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ENERGY RESOURCE TRANSPORTATION GOVERNANCE: CASE STUDIES OF THE ALBERTA OIL SANDS AND THE ARGENTINIAN VACA MUERTA SHALE OIL FIELDS

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ABSTRACT

In recent years, there has been increasing focus on the economic and other benefits of the development of "unconventional" sources of oil – resources that cannot be produced using traditional production techniques -- partly due to the increased scarcity of conventional oil reserves. This paper compares and contrasts unconventional oil resources in Canada and Argentina. Canada has deposits of bitumen known as oil sands/tar sands. Bitumen is "a thick, sticky form of crude oil that is so heavy and viscous that it will not flow unless it is heated or diluted with lighter hydrocarbons" (Government of Alberta 2009), and when mixed with sand and clay, is known as the oil sands. In Argentina there are shale oil formations, which is crude oil found in low-permeability rock formations. The unconventional hydrocarbons in Canada (the oil sands) and Argentina (shale oil) are significant resources for both countries, especially when compared with their conventional reserves. Though the institutional structure is different in both countries – Canada's oil and gas and transportation companies are privately-owned, whereas in Argentina, they are partially government owned – the rhetoric of the discussions seems to be similar in both countries: many are in favor of development due to the significance of the economic benefits. However, in both countries, the development of transport infrastructure has been hindered by different factors, on environmental grounds, notably with regard to concerns regarding greenhouse gas emissions (in Canada) and lacking sufficient planning capabilities and institutional framework for long-term investments such as railroads (in Argentina).

Keywords: tar sands, shale oil, Canada, Argentina, pipelines, railroad

INTRODUCTION

In recent years, there has been increasing focus on the economic and other benefits of the development of "unconventional" sources of oil – resources that cannot be produced using traditional production techniques -- partly due to the increased scarcity of conventional oil reserves. For example, in the United States, the production of shale oil through the use of hydraulic fracturing ("fracking") has contributed to the decline in oil imports from 11.7 million barrels of crude oil per day in 2009 to 9.2 million barrels per day in 2014 (1), creating economic benefits and enhancing energy security. However, simultaneously, there have been concerns not only about the local environmental impacts of unconventional oil production, but also the global environmental implications of increased unconventional oil due to its climate change impacts.

This paper compares and contrasts unconventional oil resources in Canada and Argentina. Canada, which is the fifth largest oil producer in the world (4.4 million barrels per day, according the United States Energy Information Administration [EIA]), has deposits of bitumen known as oil sands/tar sands. Bitumen is "a thick, sticky form of crude oil that is so heavy and viscous that it will not flow unless it is heated or diluted with lighter hydrocarbons" (Government of Alberta 2009), and when mixed with sand and clay, is known as the oil sands. In Argentina, which is the 25th largest oil producer in the world, there are shale oil formations, which is crude oil found in low-permeability rock formations. As noted in Table 1, which provides a comparison of types of resources, bitumen and shale oil deposits can only be extracted using specialized, energy-intensive techniques. As such, while the development of both sources of oil has the potential to support the economic development of both countries, there is also opposition to the development of these resources on environmental grounds.

TABLE 1 Comparison of tight/shale oil and the oil sands (Source: compiled by authors)

Characteristic	Tight/Shale oil	Oil sands
Deposit	Crude oil found in low-permeability rock formations.	Bitumen mixed with sand and clay.
Nomenclature	The terms, tight and shale oil, though not synonymous, are often used interchangeably. However, shale oil should not be confused with *oil shale*, which is a product with a different chemical composition (Maugeri 2013).	Oil sands are often referred to as tar sands due to their similar consistency.
Extraction technique	Horizontal drilling and hydraulic fracturing are typically used to extract this oil from shale/tight oil deposits.	Mining and specialized steam injection techniques are used to extract this oil.
Oil density*	Usually a medium or light crude in terms of density (CSUR 2012).	Extra heavy crude in terms of density.
Deposit locations	Tight/shale oil deposits are located in many basins in the world, including the US, Canada and Argentina. The largest producing area is the Bakken formation in North Dakota (Maugeri 2013).	Oil sand deposits (known as oil sands) are located in northern Alberta.

Arguments for and against the construction of transportation infrastructure to support increased oil production in both countries is intimately tied to development of these resources. For example, for the proposed Keystone XL pipeline from the oil sands in Canada, which would run to the US Gulf of Mexico Coast, opponents are concerned not only about negative potential environmental impacts from the pipelines themselves, such as a spill of diluted bitumen (a form of crude oil to be shipped), but also about the consequences of greenhouse gas (GHG) emissions caused by the energy-intensiveness of bitumen production and refining. Proponents counter that a denial of pipeline permits by the Canadian and US governments would lead to more crude by rail, which, they argue, would not only be less cost-effective, less safe, and less environmentally-friendly, but also ultimately lead to the same amount of GHG being emitted from the production and refining of oil sands bitumen (e.g. Krugel 2013). In other words, the debate over whether to proceed with the development of oil transportation infrastructure – such as a pipeline -- is no longer solely about the pipeline itself, but whether North American society should be expanding the capacity to produce and transport crude oil at all, especially from a "dirtier" source. Further, politically in the US, Keystone XL has become a litmus test for President Obama among environmental advocates

In this context, this paper takes a comparative analysis of the development of energy resources in Canada and Argentina, and aims to answer the following questions:

- What are the energy resources that could be developed in Argentina and Canada?
- What strategic alternatives for inbound and outbound transportation capacity are being considered to develop these resources?
- What is the role of transportation in developing these resources?
- What issues have been raised about the possible development of this capacity in both countries?
- What are the actions and strategies of public and private actors and how have they enabled or hindered the development of transportation capacity?

We answer these questions sequentially in the sections below.

OVERVIEW OF ENERGY RESOURCES

In both Canada and Argentina, the largest reserves of unconventional sources of oil are landlocked and located away from their respective coasts. As shown in FIGURE 1**,** the oil sands are located in northern Alberta, Canada. The oil sands are actually composed of multiple deposits, the largest being the Athabasca, but are often referred to as the *Canadian* or *Alberta* oil sands.

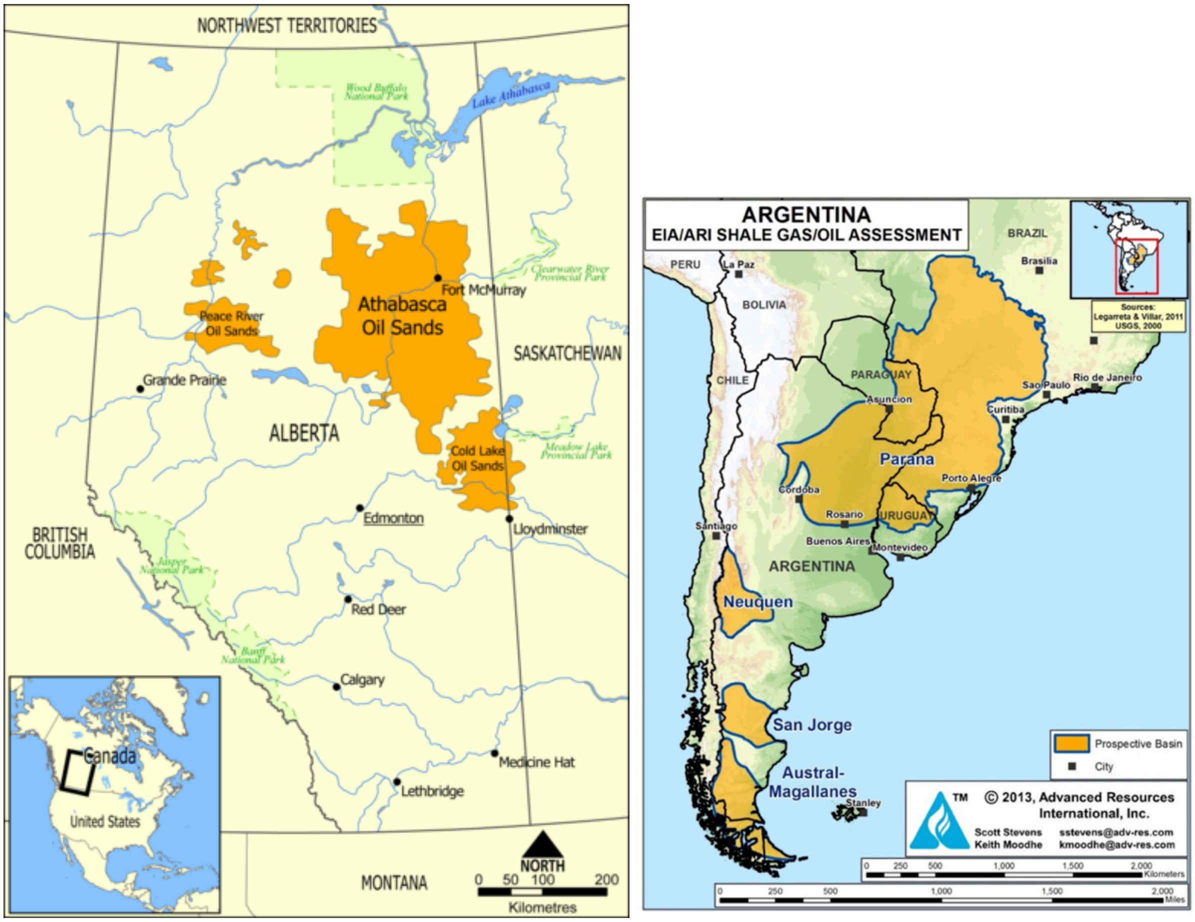

FIGURE 1 Map of oil sand deposits in Alberta relative to the rest of Canada and map of prospective shale basins of Argentina, in particular Neuquén Basin where Vaca Muerta is located (Source: Wikipedia.org for Canada and EIA 2013 for Argentina)

According to the EIA, there are four major basins in Argentina (FIGURE 1**)** three of which were superposed on conventional oil basins already exploited: Neuquén, San Jorge and Austral. The Neuquén Basin, with a long tradition of oil and gas conventional production, has the largest potential resources of gas and oil in Argentina and is the most studied basin in the country. With an extension of 137,000 km^2 (Accenture 2012), the Neuquén Basin is larger than the entire nations of Greece or South Korea and almost 4.5 times the size of Belgium. Within it there are two formations: Vaca Muerta (VM) and Los Molles (LM). The footprints of both are overlapped (cover the same surface area) but underground are at different depths. LM is deeper and thicker. In terms of potential, VM has the best characteristics not only for its potential volume but also because of the high quality of the resource (Mosquera et al. 2009). Regarding the quality of the product, VM has similar characteristics of the US "plays", the term often used for a group of oil fields in the same region with the same geology.

Increased production from these resources has the potential to dramatically alter the energy landscape in these countries. The oil sands are the source of over 98% of Canada's proven oil reserves of 173.6 billion barrels (equivalent to 7.29 trillion US gallons or 27.6 trillion liters) the third-largest proven reserves of oil in the world (US Energy Information Administration [EIA] 2012a). (According to the EIA (2014): "proved reserves are estimated volumes of hydrocarbon resources that analysis of geologic and engineering data demonstrates with reasonable certainty (greater than 90 percent probability) are recoverable under existing economic and operating conditions." Forecasts by Canadian government agencies and other industry and research groups predict major growth in oil sands bitumen production, which would make it an even larger fraction of total Canadian production. Canada's National Energy

Board's (NEB 2013) reference forecast, predicts that oil sand bitumen production is expected to rise from 1.8 MMbbl/d in 2012 to 5.0 MMbbl/d in 2035. Because conventional oil production is expected to remain relatively constant over the same period, the oil sands are expected to make up over three-quarters of Canadian oil production by 2030, up from slightly over 50% now. As such, should these forecasts materialize, oil sands production represents a significant fraction of Canada's energy resources.

Similarly, in Argentina, in 2011, a series of announcements (including a report from the EIA) noted that Argentina had large shale gas and shale oil resources, second in terms of shale gas and fourth in shale oil reserves worldwide. This means an increase of 10 times the current oil reserves (conventional) and 65 times the gas reserves, thereby having a massive impact on economic development and to potentially change the Argentine energy perspective. A special report prepared by KPMG in 2014 states: "Argentina is one of the countries with the strongest possibilities of producing shale resources (particularly in Vaca Muerta and Los Molles formations)." As happened in the US, geologists had known that the source rock contained significant quantities of oil and gas, but it was unclear whether they would be commercially exploitable.

TRANSPORTATION REQUIREMENTS

The main transportation constraint in Canada in further developing the oil sands is the transportation capacity for *outbound* crude oil. In 2015, The Canadian Association of Petroleum Producers (CAPP) estimated that total transportation capacity for Western Canadian crude oil (including oil sands production) at approximately four million barrels per day, and is operating at or near capacity (CAPP 2015). Currently, most of Canada's oil production is transported to the US; of Canada's total production of 3.2 MMbbl/d in 2012, Canada exported approximately 2.6 MMbbl/d to the US, which represents 97 percent of Canada's crude oil exports. Most Canadian oil is destined to the US Midwest, but there is interest in increasing shipments to the US Gulf of Mexico Coast, where the majority of US heavy oil refining capacity is located (US Department of State 2013a), as well as to the East and West Coasts of Canada, for export abroad.

To this end, in order to allow greater quantities of crude oil from the oil sands to coastal areas, where refineries are located and/or bitumen can be exported, several strategic alternatives are being proposed. As shown in FIGURE 2, the strategic alternatives can be classified at the highest levels by route (i.e. ultimate destination) and transport mode (e.g. by rail or pipeline). There are several proposals to build new pipelines directly from Alberta to the West and East Coast of Canada, and US Gulf of Mexico Coast (USGC), notably the Keystone XL, to accommodate additional oil sands production. These projects would not only allow Canadian producers to sell increasing amounts of bitumen to Asian markets by shipping oil via tankers, but also allow refineries on the East Coast of Canada to reduce the amount of oil they import from abroad.

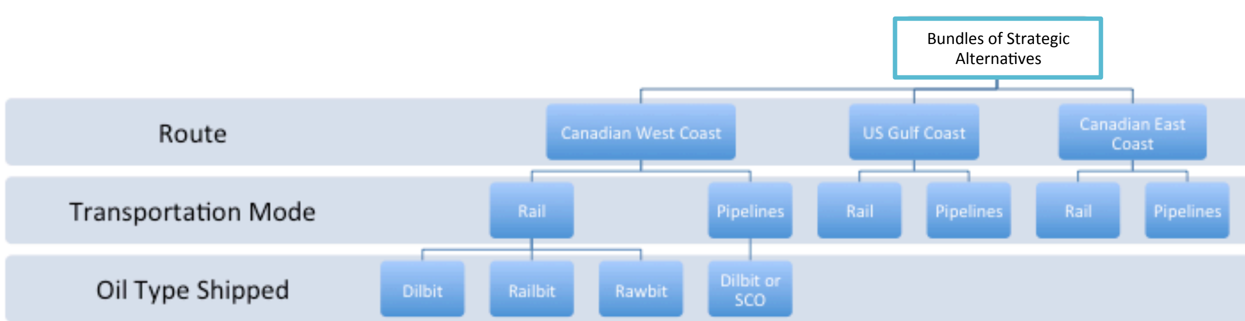

FIGURE 2 Bundles of strategic alternatives for crude oil transportation capacity from the oil sands (Source: authors)

Bitumen is also typically more costly to ship than the light crude oil produced from shale oil formations. After raw bitumen (*rawbit*) is extracted from the deposits, it typically requires additional processing or special handling in order to be shipped. In order to be transported by pipeline, bitumen either needs to be upgraded into a lighter form of crude oil that can flow at ambient temperatures called *synthetic crude oil (SCO)* – which requires a capital-intensive facility known as an upgrader -- or diluted with a lighter (less-dense) hydrocarbon, such as condensate – which effectively reduces the available transportation capacity to ship bitumen. The product resulting from mixing condensate with bitumen is referred to as *dilbit (diluted bitumen)*. Rail tank cars can be used to ship dilbit or SCO. Tank cars can also be used to ship rawbit and *railbit* (a less diluted form of bitumen as compared to dilbit) but special equipment, such as insulated tank cars and heating facilities at terminals are required (Fielden 2013a, Cairns 2013a). Additionally, because feeder pipeline are used to ship dilbit from the oil production areas to the rail car loading facilities, a diluent recovery unit (DRU) at the loading facility is also required if rawbit or railbit is to be shipped.

By contrast, in the case of Vaca Muerta, the declining of the conventional oil production in the Neuquén Basin in the last decade is leaving available capacity in the existing pipelines for the outbound transportation of crude oil and natural gas, at least in the short term. In fact this configuration of the system was used in 1998 when 30% more crude oil was moved (historic record). The main constraints for the massive development of Vaca Muerta are related to the inbound transportation of the supplies required by the two essential technologies for the shale exploitations: hydraulic fracturing and horizontal drilling. As the US case shows, the massive inputs needed in shale development significantly increases the transportation and logistics requirements at the well site, in comparison with conventional exploitations.

Additionally, the US experience showed that the shale developments cause a significant deterioration of public infrastructure, particularly highways and roads. The main studies on this matter were developed by the Upper Great Plains Transportation Institute of North Dakota State University (UGTPI 2013 and 2014), University of Texas at Austin (Banerjee 2012) and Texas A&M (Quiroga et el. 2012), funded by state DOTs and the Federal Highway Administration. In general all these studies conclude with the need to identify the marginal deterioration caused by shale operations and encourage local and regional governments to act in time to avoid citizen complaints, especially from neighbors of the shale operations.

In order to increase inbound transportation capacity to Vaca Muerta, several strategic alternatives are being proposed. This paper analyses the main East-West supply corridor between Bahía Blanca (Atlantic port) and Vaca Muerta, where both rail and road infrastructures are in place, even though high investments are required to increase capacity in both systems. As shown in FIGURE 3, three classification levels are proposed, as above, collectively called *bundles of strategic alternatives.*

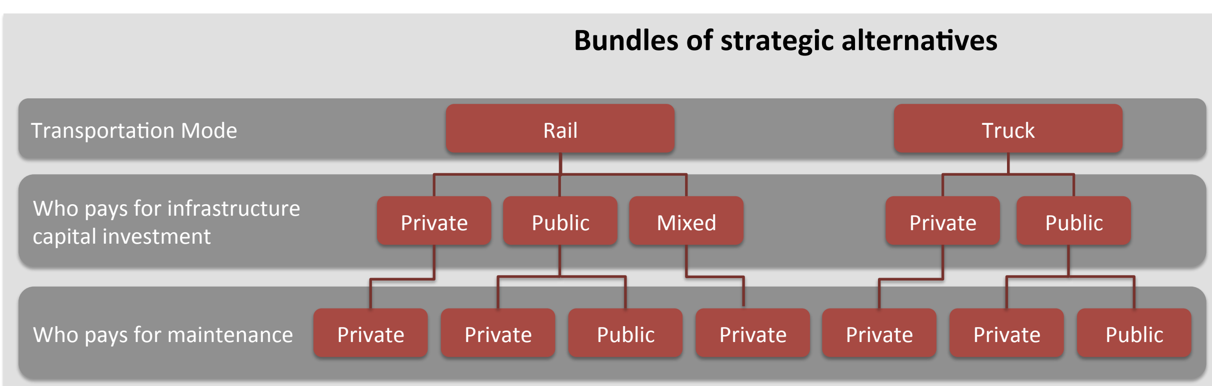

FIGURE 3 Bundles of strategic alternatives East-West VM supply corridor (Authors)

INSTITUTIONAL ROLES FOR THE DEVELOPMENT OF TRANSPORATION INFRASTRUCTURE

Alberta Oil Sands

Private-sector companies, overseen by government regulation, control energy sector and pipeline development in Canada. As shown in Table 2, the Canadian federal government exercises the most direct control over the development of pipelines crossing provincial borders. Additionally, because one of the intended destinations of oil sands bitumen is the United States, notably the Midwest and US Gulf of Mexico Coast, governments in both the US and Canada have a role to play in the development of transportation capacity.

For pipeline projects crossing international borders, the NEB and US Department of State are responsible for preparing the Environment Assessments (EAs) and Environmental Impact Statements (EISs) in Canada and the US, respectively. Once these documents are complete, final approvals of new interprovincial and international pipeline projects are provided by the Governor-in-Council (i.e. cabinet) in Canada and the president in the US. Provincial and state governments have limited power to stop these projects due to the division of powers within the Canadian and American constitutions. However, in the US, state governments can legislate around issues of local concern, such as pipeline siting. This power has become apparent with the court case related to Nebraska's approval of the Keystone XL route (Bernstein 2014).

TABLE 2 Pipeline Approval Responsibilities in Canada and the US

Canada	United States
Federal Government Under the most recent version of the Canadian Environmental Assessment Act (CEAA) passed in 2012, the Governor-in-Council (i.e. the prime minister and his/her cabinet) has ultimate authority to approve or deny a permit for a project following the completion of an Environmental Assessment under the act (CEAA 2012).	**Federal Government** The president of the US has ultimate authority to approve a permit for international pipelines if he/she finds the project in the "national interest", which is not explicitly defined (Parformak et al. 2013). However, there are currently questions as to whether Congress could override the president's veto regarding the approval of the Keystone XL using Congress' legislative authority. (Vann et al. (2012) of the Congressional Research Service observes that ". . . legislation altering the pipeline border crossing approval process appears likely to be a legitimate exercise of Congress's constitutional authority to regulate foreign commerce . . ." However, overruling the President's decision would require a veto-proof [two-thirds] majority in both the House of Representatives and Senate, which has not been achieved.)
Provincial Governments While pipeline projects cross across provincial land, their governments may not have any "legal basis" to stop pipeline projects should they object to their construction, as interprovincial and international pipeline projects are under federal jurisdiction (Centre for Constitutional Studies 2012)	**State Governments** The federal government, as the regulator of interstate commerce, has ultimate authority over the approval of interstate pipelines. States generally have the authority over the particular route ("siting") that a pipeline will take, provided the actions that they take do not overly harm interstate commerce. However, states "are given significant deference by courts to establish environmental, public health, and safety standards" that may harm interstate commerce (Vann et al. 2012).

In Canada, rail service to transport crude oil is provided by two vertically integrated companies (i.e. control both infrastructure and operations): Canadian National (CN) and Canadian Pacific (CP); oil would flow by pipelines to loading facilities on the respective railways for further transport. Because much of the necessary infrastructure to transport additional bitumen by rail is already in place, governmental actors, particularly at the federal level, have fewer mechanisms to control the transportation of crude oil by rail. In Canada, where much of the necessary loading facilities might be built, approval by the

Canadian Transportation Agency (CTA) of new railway lines is generally only required when the new line is over 100 meters away from the centerline of an existing rail line, and then only if the rail line is longer than three kilometers. Furthermore, environmental assessments are only required for new rail construction over 32 kilometers (20 miles) long (CTA 2011). However, government regulators can influence available capacity through the implementation of more stringent safety regulations, such as tank car standards and operating procedures, increasing the cost of shipping crude by rail.

In contrast to the Canadian energy sector, the upstream sector in Argentina is mainly controlled by YPF (national oil company) with 41% of crude oil production and 29% of natural gas in 2014 in Argentina, and private oil companies, with local and foreign participation, are producing the rest. As such, YPF is the leading actor in the development of VM and understands that, to succeed in the shale development, it needs to achieve efficient operations, in which transportation and logistics are critical (YPF 2014).

YPF's relationship with the national and provincial government is complex because of the dual relationship of owners and regulators. At the same time YPF defines itself as a mix-company (like Petrobras in Brazil) that is not state-owned in the sense that it is not governed by rules applying for state-companies and is committed to producing profits for its shareholders. With its leadership, YPF is making decisions in much of the supply chain, having an important role in the planning of the required logistics infrastructure. The rest of the oil and gas (O&G) producers have a more traditional relationship with governments.

The two governments (national and provincial) have different responsibilities and receive different revenues. The provinces are the owners of the natural resources, and their governments regulate the concessions, collect the royalties and are responsible for the environmental and safety regulations. The national government, in places where concessions are provincial[1], maintains the role of controller, but it has a strong influence in the decision of capital investment on national transportation infrastructure (roads, highways, pipelines).

In the railroad sector, the institutional framework is still uncertain, but it is clear that the decision for new railroad capital investment will be made by the national government, which regulates the concession and will be the eventual infrastructure manager (IM). The private concessionaire, up to now, does not have a proper investment horizon to make large investments. Ferrosur Roca has the concession for the railroad to VM (Roca line), which started in 1993 and will end in 2023; that was issued by the national government in return for an annual fee. However, the Argentine Congress approved a law in April 2015 that allows Open Access to the railroad infrastructure (including the private concessions), allowing other operators to eventually compete with Ferrosur Roca on the Roca line in the short term. In fact, this law foresees renegotiation of the concessions.

In this new Open Access regulation, the government will be the IM, charging operators for the use of the tracks. The debate about how to allocate capacity and how to charge for this infrastructure is open and complex; for example, Peña-Alcaraz (2015) developed a mechanism to analyze the capacity pricing and allocation for shared railway systems.

Trucks can also be used to transport inbound supplies. The trucking industry is much more fragmented due to the nature of the business and is also less regulated. The sector is mainly driven by competition and it is not clear to what extent the trucking rates include the actual deterioration of the infrastructure.

IMPACTS AND ACTOR RESPONSE

In both Canada and Argentina, the three main impacts related to the development of the respective energy

[1] In offshore exploitations, for example, the national government is the owner of the resources and is in charge of issuing the concession and permits, and regulating.

resource relate to the potential economic benefits, environmental concerns, and safety concerns.

Economic

Production from the oil sands is a major economic driver in Canada. Currently, in Alberta, one out of 14 jobs is in the oil and gas sector (Government of Alberta 2013), and assuming plausible growth in oil sands production, oil sands jobs could grow from 75,000 jobs (direct, indirect and induced) in 2010 to 905,000 jobs in 2035. Over the next 25 years, given plausible oil sands growth in production, the Government of Alberta and the Government of Canada could expect to receive $455 billion (in tax revenue and royalties) and $311 billion (in tax revenue), respectively, over this period (Honarvar et al. 2011).

The economic development potential of the oil sands is so significant that all major Canadian federal political parties support some continued expansion of the oil sands and some of the necessary transportation capacity to support it. In addition to the current Conservative government, which strongly supports pipeline development, the centrist federal Liberal Party also appears to support some pipeline development, with leader Justin Trudeau praising former Alberta Premier Alison Redford for her lobbying efforts in the US supporting the Keystone XL (The Canadian Press 2013a). The more left-wing federal New Democratic Party (currently the official opposition) is supportive of pipelines that would allow bitumen to be refined in Canada, such as the TransCanada Energy East, instead of exported, such as with the Keystone XL, Enbridge Northern Gateway, and the Kinder Morgan Trans Mountain Expansion (Barton 2013). (The author refers readers to Hoberg (2013) for a further discussion of the response by Canadian political parties to proposed pipelines.) While each political party has a different strategy, they all recognize the economic potential of the oil sands.

Similarly, production from Vaca Muerta will be a major economic driver in Argentina, not only because of the substitution of imports but also for an eventual boost to the manufacturering sector by lowering the cost of energy produced by natural gas. Assuming a plausible growth in shale production, VM jobs could grow 56% by 2019, creating 144,000 new jobs (direct and indirect) (CAC 2014). In 2030, it is expected that the production of oil and gas of VM could be $62+ billion per year (Argentinean National Engineering Academy 2014).

Locally in Neuquén, VM is expected to double the regional GDP by 2019, boosted by an investment of the private and public sector of $18+ billion (CAC 2014).

Environmental

In Canada, though there has been concern over the local environmental impacts of oil sands production, much of the debate has centered on the potential impacts on climate change. Production and refining of crude oil derived from bitumen from Alberta results in more climate-change causing greenhouse gas (GHG) emissions as compared to crude oil from most other sources refined in the US, because

> 1. *oil sands [bitumen] is heavier and more viscous than lighter crude oil types on average, and thus [requires] more energy- and resource-intensive activities to extract [from the ground]; and*
>
> 2. *oil sands [bitumen] is chemically deficient in hydrogen, and [has] a higher carbon, sulfur, and heavy metal content than lighter crude oil types on average, and thus [requires] more processing to yield consumable fuels by U.S. standards.* (Lattanzio 2013)

Federally, Canadian Prime Minister Stephen Harper generally downplays the issue of GHG emissions from the oil sands: "[emissions from oil sands production are] almost nothing globally" (Fitzpatrick 2013). Furthermore, although Canada has a GHG emissions reduction target for 2020, Canada does not have any federal policy for GHG emissions reductions from the oil sector. As a result, Canada is currently on a path to *increase* carbon emissions by 2020 from the baseline year (2005) used in the proposed target.

However, in 2015, the Alberta government is raising its carbon tax on large industrial emitters to $30 per tonne in 2017 (Giovannetti 2015), and all provincial premiers have agreed to a National Energy Strategy with several goals related to "transitioning to a lower carbon economy" (Canada's Premiers 2015)

By contrast, in Argentina, much of the debate, if any, has centered on the local environmental impacts of the development. In Argentina, the discussion on environmental regulation for shale developments is still pending. In 2014 a new hydrocarbons law was approved by the Argentine Congress that only contains one mention on this subject: that the provincials and federal governments will be encouraged to have new uniform environmental standards, following the provisions of the 1994 constitutional reform to "achieve the development of the activity with proper care of the environment." This article states that the main objective of this new regulation will be to apply best environmental management practices to the tasks of exploration, exploitation and / or transport of hydrocarbons in order to achieve the development of the activity with proper care of the environment.

The debate about environmental risks is still incipient in the Argentine society. According to surveys in the second half of 2014, 68% of the population agrees with the exploitation of VM, while only 15% is opposed. However, when asked what degree of environmental damage VM can generate, nearly 50% said that "Much" or "Enough", but in the same sample, over 85% responded that the impact on the economy will also be "A lot" or "substantial" (Poliarquia 2014). In short, it can be concluded that the majority perception of civil society is that the economic impact would justify the development of VM, even when a large group of the population thinks that there may be significant environmental damage. Therefore it reflects the need for a substantive debate about the necessary environmental regulation.

Transportation Safety

With regard to the shipment of bitumen, should a transportation accident occur, there have been particular concerns regarding the environmental consequences of a diluted bitumen spill. A pipeline spill in Kalamazoo, Michigan involving diluted bitumen has proven to be difficult to clean up and has cost upwards of $1 billion, the costliest on-shore spill in US history (National Transportation Safety Board [NTSB] 2012). However, bitumen does not have the same volatility as the light crude oil from the Bakken formation (Standing Senate Committee on Energy, the Environment and Natural Resources 2013): According to PHMSA (2014) crude oil from the Bakken region "may be more flammable than traditional heavy crude oil." Additionally, according to a Transportation Research Board study, there is no evidence that diluted bitumen increases the likelihood of a pipeline spill (Barteau et al. 2013).

Following the accident at Lac-Mégantic, Quebec, Canada involving a crude oil unit train (Transportation Safety Board [TSB] 2014c), there has been additional concern regarding the safety of the transport of bitumen by rail. Both the AAR (2013b) and the Manhattan Institute for Policy Research (Furchtgott-Roth 2013) analyzed historical safety data for the transport of crude oil by pipelines and railway. Railroads typically have a higher incident rate than pipelines. However, in these historical data, railroads have a lower rate of amount released per incident, and as a result, railroads have a lower spill rate in barrels per million ton-miles than pipelines.

It has also been argued that rail transport *may* be advantageous from a safety perspective because the bitumen can be transported in its raw form (rawbit), which does not flow at ambient temperatures (Fielden 2013a). As a result, it does not require the addition of diluent, which can be highly flammable and its evaporation caused adverse health impacts following a pipeline release in Michigan (Crosby et al. 2013). However, Frittelli et al. (2014) find "location matters more: a major spill away from shore will likely cost considerably less to abate than a minor spill in a populated location or sensitive ecosystem."

Though most of the safety concerns over oil sands development have pertained to the transportation of the bitumen, there have also been concerns about the safety of road transport between Edmonton and Fort McMurray, the nearest city to the oil sands development. Highway 63, a two-lane highway (one lane in each direction) is used to transport much of the heavy equipment used by oil sands facilities and many of the workers that from the area. Though an article reports that the highway has a lower than average collision rate for similar highways in Alberta, it has sometimes been called “Canada’s Highway of Death” (e.g. Modjeski 2013). In response to these concerns, the Government of Alberta is in the process of twinning the highway to create two lanes in each direction (Alberta Transportation 2014).

The debate about transportation safety related to VM goes towards traffic accidents on roads, rather than concerns about the hazardous characteristics of the material. This is probably because a large portion of VM production is transported by pipeline, and there have not been accidents of significance in the history of Argentine pipelines. On this basis, the overall concern of the population is that because of the substantial increase in truck traffic, the number of road accidents will significantly increase. Argentina has average mortality rates in road accidents: 12.6 deaths per 100,000 inhabitants, that is, slightly larger than the US (11.4) but significantly higher than Canada (6.8). This is a point of concern for the general public, which prompted the creation of a National Road Safety Agency implemented in 2008, led by the national government and financed by the World Bank. The process of twinning the Route 7 in Neuquén that connects Neuquén city with Vaca Muerta is about to begin, justified by the reduction of traffic accidents, similar to what is ongoing in Alberta.

So far, the impact of VM in transportation safety is still uncertain, and for now is limited to complaints about VM from nearby communities, towns and cities that are crossed by the main highway that lead to VM. However there is a critical need to study this issue, which also should include an analysis of the regulations for the transport of hydrocarbons, since a massive development of VM will increase the likelihood of accidents on roads, rail and pipeline, a scenario that Argentina has not yet seen in its history.

CONCLUSIONS

The unconventional hydrocarbons in Canada (the oil sands) and Argentina (shale oil) are significant resources for both countries, especially when compared with their conventional reserves. Though the institutional structure is different in both countries – Canada’s oil and gas and transportation companies are privately-owned, whereas in Argentina, they are partially government owned – the rhetoric of the discussions seems to be similar in both countries: many are in favor of development due to the significance of the economic benefits.

However, in both countries, the development of transport infrastructure has been hindered by different factors. In Canada further development of pipelines has been slowed down by opposition in the US (for the north-south Keystone XL) and some domestic opposition (for east-west pipelines) on environmental grounds, notably with regard to concerns regarding GHG emissions from oil sands production, but also concerns over the impacts of production and transportation. By contrast, in Argentina, the more significant barrier is that the emerging industry still lacks sufficient planning capabilities and institutional framework for long-term investments (such as railroads). Environmental concerns do exist in Argentina and debate of a new regulation is still pending. A comparative analysis of environmental impacts of shale oil development in the US and Canada would be beneficial to have a better understanding of the environmental concerns, best practices and regulations required.

As for safety issues, the experience of Canada and the US can be the driver in the coming years to better understand the systems and move towards safer practices. Transportation is crucial for oil and gas development, as it is to other industries, so it is in the middle of these discussions in relation to non-conventional resources both in Canada and Argentina. That is why progress in identifying the differences and similarities of the case studies will allow us to ultimately better understand the problems and look for common solutions.

Finally, in this energy-thirsty world, despite the environmental concerns associated with the development of these resources, it is difficult for an individual nation to turn its back on economic gains through the development of energy-based resources absent international environmental agreements, especially with respect to global climate change. Both Argentina and Canada view the energy plays under discussion as potential economic game-changers, moving them up the pecking order among the world's nations. Asking them to forego this possibility without international agreements is simply unrealistic.

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