MICHIGAN REFINING SECTOR: ALTERNATIVES TO ENBRIDGE LINE 5 FOR TRANSPORTATION

Prepared for

National Wildlife Federation

By

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London Economics International LLC ("LEI") was retained by the National Wildlife Federation ("NWF") via a grant from the Charles Stewart Mott Foundation ("CS Mott") to examine alternatives to Enbridge Energy, Limited Partnership ("Enbridge") Line 5 for oil refineries in Michigan and nearby.

LEI focused its analysis on the impact on the one refinery in Michigan and the two in Toledo. The refineries as a group would need to make up about 68,579 barrels per day (about 15 percent of their maximum crude oil demand) from deliveries other than pipeline supplies, assuming no other pipelines are expanded. These other supplies would be delivered by truck or rail. The cost increase to Detroit/Toledo refineries would be an estimated $0.45 per barrel. If refiners could pass along the entire cost increase to gasoline consumers, it would translate to a less than one-cent increase (0.65 cents) in the retail cost of a gallon of gasoline.

Enbridge has reported that by increasing operating pressure, it can expand capacity on Line 78, which already serves the Detroit/Toledo area refineries. If Line 78 capacity is expanded, the Michigan and Toledo refineries would not need crude oil by rail, and truck deliveries would have to compete with pipeline supplies. The cost to refiners would increase by an estimated $0.40 per barrel. The impact on consumers would be less than one cent per gallon—an estimated 0.58 cents per gallon.

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1 Introduction and executive summary

1.1 Enbridge Line 5

The 540,000 barrel-per-day Enbridge Line 5 liquids pipeline was built in 1953. It begins in Superior, WI, and traverses Michigan's Upper Peninsula and Lower Peninsula to terminate in Sarnia, Ontario ("ON"). It runs at the bottom of the Straits of Mackinac for 4.5 miles (see Figure 1). Line 5 carries light crude oil, light synthetic crude, and natural gas liquids ("NGLs"). Most of the liquids shipped on Line 5 are delivered to the Sarnia terminal; from there, they supply refineries in Ontario and as far east as Montreal and Quebec.

Figure 1. Enbridge Line 5

Source: Enbridge[1]

LEI was engaged to assist in understanding the current and potential future role of Enbridge Line 5 from the perspective of Michigan refineries and Michigan consumers of refined products. NWF wished to understand the degree of reliance on Enbridge Line 5 for refinery supply of

[1] Enbridge. "About Line 5." Accessed on April 2018. <https://www.enbridge.com/projects-and-infrastructure/public-awareness/line-5-michigan/about-line-5>

crude oil, whether there are viable alternative options; and understand the potential impact on consumers.

In this report, LEI provides an independent view of the extent to which Enbridge Line 5 is needed for refineries which supply Michigan consumers; and what the cost impact would be if Enbridge Line 5 into Michigan did not exist.

A report by Dynamic Risk Assessments, Inc ("Dynamic Risk")—funded by Enbridge Energy and overseen by the State of Michigan—also estimated the potential impact on costs to oil refineries.[2] LEI did not perform a comprehensive critique of the Dynamic Risk report, which covers a wide variety of issues in addition to the impact on refiners. However, Dynamic Risk provided specific assumptions about some elements of pipeline, rail, and trucking costs, which LEI compared to publicly-available data and then used to evaluate the impact on the cost to refiners. Dynamic Risk's assumptions and their resulting estimates for the cost of alternatives to Enbridge Line 5 provide a useful comparison to LEI's, and this report refers to Dynamic Risk's assumptions and results.

LEI focused its analysis on the impact on refineries which supply Michigan directly. These are located in Detroit and Toledo (see Figure 2). They are part of the broader market area served by Line 5 and two other key pipelines. As needed, LEI's analysis refers to the broader market area which includes other refineries.

Figure 2. Detroit/Toledo refineries

Location	Refinery owner	Capacity (bbl/day)
Detroit, MI	Marathon	139,000
Toledo, OH	BP Husky	155,000
Toledo, OH	PBF Energy	172,800
Total		**466,800**

Source, US refineries: EIA. "Form EIA-820, Refinery Capacity Data by individual refinery as of January 1, 2018." Accessed on August 2018. <https://www.eia.gov/petroleum/refinerycapacity/

1.2 Key findings and conclusions

The lowest-cost way to transport large volumes of crude oil over land is by pipeline; and the Detroit/Toledo refineries use large volumes of oil. Without Line 5 serving the Detroit/Toledo and Sarnia area refineries, LEI found that, assuming no expansion of Enbridge Line 78, which also serves the region:

[2] Dynamic Risk. "Final Report: Alternatives Analysis for the Straits Pipelines." Prepared for the State of Michigan. October 26, 2017.

1. The Detroit/Toledo refineries as a group would need to make up about 68,579 barrels per day of light crude oil supplies which they had previously received by pipeline (see Figure 3);
2. Assuming no expansion of Enbridge Line 78, the 68,579 barrels per day would be made up partly by trucked supplies of Michigan crude oil and partly by the next-least expensive option, which would be North Dakota Bakken crude oil by rail;
   i. The average cost of delivered crude oil (supply area cost plus transportation cost) for the Detroit/Toledo refineries would increase by an estimated $0.45 per barrel (see Figure 3).
   ii. If refiners could pass along the entire cost increase to gasoline consumers, this translates to a less than one-cent increase in the retail cost of a gallon of gasoline (0.65 cents) based on a 61 percent share of crude oil cost in the retail price of gasoline.
   iii. Detroit/Toledo refiners would probably not be able to pass the entire increase into gasoline prices, because they do not have a monopoly on supplies to Michigan.
   iv. A less-than-one-cent increase in the price of gasoline would be lost in the noise of typical weekly gasoline price volatility, which can vary by nearly a dollar across a year.

Figure 3. Cost impact on Detroit/Toledo refiners, assuming Line 78 at 570,000 barrels per day

	With Enbridge Line 5	Without Enbridge Line 5
Pipeline supplies (barrels per day)	**466,800**	**398,221**
of which:		
Light oil supplies (barrels per day)	231,800	163,221
Edmonton Light price per barrel (2015/17 average)	$ 44.88	$ 44.88
Pipeline tariff per barrel, light, Edmonton to Stockbridge	$ 4.54	$ 4.94
Heavy oil supplies (barrels per day)	235,000	235,000
Canadian heavy blend (WCS) supply area price (2015/17 average)	$ 34.63	$ 34.63
Pipeline tariff per barrel, heavy, Edmonton to Stockbridge	$ 5.39	$ 5.79
Non-pipeline supplies (barrels per day)		**68,579**
of which:		
Trucked crude oil (barrels per day)		15,000
Michigan first purchase price per barrel (2015/17 average)		$ 46.65
Cost per barrel to truck to market		$ 2.80
Rail from Bakken (barrels per day)		53,579
North Dakota first purchase price per barrel (2015/17 average)		$ 41.62
Cost for Canadian Pacific Bakken to Detroit		$ 8.77
Weighted average cost of crude oil (dollars per barrel)	**$ 44.69**	**$ 45.14**
Difference (dollars per barrel)		$ 0.45

3. Assuming an expansion of Enbridge Line 78, which Enbridge has said can increase to by 230,000 barrels per day (to 800,000 barrels per day) if operated at a higher pressure:[3]

   i. An additional 230,000 barrels per day of pipeline capacity would be available to the Detroit/Toledo refineries.

   ii. With the additional 230,000 barrels per day of capacity, the Detroit/Toledo refiners would not need crude oil shipped by truck (though they would take trucked oil if the oil producers sold the oil at a price that was competitive with pipeline supplies); and they would not need rail. In that case, the increased cost to refiners would be an estimated $0.40 per barrel or less.

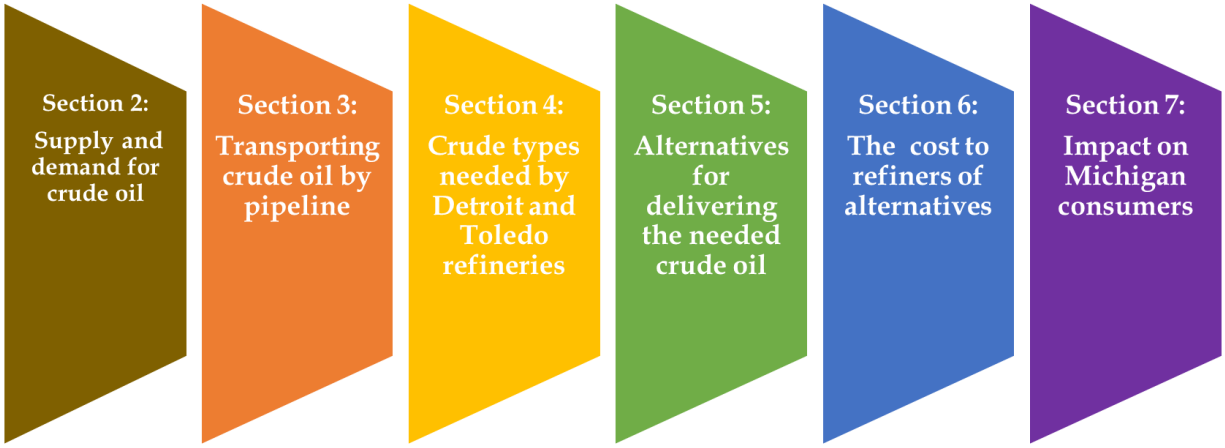
   iii. The cost increase for a gallon of gasoline to Michigan consumers would be even lower, at 0.58 cents (less than one cent) per gallon, even if refiners could pass along the entire price increase to consumers.

1.3 LEI's approach, and roadmap to this report

LEI took a six-step approach to the analysis (see Figure 4). LEI began our analysis with an overview of crude oil supply and demand in North America, and exports from North America (Section 2). These trends broadly determine the flows of crude oil between key supply areas and the rest of the country. Then LEI examined the pipeline infrastructure which serves the Michigan and Sarnia area specifically (Section 3). LEI estimated the amount of crude oil the Detroit/Toledo refineries would have to replace if Line 5 were not operating (Section 4). Then, LEI explored alternatives to Line 5 (Section 5); and estimated the cost of several alternatives and examined the impact of these costs on the Detroit/Toledo refineries (Section 6). LEI looked at the cost impact on consumers of refined products in Michigan (Section 7). LEI's conclusions and the implications of the analysis are in Section 8.

[3] Michigan Public Service Commission Case No. U-17020 Exhibit A-2 p. 5 April 16, 2012. https://mi-psc.force.com/sfc/servlet.shepherd/version/download/068t0000000wdBtAAI

Figure 4. Overview of LEI's approach and corresponding report sections



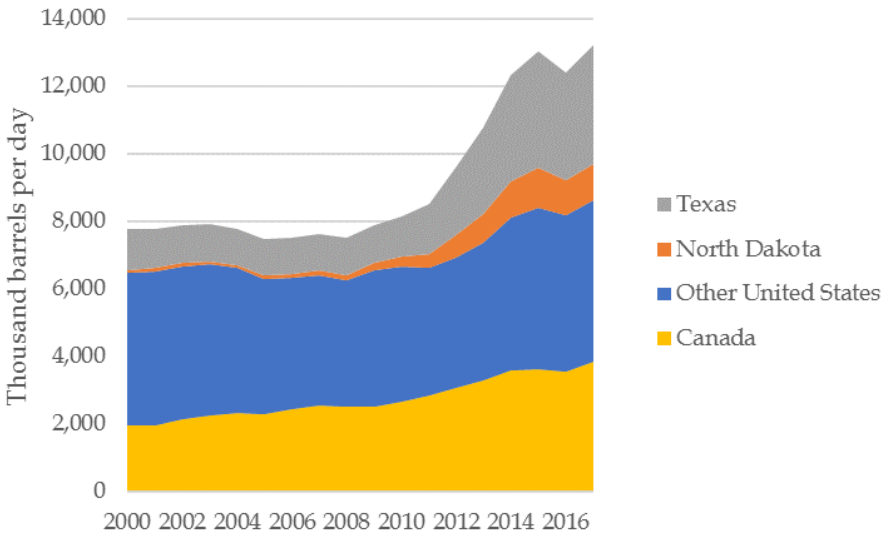
2 Supply and demand for crude oil

Trends in crude oil production and consumption in North America broadly determine flows on existing crude oil pipelines, and the potential need to expand, reverse, or decommission pipelines.

2.1 US and Canadian crude supplies and exports are growing

Crude oil production in the United States and Canada has grown substantially over the past several years (see Figure 5). In Canada, the oil sands in Alberta has led the growth. In the United States, shale oil resources in Texas and the Bakken region in North Dakota have been the key drivers for this growth.

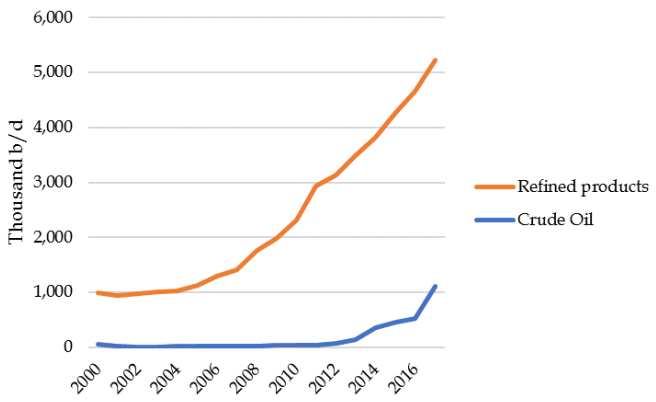
Figure 5. Production of crude oil by the United States and Canada



Source: EIA Crude Oil Production http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbblpd_a.htm; and NEB Estimated Production of Canadian Crude Oil and Equivalent https://www.neb-one.gc.ca/nrg/sttstc/crdlndptrlmprdct/stt/stmtdprdctn-eng.html#wb-cont

In December 2015, the US Congress passed a law allowing exports of crude oil to markets around the world. Previously, exports were permitted only to Canada. By 2017, US crude oil exports reached over 1 million barrels per day (see Figure 6).

Figure 6. US exports of crude oil and refined products

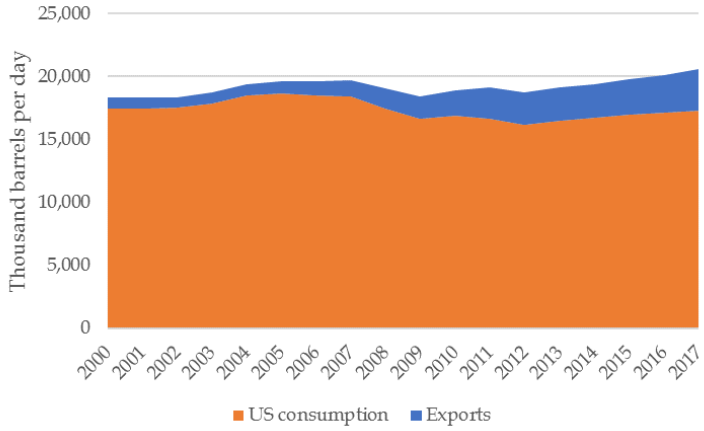


Source: EIA. US Exports of Crude Oil and Petroleum Products
http://www.eia.gov/dnav/pet/pet_move_exp_dc_nus-z00_mbblpd_a.htm

2.2 US demand for refined products is flat; exports are growing

In contrast to the strong growth in supply and exports, crude oil demand in the United States and Canada has been essentially flat. Crude oil is used only as a refinery input, for the most part, and demand for refined products in the United States has been flat-to-declining for over a decade (see Figure 7). With cost-effective sources of North American crude oil, however, US refineries have generally remained busy providing refined products for export.

Figure 7. US consumption and export of finished refined products



Note: EIA uses product supplied as a proxy for US petroleum consumption. Product supplied measures the disappearance of finished refined products from petroleum refineries, natural gas processing plants, blending plants, pipelines, and bulk terminals.
Source: EIA. Product Supplied of Finished Petroleum Products
http://tonto.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MTPUPUS2&f=A, and EIA. Exports of Finished Petroleum Products http://tonto.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MTPEXUS2&f=A

3 Transporting crude oil by pipeline

Generally, pipelines are the lowest-cost way to transport large quantities of crude oil over land. The North American pipeline system covers most of the continent, to carry crude oil from supply regions to refineries and export terminals.

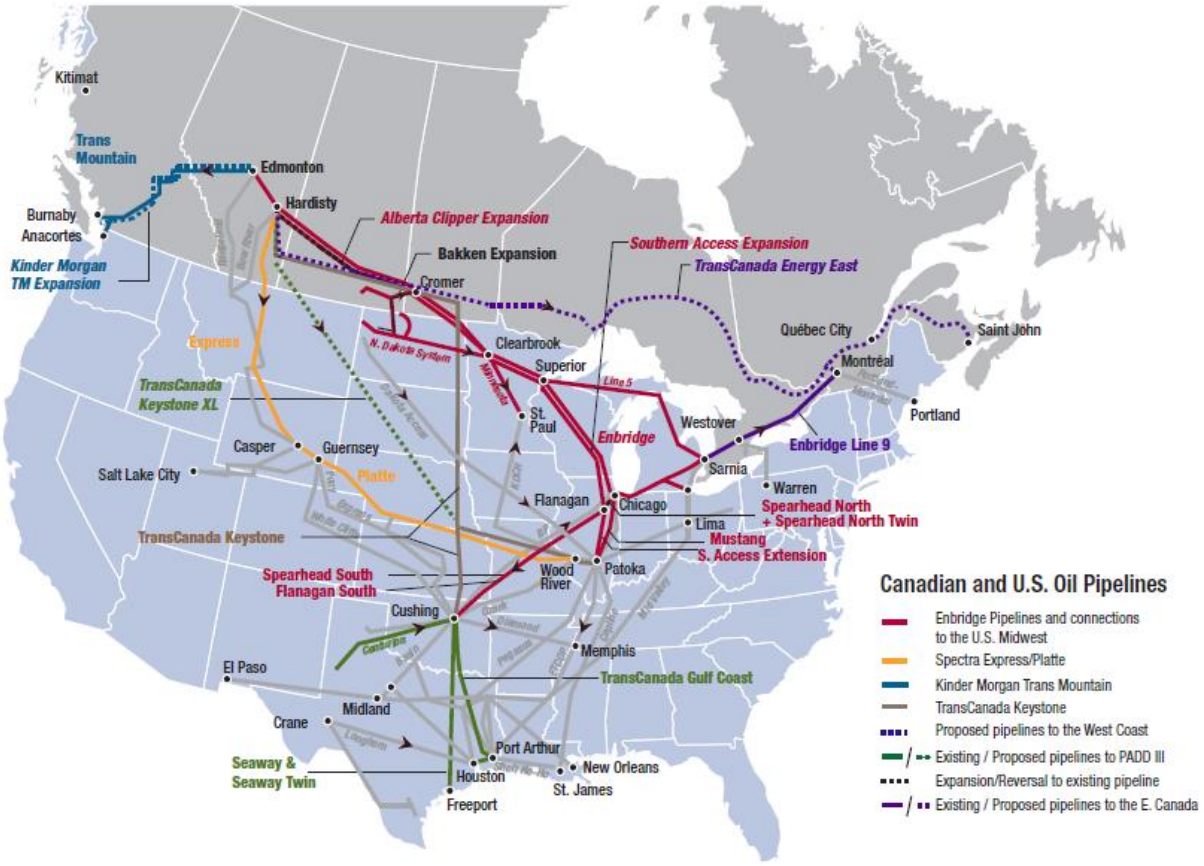
3.1 The big picture: Pipelines move crude across the continent, including into Michigan

With strong growth in crude oil supplies from Western Canada and the Bakken region in North Dakota, new pipelines have been built, and existing pipelines have been reversed and/or expanded, to bring crude oil ultimately to the US Gulf Coast for export (see Figure 8). New lines have included the Keystone Pipeline (not to be confused with Keystone XL, which is not yet completed) which began operations in 2010, and the Dakota Access Pipeline ("DAPL") completed in 2017.[4]

Major pipeline routes bring crude oil to important terminals (Flanagan and Patoka, in Illinois, and Superior, in Wisconsin), which makes them accessible to Detroit/Toledo refineries. These refineries receive crude oil from Western Canadian producing areas, from the US Bakken region (North Dakota), and even the US Gulf Coast, from a variety of major pipelines. North Dakota oil passes through Flanagan or Patoka making it accessible to the Michigan area, as well as the US Gulf Coast. Canadian crude passes through Chicago or Superior on its way to the Michigan area.

[4] TransCanada. *Operations Maps.* <https://www.transcanada.com/en/operations/operations-map/> and Energy Transfer Partner. https://www.energytransfer.com/ops_bakken.aspx

Figure 8. Major crude oil pipelines in North America, 2017



Source: Canadian Association of Petroleum Producers ("CAPP"). *2017 Crude Oil Forecast, Markets and Transportation*

3.2 A closer look: Detroit/Toledo and Sarnia area served by three key pipelines

Three large pipelines transport crude oil from oil-producing regions to the Detroit/Toledo area. These are Enbridge Line 5, Enbridge Line 78 (formerly 6B) and the Mid-Valley pipeline (see Figure 8). Their combined capacity currently totals 1.35 million barrels per day, assuming Line 78's capacity is 570,000 barrels per day to Sarnia.[5] The 570,000 barrels per day may understate the capacity which could be available in Michigan, however, as Enbridge has indicated Line 78's operating capacity into Stockbridge, MI could ultimately reach 800,000 barrels per day (based on design capacity of 889,000 barrels per day) depending on operating pressure.[6]

[5]Enbridge Energy "Enbridge's Energy Infrastructure Assets." July 12, 2018. https://www.enbridge.com/~/media/Enb/Documents/Factsheets/FS_EnergyInfrastructureAssets.pdf?la=en

[6]Michigan Public Service Commission Case No. U-17020 Exhibit A-2 p. 5 April 16, 2012. https://mi-psc.force.com/sfc/servlet.shepherd/version/download/068t0000000wdBtAAI

Figure 9. Key pipelines serving the Michigan area

Pipeline	Capacity (thousand barrels per day)	Terminal	Type of crude oil
Enbridge Line 5	540	Sarnia	Light
Enbridge Line 78 (6B)	570 - 800	Stockbridge	Various
Mid-Valley	240	Toledo	Various
Total	**1,350 to 1,580**		

Source: Map, EIA; Data: Enbridge Energy "Enbridge's Energy Infrastructure Assets." July 12, 2018. https://www.enbridge.com/~/media/Enb/Documents/Factsheets/FS_EnergyInfrastructureAssets.pdf?la=en, and Energy Transfer Partners SEC Filing 10-k, and Michigan Public Service Commission Case No. U-17020 Exhibit A-2 p. 5 April 16, 2012. https://mi-psc.force.com/sfc/servlet.shepherd/version/download/068t0000000wdBtAAI

3.2.1 Line 5 is part of an integrated Enbridge system

Line 5 is part of Enbridge's Mainline system, which transports crude oil from Canada and North Dakota eastward, ultimately to Sarnia. The system transports heavy crude oil, light crude oil, condensate, and NGLs. Enbridge Line 5 carries light crude oil and NGLs from Superior Wisconsin where it interconnects with Enbridge Line 3 to the Sarnia market area in Ontario.

Broadly, the Enbridge Mainline system offers two routes from Superior to Sarnia: one through Michigan, and the other through Flanagan, Illinois and eventually across Michigan (see Figure 10). From Sarnia, Enbridge Line 9, with a capacity of 300,000 barrels per day,[7] transports crude oil to refineries as far east as Montreal.

Figure 10. Overview of Enbridge liquids pipeline system

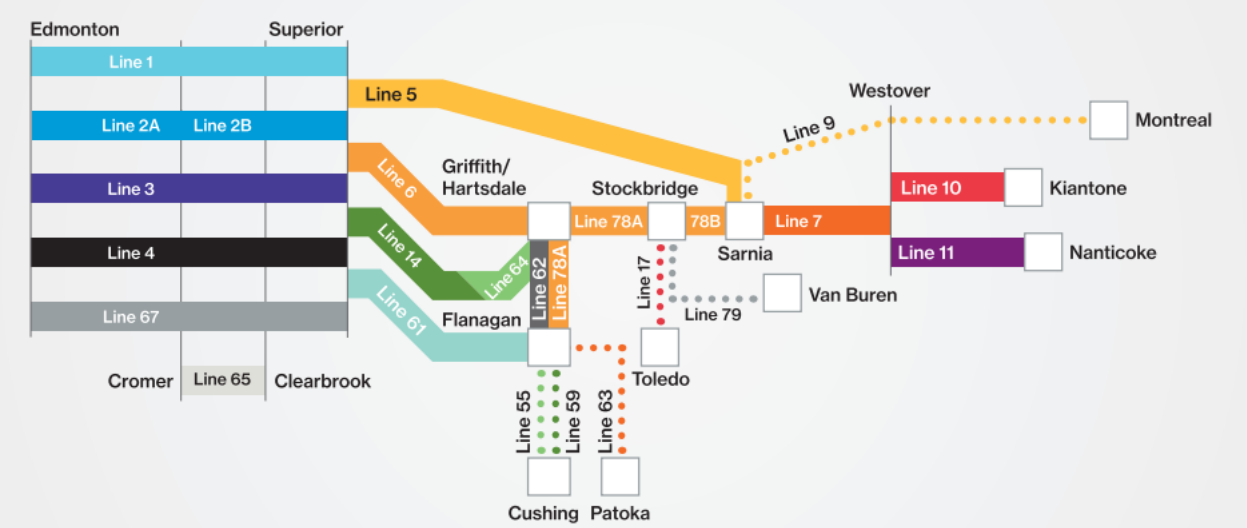
Source: National Energy Board. https://www.neb-one.gc.ca/nrg/ntgrtd/trnsprttn/2016/grp1cmpns/lndlqds/nbrdg-ppln-nc-nbrdg-mnln-eng.html

[7] Enbridge. https://www.enbridge.com/~/media/Enb/Documents/Infographics/ENB%20Mainline%20Pipeline%20System.pdf

3.2.2 The Enbridge system has more than one route to Michigan and Sarnia

The Enbridge Mainline system can serve similar routes with multiple pipelines. Shippers specify volumes to be shipped, an injection point, and a delivery point. If multiple pipelines can serve the route, Enbridge decides which physical pipelines to use to ship the crude oil. Tariffs (discussed in more detail in Section 6) are determined based on receipt points and delivery points. Line 5 and Line 78 (formerly 6B) both access Michigan and Sarnia (see Figure 11).

Figure 11. Detailed view of Enbridge liquids pipeline system



Note: Pipelines indicated by dotted lines are not part of the Enbridge Mainline system, they are other Enbridge lines.
Source: Enbridge. Q1 2018. https://www.enbridge.com/~/media/Enb/Documents/Infographics/ENB%20Mainline%20Pipeline%20System.pdf

The total capacity of the Enbridge system which can be delivered at Sarnia was reported at 1,013,000 barrels per day for 2015/17.[8] This is slightly less than the 1,110,000 nameplate capacity which is the sum of the 570,000 barrels per day on Line 78 to Sarnia and the 540,000 barrels per day on Line 5, owing to month to month variations based on crude slate, injection and delivery patterns, unplanned outages, planned maintenance, short-term pressure restrictions, and operational outages.[9]

[8] https://www.neb-one.gc.ca/nrg/ntgrtd/pplnprtl/pplnprfls/crdl/nbrdgmnln-eng.html

[9] https://www.neb-one.gc.ca/nrg/ntgrtd/pplnprtl/pplnprfls/crdl/nbrdgmnln-eng.html

4 Crude types needed by the Detroit/Toledo refineries

The quantity of heavy versus light crude oil that the Detroit/Toledo refineries require will have an impact on the cost to those refineries in the absence of Line 5. The crude oil requirements of other refineries which use the same set of pipelines will impact the amount of pipeline crude oil that is available to the Detroit/Toledo refineries.

4.1 Heavy crude oil supplies

Several area refineries use heavy crude oil, which is not carried on Enbridge Line 5:

- The BP Husky Toledo refinery is currently configured to run 155,000 barrels per day of heavy crude oil.[10] This crude is supplied by pipeline from the Enbridge system via Line 78 and the Mid-Valley pipeline from Lima.[11]

- The Marathon Detroit refinery is configured to run 80,000 barrels per day of heavy crude oil.[12] As Line 5 does not deliver heavy crude oil, Marathon gets this crude from Enbridge Line 78 and/or the Mid-Valley pipeline.

LEI estimated the combined maximum heavy oil requirement for these two refineries, assuming no adjustment for capacity utilization, at 235,000 barrels per day (see Figure 12).

4.2 Light crude oil supplies

Several refineries use light crude oil, which may be supplied by Line 5 and/or Line 78 and/or the Mid-Valley pipeline:

- The PBF Energy Toledo refinery, with a capacity of 172,000 barrels per day, is reported to use only light oil.[13]

- As the Marathon Detroit refinery is configured to run 80,000 barrels per day of heavy oil, LEI assumes it runs the balance of its 139,000 barrels per day capacity (59,000 barrels per day) on light or medium crude oil.

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[10] Morningstar *Heavy Bets Pay Off for Midwestern Refineries; Growth limited by static demand in PADD 2*. March 27, 2017. http://www.morningstarcommodity.com/Research/heavy-bets-pay-off-for-midwest-refiners-FINAL-Outlook.pdf

[11] Ibid.

[12] Marathon http://www.marathonpetroleum.com/Operations/Refining_and_Marketing/Refining/Detroit_Refinery/

[13] PBF Energy. https://www.pbfenergy.com/refineries

Based on this data, LEI estimated the maximum demand from the Detroit/Toledo refineries would be 235,000 barrels per day of heavy oil, and 231,800 barrels per day of light oil.

Figure 12. Detroit/Toledo refinery estimated light oil and heavy oil requirements

Location	Refinery owner	Capacity (bbl/day)	Light or medium oil (bbl/day)	Heavy oil (bbl/day)
Detroit, MI	Marathon	139,000	59,000	80,000
Toledo, OH	BP Husky	155,000	0	155,000
Toledo, OH	PBF Energy	172,800	172,800	0
Total		**466,800**	**231,800**	**235,000**
Mid Valley and Line 78 maximum deliveries to Detroit/Toledo		**466,800**	**231,800**	**235,000**
Mid Valley and Line 78 capacity total		810,000		
Mid Valley and Line 78 capacity NOT used by Detroit/Toledo		343,200		

Sources: Form EIA-820, Refinery Capacity Data by individual refinery as of January 1, 2018." Accessed on August 2018. <https://www.eia.gov/petroleum/refinerycapacity/ and http://www.marathonpetroleum.com/Operations/Refining_and_Marketing/Refining/Detroit_Refinery/

The maximum total crude oil required by the Detroit/Toledo refineries would be 446,800 barrels per day (if LEI accounted for utilization rates, it would make this number somewhat lower). This is less than the total combined current capacity of the Mid-Valley pipeline (240,000 barrels per day) and Enbridge Line 78 (570,000 barrels per day) of 810,000 barrels per day. The purpose of this analysis is to demonstrate that, if all the Detroit/Toledo requirements were met by Line 78 and the Mid-Valley Pipeline, there would be 343,200 barrels per day of capacity left over. This analysis does not require making any assumptions about pipeline capacity utilization. This left-over capacity (in addition to Line 5) is used by refineries which are interconnected to the same pipeline system as the Detroit/Toledo refineries. It is the demand from all refineries which use the same system which is relevant to our analysis of the impact of the closure of any one of the pipelines (like Line 5) which serve that demand area. This is examined next.

4.3 Refineries further east are interconnected to the Detroit/Toledo refineries

Refineries in Detroit/Toledo are not the only ones connected to the three pipelines which bring crude oil into Michigan. Enbridge Line 78 and Line 5 serve Sarnia, ON, with three refineries; and Line 78 and Line 5 also indirectly (via Enbridge Line 9) serve refineries in Nanticoke, ON, Warren, PA, and in Quebec province. Enbridge Line 9 interconnects with the Enbridge Line 5 in Sarnia (see Figure 11 previously). The total capacity of the other refineries which access the same pipeline system as the Detroit/Toledo refineries is 830,000 thousand barrels per day (see Figure 13). LEI refers to this as the broader Line 5 demand area.

Figure 13. Refining capacity (maximum crude oil demand) in the broader Line 5 demand area

Location	Refinery owner	Capacity (bbl/day)
Sarnia, ON	Imperial	121,000
Sarnia, ON	Suncor	85,000
St. Clair, ON	Shell Corunna	75,000
Warren, PA	United	65,000
Nanticoke, ON	Imperial	112,000
Montreal, QC	Suncor	137,000
Levis, QC	Valero	235,000
Total		**830,000**

Source, Canadian refineries: Oil Sands Magazine. "Canadian Refineries." Accessed on August 2018. <http://www.oilsandsmagazine.com/projects/canadian-refineries>
Source, US refineries: EIA. "Form EIA-820, Refinery Capacity Data by individual refinery as of January 1, 2018." Accessed on August 2018. <https://www.eia.gov/petroleum/refinerycapacity/

If the total pipeline capacity not used by the Detroit/Toledo refineries (343,2000 barrels per day, from Figure 12 shown previously) is added to the light oil shipped on Line 5 in 2015/16 (the years for which Enbridge and shippers provided data),[14] an estimated 757,200 barrels per day must have been shipped to the rest of the broader Line 5 area in 2015/16 (see Figure 14). This accounts for a large portion of the maximum demand for crude oil (830,000 barrels per day) from the broader Line 5 area refineries.[15]

Figure 14. Estimated demand for oil from broader Line 5 demand area (barrels per day)

Capacity not used by Detroit/Toledo	343,200
Light oil on Line 5	414,000
Estimated demand for oil from broader Line 5 market area	757,200

Based on our analysis, the 757,200 barrels per day seems to be the maximum that the broader Line 5 area refineries use from some combination of Line 5, Line 78, and the Mid-Valley pipeline. The next section examines alternatives in the absence of Line.

[14] Dynamic Risk. "Final Report: Alternatives Analysis for the Straits Pipelines." Appendix C. Prepared for the State of Michigan. October 26, 2017.

[15] The 830,000 barrels per day is a maximum demand volume because it is based on refinery nameplate capacity. Nameplate capacity is the maximum volume of crude oil a refinery can be expected to run if there are no outages for maintenance or other down time.

5 Alternatives to Line 5

The volume of capacity on the Enbridge system and the other pipelines into the area will determine how much of the loss of Line 5 could be made up by shipments on those pipelines. LEI estimated spare capacity on the pipeline system which accesses the Detroit/Toledo refineries and the broader Line 5 demand area.

5.1 Spare capacity on the Enbridge system into Sarnia

Crude oil flows on the Enbridge system into Sarnia have averaged 689,000 barrels per day in 2016/17, based on heavy and light crude oil flow data from the National Energy Board ("NEB") (see Figure 15). Line 5 ran at about 414,000 barrels per day for light crude oil and 81,300 barrels per day for NGLs in 2016,[16,17] for a total of 495,300 barrels per day.[18] We can assume the remaining 175,000 barrels per day of oil must have been crude oil shipped on Line 78, as Enbridge information indicates that Line 78 does not transport NGLs.[19]

Unused capacity would have averaged 339,741 barrels per day (1,110,000 – 770,259 barrels per day) based on owners' reported nameplate capacity of 1,110,000 barrels per day (see Figure 16). Most of this, 294,960 barrels per day, would have been on Line 78. If flows are compared to adjusted capacity instead of nameplate capacity, spare capacity would have averaged 242,741 barrels per day, all on Line 78. These calculations indicate there may be spare capacity on the Enbridge system into Michigan and Sarnia, on Line 78. For the purposes of LEI's analysis, which focuses on the impact on Detroit/Toledo refineries, it is not critical if the spare capacity is 242,741 or 294,960 barrels per day; as we demonstrate in Section 5.1.2, what matters is the total demand from all the refineries in the broader demand area compared to the total capacity on Lines 78 and the Mid-Valley pipeline.[20]

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[16] Dynamic Risk. "Final Report: Alternatives Analysis for the Straits Pipelines." Appendix C. Prepared for the State of Michigan. October 26, 2017.

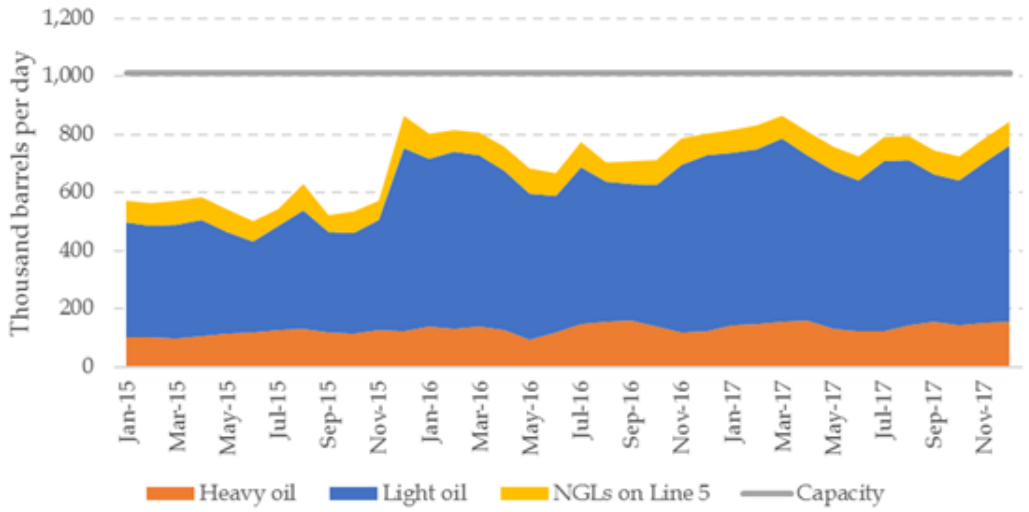
[17] LEI assumed 2017 NGL flows on Line 5 would be 81,300 barrels per day, equivalent to the 2016 average.

[18] This is lower than Line 5's nameplate capacity of 540,000 barrels per day. Enbridge has noted that "Line 5 operates at less than 25 percent of its maximum pressure capacity…" (source: https://www.enbridge.com/~/media/Enb/Documents/Factsheets/FS_Line5_OperationsMaintenance.pdf?la=en). This may account for some of the difference between flows and capacity.

[19] Enbridge. Energy Infrastructure Assets. P. 38. July 12, 2018. https://www.enbridge.com/~/media/Enb/Documents/Factsheets/FS_EnergyInfrastructureAssets.pdf?la=en

[20] Capacity utilization on the Mid-Valley pipeline in not publicly available. To be conservative, LEI assumed the Mid-Valley pipeline is operating at full capacity.

Figure 15. Capacity and flows on the Enbridge system into Sarnia



Sources: NEB. https://www.neb-one.gc.ca/nrg/ntgrtd/pplnprtl/pplnprfls/crdl/nbrdgmnln-eng.html and Dynamic Risk. "Final Report: Alternatives Analysis for the Straits Pipelines." Appendix C. Prepared for the State of Michigan. October 26, 2017.
Note: LEI assumed NGLs shipped on Line 5 at 81,300 barrels per day in 2017, the same rate as the average for 2016.

Figure 16. LEI estimate of spare capacity on the Enbridge system to Sarnia (barrels per day)

		Line 5	Line 78	Total to Sarnia
Flows	NGL	81,259	-	81,259
	Oil	413,960	275,040	689,000
	Total	495,220	275,040	770,259
Nameplate capacity		540,000	570,000	1,110,000
Spare capacity		44,780	294,960	339,741

Sources: Nameplate capacity, Enbridge Energy "Enbridge's Energy Infrastructure Assets." July 12, 2018. https://www.enbridge.com/~/media/Enb/Documents/Factsheets/FS_EnergyInfrastructureAssets.pdf?la=en; Flows, Dynamic Risk Appendix C and NEB https://www.neb-one.gc.ca/nrg/ntgrtd/pplnprtl/pplnprfls/crdl/nbrdgmnln-eng.html

5.1.1 Regulations require all shippers to share capacity

Oil pipelines are regulated by the US federal government as common carriers. They are not allowed to deny service to any potential qualified customer and must treat customers the same in terms of access to the pipeline (sometimes with adjustments made for committed volumes). Enbridge uses monthly nominations (nominations is the term used in the industry to refer to requests for space on the system), rather than contracting for committed volumes, so Enbridge must treat all existing and new customers the same.

If there is not enough capacity on a route, regulations require Enbridge to reduce the volume of crude shipped for all shippers, to accommodate everyone. "In a given month, if shippers nominate more volume than the pipeline can transport then each shipper's nominated volume is apportioned or reduced by the same percentage."[21] If a system can carry 100,000 barrels per day but shippers nominate a total of 110,000 barrels per day, each shipper's nomination is reduced by 10 percent. This is referred to as apportionment.

The exact impact on a shipper of any given level of apportionment is not straightforward. Apportionment can affect different grades of crude oil differently—heavy crude oil could be in apportionment while light crude oil shippers enjoy plenty of capacity. Pipeline companies, including Enbridge, have reported instances of shippers exaggerating nominations or using other means to increase access to pipeline capacity when little spare capacity is available.[22]

If Line 5 is not in service, shippers who used Line 5 will have to seek service on other pipelines and/or other means of transport, and Enbridge or other pipeline owners will have to accommodate them. The Detroit/Toledo refineries would not get preferential treatment even if they are already shippers on Line 78 or the Mid-Valley pipeline.

5.1.2 How much crude could the Detroit/Toledo refineries get from the pipeline system in the absence of Line 5?

If all the crude oil customers in the Line 5 market area nominate the missing 414,000 barrels per day on Line 78 and the Mid-Valley line, then total nominations would be estimated at 929,000 barrels per day (see Figure 17). This is 15 percent higher than the 810,000 barrel per day combined capacity. Every shipper would have their nominations reduced by 15 percent. The total oil needed by the Detroit/Toledo refineries is estimated at 466,800 barrels per day (as shown in Figure 12 previously); if they face 15 percent apportionment (i.e., reduction of nominations), they will be allocated 398,221 barrels per day.

[21] National Energy Board https://www.neb-one.gc.ca/nrg/ntgrtd/trnsprttn/2014/index-eng.html.

[22] FERC. Enbridge Pipeline {North Dakota) *LLC.* Order Accepting Tariff 140 FERC ~ 61,193 (2012}, and "Notice of Compliant Pursuant to Pact IV of the *National Energy Board Act*" filed with National Energy Board by BP Products North America, Inc. June 6, 2018. <https://apps.neb-one.gc.ca/REGDOCS/Item/View/3578053>

Figure 17. LEI estimate of impact on supplies to Detroit/Toledo refineries if Line 78 capacity is 570,000 barrels per day (barrels per day unless otherwise noted)

Total market supplies to be replaced if no Line 5	413,960
2016 flows on Line 78	275,040
Max flows on Mid-Valley	240,000
Total to be nominated on Mid-Valley and Line 78 if no Line 5	929,000
Line 78 and Mid-Valley capacity	810,000
Amount of nominations above Line 78 and Mid-Valley capacity	119,000
Percent apportionment	15%
Total oil needed by Detroit/Toledo	466,800
Apportioned nominations	398,221
Remaining oil to be replaced	68,579

Note: This analysis assumes that only the supplies formerly shipped on Line 5 would be added to nominations on Mid-Valley and Line 78.

The analysis shown in Figure 17 assumes that capacity to Stockbridge is 570,000 barrels per day on Line 78. As noted above, Enbridge has indicated that Line 78 can be operated at higher pressure, to increase its capacity to 800,000 barrels per day into Stockbridge. If Line 78 can supply 800,000 barrels per day as far as Stockbridge, that amounts to an additional 230,000 barrels per day that would be available to the Detroit/Toledo refineries which interconnect with Line 78 at Stockbridge, as shown in Figure 9 previously. With the additional 230,000 of capacity, the Detroit/Toledo refiners could get all the crude oil they nominate, with no apportionment (see Figure 18).

Figure 18. LEI estimate of impact on supplies to Detroit/Toledo refineries if Line 78 capacity is 800,000 barrels per day (barrels per day unless otherwise noted)

Total market supplies to be replaced if no Line 5	413,960
2016 flows on Line 78	275,040
Max flows on Mid-Valley	240,000
Total to be nominated on Mid-Valley and Line 78 if no Line 5	929,000
Line 78 and Mid-Valley capacity	1,040,000
Amount of nominations above Line 78 and Mid-Valley capacity	(111,000)
Percent apportionment	0%
Total oil needed by Detroit/Toledo	466,800
Apportioned nominations	466,800
Remaining oil to be replaced	0

Note: This analysis assumes that only the supplies formerly shipped on Line 5 would be added to nominations on Mid-Valley and Line 78.

5.2 Rail for delivery of crude oil

The Detroit/Toledo refineries currently appear to receive very little crude oil by rail, so crude oil transloading equipment may not already be present to the extent needed to handle large volumes; but it could probably be installed if needed. Refineries downstream of Sarnia such as Nanticoke, Montreal, and Quebec City, also have access to crude-by-rail.

Railroad transport is usually more expensive than pipelines, but it has some advantages over a pipeline: [23,24]

- it offers more flexible destinations and shorter-term contracts;
- trains can travel faster than oil in a pipeline (the trip from the Bakken region to the US Gulf Coast takes five to seven days by rail, compared to 40 days by pipeline);[25] and
- to transport oil from a new production location, railway companies have historically been able to quickly extend their track and build terminals, while a pipeline usually takes years to plan and construct.

Two Class-1 railroads connect important oil-producing regions to terminals near Michigan-area refineries:[26]

- Canadian National ("CN") has good access to Western Canada and provides a direct route to Detroit and Sarnia (no need to interchange with other railroads). CN has limited access to Bakken crude oil (see Figure 19).

- Canadian Pacific Railroad has good access to Bakken crude oil and direct access to Chicago. It has trackage and haulage rights from Chicago to Detroit (see Figure 20).[27]

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[23] Congressional Research Service. "US Rail Transportation of Crude Oil: Background and Issues for Congress." December 4, 2014.

[24] Philips, M. "Amid U.S. Oil Boom, Railroads Are Beating Pipelines in Crude Transport." *Bloomberg*. June 13, 2013. <http://www.businessweek.com/articles/2013-06-13/amid-u-dot-s-dot-oil-boom-railroads-are-beating-pipelines-in-crude-transport>

[25] Frittelli, J., Parfomak, P. W., Ramseur, J. L., Andrews, A., Pirog, R., & Ratner, M. U.S. Rail Transportation of Crude Oil: Background and Issues for Congress. Congressional Research Service. May 5, 2014. Retrieved October 9, 2014. <http://fas.org/sgp/crs/misc/R43390.pdf >

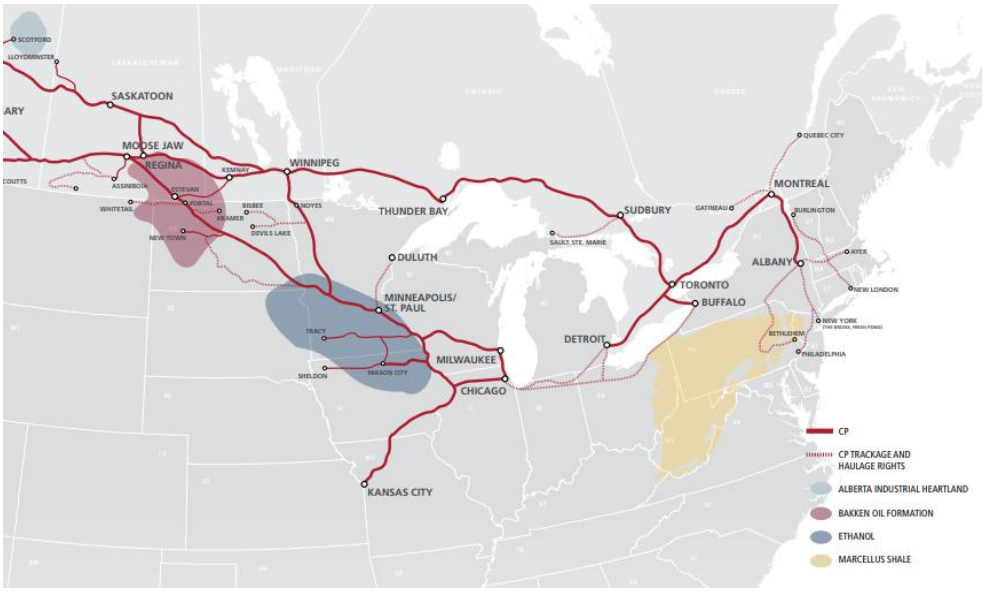
[26] A US Class-1 railroad is defined by the Surface Transportation Board as having annual carrier operating revenues of $250 million or more in 1991 dollars ($433 million or more in 2011 dollars).

[27] Trackage rights are permission for a railroad (the tenant) to run its own trains over the tracks of another railroad (the landlord), using the tenant crews. Haulage rights are similar, but the landlord provides not only the track, but also crews, dispatching services, and sometimes the locomotives. Source: http://trn.trains.com/railroads/abcs-of-railroading/2006/05/trackage-and-haulage-rights; and https://railvoices.org/the-issue/glossary-of-terms/

Figure 19. Canadian National Railway ("CN") system map

Source: https://www.cn.ca/en/our-services/maps-and-network/

Figure 20. Canadian Pacific ("CP") system map

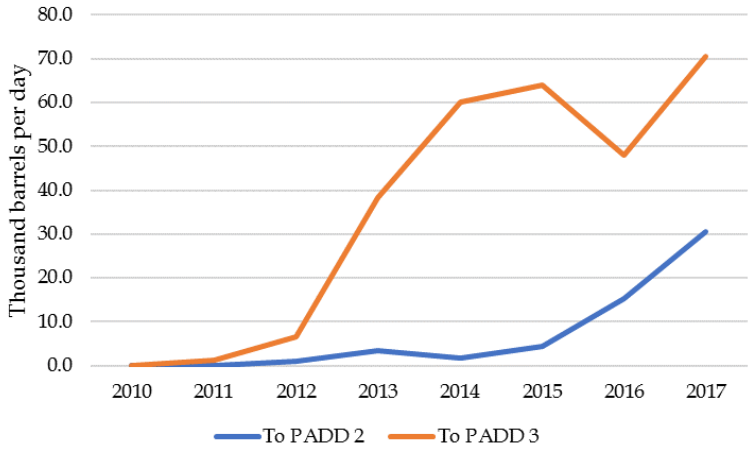


Source: Canadian Pacific Fact Book 2017. https://s21.q4cdn.com/736796105/files/doc_downloads/fact-book/2017/CPR-FactBook-2017-Web.pdf

5.2.1 Crude by rail from Canada

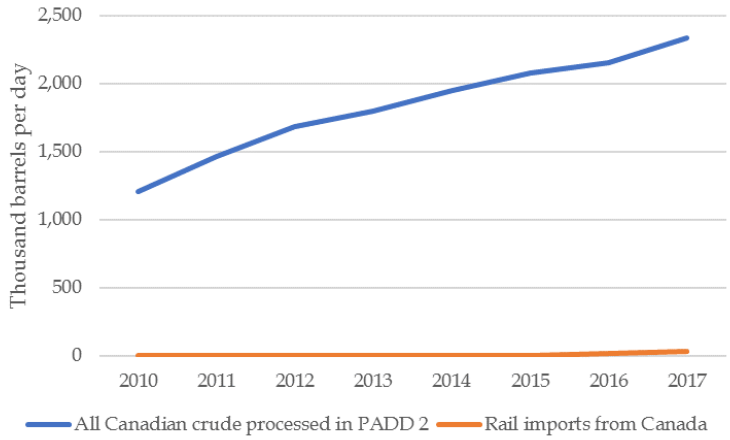
In 2017 about 30,000 barrels per day of crude oil was shipped by rail from Canada to the US Midwest (see Figure 21). But Canadian crude transported by rail to the United States was minuscule compared with total Canadian crude oil exported to the United States (see Figure 22).

Figure 21. Crude oil receipts by rail from Canada



Source: EIA. From Canada to Petroleum Administration for Defense District ("PADD") 2 (the Midwest United States) and PADD 3 (US Gulf Coast) Movements by Rail. http://www.eia.gov/dnav/pet/pet_move_railna_dc_r20-nca_mbbl_a.htm

Figure 22. Canadian crude processed in the Midwest and crude-by-rail imports from Canada

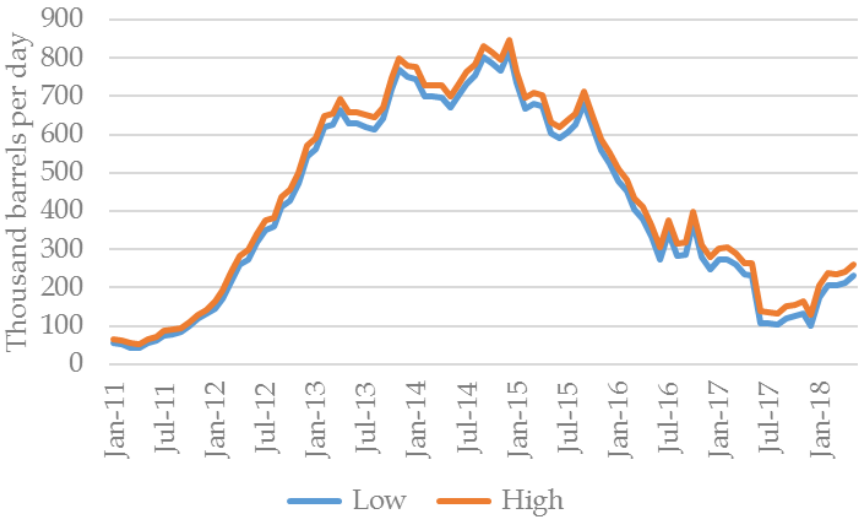


Source: EIA. Midwest (PADD 2) Imports from Canada and Midwest (PADD 2) Rail imports from Canada http://www.eia.gov/dnav/pet/pet_move_railna_dc_r20-nca_mbbl_a.htm

5.2.2 Crude by rail from North Dakota

The small volume of crude shipped by rail from Canada to Petroleum Administration for Defense District 2 ("PADD 2", the United States Midwest) was less than crude-by-rail volumes transported within PADD 2, from the Bakken region of North Dakota to various market hubs. North Dakota reported about 250,000 barrels per day of crude shipped by rail in May 2018 (to all locations, not only to PADD 2).[28] This is a recovery from the recent low of about 100,000 barrels per day in late 2017 when the combination of low oil prices (which reduced oil production) and the start-up of the Dakota Access Pipeline reduced demand for shipping by rail.

Figure 23. Estimates of crude by rail from North Dakota



Source: North Dakota Pipeline Authority. https://northdakotapipelines.com/rail-transportation/ Accessed August 2018

5.2.3 Implied numbers of trains for crude oil shipments to replace Line 5

If about 250,000 barrels per day of the 414,000 barrels per day from Line 5 is met by Line 78, this leaves 154,000 barrels per day which must be met by other means (assuming Line 78 is operating at 570,000 barrels per day). If this is all met by crude shipments by rail, it would amount to three unit-trains (100-car trains) per day in each direction, or 1,095 trains per year in each direction (see Figure 24).

[28] North Dakota Pipeline Authority. https://northdakotapipelines.com/rail-transportation/

Figure 24. Rail transport needed to replace Line 5 crude oil shipments, assuming Line 78 operated at 570,000 barrels per day

Barrels per day	164,000
Barrels per rail car	660
Railcars cars per day	248
Unit trains per day arriving	3
Unit trains per day departing	3
Unit trains per year arriving	1,095
Unit trains per year departing	1,095

6 The cost to refiners of alternatives to Enbridge Line 5

LEI examined the cost of alternative transportation routes for Detroit/Toledo refineries to access crude oil supplies. LEI first analyzed publicly-available data for components of the cost of alternative supplies and routes for crude oil. Then, LEI used this information to calculate the cost of several alternative supply routes for Detroit/Toledo and Sarnia refineries. LEI examined seven route options from supply regions to the refineries (see Figure 25).

Figure 25. Alternative routes examined by LEI

Option	Status quo: Enbridge Line 5 Edmonton to Sarnia	Option 1: Enbridge Line 78	Option 2: Michigan crude oil by truck	Option 3: Rail from Bakken to Detroit	Option 4: Truck from Superior to Detroit (southern route)	Option 5: Pipeline and truck from Bakken	Option 6: Rail Superior to Sarnia (southern route)
Crude oil supply region	Edmonton	Edmonton	Michigan	North Dakota	Edmonton	North Dakota	Edmonton
Mode of transportation	Pipeline: Enbridge Mainline	Pipeline: Enbridge Mainline	Truck	Rail: Canadian Pacific	Enbridge Mainline and Line 6 to Griffith	Pipeline: DAPL	Pipeline: Enbridge Mainline
Terminal	Superior	Superior			Griffith	Patoka	Superior
Mode of transportation	Pipeline: Enbridge Line 5	Pipeline: Enbridge Line 78 + increase in tariff			Truck	Truck	Rail: Canadian Northern
Destination	**Sarnia**	**Sarnia**	**Detroit**	**Detroit**	**Detroit**	**Toledo**	**Sarnia**

LEI's results, discussed in detail in this section, showed that at least three other options for shipping large volumes of oil are less expensive than Option 6 (rail from Superior to Sarnia), the one alternative which was examined by Dynamic Risk.[29] Dynamic Risk estimated the cost of rail from Superior to Sarnia at $6.69 per barrel; LEI found options which are less expensive.

6.1 Components of the cost of alternative sources of crude oil

LEI examined public data sources to collect information on the key determinants of the cost of crude oil to refineries served by Line 5 and related pipelines.

6.1.1 Crude oil prices in supply regions

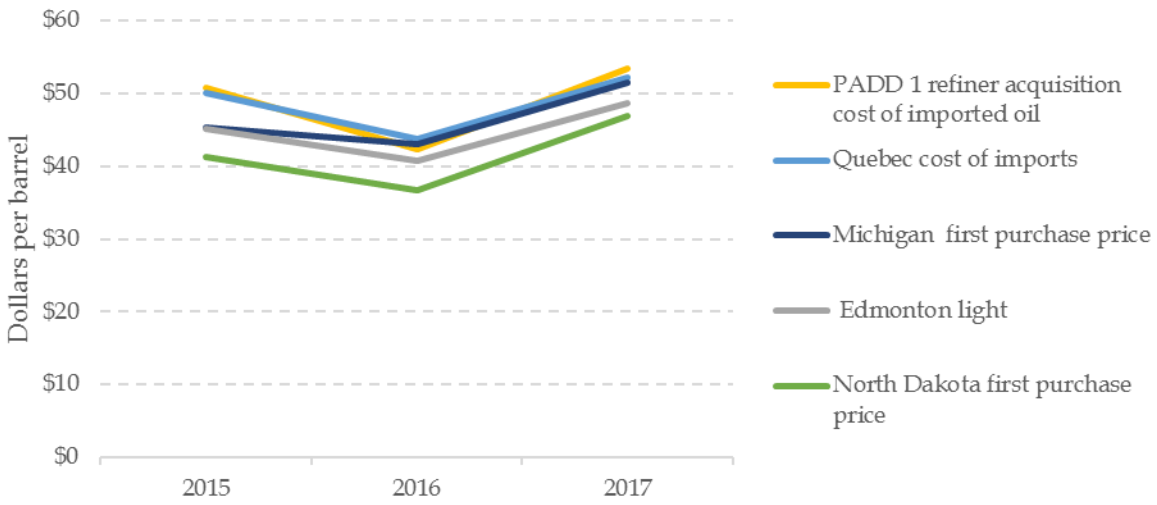
The cost of oil to a refinery is the total of the cost of crude oil at a supply location plus the cost to transport the oil to the refinery. The refineries in the Line 5 market area can access crude oil from several locations. The Enbridge system gives access to Edmonton crude oil; the Mid-Valley pipeline provides access to Bakken crude oil and other crudes which reach the US Midwest. The Michigan area has rail connections to the Bakken and Western Canada. A little-used pipeline, the Montreal/Portland line, connects the Montreal refinery to imports from Portland, Maine in

[29] Dynamic Risk. "Final Report: Alternatives Analysis for the Straits Pipelines." P. 7-12. Prepared for the State of Michigan. October 26, 2017.

PADD 1 (the Northeast United States). From Montreal, Valero transports crude oil by tanker ship to its Quebec City refinery.

Each of these locations typically has somewhat different prices for crude oil (see Figure 26). Bakken crude oil from North Dakota generally has sold at a discount to Edmonton light oil; imported oil in PADD 1 and in Quebec has typically sold at a premium to Edmonton light oil.

Figure 26. Crude oil prices at supply locations (US dollars per barrel)



Sources: EIA. Refiner Acquisition Cost of Imported Crude Oil http://www.eia.gov/dnav/pet/pet_pri_rac2_a_epc0_pft_dpbbl_m.htm; EIA. North Dakota and Michigan Crude Oil First Purchase Price http://tonto.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=F002038__3&f=M; Alberta Energy Regulator, https://www2.aer.ca/t/Production/views/CommodityPricesprices?tvwidgetsymbol=NYMEX%3ACL1!%2BNYMEX%3AICL1!#monthlyOil; and Canadian International Merchandise Trade Database. "Table 990-0027 27. Imports - Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes." Accessed July 2018.

6.1.2 Transportation cost data

Pipeline tariffs for crude oil transport are publicly available. Rail costs have many elements which are not publicly available and are not simple to estimate, but some cost information is available in the public domain. This section covers key elements of pipeline and rail costs for crude oil.

6.1.2.1 Costs by pipeline

Oil contracted for delivery via a pipeline usually pays for transportation costs at a published tariff for a specific route, with a receipt point near where the oil is produced, to a delivery point such as a refinery or terminal. Tariffs for the routes of interest are publicly-available (see Figure 27).

Figure 27. Tariffs for light oil transportation

Pipeline	Receipt	Delivery	Rate (US$/barrel)
Enbridge Mainline	Edmonton	Superior	$3.04
Enbridge Line 5	Superior	Sarnia	$1.56
Enbridge Line 6 or 14 (64)	Superior	Griffith/Hartsdale	$0.99
Enbridge Line 6B (78)	Flanagan	Stockbridge	$0.37
Enbridge Line 9	Sarnia	Montreal	$1.61
Portland-Montreal	Portland, ME	Montreal	$0.67
Dakota Access Pipeline	Bakken region	Patoka	$6.28
Marathon	Patoka	Lima	$1.48
Mid-Valley	Lima	Toledo	$0.17

Sources: FERC. "Enbridge Pipelines Inc. International Joint Rate Tariff No. 45.15.1." Effective July 1, 2018; Enbridge Lines 5, 6, and 78: FERC. "Enbridge Energy, Limited Partnership FERC ICA Oil Tariff No. 43.25.0." Effective July 1, 2018; Enbridge Line 9: National Energy Board. "Enbridge Pipelines Inc. Tolls applying on crude petroleum transported in line 9 operating in a west to east direction. NEB Tariff No. 434." Effective July 1, 2018; Portland-Montreal: FERC. "Portland Pipeline Corporation Local Tariff No. 70.15.0." Effective April 1, 2018; and National Energy Board. "Montreal Pipeline Limited NEB Tariff No. 184." Dakota Access Pipeline: FERC. "Dakota Access, LLC - Local Pipeline Tariff No. 2.2.0." Effective July 1, 2018; Marathon: FERC. "Marathon Pipe Line LLC - Tariff No. 321.10.1. " Effective July 1, 2017; Mid-Valley: FERC. "Mid-Valley Pipeline Company - Local and Local Proportional Pipeline Tariff No. 483.2.0." Effective July 1, 2012.

6.1.2.2 Elements of rail costs

Railroads offer tariffs in the form of "walk-up" rates which apply to the equivalent of a last-minute transaction. Many shippers do not pay walk-up rates. Instead, they pay discounted rates by providing their own equipment such as tanker cars, and/or committing to shipping large or fixed volumes. In 2015, the average freight revenue in the United States for Class I rail was $0.0395 per ton-mile, equivalent to $0.00593 per barrel-mile of crude oil.[30] Freight rates specific to crude oil are not publicly available.

The cost to lease railcars is another important cost component. For light crude oil,[31] this cost was about $500 per car per month in 2016, down from about $2,000 per car per month in 2014 (see Figure 28). As of February 2017, it was reported that lease rates fell further, to $399 to $375 per

[30] United States Department of Transportation. "Average Freight Revenue per Ton-Mile." Accessed on July 2018. <https://www.bts.gov/content/average-freight-revenue-ton-mile>

[31] RBN Energy. "You've Got Another Thing Comin' - Anticipated Turbulence in the Tank Car Market." November 5, 2013. https://rbnenergy.com/you-ve-got-another-thing-comin-anticipated-turbulence-in-the-tank-car-market

month.[32] Lease rates are usually fixed under a leasing agreement for a specific period, which can vary from 2 years to 20 years, depending on the type of lease.[33]

Figure 28. Crude railcar lease rates, 2013 to 2015

Source: Genscape. "Tank-Car Lease Rates Plummet on Weak Crude-By-Rail Demand, Low Crude Prices." November 11, 2015. <https://www.genscape.com/blog/tank-car-lease-rates-plummet-weak-crude-rail-demand-low-crude-prices>
Note: "30k" refers to 30,000 gallons, or about 715 barrels; "31.8k" refers to 31,800 gallons, or about 750 barrels; "29k" refers to 29,000 gallons, or about 690 barrels.

6.2 Assumptions LEI used calculating costs of alternatives

Based on the public information above and using the same assumptions as Dynamic Risk for information that was not in the public domain, LEI developed the assumptions needed to calculate the cost of the alternative rail and truck routes (see Figure 29 and Figure 30).

[32] Hull, Bradley. *Status of Infrastructure Related to Crude Oil Transportation in the Great Lakes/St. Lawrence River Region* Prepared for the Great Lakes Commission by Dr. Bradley Hull III, John Carroll University. May 31, 2017. P. 26. https://www.glc.org/wp-content/uploads/Oil-Transp-Infrastructure-Hull-May2017-FinalReport.

[33] Market Insider. Global Railcar Leasing Market 2017-2021. Press Release PR Newswire. September 2017. <http://markets.businessinsider.com/news/stocks/global-railcar-leasing-market-2017-2021-1002359341>

Figure 29. LEI assumptions for cost calculations, rail

Assumption			Units	
Volume of light crude oil per rail car		660	barrel	
Terminal time (loading + unloading)		24	hours (12 hours on each end))	
Railcar lease cost	$	750	monthly, per car	
Freight charge	$	0.186	per barrel per mile (accounts for 25% discount for unit trains)	
Transload cost (loading + unloading)	$	3.00	$/bbl	
Tankage receipt toll	$	0.0232	$/bbl	
Routes		**Distance (miles)**	**Transit time (hours)**	**Cycle time (hours)**
Superior to Sarnia (southern)		800	36	96
Superior to Detroit (southern)		749	34	92
Bakken to Sarnia		1300	59	141

Sources: Terminal time, transloading cost, tankage receipt toll, Dynamic Risk. "Final Report: Alternatives Analysis for the Straits Pipelines." Appendix J, P. J-2. Prepared for the State of Michigan. October 26, 2017. All other, LEI (based on public information)

Figure 30. LEI assumptions for cost calculations, trucking

Assumption			Units	
Volume of light crude per tractor trailer		248	barrels	
Terminal time (loading + unloading)		2	hours (1 on each end)	
Operating hours per day		24	hour/day	
Working hours per year		2,000	hours	
Truck fuel mileage		7.90	mpg	
Driver wage	$	32.51	$/hr	
Diesel fuel cost	$	2.90	$/gal	
Insurance/License/fees/permits	$	0.09	$/mile	
Truck/trailer repairs	$	0.16	$/mile	
Truck/trailer tires	$	0.04	$/mile	
Incremental overhead		0.45	man years	
Cost of overhead		80,000	$/annum	
Fixed cost recovery	$	0.20	$/barrel	
Routes		**Distance (miles)**	**Transit time (hours)**	**Cycle time (hours)**
Superior to Sarnia (southern)		770	15	35
Griffith to Detroit		259	5	14
Patoka to Toledo		413	8.26	21

Sources: Driver wage, diesel fuel price, distances, LEI (based on public information); all others, Dynamic Risk. "Final Report: Alternatives Analysis for the Straits Pipelines." Appendix J, P. J-4. Prepared for the State of Michigan. October 26, 2017

6.3 Results: Cost of alternatives for Detroit/Toledo and Sarnia refineries

LEI used the annual average 2015/17 supply area prices for Edmonton light crude oil, Bakken light crude oil (North Dakota first-purchase price), and the Michigan first-purchase price (see Figure 31). Based on these supply-region prices and the cost assumptions above, LEI found:

- Status quo (ship on Line 5): This is the cheapest source for large supplies of crude to Sarnia, at a total cost of $49.48 per barrel based on 2015/17 average crude oil prices. It is not available if Line 5 is not in service. LEI included it in the analysis so that the other costs could be compared to it.

- Option 1 (ship on Line 78 (6B)): LEI assumed that the cost to ship on Line 78 would increase to cover the estimated $0.40 per barrel costs which Enbridge would be allowed to recover from shippers if Line 5 were shut down.[34] It is the next-cheapest pipeline option if Line 5 is not operating. Shippers could ship at least a portion of their needs on this route if Line 78 is operated at 570,000 barrels per day. If Line 78 is operated at 800,000 barrels per day, the Detroit/Toledo refiners could meet all their crude oil needs using this option. They would not need Options 2-6.

- Option 2 (truck Michigan crude oil to Detroit): Crude oil producers in Michigan would truck crude to the nearest refinery, for a total delivered cost of $49.45 per barrel based on 2015/17 crude oil prices (and the maximum trucking distance, from the northern regions of the Lower Peninsula). It is no co-incidence that this cost is within pennies of the cost of the status quo. The Michigan crude oil producers are currently competing with pipeline supplies, so cannot charge much more than the total cost of pipeline crude; and if their own costs are currently lower than the status quo cost for pipeline oil, they can charge more and recover more than their total costs.

- Option 3 (ship by rail from the Bakken region): This is the next least-expensive option on a delivered cost basis. Bakken crude oil is cheaper than Edmonton light, which makes it economic to pay the rail cost to deliver it to Detroit. It would make economic sense for Detroit/Toledo refiners to ship any incremental oil they need above their apportioned deliveries on Line 78 plus trucked Michigan crude oil using this supply source and route.

- Option 4 (Enbridge mainline to Griffith and trucking from Griffith to Detroit): This would avoid the apportionment on Line 78, but it is more expensive than Option 4.

- Option 5 (ship by pipeline and truck from Bakken region): Another option based on the Bakken supply region would be to ship by DAPL to Patoka, IL, then truck from Patoka to Toledo. This would be more expensive than the rail route from Bakken.

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[34] Dynamic Risk. "Final Report: Alternatives Analysis for the Straits Pipelines." Prepared for the State of Michigan. October 26, 2017 P. 4-19 - 4-20. The $0.40 accounts for the increased cost to shippers when flows on a pipeline system such as the Enbridge Mainline (of which Line 5 is a component) decline dramatically, as they might if Line 5 were shut down. The fixed costs a pipeline company can recoup from customers is typically allowed to be spread over a smaller number of shipments. This increases the cost per barrel of oil shipped. Also, costs to abandon Line 5 would be added to the rate base. LEI assumed the additional $0.40 would apply to tariffs for oil shipments regardless of grade.

- Option 6 (pipeline to Superior and rail from Superior to Sarnia). This was the most expensive option LEI examined. It was the only non-pipeline option examined by Dynamic Risk for transporting large quantities of crude oil.[35] But of all the options examined by LEI, it is the least likely to be used by any of the refiners, because there are at least three other options for shipping large volumes (Options 3, 4, and 5) that are cheaper.

Figure 31. LEI's average annual cost of crude transportation ($ per barrel) for Detroit/Toledo and Sarnia refineries

Option	Status quo: Enbridge Line 5 Edmonton to Sarnia	Option 1: Enbridge Line 78	Option 2: Michigan crude oil by truck	Option 3: Rail from Bakken to Detroit	Option 4: Truck from Superior to Detroit (southern route)	Option 5: Pipeline and truck from Bakken	Option 6: Rail Superior to Sarnia (southern route)
Supply region, crude type	Edmonton light	Edmonton light	Michigan first purchase price	North Dakota first purchase price	Edmonton light	North Dakota first purchase price	Edmonton light
Crude price at supply area ($/bbl) (2015-2017 average)	$44.88	$44.88	$46.65	$41.62	$44.88	$41.62	$44.88
Mode of transportation	Pipeline: Enbridge Mainline	Pipeline: Enbridge Mainline	Truck to Detroit	Rail: Canadian Pacific	Enbridge Mainline and Line 6 to Griffith	Pipeline: DAPL	Pipeline: Enbridge Mainline
Cost of transportation ($ per barrel)	$3.04	$3.04	$2.80	$8.77	$4.03	$6.28	$3.04
Receipt point	Superior	Superior			Griffith	Patoka	Superior
Mode of transportation	Pipeline: Enbridge Line 5	Pipeline: Enbridge Line 78 + increase in tariff			Truck	Truck	Rail: Canadian Northern
Cost of transportation ($ per barrel)	$1.56	$1.96			$3.48	$5.10	$6.73
Destination	**Sarnia**	**Sarnia**	**Detroit**	**Detroit**	**Detroit**	**Toledo**	**Sarnia**
Total cost ($ per barrel)	$49.48	$49.88	$49.45	$50.38	$52.39	$53.00	$54.65
Difference compared to Option One		**$0.40**	**-$0.03**	**$0.90**	**$2.91**	**$3.52**	**$5.17**

The key take-away is that there are combinations of supply region and transport options that shippers could choose. If Enbridge operates Line 78 at 800,000 barrels per day, Detroit/Toledo refiners would have little reason to use Options 2-6 at all. Options 2-5 are all more expensive than Line 5, but none of them is as expensive as the one route (Option 6) which Dynamic Risk chose to analyze and on which Dynamic Risk's conclusions were based.

6.4 An alternative for Montreal delivery

In the past, the Montreal/Portland pipeline delivered large quantities of imported crude oil from Portland, Maine to Montreal, until Enbridge reversed flows on Line 9 to deliver Western

[35] Dynamic Risk. "Final Report: Alternatives Analysis for the Straits Pipelines." Prepared for the State of Michigan. October 26, 2017 Pp. 7-1 – 7-13.

Canadian crude to Montreal. With the reversal of Line 9 deliveries from Maine to Montreal slowed to a trickle, leaving the Montreal/Portland line (with a capacity of about 250,000 barrels per day) with plenty of spare capacity.[36] However, shippers wishing to ship large volumes from Maine to Montreal in the future may encounter regulatory or legislative roadblocks. For example, Maine has legislated against the loading of crude oil for export from Line 9.[37] Therefore LEI has not presented a detail economic analysis of the Montreal/Portland pipeline option.

6.5 Impact on Detroit/Toledo refiners

With Line 5 out of service, all crude oil customers would turn to the next-least expensive source of supply. This would increase demand for Line 78 and the Mid-Valley line as discussed above. Even if Line 78 is operated at 570,000 barrels per day into Stockbridge, Detroit/Toledo refiners would be able to get a significant portion of their crude oil from the two pipelines (a total of 398,221 barrels per day), which is 15 percent lower than their maximum requirement of 466,800 barrels per day (see Figure 17 previously). They would make up the difference with trucked crude oil from Michigan and Bakken oil delivered by rail

- **Pipeline supplies**: The 398,221 barrels per day would be split between light crude oil and heavy crude oil, from a combination of Line 78 and the Mid-Valley pipeline (see Figure 32). The tariff on Line 78 for light oil would be an assumed $4.94 per barrel ($0.40 per barrel more than the current tariff). The tariff for heavy oil would be an estimated $5.79 per barrel (also $0.40 per barrel more than the current tariff).

- **Trucked supplies:** If Line 5 is operated at 570,000 barrels per day, the refiners would presumably take all the (light) crude oil produced in Michigan (about 15,000 barrels per day), which would be trucked in at an estimated cost of $2.80 per barrel.[38] This price represents the cost to truck crude oil from the Northern region of the Lower Peninsula; trucking costs would be lower for oil from the Central and Southern regions. LEI assumes that refiners rather than crude producers will ultimately pay the trucking cost, because the total cost of Michigan-produced crude oil at the refinery, including the trucking cost ($46.65 + $2.80 = $49.45), is lower than the refiner's next-lowest-cost alternative (crude by rail from North Dakota, at $41.62 + $8.77 = $50.38).

- **Rail supplies**: If Line 78 is operated at 570,000 barrels per day, the refiners would be expected to make up the remaining 53,579 barrels per day using light oil from the Bakken by rail because it is the next-cheapest option.

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[36]NEB. https://www.neb-one.gc.ca/nrg/ntgrtd/trnsprttn/2016/grp2cmpns/lndlqds/mntrl-pp-ln-lmtd-mntrl-pp-ln-eng.html

[37] The large-scale expansion of shipments on the Montreal/Portland line is not favored by NWF.

[38] London Economics International. "Michigan crude oil production: Alternatives to Enbridge Line 5 for transportation." Confidential draft prepared for National Wildlife Federation. August 23, 2018.

On a weighted average basis, this would increase the cost of crude oil to the Detroit/Toledo refiners by an estimated $0.45 per barrel (see Figure 32). This is substantially lower than the $1.362 per barrel result from Dynamic Risk's analysis.[39]

Figure 32. Cost impact on Detroit/Toledo refiners, assuming Line 78 operated at 570,000 barrels per day

	With Enbridge Line 5	Without Enbridge Line 5
Pipeline supplies (barrels per day)	**466,800**	**398,221**
of which:		
Light oil supplies (barrels per day)	231,800	163,221
Edmonton Light price per barrel (2015/17 average)	$ 44.88	$ 44.88
Pipeline tariff per barrel, light, Edmonton to Stockbridge	$ 4.54	$ 4.94
Heavy oil supplies (barrels per day)	235,000	235,000
Canadian heavy blend (WCS) supply area price (2015/17 average)	$ 34.63	$ 34.63
Pipeline tariff per barrel, heavy, Edmonton to Stockbridge	$ 5.39	$ 5.79
Non-pipeline supplies (barrels per day)		**68,579**
of which:		
Trucked crude oil (barrels per day)		15,000
Michigan first purchase price per barrel (2015/17 average)		$ 46.65
Cost per barrel to truck to market		$ 2.80
Rail from Bakken (barrels per day)		53,579
North Dakota first purchase price per barrel (2015/17 average)		$ 41.62
Cost for Canadian Pacific Bakken to Detroit		$ 8.77
Weighted average cost of crude oil (dollars per barrel)	**$ 44.69**	**$ 45.14**
Difference (dollars per barrel)		$ 0.45

If Enbridge operated Line 78 at 800,000 barrels per day, the Detroit/Toledo refineries would not need trucked crude oil or crude by rail. They could receive all their crude oil by pipeline, for a tariff increase of an assumed $0.40 per barrel (see Figure 33). As discussed previously, part of the $0.40 increase would be the result of the loss of shipments on the Enbridge Mainline if Line 5 were shut down. However, if a portion of those shipments were carried by the Line 78 expansion, the increase in tariffs would be less than $0.40.

[39]. Dynamic Risk. "Final Report: Alternatives Analysis for the Straits Pipelines." Prepared for the State of Michigan. October 26, 2017. P. 7-13.

Figure 33. Cost impact on Detroit/Toledo refiners, assuming Line 78 operated at 800,000 barrels per day

		With Enbridge Line 5		Without Enbridge Line 5
Pipeline supplies (barrels per day)		**466,800**		**466,800**
of which:				
Light oil supplies (barrels per day)		231,800		231,800
Edmonton Light price per barrel (2015/17 average)	$	44.88	$	44.88
Pipeline tariff per barrel, light, Edmonton to Stockbridge	$	4.54	$	4.94
Heavy oil supplies (barrels per day)		235,000		235,000
Canadian heavy blend (WCS) supply area price (2015/17 average)	$	34.63	$	34.63
Pipeline tariff per barrel, heavy, Edmonton to Stockbridge	$	5.39	$	5.79
Weighted average cost of crude oil (dollars per barrel)	**$**	**44.69**	**$**	**45.09**
Difference (dollars per barrel)			$	0.40

Michigan crude oil producers would be competing with inexpensive pipeline supplies and would not be able to pass their increased transportation costs on to the refiners. Michigan producers would have to match the total cost of pipeline crude oil to the refinery. For the purposes of the analysis we assume the cost to refiners (Michigan crude oil price plus transportation) is the same as for light crude by pipeline.

In summary, LEI's analysis shows that the impact on Detroit/Toledo refiners could be as much as $0.45 per barrel on the high end, if they need to rely on rail deliveries, or as low as $0.40 per barrel (or even lower) on the low end. In the next section LEI examines the impact of those cost increases on consumers.

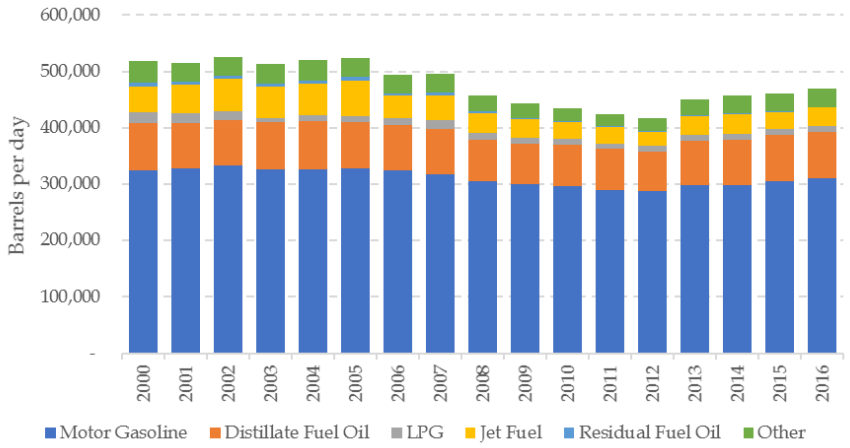
7 Impact on Michigan consumers of refined products

LEI's analysis focused on the impact on gasoline prices. Changes to gasoline prices will impact Michigan consumers more than changes to other refined product prices because: i) gasoline is the most widely-consumed refined product in Michigan, and ii) consumers use gasoline directly.

7.1 Gasoline is the most widely-consumed refined product in Michigan

Michiganders consumed over 400,000 barrels per day of petroleum products including gasoline, distillate (including diesel fuel), and other products in 2016 (see Figure 34). Gasoline is by far the most widely-consumed refined product in Michigan.

Figure 34. Consumption of petroleum products in Michigan, 2016



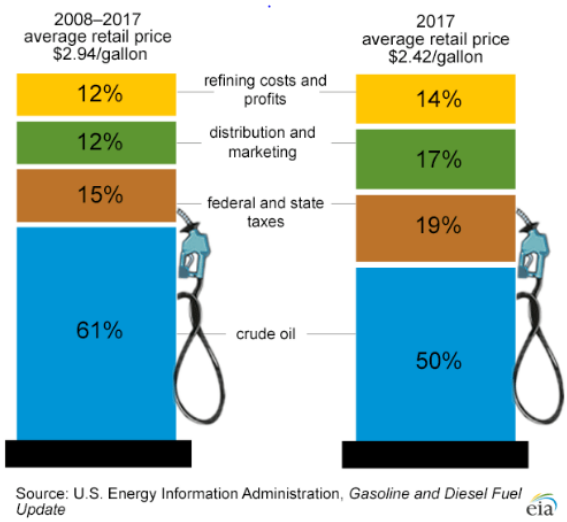
Source: EIA, State Energy Data System https://www.eia.gov/state/seds/archive/seds2016.pdf

Consumers use gasoline directly, while most other refined products find their way into other goods and services Michiganders buy. For instance, distillate is used mostly as on-road diesel to fuel tractor-trailer hauling, and jet fuel supports air travel. Higher costs for these fuels could impact consumers, but the impacts would be indirect. The impact on consumers is more direct for changes in gasoline prices than for most other refined products.

7.2 Cost components of retail gasoline prices

The cost of crude oil is the largest portion of the average retail price of a gallon of gasoline. EIA estimates this share at 61 percent for the past ten years from 2008-2017 (see Figure 35).

Figure 35. Share of crude oil cost and other costs in gasoline retail prices



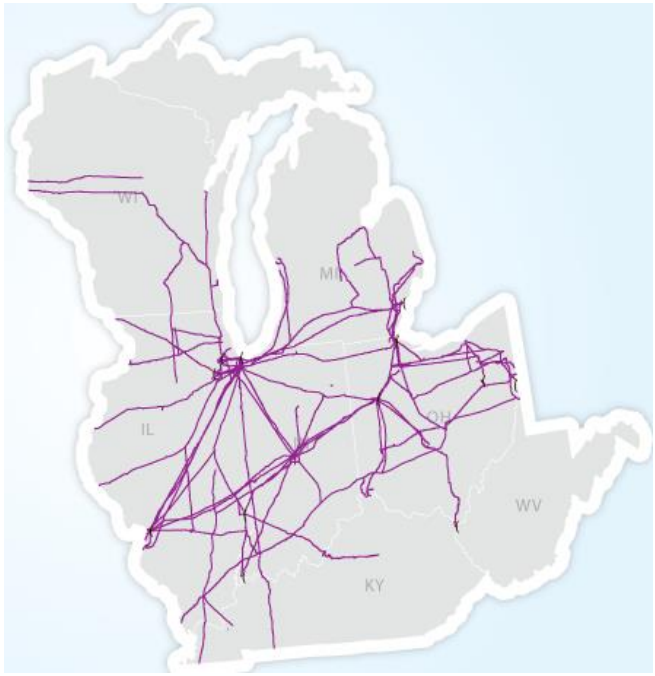
Source: EIA. https://www.eia.gov/energyexplained/index.php?page=gasoline_factors_affecting_prices

Based on EIA's ten-year estimate, the $0.45 increase per barrel would increase the cost of retail gasoline by $0.27 per barrel ($0.45 * 61 percent share of crude oil cost = $0.27 per barrel). The $0.27 per barrel is equivalent to 0.65 cents per gallon (under one cent per gallon), assuming refiners can pass along the entire $0.45 per barrel cost increase to consumers. An increase of $0.40 per barrel for crude oil costs would result in an increase of 0.58 cents per gallon, assuming refiners can pass along the entire cost increase.

7.3 Refined product supply in Michigan is not a monopoly

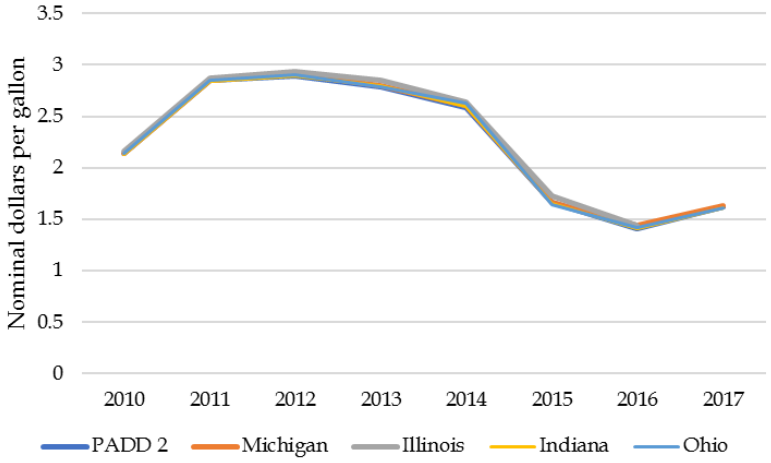
The Detroit/Toledo refineries may only be able to pass part of their increased costs. This is because they face competition from other refineries, which are connected by a dense system of product pipelines to the Michigan area (see Figure 36). This system of product pipelines provides flexibility to meet changes in demand or supply. Refiners with access to this system can respond quickly to price signals, to ship gasoline, diesel, or other products in response to changes in prices. If refineries in Detroit/Toledo raise their prices, then refiners in other states will see this increase and seek out those higher prices. This is demonstrated by data for prices within PADD 2 (see Figure 37): because the PADD 2 market is so well-integrated by product pipelines and crude oil pipelines, there is very little difference in wholesale gasoline prices across states.

Figure 36. Refined product pipelines in the Michigan area



Source: http://www.pipeline101.org/where-are-pipelines-located

Figure 37. Wholesale gasoline prices within PADD 2



Source: EIA. Midwest (PADD 2) Total Gasoline Wholesale/Resale Price by Refiners source http://tonto.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=EMA_EPM0_PWG_R20_DPG&f=A

8 Conclusions and implications

LEI estimated the increase in cost to refiners in Detroit/Toledo to be $0.45 per barrel on the high end (assuming Line 78 operates at 570,000 barrels per day). This would amount to a rise of less than one cent (0.65 cents) to gasoline prices even assuming the refiners could pass along the whole cost increase. On the low end (assuming Line 78 operates at 800,000 barrels per day) the impact on Detroit/Toledo refiners would be $0.40 per barrel; and the impact on gasoline prices would be about a half of one cent (0.58 cents) if the refiners could pass along the whole cost increase. And refiners may indeed only be able to charge to customers a portion of that increase.

This impact on gasoline price is lower than the 3.8 cents per gallon price impact found by Dynamic Risk.[40] Dynamic Risk assumed the refineries would adopt a supply option (LEI's Option 6) which is not the lowest-cost option based on LEI's analysis.

8.1 Refined product prices in Michigan reflect volatile global crude oil prices

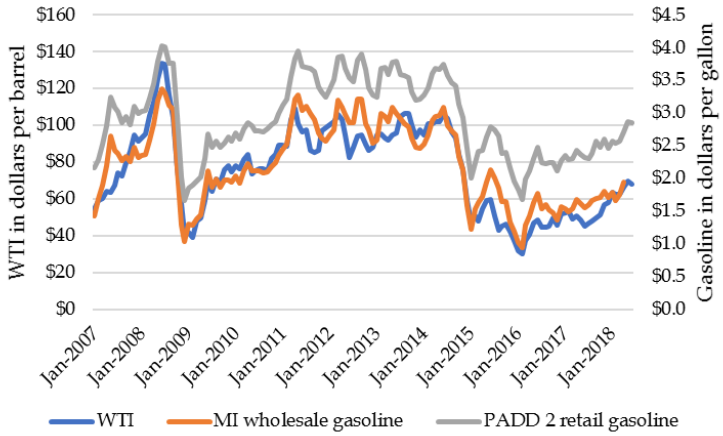
The cost of crude oil and refined products like gasoline in a local market, such as in Michigan, reflects not only local supply and demand for gasoline, and local refinery costs, but also depends on global supply and demand for crude oil. This is because, compared to its value, crude oil is cheap and easy to transport globally by ships. This global economic competitiveness is evident in the very high share of global trade in crude oil compared to oil consumption. In 2016, global trade in crude oil reached 42.4 million barrels per day, 44 percent of total global consumption of crude oil.[41] Because the oil market is integrated globally, events that impact supply or demand in one part of the world impact crude oil prices all over the world.

This can be seen clearly in the trend in global oil prices compared with local gasoline prices. The wholesale price of gasoline in Michigan tracks the global benchmark West Texas Intermediate ("WTI") crude oil price closely (see Figure 38). Other factors matter to the price of refined products, but the most important one is the global price of crude oil. Retail gasoline prices also track global crude oil prices closely but are higher than wholesale prices. Retail prices include state-level sales taxes and other components as shown in Figure 35 above.

[40] Dynamic Risk. "Final Report: Alternatives Analysis for the Straits Pipelines." Prepared for the State of Michigan. October 26, 2017. P. 7-13.

[41] BP Statistical Review of World Energy, 2017. <http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/oil/oil-trade-movements.html>

Figure 38. WTI crude oil prices and gasoline prices



Source: EIA. Cushing, OK WTI Spot Price FOB http://tonto.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RWTC&f=M, Michigan Total Gasoline Wholesale/Resale Price by Refiners http://www.eia.gov/dnav/pet/pet_pri_refmg_dcu_smi_m.htm, and Midwest (PADD 2) Gasoline and Diesel Retail Prices http://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_r20_m.htm

8.2 A less-than-one-cent increase would be lost in the noise of typical gasoline price volatility

Weekly retail gasoline prices in PADD 2 during 2015/17 were as low as $1.60 per gallon and as high as $2.87 per gallon (see Figure 39). A price increase of less than one cent would be insignificant relative to the price volatility of Midwest retail gasoline prices.

Figure 39. Maximum and minimum weekly retail gasoline price in PADD 2

Source: EIA. Weekly Midwest All Grades All Formulations Retail Gasoline Prices. http://www.eia.gov/oil_gas/petroleum/data_publications/wrgp/mogas_history.html