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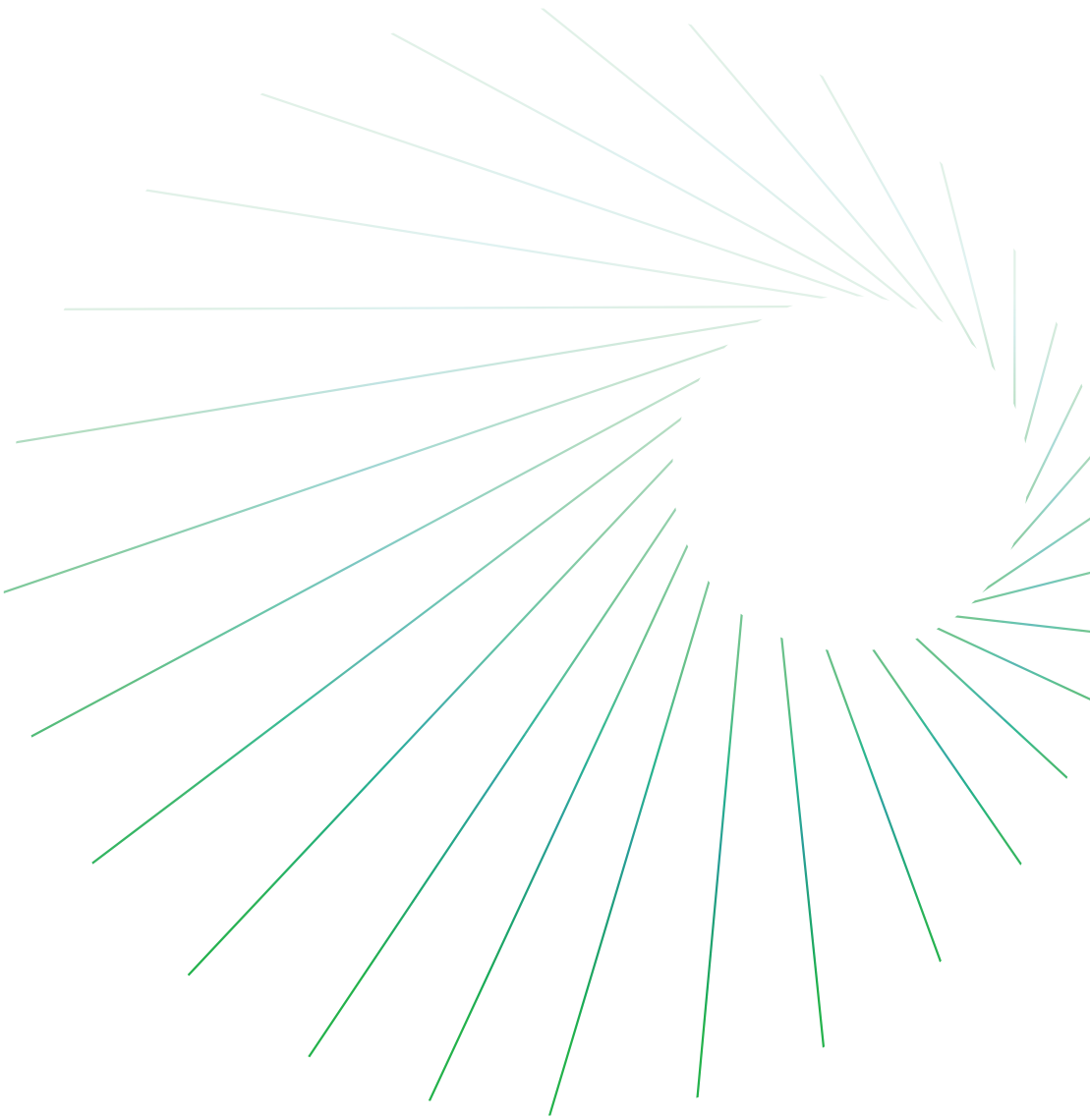
Canadian crude logistics

3 August 2021



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Canadian crude logistics

Although it is not well-known, Canada is the third-largest exporter of crude oil globally. Owing to its geography, Canada also relies on crude oil imports to meet domestic demand. Meeting regional supply and demand as well as those in export markets has resulted in a complex crude oil logistics system. However, knowledge about where, how much, and by what mode crude oil is handled differs across Canada. This report explores the key issues surrounding the current and future outlook of how oil moves in Canada—that is, Canadian crude oil logistics.

Key implications

- **IHS Markit estimates that in 2019, Canada handled about 6.6 MMb/d—2.0 MMb/d more than it produced.*** Handled is defined as long-distance movement of imports, exports, and internal transfers of crude oil and condensates. This does not include any shorter distance movements such as upstream gathering.

- **Because of crude quality and Canadian geography, regions that are distant from its oil production rely on imports, internal transfers, and reexports (where Canadian production went through the United States and then went back into Canada) to meet demand.** In 2019, IHS Markit estimates Canada imported over 850,000 b/d of crude oil, internally transferred over 1.2 MMb/d, and transferring through the United States approximately 480,000 b/d.

- **Pipelines represent the backbone of the Canadian crude oil logistical system, accounting for about four-fifths or 5.4 MMb/d of the long-distance movements in 2019.** The next largest mode of transport was marine, which handled 14% of movements by volume almost exclusively on the east coast. Crude-by-rail accounted for about 5% as it proved to be a critical backstop as western Canadian pipeline export capacity has struggled to keep up with demand.

- **Looking forward, pipelines will remain the dominant mode of transportation; however, with increased pipeline capacity to the west coast, a rise in tanker movements is also expected.** IHS Markit estimates by 2025, total crude oil volumes handled in Canada could increase by over 650,000 b/d to over 7.3 MMb/d. Most of these movements are expected to occur in western Canada via greater overland pipeline and marine exports.

*Because of the 2020 global pandemic and the resulting extreme market disruptions, 2019 was used for the historical analysis included in this report.

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About this report

Purpose. There are differences of opinion about Canadian crude oil transportation infrastructure, experience handling crude oil, and the demand for the expansion of export pipeline capacity. This report explores Canada's experience handling and moving crude: how much, where, why, and how?

Context. Since 2009, IHS Markit has provided research on issues surrounding the development of Canadian oil sands. This report is part of a series of reports from the IHS Markit Canadian Oil Sands Dialogue. The dialogue convenes stakeholders to participate in an objective analysis of the benefits, costs, and impacts of various choices associated with Canadian oil sands development. This report and past Oil Sands Dialogue reports can be downloaded at www.ihsmarkit.com/oilsandsdialogue.

Methodology. IHS Markit conducted extensive research and analysis on this topic, both independently and in consultation with stakeholders. IHS Markit has full editorial control over this report and is solely responsible for its content. Because of the 2020 global pandemic and the resulting extreme market disruptions, the year 2019 was used for the historical analysis included in this report. This report considers the long-distance transportation of both crude oil and condensate, but not refined products. The report does not cover movements associated with the extensive pipeline gathering systems that connect key producing fields to terminals. Pipelines connected to marine tanker terminals would be counted as separate movements provided they are long distance.

Structure. This report has five sections:

- Introduction
- Mind the gap: Canada's distinct supply and demand regions
- The Canadian experience moving crude oil: By pipe, ship, and railcar
- The future of crude oil logistics
- Concluding remarks

Introduction

Canada is among the world's largest producers and exporters of crude oil. In 2019, Canada was the fourth-largest producer, the third-largest exporter, and the ninth-largest consumer of crude oil. This equated to production of 4.6 MMb/d, exports of 4.1 MMb/d, and imports of over 850,000 b/d. The scale of crude trade in Canada is therefore much greater than production alone. To meet supply and demand within Canada and abroad, it relies on an extensive logistics system.

Ninety-five percent of Canadian production occurs onshore, inland, and often in remote areas in the western Canadian provinces of Alberta and Saskatchewan. The remainder principally comes from offshore platforms off the east coast of Canada. The main consuming regions are located far from production in the more populous central regions of Ontario and Quebec. For these reasons and the country's overall geography, meeting domestic demand has historically necessitated imports.

Every day, Canada moves approximately 2 MMb/d more crude oil than is produced. In 2019, IHS Markit estimates that the long-distance transportation system, which includes pipeline, rail, and marine transport handled about 6.6 MMb/d. This is similar in magnitude to two-fifths of all North American oil refinery demand. Gathering, or small diameter that typically move production from the field to processing facilities, were not included in this transportation total. If oil gathering movements were included, the volume being handled would be much greater.

This report reviews Canada's experience moving crude oil from where it is produced, to where it goes, how it gets to its location, and whether that could change in the future.

Mind the gap: Canada's distinct supply and demand regions

The Canadian crude oil market can be divided into three regions: the west being the largest-producing region (Alberta, Saskatchewan, and to a lesser extent northern British Columbia and southern Manitoba), the central region being Canada's main consuming region (Ontario to Quebec), and the east coast region being both a smaller producing region and consuming region than Canada's west and central regions, respectively (see Figure 1).[1]

To meet demand—both domestic and foreign—Canada transfers crude and condensate internally and through the United States, exports and imports crude oil, and processes crude oil in its various regions. Although Canadian crude oil production is over two and a half times greater than domestic demand, imports are still required to meet demand. In 2019, IHS Markit estimates that Canada produced over 4.6 MMb/d, imported over 850,000 b/d, processed via domestic refineries 1.7 MMb/d, exported 4.1 MMb/d, and transferred (internally and through the United States) about 1.7 MMb/d (see Figure 2).[2]

Despite Canada producing over 4.6 MMb/d, imports still occur for three primary reasons:

Geography. Canada is a geographically large nation with nearly two-thirds of its population located in its central provinces of Ontario and Quebec (principally along the Quebec City–Windsor Corridor). This region is approximately 1,800 miles (over 3,000 km) from western Canadian production. For western Canadian producers, the US Midwest is both a larger and more approximate market than central Canada. Chicago is about 500 miles (800 km) closer with oil demand of 3.8 MMb/d compared with 650,000 b/d in central Canada. As western Canadian production rose, most western Canadian pipelines were designed to connect into the US

1. Consumption of oil refers to refineries using crude oil to produce refined products, such as gasoline.

2. These numbers include both crude and condensate.

Figure 1

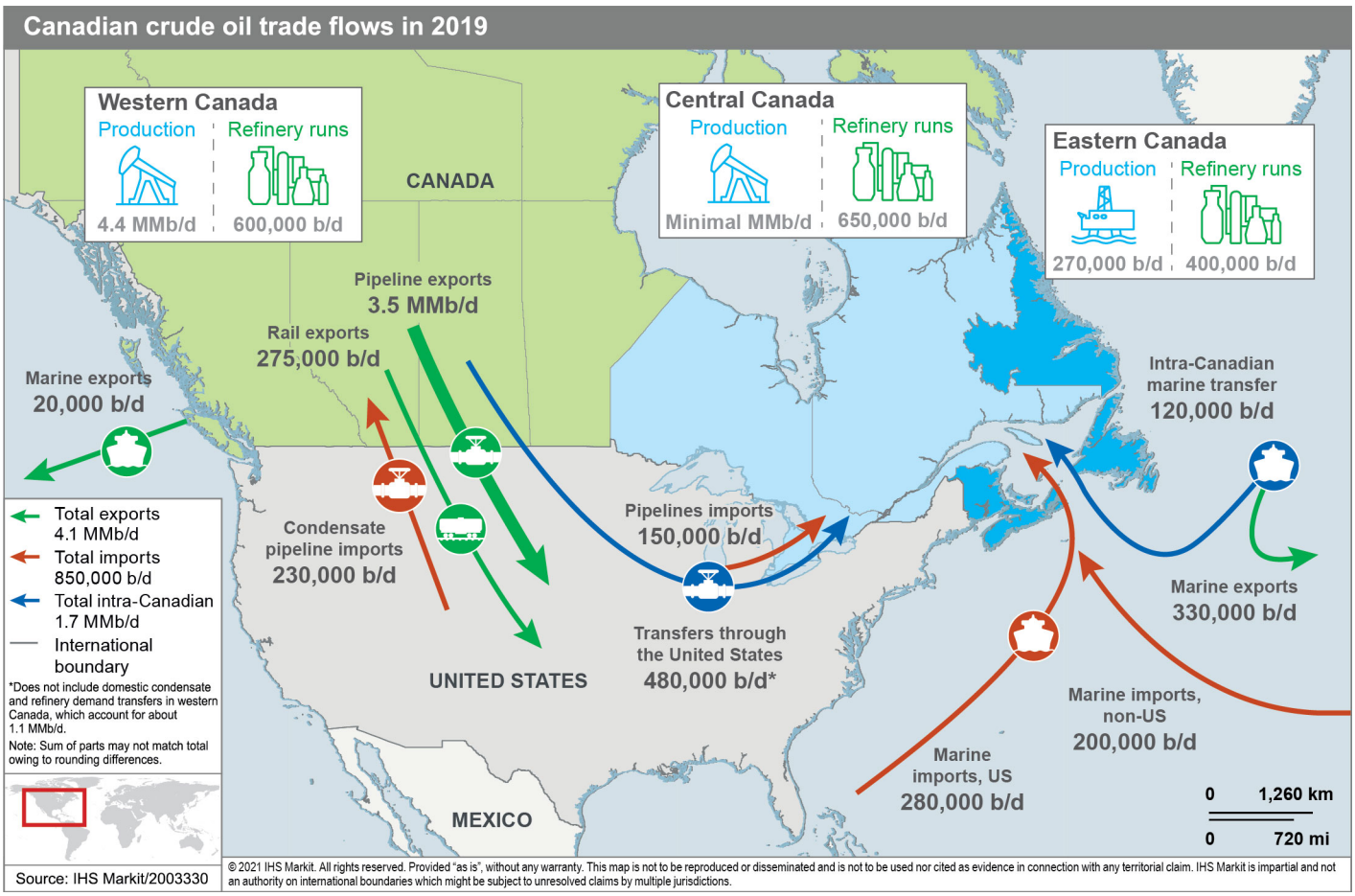
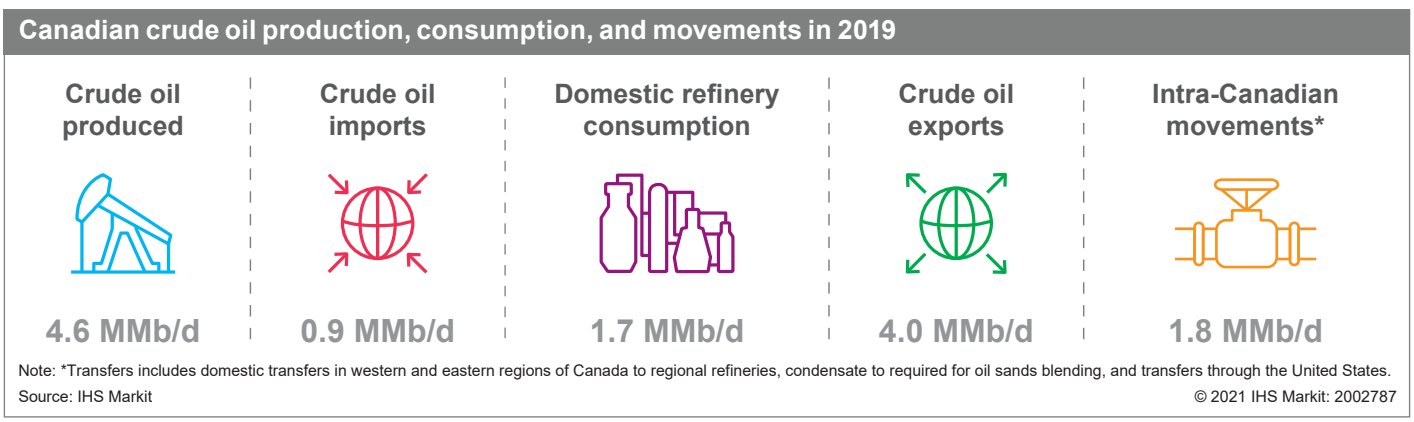


Figure 2



Midwest (PADD 2) market. With most pipeline infrastructure heading into the US Midwest, central Canadian refineries have relied on deliveries of crude oil coming up from the US Midwest as well as offshore imports via eastern Canadian and historically US ports. These deliveries include transfers of Canadian crude oil through the United States, US imports, and imports from offshore.

Oil sands blending. Bitumen, which is the dominant form of western Canadian production, is an extra heavy sour crude oil derived from the oil sands. In its natural state, bitumen is too viscous to be transported by pipeline. To meet pipeline requirements, bitumen is either upgraded into a light synthetic crude oil or blended

(diluted) with lighter or less dense hydrocarbons. The market for diluents is significant. In 2019, about 60% of bitumen production required dilution, demanding about 750,000 b/d of diluents. The most common diluent is a pentane plus material known as condensate. Domestic demand for bitumen blending outstrips regional condensate supply and imports of condensate are required. In 2019, the oil sands imported nearly 230,000 b/d of condensate by pipeline from the United States.

Refinery configurations. The type of oil demanded in each region also plays a role in crude oil imports. As western Canadian output rose over the past two decades, most of the production has come from heavier, more sour crude oil, which requires specialized heavy oil processing units in order to be economically processed. US Midwest refineries invested in these heavy processing units to take advantage of growing western Canadian heavy oil, while refineries in Ontario and Quebec remained geared toward lighter crude grades. In 2019, refineries in central and eastern Canada demanded about 1.1 MMb/d of which over four-fifths was lighter oil. In comparison, the US Gulf Coast (USGC) refinery complex is only modestly farther away (approximately 2,200 miles compared with 2,000 miles or approximately 3,500 km compared with 3,000 km away from western Canadian production) and was both significantly larger (nearly 9 MMb/d on average in PADD 3 versus 650,000 b/d for Ontario and Quebec) and already configured to consume significant volumes of heavy sour crude oil. In 2019, the USGC processed about 1.9 MMb/d of heavy sour crude oil. This presented both western Canadian producers and USGC refineries with an attractive solution. This has led to and continues to lead to projects that would further expand pipeline capacity from the US Midwest and western Canada to the USGC region.

The Canadian experience moving crude oil: Pipe, ship, and railcars

Canada moves over 6.6 MMb/d of crude oil from domestic production to domestic and US refineries and other export markets, as well as imports of condensate for oil sands blending and crude oil bound for central and eastern refineries. For this to occur, Canada relies on an extensive long-distance logistics system composed of thousands of miles of transmission pipelines, an extensive rail system, and marine handling capability to manage maritime tankers and barges on both coastlines. Each mode represents a critical link in a chain that ensures an uninterrupted supply, enabling trade, energy production, processing, and consumption. However, Canada's reliance and familiarity with crude oil transportation modes vary across its diverse regions. This section discusses Canada's familiarity with each mode. See Appendix A–C for additional details related to pipe, tanker, and crude-by-rail.

Pipelines form the backbone of Canadian crude logistics

Pipelines predate the Canadian confederation. The first pipeline was built in 1862 to connect an oilfield in Petrolia, Ontario to Sarnia, Ontario.[3] Today, pipelines are the dominant mode of crude oil transportation in Canada. Canada also makes use of other modes including rail, tanker, barge, and even trucks.[4] IHS Markit estimates in 2019, that Canada moved about 6.6 MMb/d or about 2.4 billion barrels a year.

As shown in Figure 3, pipelines account for the majority of long-distance crude oil movements in Canada. Most pipelines originate in western Canada and head southeast into the US Midwest. Some pipelines, in turn, head back from the US Midwest into central Canada, and others move further south connecting to Cushing, Oklahoma—the main North American crude oil trading hub—and some move further south still onto the USGC region, which is the largest processing region in North America.

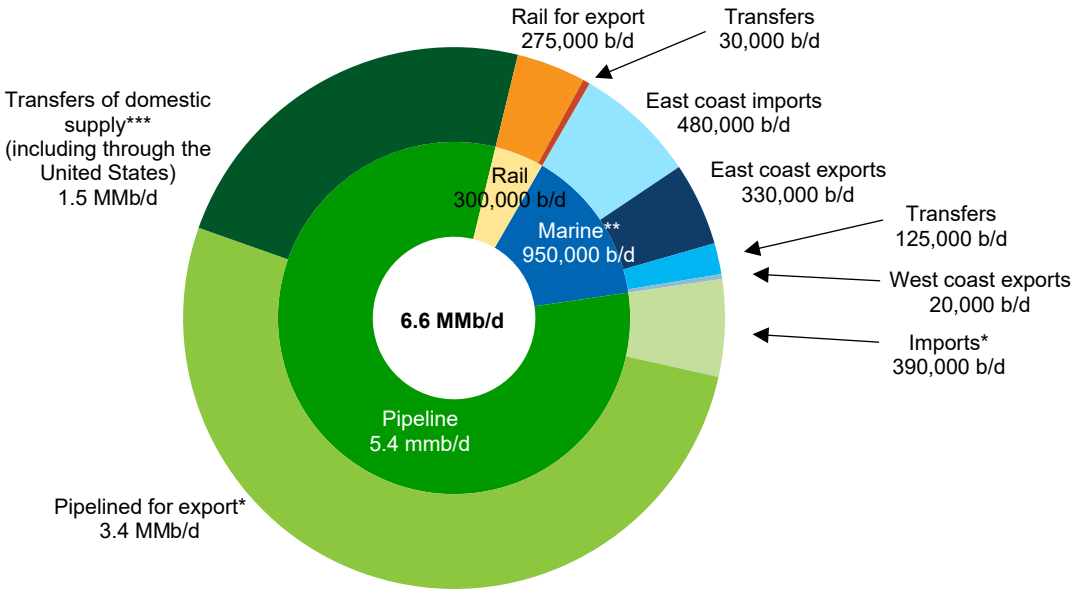
Long-distance transportation pipelines accounted for four-fifths of all Canadian crude oil movements in 2019. About two-thirds of these movements were for export. Under a-third of movements were intra-Canadian

3. See About Pipelines, "How long have pipelines operated in Canada?", https://www.aboutpipelines.com/en/pipeline-101/pipeline-history/.

4. Trucks are not accounted for as part of the totals in this report because they would be considered short distance and part of the field gather system.

Figure 3

Estimate of Canadian handling of imports, exports, intra-Canadian crude within Canada in 2019 (does not include gathering)



Note: *Onshore internal gathering, transfering, storage is not included. Long-distance offshore transfers from producing fields to terminals are included. **Marine includes both Canada east and west coast. International crude transfers, lighering, and barging within Canadian waters are not included. *Includes transfers of crude oil for offshore export via the Port of Vancouver. **Includes US imports into Ontario and condensate in western Canada. ***Includes internal transfers of domestic crude oil and condensate to western Canadian refineries and oil sands operations and transfers exiting western Canada transiting through the United States to Ontario.

Source: IHS Markit, National Energy Board and various other sources

transfers for western Canadian crude traveling through US PADD 2 to the central Canada refining region. Less than one-tenth of these movements, but still significant volumetrically at about 390,000 b/d, were imports from the United States going to either refineries in Canada's central and eastern regions or imports of condensate into western Canada for bitumen blending.

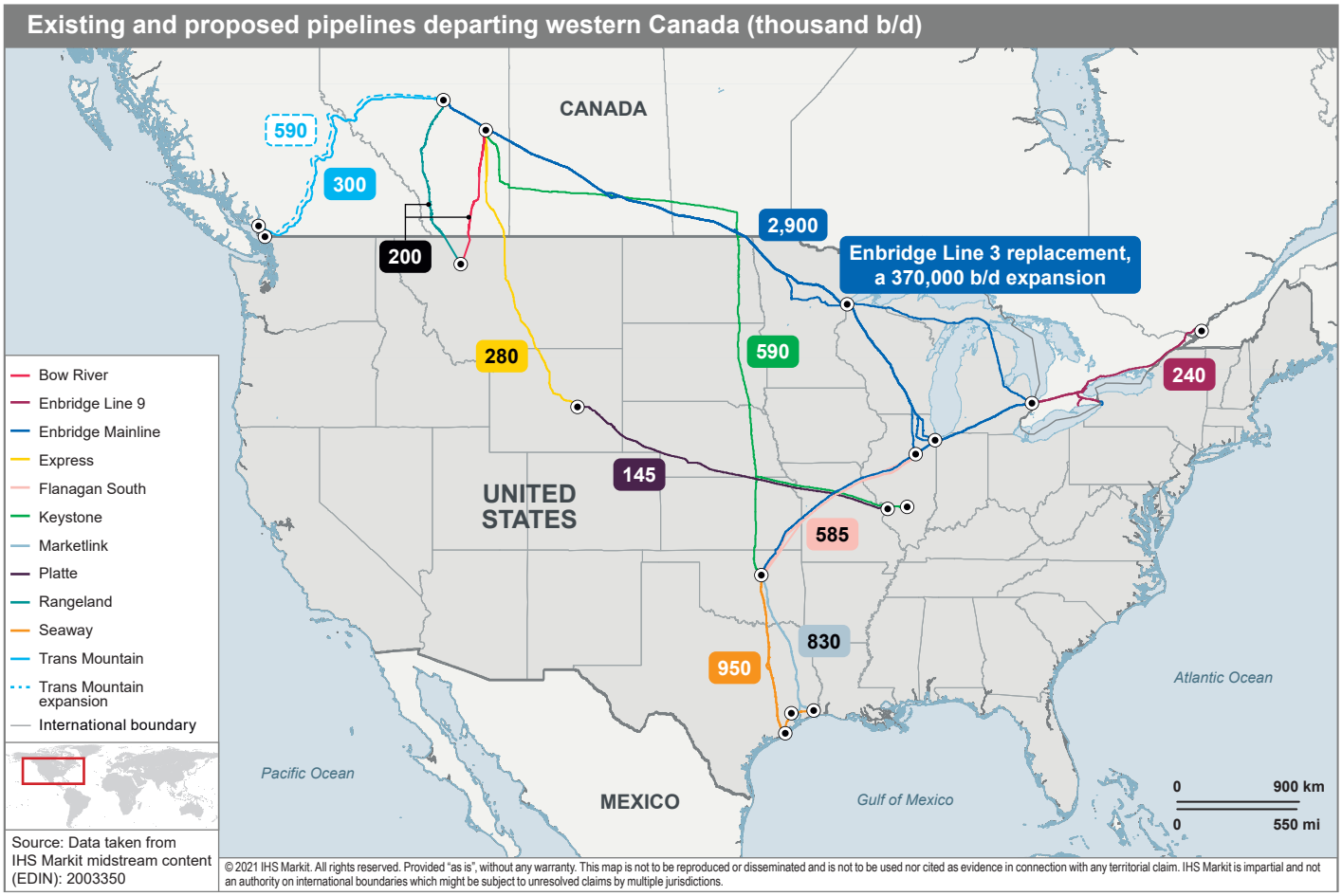
Most crude oil exports and pipeline movements are handled by the Enbridge Canadian Mainline system and TC Energy's Keystone system (see Figure 4). In 2019, these two systems collectively transported nearly four-fifths of all western Canadian exports and over two-fifths of total Canadian movements (imports, exports, and intra-Canadian movements). The other major existing pipelines—Trans Mountain, Plains Midstream's Rangeland, Inter Pipeline's Milk River, and Enbridge's Express account for the remainder. Except for the Trans Mountain system, all these pipelines transport crude oil to the United States.

The Trans Mountain pipeline is the only western Canadian pipeline capable of accessing tidewater on its own. However, the majority of the capacity on the Trans Mountain pipeline has been taken up to support transfers of crude oil and refined products to the Vancouver area and pipeline exports to Washington state. Little room remains for offshore exports at this point (see Figure 5).

Marine transport occurs principally off Canada's east coast

Marine tanker transport is the second most common mode of crude oil transportation in Canada (although it is the most common globally). In 2019, about 15% of total Canadian crude movements, or 950,000 b/d, were handled by marine vessels. Marine movements in this context typically employ Aframax and Suezmax class size vessels capable of holding 750,000 bbl to 900,000 bbl (see Figure 6). Smaller coastal tankers and barges, of which there are a vast number that make numerous short-haul trips along both the west and east coasts, are

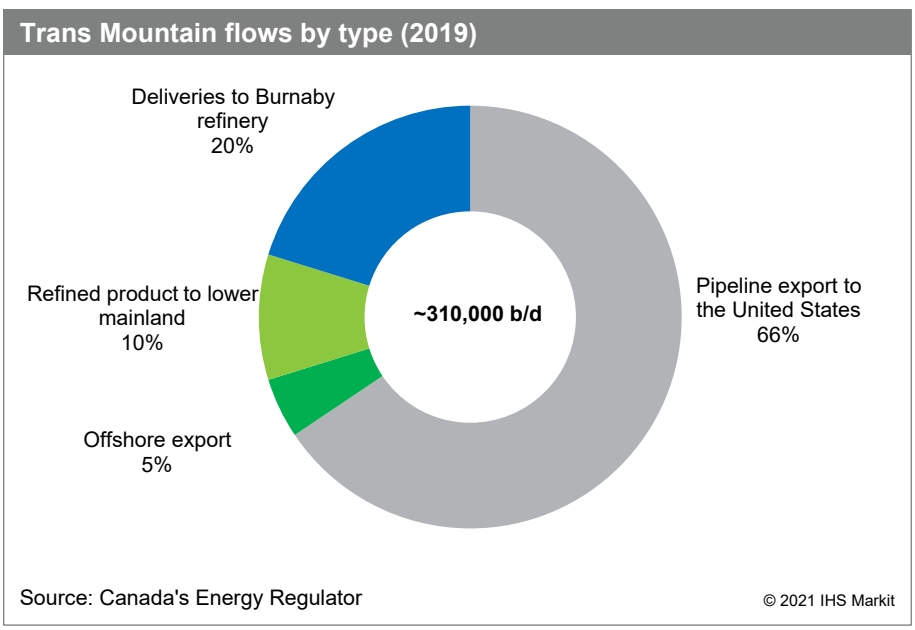
Figure 4



not considered in this tally because of data availability. Many of these smaller vessels are often employed for internal transfers and lightering.[5]

Almost all of Canada's large-scale marine movements of crude oil occur in the waters off the east coast of Canada. This is primarily because of there being eight refineries in central and eastern Canada, four of which have direct access to tidewater. Less than 1% of movements currently occur on Canada's west coast. In 2019, there were 295 individual crude tanker movements in Canadian waters, carrying about 350 MMbbl, or about 2.0% of total global oil

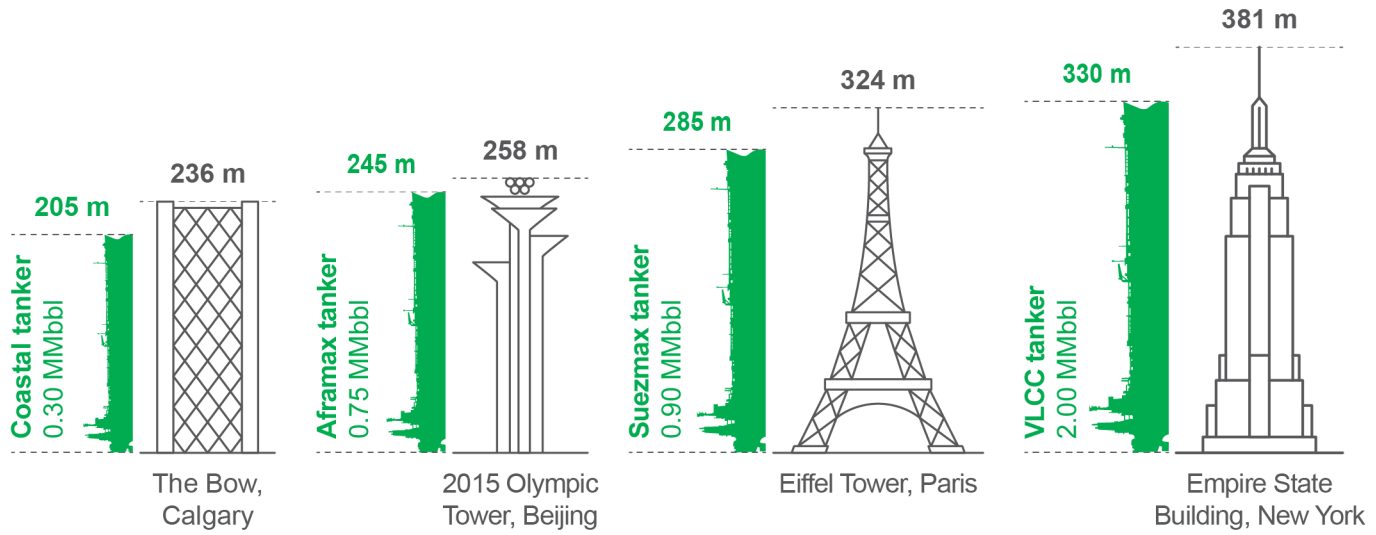
Figure 5



5. Lightering means to transfer cargo from one ship to another. In the case of crude oil, lightering is done to move oil from a large vessel that is not able to enter a port onto a smaller vessel that is able to enter a port.

Figure 6

Crude oil tanker size comparison



Note: VLCC = very large crude carrier.
The ultra-large crude carrier class of tankers is not widely used, beyond storage. This vessel is approximately 415 m long and can hold up to 4 MMbbl of crude oil.

Source: IHS Markit

marine movements.[6] Approximately half of all Canadian marine movements are imports, primarily from the United States and heading to refineries via the Port of Quebec, Quebec and Saint John, New Brunswick. Just over one-third of marine movements are for export from Canada's east coast offshore fields, principally to markets in the United States and Europe. Over 10% of large, long-distance movements are intra-Canadian, which include transfers from east coast offshore production platforms to the marine terminal at Whiffen Head in Newfoundland and refineries in Canada's eastern region.

Crude-by-rail fills a critical gap in Canadian export capacity

Crude oil exports by rail have risen in recent years as western Canadian output has exceeded regional pipeline export capacity. In 2019, the railroads handed nearly 5% of all Canadian movements or about 300,000 b/d.[7] Nearly all rail movements were for export to the United States, predominantly moving to the USGC from western Canada with a small volume being moved within Canada (see Figure 7). The impact of COVID-19 led to a dramatic albeit temporary drop in western Canadian output, which collapsed crude-by-rail movements in 2020. The manufacturing-style nature of oil sands operations, where the underlying resource is plentiful and output is limited by processing capacity, dominates Canadian output and has allowed production to more than recover to previous yearly levels.[8] The resumption of oil sands output, coupled with the fact that some conventional heavy sour operations have long made use of rail, resulted in a modest recovery of crude-by-rail movements over 2021. Should pipelines currently in construction—Enbridge Line 3 Replacement and Trans Mountain Expansion (TMX)—be completed as scheduled, crude-by-rail exports may never again reach the historical heights, but they are expected to remain a facet of western Canadian exports. Some western

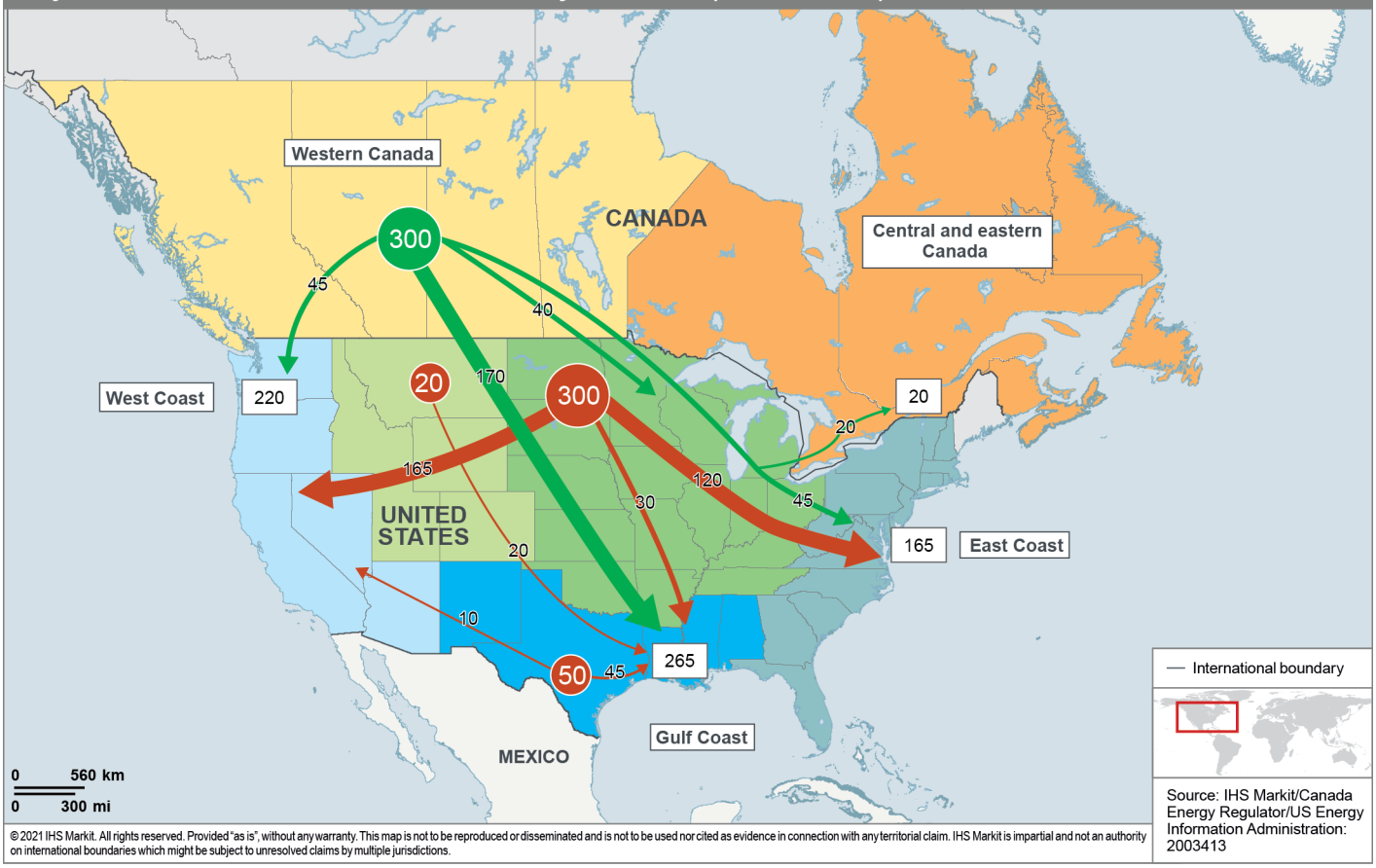
6. This total does not include coastal tanker movements, which are used for short-haul trips along the coast.

7. After reaching record levels of over 400,000 b/d in early 2020, the temporary, albeit dramatic, COVID-19-led production shut-in of second quarter 2020 collapsed rail movements to record lows.

8. For more information see IHS Markit blog, "Canadian oil sands running above pre-pandemic highs, but the lingering impacts of COVID-19 and acceleration of energy transition have lowered the growth prospects", 23 June 2021, https://ihsmarkit.com/research-analysis/canadian-oil-sands-running-above-prepandemic-highs.html

Figure 7

Major movements of North American crude by rail in 2019 (thousand b/d)



Canadian operators have already invested in crude-by-rail capacity, which can provide the benefit of reaching refineries that are unconnected to overland pipeline systems.

Future of Canadian crude logistics: More pipe and tankers

Since the price collapse in 2014–15, Canadian crude oil supply has continued to increase as Canadian projects under construction were completed and brought online. This includes mega oil sands projects such as the Fort Hills mine as well as the large gravity-based offshore project, Hebron. In western Canada, from 2015 to 2019, crude oil supply increased by nearly 650,000 b/d. However, over this same period, IHS Markit estimates the effective western Canada pipeline export capacity only increased by 340,000 b/d. Although the impacts of the COVID-19 demand destruction are anticipated to have short- and medium-term implications on oil production in western Canada, over the next 10 years from 2020 to 2030, IHS Markit estimates that Canadian crude supply could still rise by nearly 900,000 b/d. Most—nearly four-fifths—of this growth comes from the ramp-up and optimization of the Canadian oil sands and, to a lesser extent, the completion of oil sands projects where some capital has already been invested.[9] The rise from today to the mid-2020s is particularly stable with almost all of the rise in output coming from the ramp-up and optimization of existing output. Higher levels of output will require greater movements of crude oil. As noted in Figure 8, IHS Markit estimates total movements could increase by over 650,000 b/d from 2019 to 7.3 MMb/d by 2025.

9. See IHS Markit blog, "Canadian oil sands running above pre-pandemic highs, but the lingering impacts of COVID-19 and acceleration of energy transition have lowered the growth prospects," 23 June 2021, https://ihsmarkit.com/research-analysis/canadian-oil-sands-running-above-prepandemic-highs.html

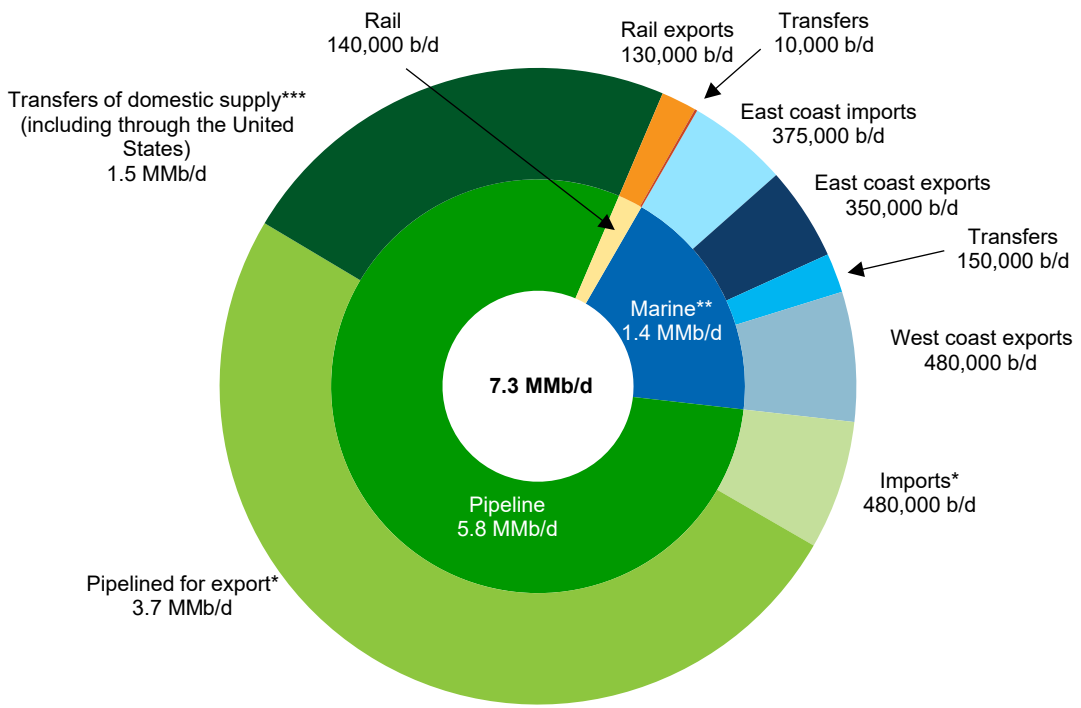
New pipelines increase capacity and optionality for producers

Pipelines could see the greatest increase, followed by marine, while the system's reliance on rail has the potential to decline (depending on the timing of advancing pipelines). However, on a percentage basis, long-distance tanker movements could see the greatest rise—nearly doubling—as a result of the expansion of existing pipeline capacity to Canada's west coast. On the pipeline side, advancing projects have long suffered from delays. Currently two large long-distance pipelines projects—Enbridge Line 3 Replacement and TMX—are in construction that could add nearly 900,000 b/d of incremental capacity over the short to medium term.[10] Despite the potential improvement in pipeline export capacity, rail is expected to remain a key part of the western Canadian export system. However, the completion of these pipelines and optimization projects are not set-in-stone and delays to the in-service dates may occur that could result in greater movements of crude-by-rail than currently anticipated.

Moreover, in addition to assumptions regarding advancing pipeline projects, this report analysis (as shown in Figure 8) also assumes all existing in-service pipelines remain in-service. However, in recent years, existing pipelines have also come under greater scrutiny and even opposition. Canada's central regions of Quebec and Ontario continue to rely on pipeline imports of US crude oil and transfers of Canadian crude oil through the US Midwest to meet regional refinery and heating demand. The state of Michigan in recent years has sought

Figure 8

Estimate of Canadian handling of imports, exports, and intra-Canadian crude within Canada in 2025 (does not include gathering)



Note: *Onshore internal gathering, transfering, storage is not included. Long-distance offshore transfers from producing fields to terminals are included. **Marine includes both Canada east and west coast. International crude transfers, lighering, and barging within Canadian waters are not included. *Includes transfers of crude oil for offshore export via the Port of Vancouver. **Includes US imports into Ontario and condensate in Western Canada. ***Includes internal transfers of domestic crude oil and condensate to western Canadian refineries and oil sands operations and transfers exiting western Canada transiting through the United States to Ontario.

Source: IHS Markit, National Energy Board, and various other sources

10. The Keystone XL pipeline was put on hold after President Biden revoked the cross-border permit on 20 January 2021. The pipeline was subsequently canceled by TC Energy on 9 June 2021.

to shut down one of these critical connectors—Enbridge Line 5 pipeline, which transfers light crude oil and natural gas liquids through to Michigan and into the surrounding United States and Canada's central regions. Any disruption of existing infrastructure could have significant implications to the Canadian and broader North American crude oil logistical system, and energy security.[11]

Tankers on the west coast set to rise

Less than 1% of Canadian tanker movements occurred on Canada's west coast in 2019. In total, only eight tankers visited the Port of Vancouver in 2019, all of which were loaded with crude to be exported. Four of the tankers were destined for Asia and the remainder to the United States. Although Canadian movements are relatively low on its west coast, Cherry Point and Anacortes, two of the major ports in Washington state, handled about 165 tanker movements in 2019.

To access new markets for the western Canadian oil industry, the TMX is currently under construction. TMX would twin an existing pipeline from Edmonton, Alberta to the Westridge Marine Terminal in Burnaby, British Columbia in the Port of Vancouver. This would lead to a rise in both pipeline movements to and tanker movements from the west coast of Canada. When complete, crude oil transportation capacity to the west coast would increase by 590,000 b/d to nearly 900,000 b/d. It is estimated tanker movements from the Port of Vancouver could increase to 400 movements a year.[12]

Concluding remarks

Over the past decade, the movement of crude oil in Canada and other nations has come under heightened scrutiny. However, it is often less understood precisely where, how, how much crude oil is handled, and why. In Canada, pipelines have dominated the long-distance movement of crude oil, principally for export, followed by tankers and rail.

Looking forward, we anticipate Canada's handling of crude oil will increase. By 2025, total movements could increase by 650,000 b/d, largely underpinned by domestic production increases with four-fifths of the rise coming from the ramp-up and optimization of existing facilities.

The majority of these new movements will be handled by pipeline, but marine tanker traffic is also likely to rise. While the majority of tanker movements will continue to occur in the east coast offshore, pipeline and then subsequently tanker movement for export are set to rise from Canada's west coast. Although crude-by-rail has proven capable of moving large qualities of crude oil and is expected to remain an important mode of transportation, it may never again reach historical heights.

Pipelines, crude-by-rail, and marine movements all play an important part in the movement of Canadian crude oil. This report sought to review the role of each mode in ensuring Canada can meet its energy demand each day, as well as key exports markets' demand for Canadian crude oil. Safety is also a key area of interest focused on the transportation of crude oil. Although this was not the focus of this report, there is a brief discussion in the appendices.

11. For more information on Line 5 see: IHS Markit blog, Potential NGL impacts of Enbridge Line 5 shutdown are substantial, 7 May 2021 and Line 5 shutdown could create a logistical scramble, reducing competitiveness of crude oil producers and refiners, 7 May 2021.

12. Trans Mountain estimates that the expanded terminal would handle 37 vessels per month: 34 Aframax and three barge vessels. See Transmountain, "Marine Plans", https://www.transmountain.com/marine-plans.

Appendix A: Pipelines are the backbone of Canadian crude transportation

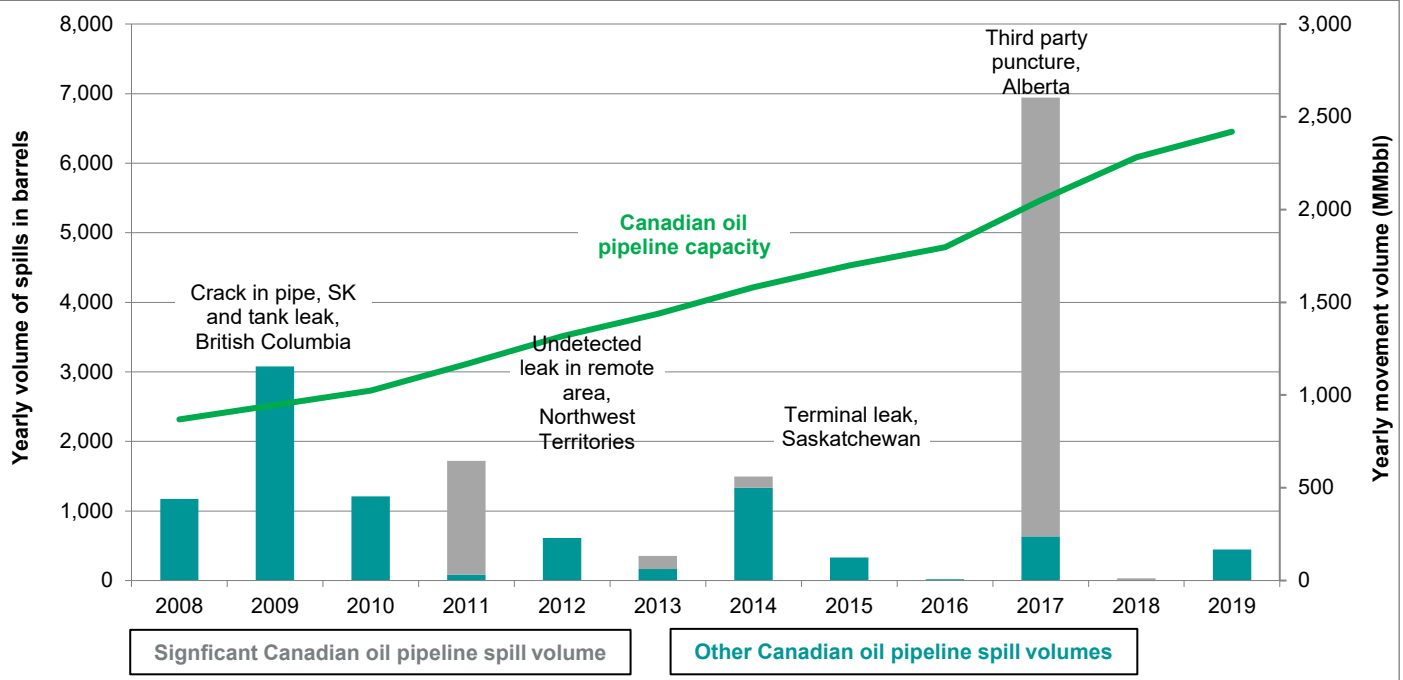
Pipelines have emerged as the dominant form of overland crude oil transport. Canada has an expansive network of pipelines, the majority of which originate in western Canada and head south into the US Midwest. Some pipelines, in turn, head back from the US Midwest into central Canada, while others move further south to the USGC region. There are also gathering and intraprovincial pipelines that move oil from wells to processing facilities, storage tanks, and long-distance transmission systems. Transmission pipelines, or large diameter pipelines, move higher volumes of crude oil, over greater distances than gathering lines. These pipelines are typically buried 3–6 feet (1–2 meters) below the surface, which provides shippers greater predictability than other overland modes of crude oil transportation, such as truck or rail, because movements are largely unimpeded by weather or other external factors. Conversely, pipelines are less flexible, providing a fixed capacity over a fixed route, whereas rail, for example, can more quickly scale capacity up or down based on regional supply and demand opportunities and move to and from different geographies using an established rail network.

Pipeline safety

As the volume of crude oil transported in Canada increased over the past decade, there have been increasing concerns over the ability to safely transport it by pipelines, with concerns being expressed over potential leaks and ruptures. Data from the Canada Energy Regulator (CER) of incidents involving the unintentional release of crude oil from major long-distance pipelines indicate that as the volume of movements has increased the number of incidents has declined. This is shown in Figure A-1.

Figure A-1

Yearly volume of crude oil and condensate spill incidents in Canada



Note: Spill volume percent of total pipeline volume ranged from 0% to 0.34% with the average being 0.11%.
Source: IHS Markit, Canadian Energy Regulator

Most spills associated with major export pipelines occur within the containment areas of terminals or pumping stations. When spills do occur, operators are required to have in place emergency response plans to shut down operations, contain, respond, and remediate spill sites, including the recovery of spilled volumes.

In some instances, the cause of a spill is arguably not in the control of the operator. For example, the large spill shown in Figure A-1 in 2017 occurred in a petrochemical industrial area in Sherwood Park, Alberta when a third party punctured the Enbridge Line 2 pipeline (a 24-inch pipeline) while drilling across the pipeline's right of way. Of the nearly 6,300 bbl of condensate released, most of the liquid was recovered.[13]

13. See the full investigation report from the Transportation Safety Board of Canada.

Appendix B: Marine movements predominantly on one coast

Marine transportation is the most common form of crude oil transport globally. In 2019, IHS Markit estimates nearly 40 MMb/d of crude oil and condensate were moved globally.[14] Marine transport is the most efficient form of long-distance crude oil transport. It provides greater flexibility than other modes, allowing producers to move their crude from regions that may be better supplied and realize lower prices to regions that may be in more demand and thus the ability to obtain higher prices.

In marine shipping, larger vessels generally benefit from greater economies of scale (higher absolute cost but greater capacity thus reducing the unit cost). Generally, smaller vessels are often used for shorter distances and have greater access to ports due to smaller size. Marine tanker size can range significantly. Short- to medium-distance vessels include the Panamax tanker, the Aframax tanker, and the Suezmax tanker, which range from 250 m to 290 m in length and can carry 0.75 MMbbl to 0.9 MMbbl of crude oil. The scale of some of the largest classes of vessels, such as the very large crude carrier (VLCC), are so massive they are restricted in terms of which ports they can access. These vessels may often be lightered offshore—where the cargo is unloaded into smaller vessels capable of reaching the final destination.

Marine safety

The marine transportation of crude oil and associated potential environmental risk should a spill occur has long been a source of concern to coastal communities. The issue of spills is not isolated to crude oil tankers. As the scale of global trade has increased and marine vessels gained scale, the volume of fuel on vessels has also grown. All major ocean-going vessels, such as tugboats, ferries, and bulk carriers, can carry significant fuel onboard. The amount can be significant—from 40 boe to well over 300,000 boe—the upper end being similar in volume to a small coastal tanker.

A survey of global tanker incidents indicates that despite a rise in the global transport of crude oil over the past several decades, the occurrence of both spills and spill volumes declined into the early 2010s where they have remained relatively low, as noted in Figure B-1. The major drivers have been improvements to tanker technology and tanker operations, including the adoption of double-hulled tankers, improved navigational systems, increased monitoring and enforcement, and requirements for crew competency to name a few.[15]

Over the past decade, on average, less than 0.2% of total crude oil volume moved was spilled.[16] When a spill has occured they are typically relatively small and contained. Over the past decade, there was only one incident of a large-scale event. In January 2018, *Sanchi*, a suezmax class tanker laden with 950,000 bbl of condensate (an ultra-light crude oil), collided with a cargo ship off the coast of China. The tanker caught fire and burnt before sinking a week later. The official investigation cited both vessels as failing to comply with proper look-out and to make a full appraisal of the situation and risk of collision.

In Canada, there have been no major incidents involving the transportation of crude oil in the past two decades. However, there were two notable incidents involving the discharge of marine transportation fuels from non-tankers: in 2015, MV *Marathassa*, a bulk carrier on its maiden voyage from Japan to Canada released 2,700 liters of bunker fuel owing to a design defect near the Port of Vancouver off the Coast of British Columbia, and in 2016, when tug *Nathan E. Stewart* and tank barge DBL 55 ran aground near Bella Bella, British Columbia and sank, releasing 110,000 liters of diesel fuel.[17]

14. IHS Markit Commodities by Sea, https://ihsmarkit.com/products/commodities-at-sea.html.

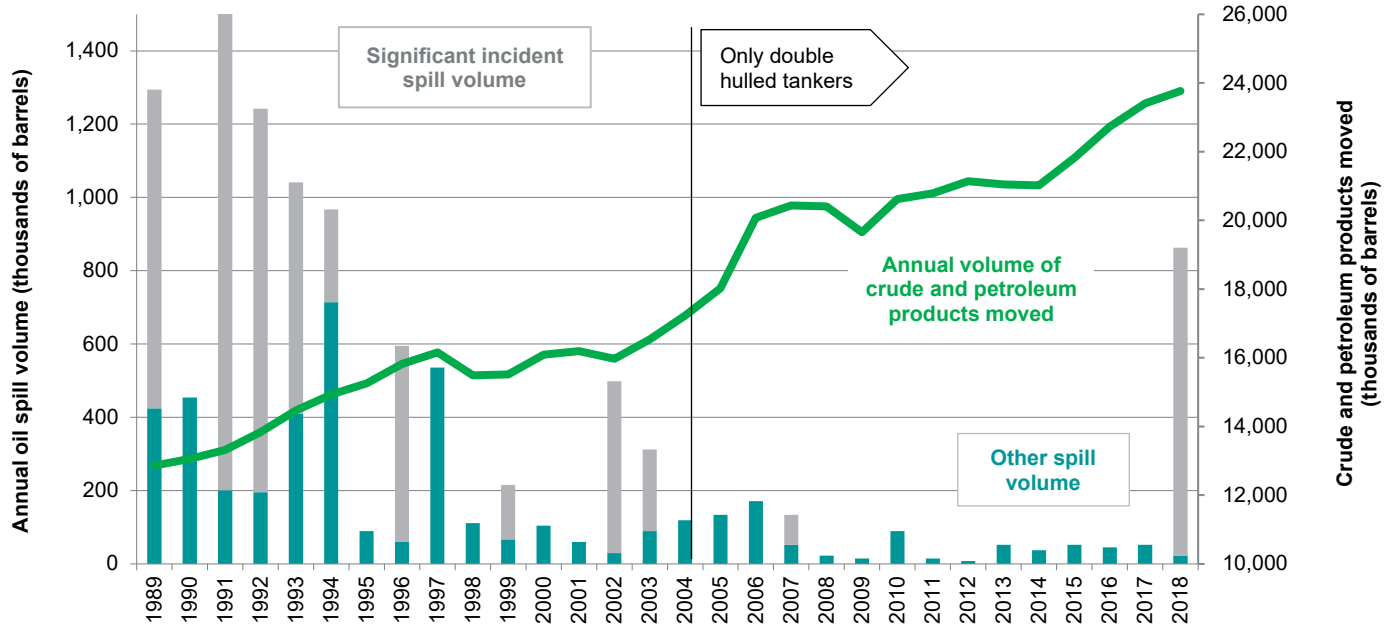
15. For more information on the transformation of the shipping industry, see the 2013 Canadian Oil Sands Dialogue special report.

16. 2019 is the last year of available data from ITOPH for marine oil spills.

17. Information on MV *Marathassa* can be found here. Information on tug *Nathan E. Stewart* can be found here.

Figure B-1

Global frequency and volume of crude oil spills from total volume shipped



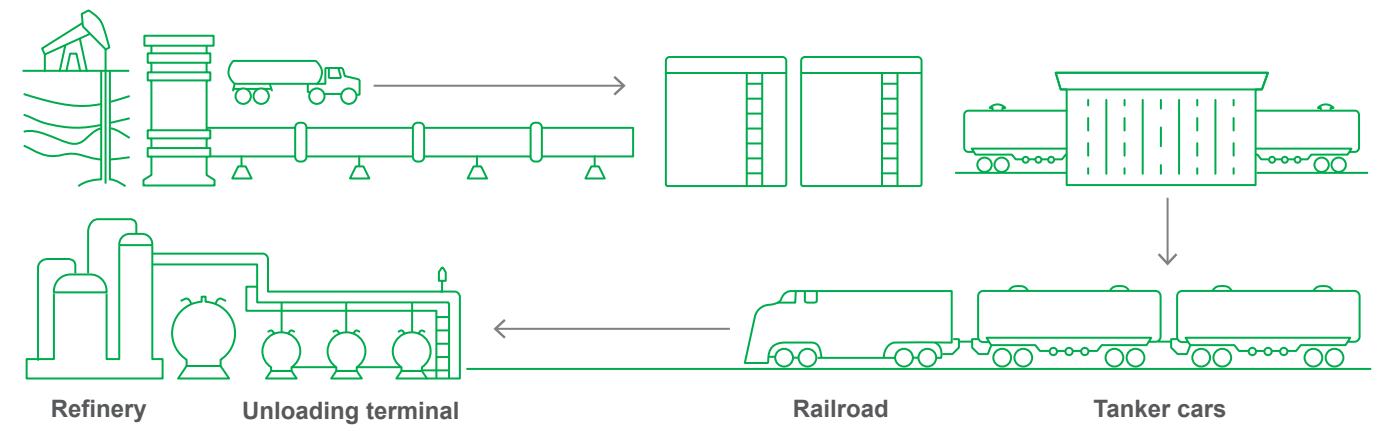
Source: IHS Markit, UNCTADStat, ITOPF

Appendix C: Crude-by-rail provides a critical hedge for western Canadian producers

Although crude-by-rail handled the least volume over the past few years, its importance and role in being able to balance the western Canadian oil market have increased. However, it comes at a greater transportation cost and is arguably more complex from a shipper's perspective. Crude-by-rail involves multiple components, as noted in Figure C-1, including loading/unloading terminals, specialized railcars known as tank cars, and the railroads to provide the horsepower and tracks to move the cars and thus oil to the market. Compared with pipelines, as an overland transportation method, crude-by-rail is relatively more expensive. Additionally, the two primary types of contracts—manifest and unit—impact the economics of crude-by-rail. Manifest trains can carry several types of cargo and can stop at multiple locations along their way prior to the cargo reaching the final destination—this adds time and thus cost for shippers. Dedicated crude trains, known as unit trains, consist of approximately 100–120 cars that move directly from origin to destination. This results in lower transportation costs for shippers compared with manifest trains. However, from the railroad perspective, this requires dedicated capacity and may require fixed-term contracts from shippers to justify the capital outlay. However, with a system of over 280,000 miles of track, railroads offer greater flexibility and ability to reach more distant refineries that may have less pipeline connectivity. However, being susceptible to surface issues such as weather and track congestion, crude-by-rail has greater potential for disruption than pipeline.

Figure C-1

Components of moving crude by rail



Source: IHS Markit

Crude-by-rail safety

Rail safety data are not gathered about specific commodities in Canada and the United States. Rather, the classification of goods is used. Crude oil is categorized as a "hazardous material" in the United States and a "dangerous good" in Canada. These categorizations include other substances such as chlorine gas, hydrochloric acid, and molten sulfur, which complicates the understanding of crude-by-rail safety. Additionally, there are subtle differences between Canadian and US rail safety statistics that can make direct comparison difficult. For these reasons, as well as the United States being a much larger market with a higher number of movements, we made use of US safety data.

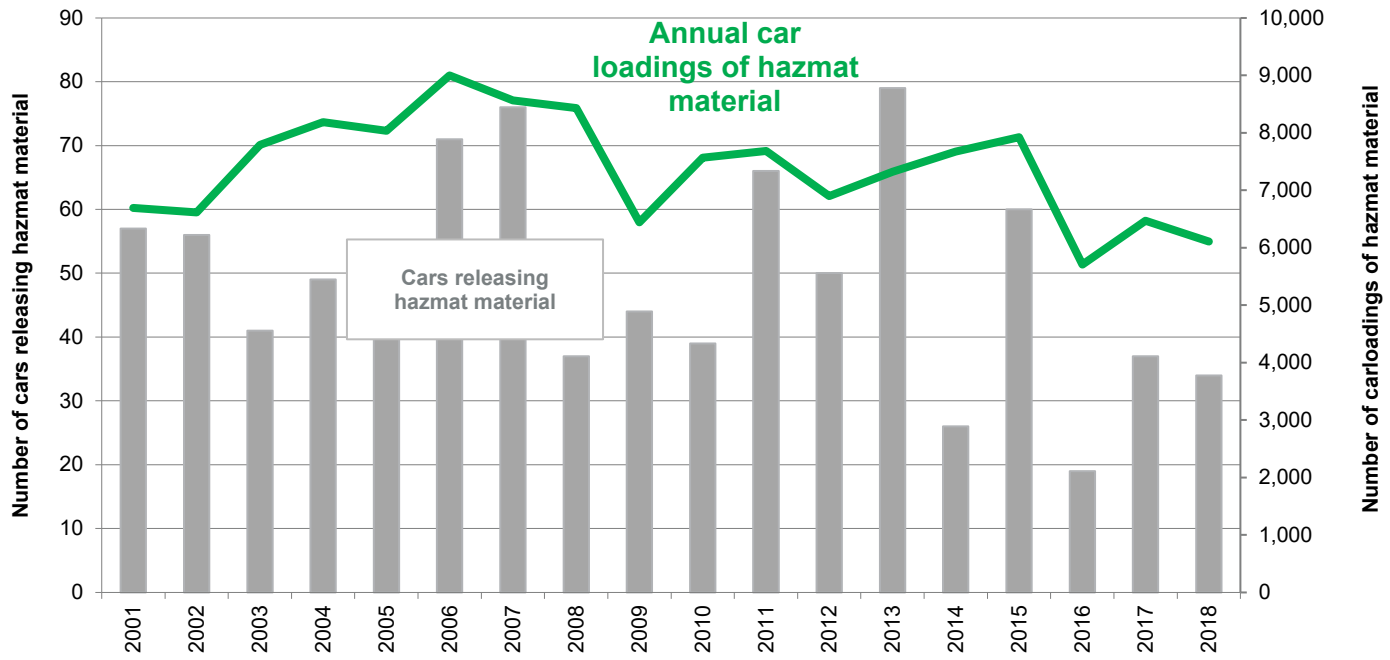
US data indicates that both the number of incidents and the number of rail cars involved in an incident have trended downward in the past two decades. There is a difference between an incident that poses the potential

for a release and an actual release of hazardous material. As noted in Figure C-2, over the past couple of years the number of cars releasing hazardous material have declined.

Over the past half-decade, there have been a number of high-profile accidents involving crude-by-rail in North America. Most notably, the tragic incident in Lac-Mégantic, Quebec that involved a train carrying approximately 50,000 bbl of light sweet crude oil from North Dakota that caught fire and exploded. This incident led to the death of 47 people. In response to this and other incidents, the industry and regulators advanced increasingly stringent safety measures for the transport of crude oil by rail. Some examples include introducing speed limits, special routing measures, and phasing out older style tank cars in favor of heavier, more robust tank cars with thermal barriers.[18,19] The introduction of the new DOT-117 (TC-117 in Canada) tank car includes double hulls, front and back head shields, thermal insulation, top and bottom valve protection, and heavier/thicker steel—essentially armoring up the cars to improve their resiliency in the event of an incident.[20]

Figure C-2

Railway hazmat release incidents and total hazmat carloadings



Source: IHS Markit, Federal Railroad Association

18. Canadian regulators have moved to phaseout older style tank cars on an accelerated timeline from early 2020 to early 2019. https://www.canada.ca/en/transport-canada/news/2018/09/transport-canada-speeds-up-removal-of-least-crash-resistant-rail-tank-cars-from-service.html

19. US Department of Transportation, "Fleet Composition of Rail Tank Cars Carrying Flammable Liquids: 2019 Report". https://www.bts.dot.gov/sites/bts.dot.gov/files/docs/browse-statistical-products-and-data/surveys/annual-tank-car-facility-survey/227571/tankcarreport2019.pdf

20. See: Infographic - TC-117 Tank Car.

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