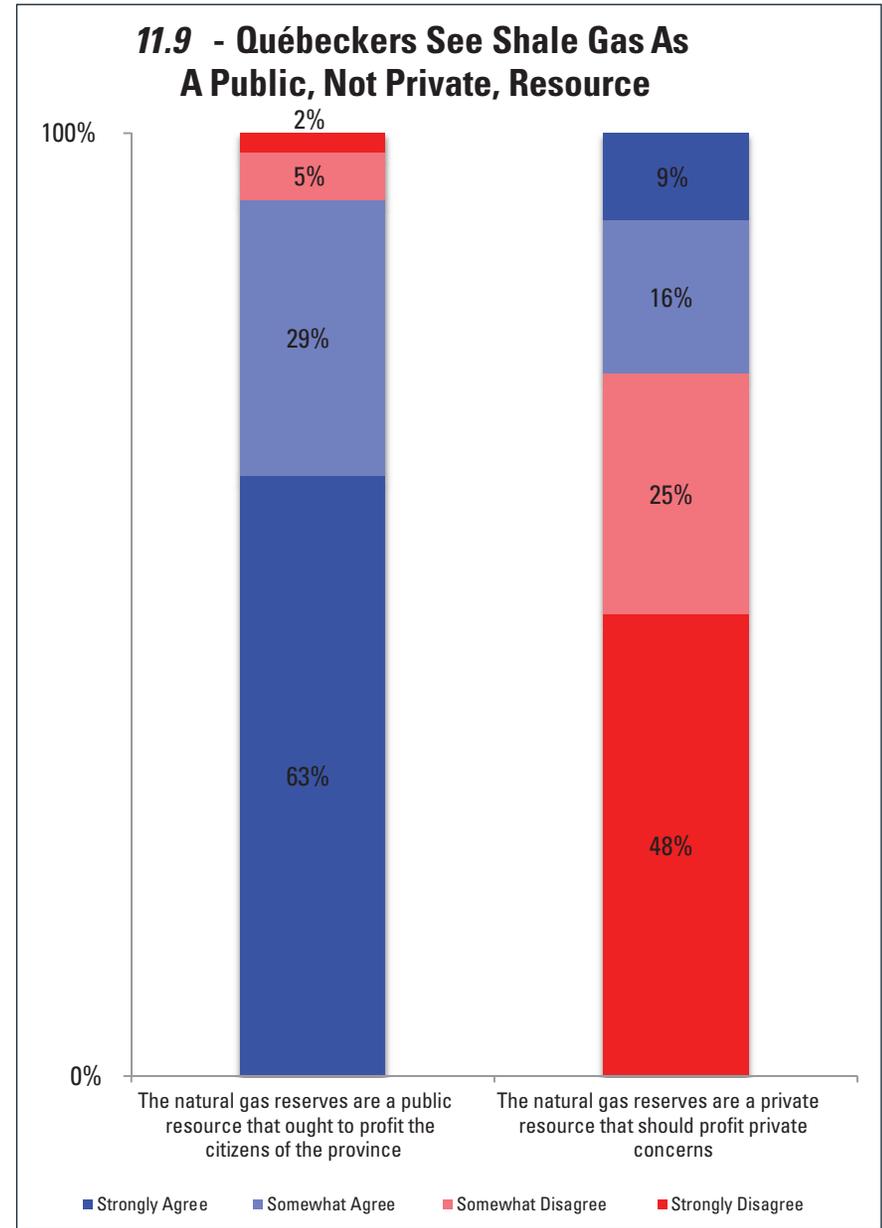
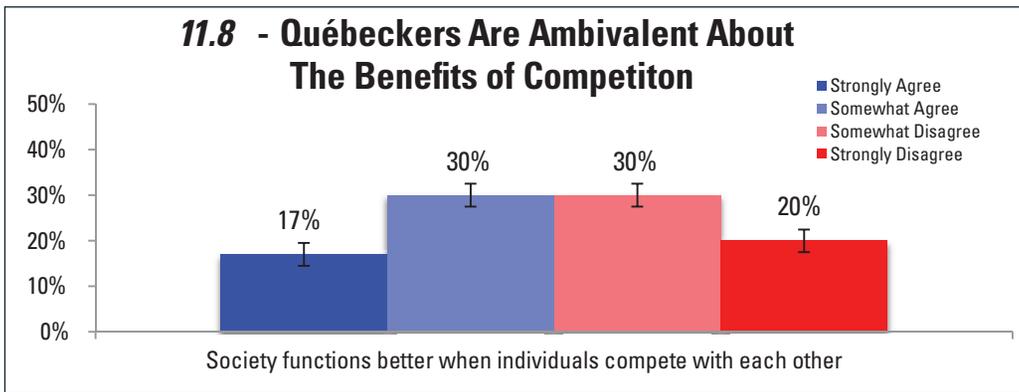
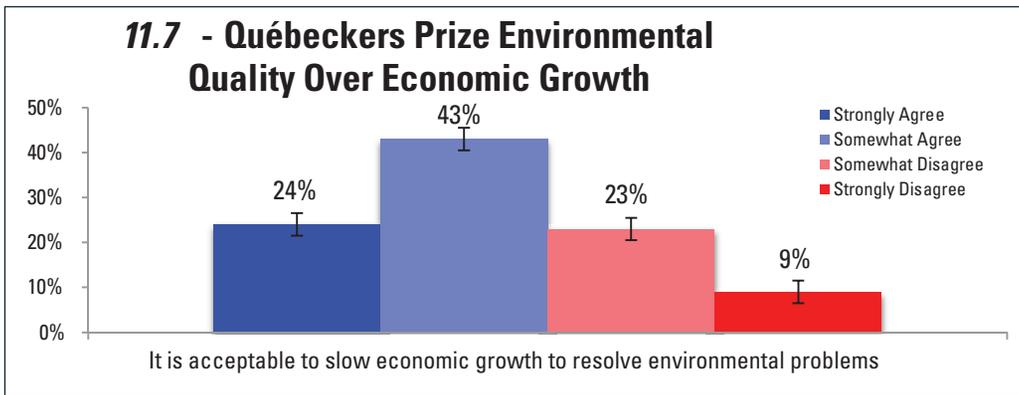
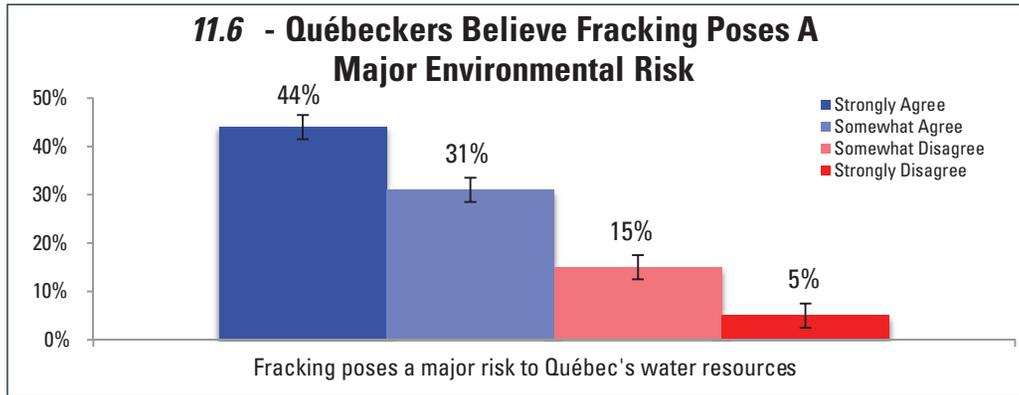
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j For technical information regarding these polls, refer to the caption in *Figure 11*.

k Albeit in response to slightly different questions. The question in January 2012 was, "Would you strongly support, somewhat support, somewhat oppose, or strongly oppose a moratorium on all fracking for natural gas until all the federal environmental reviews are complete?" while the question in November 2012 was, "In general, would you say that you strongly agree, somewhat agree, somewhat disagree, or strongly disagree with the extraction of natural gas through shale wells in Québec?" (my translation).

Figure 11  
 Québec Public Opinion Poll Results.





Data are from Montpetit & Lachapelle (2013) except "Jan 2012 – QCs in favor of a national moratorium in Canada," which comes from the Council of Canadians poll. Montpetit & Lachapelle survey data are from a telephone poll conducted in Québec by Léger Marketing from October 29 to November 14, 2012, n=1531, margin of error +/-2.5%. Council of Canadians poll data from a nationwide (Canada) telephone poll conducted by Environics from January 5-15, 2012, n=2000 (Québec n = 500), margin of error = +/- 2.19%. (Québec margin of error = 4.38%). Source: Lachapelle, E., & Montpetit, É. (2013). Gaz de schiste: Lorsqu'une valeur politique alimente la crainte des risques. In *L'État du Québec 2013-2014* (380-386). Montréal: Boréale Institut du Nouveau Monde. Environics Research Group (2012). Omnibus National Telephone Survey, January 5-15, 2012. Toronto: Environics Research Group.

### Conclusion

The potential economic and environmental consequences of development are integral to any response to the question of shale gas in Québec. In addition, it is crucial to account for the “X-Factor” that is Québec’s desire to exercise its autonomy. Québec’s politicians have exploited policy questions at the intersection of energy and the environment in the past to take positions that draw a contrast between Québec and the “Rest of Canada,” especially Alberta. This occurred with the creation of hydroelectric power generation and carbon markets. It may occur once again with shale gas.

In this case, the desire to “stick it” to the ROC may align with the results of Québec’s cost/benefit analysis and public consultation on the acceptability of shale gas. Allowing the development of shale gas to proceed appears to promise minimal economic benefits and threaten social upheaval. Québec’s natural features introduce considerable risk into a process that is already rife with uncertainty. While there is little doubt fracking and exploitation can be done in an environmentally responsible manner, the unavoidable risks of inconsistent adherence to best practices and human error make it difficult to impossible to ensure environmental integrity. Finally, the public acceptability of shale gas has plummeted over time, especially in areas in which the gas industry is already present.

Québec’s cautious approach may serve as an example for other jurisdictions weighing the merits of shale gas development. Democracies often struggle to balance democratic decision-making with informed decision-making, but, in this case, Québec managed to do just that. By first gaining the expert opinions of scientists on the potential risks and rewards and then consulting the public on the issue, Québec’s process is an excellent model of how a difficult and complex policy issue can be evaluated in a way that both respects the opinion of technical experts while closely hewing to the public will.

The EES’s conclusion that, “From the point of view of social value, the context is not favorable for the development of the shale gas industry in Québec,” will only have strengthened support for a ban on fracking.<sup>89</sup> As the BAPE’s second consultation comes to a close at the end of this year, it appears likely that Québec will reject shale gas development with a hostile public, little to gain, and so much to lose.



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