

# **CANADA'S SHIFTING SANDS: OIL PRODUCTION, DISTRIBUTION AND IMPLICATIONS, 2005 TO 2014**

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## **SHIFTING SANDS**

In 2008, Canada's energy sector appeared to have reached a turning point. The price of crude oil had steadily increased since 2002, causing concern about the impact of higher prices on Canadian consumers.<sup>1</sup> Despite the vast reserves of crude oil in Canada, imports continued to supply almost half of crude oil refined domestically. That same year however, higher oil prices also helped to catapult energy into Canada's largest export earner, surpassing motor vehicles and parts.

By 2015, energy's run as Canada's biggest export ended with declining oil prices becoming a cause for concern.<sup>2</sup> The world was grappling with an over-supply of oil that stemmed from changing demand and from the supply of non-conventional crudes. In Canada, growing oil production has altered distribution channels to refineries and markets. Together, these changes may also have consequences for the environment.

This article examines trends from 2005 to 2014 in Canadian oil production and distribution as well as some possible implications. It focuses on two potential environmental concerns arising from these trends: The risk of accidents during transport and higher GHG emissions related to overall industry growth and the increased extraction from non-conventional reserves.<sup>3</sup>

## **DATA AND DEFINITIONS**

Data for this article are from the environment, energy and transportation statistics programs at Statistics Canada; with corresponding CANSIM table numbers provided. Other data sources include Transport Canada's Dangerous Goods Accidents Information System, the Transportation Safety Board's Occurrence Database System, and Environment and Climate Change Canada's (2015) National Inventory Report of GHG Sources and Sinks.

Crude oil is a naturally occurring hydrocarbon formed by decaying organic material in the ground under intense heat and pressure for millions of years. It ranges in viscosity based on its hydrocarbon composition. With a density of less than 900 kg/m<sup>3</sup>, light to medium crudes flow freely at room temperature. In general, lighter crudes command higher prices as they can be more easily refined to produce higher value products such as motor gasoline. With a density of 900 kg/m<sup>3</sup> or greater, heavy crude generally requires a diluent to allow pipeline flow.

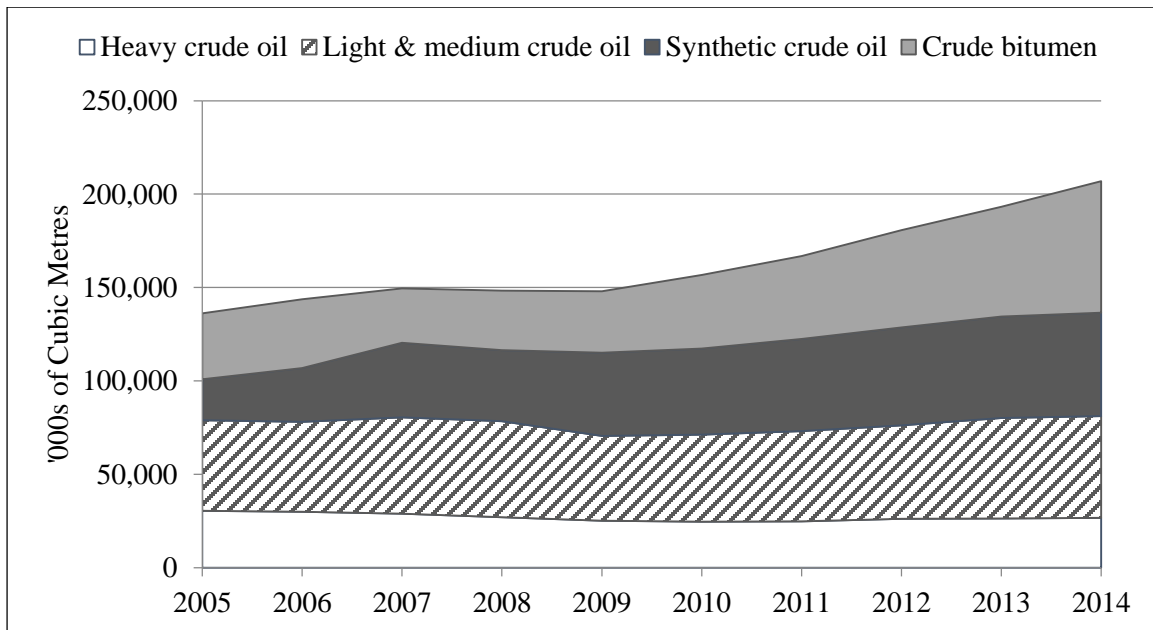
Although heavier crudes can be refined into lower priced products such as asphalt, additional refining is needed to create higher value products. Crude bitumen is the thickest, heaviest form of crude oil and must be either heated or diluted before it can flow. A conventional oil refinery has to be modified to use crude bitumen or additional processing is required at an upgrading facility. The output from upgrading crude bitumen is synthetic crude, which can be sent to conventional refineries for processing into higher value products.

## PRODUCTION: A SHIFT TO NON-CONVENTIONAL OIL

Canada's oil industry has evolved dramatically since the first well was drilled over a hundred and fifty years ago in Oil Springs, Ontario. In 1947, the discovery of vast oil reserves near Leduc, Alberta helped to fundamentally transform the Albertan economy. While crude bitumen from the oil sands was first upgraded in Alberta almost 50 years ago, upgrading capacity has been steadily and significantly added ever since. During the last twenty years, oil reserves off the coast of Newfoundland and Labrador have been developed. And more recently, Saskatchewan's Bakken fields have become commercially viable as a result of rising prices and technological improvements in extraction methods.

Crude oil is a mixture of hydrocarbons trapped in an underground reservoir. Conventionally, it was extracted by drilling a well into the reservoir and the oil is either pumped or the natural pressure is high enough for it to flow to the surface. With technological improvements in exploration and extraction, other reserves are being tapped: Conventional crude by horizontal drilling which pumps liquids ("fracking fluids") in order to fracture the geological formation, facilitating the flow, and non-conventional crude, by extracting in situ oil sands using steam to help crude bitumen flow. However, these newer methods involve higher production costs and may have greater environmental impacts from production (i.e. more energy intensive extraction) and from distribution (i.e. more remote locations).

Despite declining conventional reserves, rising world prices and technological advances in extraction spurred a 50% growth in Canadian crude production from 2005 to 2014 (Figure 1).<sup>4</sup> Indeed, 2014 was the fifth consecutive year in which crude oil accounted for the largest share of primary energy production in Canada, after replacing natural gas.<sup>5</sup> However, the aggregate contribution of light, medium and heavy crude production declined from almost 60% of the total in 2005 to under 40% by 2014. Growth in the extraction of crude bitumen and the production of synthetic crude accounted for virtually all (97%) of the increase.



**Figure 1: Total Crude Production in Canada, 2005 to 2014**

Source: Statistics Canada, CANSIM Table 126-000

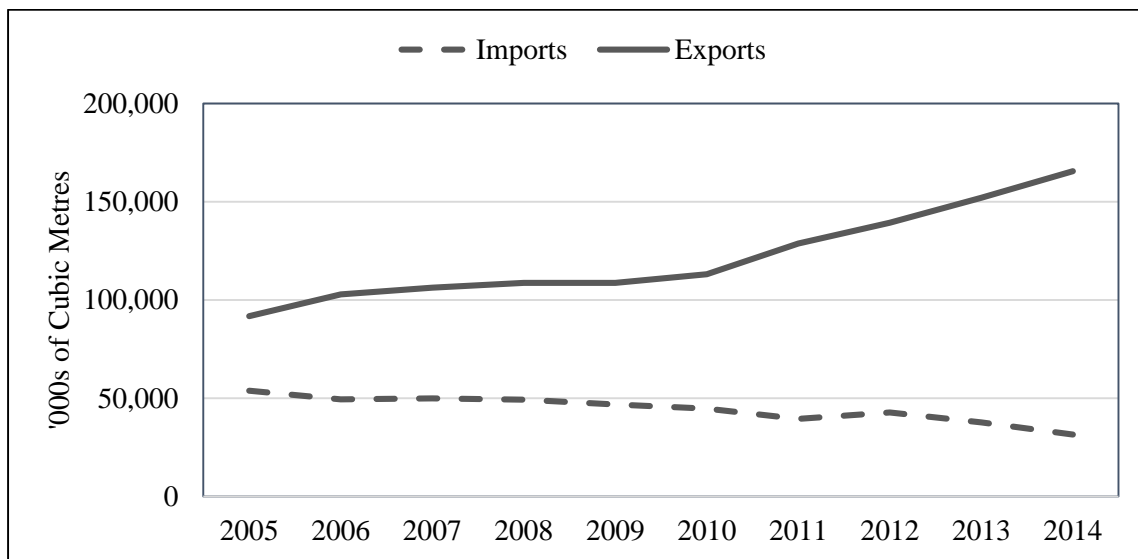
## DISTRIBUTION: DELIVERING OIL TO MARKET

In its raw form, crude oil has limited economic value and is shipped to an oil refinery for separation into a range of products such as motor gasoline, aviation fuel, asphalt and propane. The outputs from a refinery partly depend on the type of crude used as input. For example, a lighter crude oil produces a larger proportion of lighter and higher value products such as motor gasoline. Although some oil refineries are located in Western Canada, the majority of Canadian crude is processed in refineries located close to eastern markets that are equipped to refine imported oil, which generally consists of lighter crudes. And Canada's pipeline network was designed to serve this refining capacity.

Increasingly, more oil is extracted from non-conventional reserves, often in remote areas. In particular, crude bitumen from the Oil Sands is an extra-heavy crude that is characterized by a higher viscosity. A diluent must be added so the bitumen can be pumped through pipelines, adding to transportation costs. And in theory, a heavier raw material such as crude bitumen should be processed closer to the source of extraction. Bitumen often requires treatment in an upgrader facility to remove carbon through coking and/or to add hydrogen. This treatment creates a higher value synthetic crude that can be more easily shipped by pipeline for conventional refining.

During the study period, the growth in domestic crude oil production resulted in higher levels of exports, jumping 80% from 2005 to over 165 million cubic metres (m<sup>3</sup>) in 2014 (Figure 2). Over the same period, imports declined, falling 42% from about 54 million m<sup>3</sup> in 2005 to just over 31 million m<sup>3</sup> in 2014. Despite these changes, refining capacity has remained more or less fixed both in scale and in location. Although there appears to be insufficient mainline pipe for the growing volume of oil production in the long term, in the short term more crude oil was shipped to markets in one of two ways.

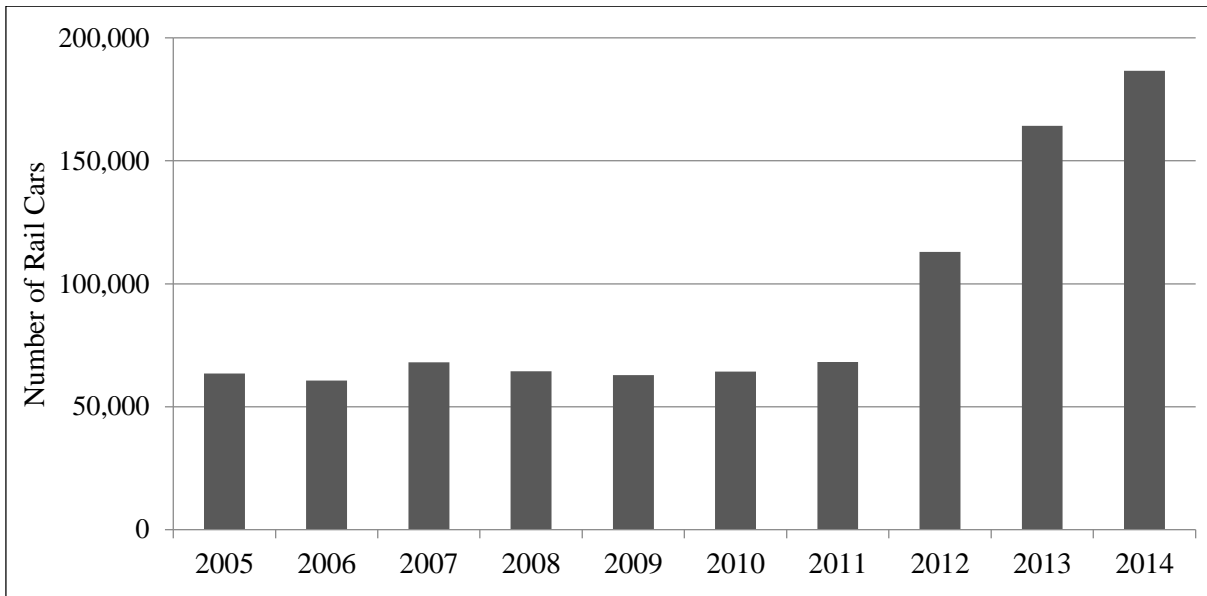
First, more oil was pumped by enhancing capacity of the existing pipeline network. From 2005 to 2014, the total net pipeline deliveries of crude oil increased by 58% or roughly 116 million m<sup>3</sup>. More than half of this increase was accounted for by exports, enabled by a combination of key new pipeline segments<sup>6</sup> along with selected line conversions (i.e. natural gas to oil). Another significant portion of this overall volumetric increase was for net deliveries to plants, enabled by higher pipeline throughput using more powerful pumps as well as by both line conversions and line reversals that change the direction of flow.<sup>7</sup>



**Figure 2: Canadian Crude Oil Imports and Exports, 2005 to 2014**

Source: Statistics Canada, CANSIM Table 126-0001

Another way of shipping oil, accounting for part of the increase in deliveries from 2005 to 2014, is by rail. One indication is that pipeline shipments of crude oil classified as “net deliveries to other”, which includes rail loading facilities, have increased from roughly 8 million m<sup>3</sup> in 2005 to almost 22 million m<sup>3</sup> by 2014. The movement of crude oil by rail is now viewed as a short term solution that is necessary given insufficient pipeline capacity. Indeed, the number of filled tank cars loaded with “fuel oils and crude petroleum” shipped by Canadian railways has tripled from 2005 to 2014, with the growth occurring after 2011 (Figure 3).<sup>8</sup>



**Figure 3: Railway Carloadings of Fuel Oils and Crude Petroleum, Canada 2005 to 2014**

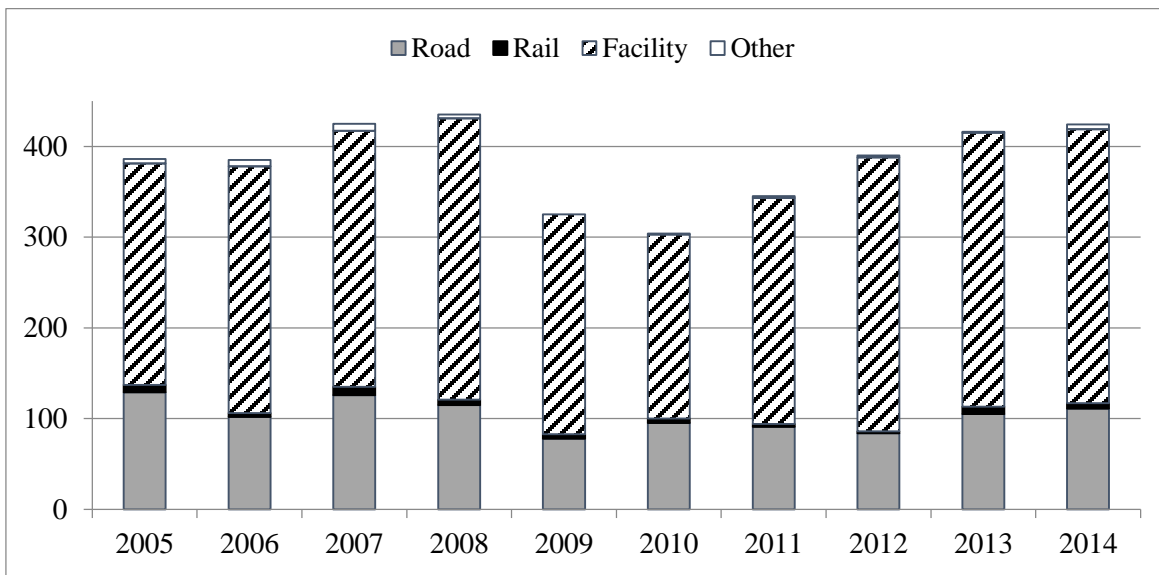
*Source: Statistics Canada, CANSIM Table 404-0002*

## ENVIRONMENTAL IMPLICATION: RISK OF ACCIDENTS

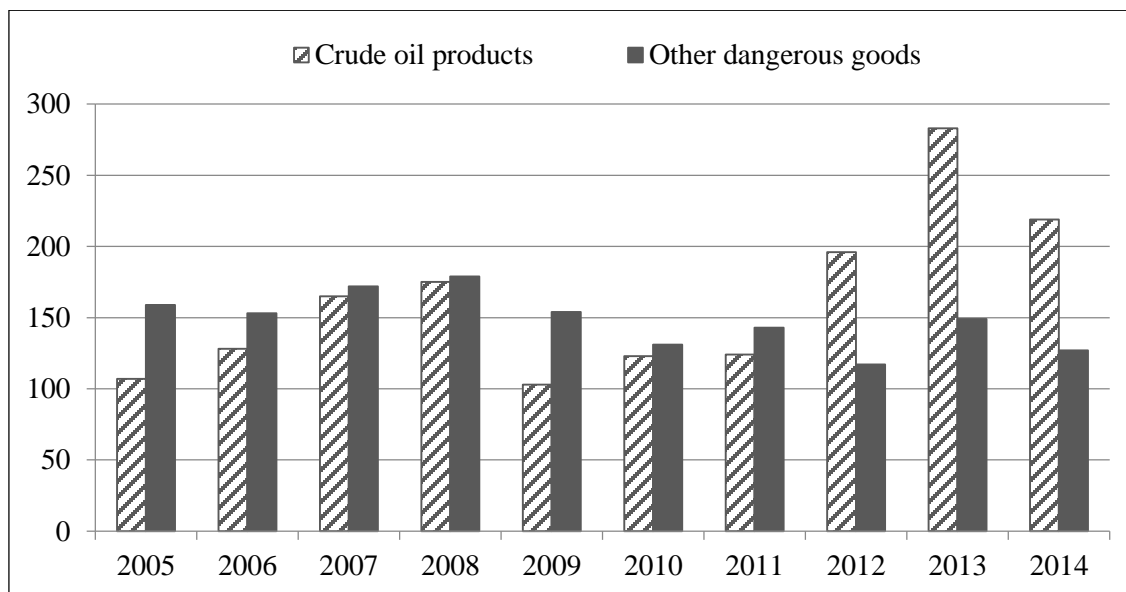
What is the risk of shipping a greater volume of oil to refineries or export markets? The recent growth of Canada’s oil production has spawned debate on the most appropriate method of shipping crude, often pitting pipeline construction against shipping more by rail.<sup>9</sup> There are two data sources that are used to help illuminate the safety issue: 1) Transport Canada’s Dangerous Goods Accident Information System (DGAIS) and, 2) the Transportation Safety Board’s (TSB) Rail and Pipeline Occurrence Database Systems.

The Transportation of Dangerous Goods regulations (Section 8) require handlers of dangerous goods to report accidents to Transport Canada<sup>10</sup>; DGAIS data are then disseminated by Statistics Canada via CANSIM. The total number of reportable dangerous goods accidents dipped following the economic downturn of 2008 (Figure 4). Most reportable accidents of dangerous goods occur during handling at facilities (i.e. terminals and warehouses) rather than in transit. Of those occurring in transit, a vast majority happen during road transport, while those by rail fluctuated between 1% and 2% of the total.

Crude oil is usually transported as a Class 3 (Flammable Liquids) dangerous good, which requires the reporting of accidents involving spills of 200 litres or more. Accidents involving crude oil products fell after the 2008 economic downturn but have increased steadily since and now exceed those involving all other dangerous goods (Figure 5). As previously noted, the bulk of such accidents occur in facilities such as “bulk storage facilities”. In 2014 for example, more than three-quarters (77%) of all dangerous goods accidents occurred in a facility with the top initiating events reported as “improper loading / unloading and handling” (33%), “overfill” (27%) and “defective fittings, valves and covers” (23%).



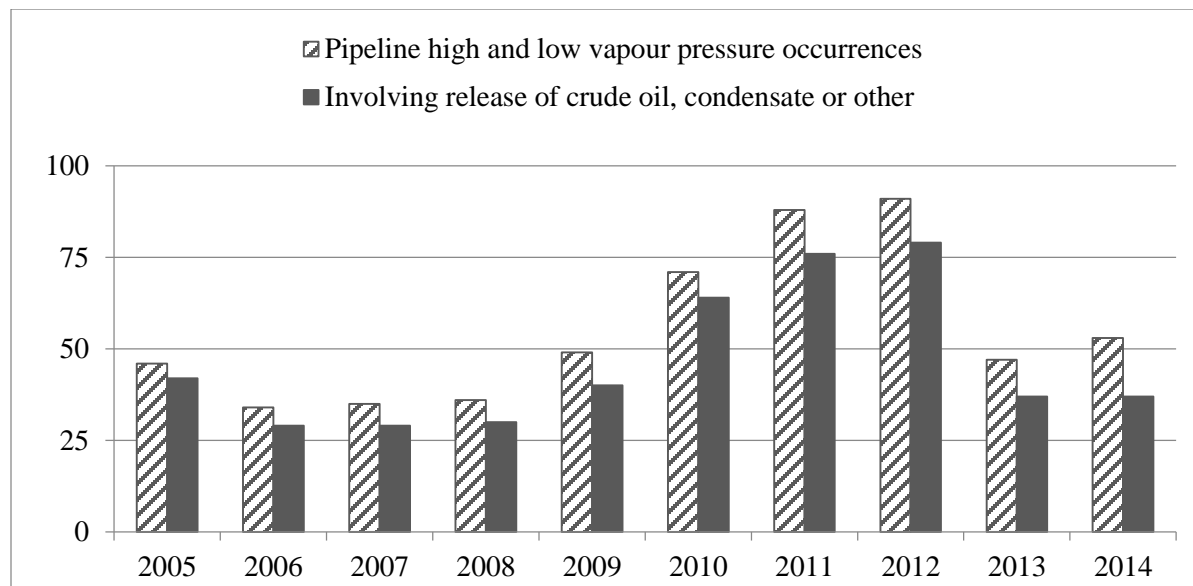
**Figure 4: Number of Reportable Dangerous Goods Accidents by Mode, Canada 2005 to 2014**  
 Source: Transport Canada DGAIS, CANSIM Table 409-0001



**Figure 5: Number of Dangerous Goods Accidents by Commodities, Canada 2005 to 2014**  
 Source: Transport Canada DGAIS, CANSIM Table 409-0006

A second source of information is the TSB regulations, pursuant to the Canadian Transportation Accident Investigation and Safety Board Act. They require the operator of a pipeline to report selected occurrences (e.g. release of product, injury or damage) to the Board. From 2005 to 2014, there were an average of 55 oil pipeline occurrences each year with 84% of them resulting in a release of crude petroleum, condensates, or a refined product (Figure 6). The average, non-zero volume of product released was 36 m<sup>3</sup> per occurrence. However, this value may not reflect the actual amount released since mandatory reporting of

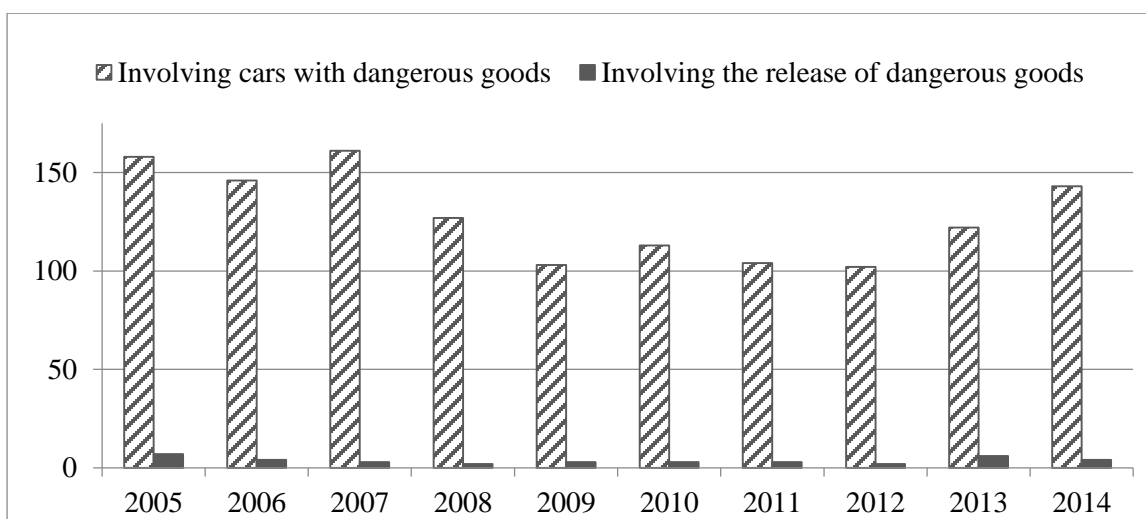
the quantity released has only been required since July of 2014.<sup>11</sup> In addition to the occurrences reported to the TSB, there have also been some notable pipeline accidents, both after the study period and by a Canadian operator outside of Canada.<sup>12</sup>



**Figure 6: Number of Oil Pipeline Occurrences, Canada 2005 to 2014**

Source: Transportation Safety Board, Pipeline Occurrence Database System

Similarly, operators of rolling stock and rail are required to report a railway occurrence to the TSB. Since 2014, a derailment occurs “any time at least one wheel of rolling stock comes off the normal running surface of the rail”. From 2005 to 2014, there was an annual average of 780 train derailments in Canada with more than 85% occurring on non-mainline tracks (branch lines, sidings, railyards). On average, less than one-third (31%) of total derailments involved trains with rail cars carrying dangerous goods, and only a small number resulted in a release (Figure 7).



**Figure 7: Number of Derailment Occurrences Involving Dangerous Goods, Canada 2005 to 2014**

Source: Transportation Safety Board, Rail Occurrence Database System

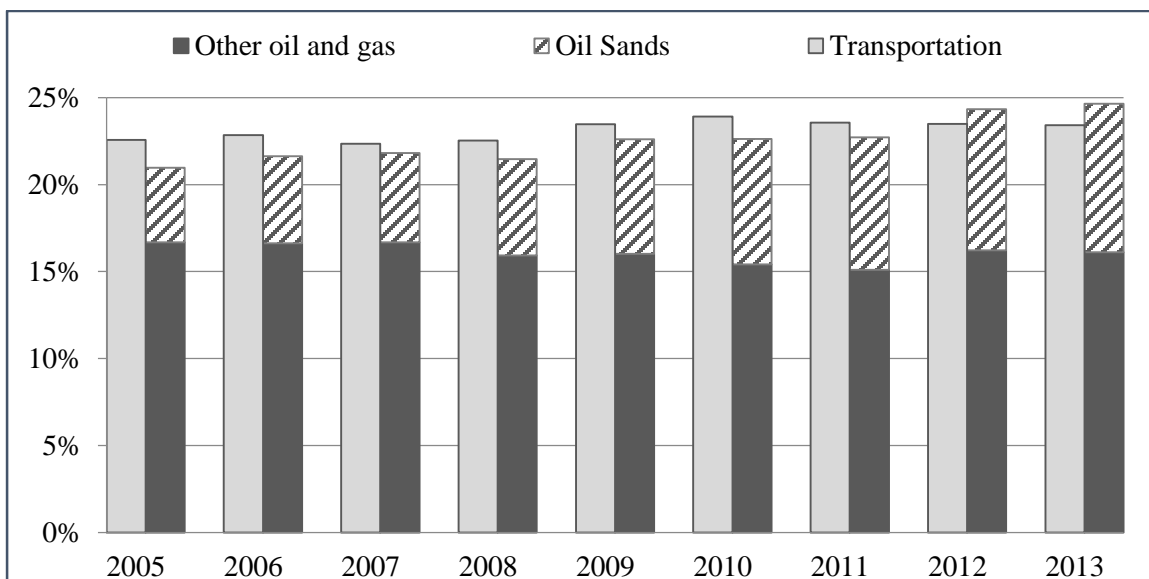
In 2013, there were six derailments that resulted in a release of dangerous goods. However, one of the six involved a major mainline derailment of a Montreal, Maine & Atlantic Railway train during July in the Québec town of Lac Mégantic. This spill released a large quantity of crude oil that resulted in an explosion, fire, evacuation, major damage to the surrounding community and 47 fatalities. Since that catastrophic event, the policy debate on the merits of moving crude oil by rail versus building more pipelines has intensified (see footnote 9).

**ENVIRONMENTAL IMPLICATION: HIGHER EMISSIONS**

The steady increase in world oil prices from about 2002 into 2014 drove technological advances in extraction and made non-conventional reserves more commercially viable. Again, this served to change the composition of oil production in Canada. And measured along the entire supply chain (i.e. extracting, transporting, refining, marketing, and combusting), some types of heavy crude from non-conventional reserves have been estimated to emit about one and a half times the kilograms of carbon-dioxide (CO<sub>2</sub>) equivalent per barrel than did a lighter crude oil.<sup>13</sup>

Canada reported a drop of 31% in overall emission intensity (tonnes of GHG per GDP) between 1990 and 2013. However, the emission intensity of oil production - defined as the average amount of GHG emissions generated per barrel of oil equivalent - increased by about 12% over the same period. This resulted from an increase in total crude production and a substitution of more GHG-intensive oil.<sup>14</sup> Allocating emissions according to economic activity or sector, oil and gas surpassed transportation in 2012 as the largest contributor to GHG emissions in Canada (Figure 8). In 2013, the oil and gas sector contributed almost one quarter (24.7%) of Canada’s emissions, with the Oil Sands contributing 8.5% (Figure 8).

As such and given the larger volume of Canada’s oil exports, the recent growth in the oil and gas sector contributes significantly to domestic GHG emissions associated with the production of goods for export. In 2012, “Conventional and synthetic crude” and “Crude and diluted bitumen” were estimated to account for a combined 28% of the 295 mega-tonnes of GHG emissions embedded in Canadian commodity exports.



**Figure 8: Share of Total GHG Emissions by Selected Sector, Canada 2005 TO 2013**  
 Source: Environment and Climate Change Canada (2015), Table 2-14 and custom tabulation 2006-08

The recent decline of oil prices continues to affect the Canadian energy sector. However, the International Energy Agency (IEA) asserts that, while the overall oil supply from most non-OPEC countries could be headed for a significant drop, Canada's output is expected to rise in 2015 and again in 2016. Therefore, the larger policy discussion on the role of energy in the Canadian economy is poised to continue, including concerns over the risk of accidents during delivery (i.e. pipelines versus rail) and the energy sector's contribution to GHG emissions.<sup>15</sup>

## ENDNOTES

<sup>1</sup> Cross, P. and Z. Ghanem (2008). Over a barrel? Canada and the rising costs of energy, *Canadian Economic Observer*, August. Statistics Canada: 11-010.

<sup>2</sup> In July of 2015, exports of motor vehicles and parts (\$7.6 billion) surpassed those of energy (\$7.3 billion) for the first time since 2007 (Statistics Canada, *The Daily*, 03/09/15).

<sup>3</sup> There are others; for example, open-pit mining can damage boreal forests and separating the oil and sand at the mine site uses large quantities of water and creates enormous tailings ponds.

<sup>4</sup> One U.S. barrel of oil = cubic metres x 6.2898.

<sup>5</sup> Statistics Canada (2015). Energy supply and demand, 2014. *The Daily* (10/12/15).

<sup>6</sup> In 2010, Phase I of the Keystone pipeline connected Hardisty, Alberta with Patoka, Illinois via Steele City, Nebraska. In 2011, Phase 2 extended the pipeline from Steel City to Cushing, Oklahoma. Both phases allowed for an increase in Canadian crude oil exports to the U.S. Approval for the Keystone XL (Phase 4), to connect Hardisty to Steele City more directly with a larger diameter pipe, was indefinitely delayed by U.S. President Obama on November 7, 2015.

<sup>7</sup> Previously, Enbridge's "Line 9" pumped up to 240,000 barrels per day (bpd) of imported crude westward from Québec to Sarnia. After a shutdown, in December of 2015 flow was reversed to pump up to 300,000 bpd of crude eastward from Sarnia to refineries in Ontario and Québec.

<sup>8</sup> The Standard Classification of Transported Goods (SCTG), used by the railway commodity survey, defines "Fuel oils and crude petroleum (including bituminous mineral oil and tar sands)".

<sup>9</sup> See, Senate of Canada (2013). *Moving Energy Safely: A Study of the Safe Transport of Hydrocarbons by Pipelines, Tankers and Railcars in Canada*, Standing Committee on Energy, the Environment and Natural Resources; Cairns, M. (2013). Rail Safety in Transporting Dangerous Goods in Canada. *Canadian Transportation Research Forum, Policy Brief* (November); Winter, J., (2014), Safety in Numbers: Evaluating Canadian Rail Safety Data, *SPP Communique*, 6 (2), University of Calgary, School of Public Policy; Green, K. and T. Jackson (2015). Safety in the Transportation of Oil and Gas: Pipelines or Rail? *Fraser Institute, Research Bulletin*, (August); and Oliver Wyman Companies (2015). *Canadian Crude Oil Transportation: Comparing the Safety of Pipelines and Railways*. Prepared for the Railway Association of Canada (December).

<sup>10</sup> Regulations, pursuant to the 1992 Transportation of Dangerous Goods Act, require that "any person who has charge, management or control of a means of containment shall report to Transport Canada any release or anticipated release, loss or theft of dangerous goods that is or could be in excess of a quantity specified, by regulation, from the means of containment if it endangers, or could endanger, public safety".

<sup>11</sup> Of the 463 oil pipeline occurrences from 2005 to 2014 involving release of a product, 70% of filings either could not or did not quantify the amount released. As of 2014, the TSB Regulations for Pipeline Occurrences (4 (2) (h)) require "a list of commodity contained in or released from the pipeline and an estimate of the volume of commodity released and recovered".

<sup>12</sup> For example, in July of 2015, a Nexen Energy ULC pipeline was discovered to have released about 6,000 m<sup>3</sup> of a bitumen by-product over 16,000 square metres of wilderness south of Fort McMurray, Alberta. And in July of 2010, Enbridge's 41-year-old 6B pipeline ruptured in Michigan, leaking 19,500 barrels of crude oil of which about 8,500 spilled into the Kalamazoo River.

<sup>13</sup> A type of Canadian Synthetic Crude was estimated to emit over 800 Kg of CO<sub>2</sub> equivalent per barrel compared to under 500 Kg for a barrel of Canadian Hibernia (See Gordon, D., A. Brandt, J. Bergerson & J. Koomely (2015). *Know Your Oil: Creating a Global Oil-Climate Index*. Washington: Carnegie Endowment for International Peace. p. 36).

<sup>14</sup> CANSIM Table 153-0129 and custom tabulation derived therefrom.

<sup>15</sup> The IEA's February 2016 *Oil Market Report* forecasts Canadian output rising to 4.46 million bpd in 2016 with heavy oil supplies growing from the start-up of new projects long in the planning, (<https://www.iea.org/media/omrreports/fullissues/2016-02-09.pdf>, accessed 250216). Continued low crude oil prices however, could alter this forecast.