Analysis of Propane Supply Alternatives for Michigan

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PSC

PUBLIC SECTOR CONSULTANTS

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Key Terms

Definitions of report key terms are provided by the U.S. Energy Information Administration online glossary tool (U.S. EIA n.d.b). Having accessible knowledge of industry terminology will support understanding of the propane life cycle as it relates to production, supply, and transportation.

Barrels: A unit of volume equal to 42 U.S. gallons.

Bulk terminal: A facility used primarily for the storage and/or marketing of petroleum products, which has a total bulk storage capacity of 50,000 barrels or more and/or receives petroleum products by tanker, barge, or pipeline.

Crude oil: A mixture of hydrocarbons that exists in liquid phase in natural underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities.

Dry natural gas: Natural gas which remains after: 1) the liquefiable hydrocarbon portion has been removed from the gas stream (i.e., gas after lease, field, and/or plant separation); and 2) any volumes of nonhydrocarbon gases have been removed where they occur in sufficient quantity to render the gas unmarketable. Note: Dry natural gas is also known as consumer-grade natural gas.

Fractionation: The process by which saturated hydrocarbons are removed from natural gas and separated into distinct products, or 'fractions,' such as propane, butane, and ethane.

Hydrocarbon gas liquids (HGL): A group of hydrocarbons including ethane, propane, normal butane, isobutane, and natural gasoline, and their associated olefins, including ethylene, propylene, butylene, and isobutylene. As marketed products, HGL represents all-natural gas liquids . . . and olefins. EIA reports production of HGL from refineries (liquefied refinery gas, or LRG) and natural gas plants (natural gas plant liquids, or NGPL). Excludes liquefied natural gas (LNG).

Liquified petroleum gases (LPG): A group of hydrocarbon gases, primarily propane, normal butane, and isobutane, derived from crude oil refining or natural gas processing. These gases may be marketed individually or mixed. They can be liquefied through pressurization (without requiring cryogenic refrigeration) for convenience of transportation or storage. Excludes ethane and olefins.

Natural gas liquids (NGL): A group of hydrocarbons including ethane, propane, normal butane, isobutane, and natural gasoline. Generally include natural gas plant liquids and all liquefied refinery gases except olefins.

Natural gas plant liquids (NGPL): Those hydrocarbons in natural gas that are separated as liquids at natural gas processing, fractionating, and cycling plants. Products obtained include ethane, liquefied petroleum gases (propane, normal butane, and isobutane), and natural gasoline. Component products may be fractionated or mixed. Lease condensate and plant condensate are excluded.

Natural gas processing plant: Facilities designed to recover natural gas liquids from a stream of natural gas that may or may not have passed through lease separators and/or field separation facilities. These facilities control the quality of the natural gas to be marketed. Cycling plants are classified as gas processing plants.

Refinery: An installation that manufactures finished petroleum products from crude oil, unfinished oils, natural gas liquids, other hydrocarbons, and oxygenates.

Wet natural gas: A mixture of hydrocarbon compounds and small quantities of various nonhydrocarbons existing in the gaseous phase or in solution with crude oil in porous rock formations at reservoir conditions. The principal hydrocarbons normally contained in the mixture are methane, ethane, propane, butane, and pentane. Typical nonhydrocarbon gases that may be present in reservoir natural gas are water vapor, carbon dioxide, hydrogen sulfide, nitrogen, and trace amounts of helium. Under reservoir conditions, natural gas and its associated liquefiable portions occur either in a single gaseous phase in the reservoir or in solution with crude oil and are not distinguishable at the time as separate substances.

Executive Summary

Propane is an important part of Michigan's energy supply portfolio, with more than 8 percent of the state's population using the fuel to support vital functions like home heating, cooking, and transportation. Propane serves consumers' economic needs as well, providing energy to many rural businesses, farms, and industrial customers. Considering the fuel's influence on the lives of Michigan residents, the State has invested significant time and resources into ensuring that propane customers have adequate, reliable, and affordable propane supplies.

With the creation of the Upper Peninsula (U.P.) Energy Task Force in June 2019, Gov. Gretchen Whitmer made Michigan's long-term energy security a priority. One of the primary objectives for the task force is to develop a plan for the state's propane supply in the event of a major disruption, such as the shutdown of the Line 5 pipeline that crosses the Straits of Mackinac. On August 5, 2019, the State issued a request for proposals seeking an assessment of alternative means for meeting Michigan's propane supply needs and recommendations for the best way to ensure Michigan residents and businesses have access to the energy they need into the future. The Michigan Department of Environment, Great Lakes, and Energy (EGLE) and the Michigan Public Service Commission (MPSC) engaged Public Sector Consultants (PSC) to support the work of the U.P. Energy Task Force and provide the State with the necessary information to understand alternatives for supplying Michigan's propane needs.

Issues related to Enbridge's Line 5 pipeline have garnered significant attention over the past five years, including a number of studies assessing the pipeline's safety, alternatives to the existing pipeline span crossing the Straits of Mackinac, the environmental impacts of a pipeline failure, and the impacts the disruption or closure of the pipeline would have on Michigan residents. This report does not seek to address the same questions posed in these earlier research efforts or to take issue with prior assessments, instead the State of Michigan has provided PSC with a clear directive: "Identify alternative approaches to meeting the propane needs of Michigan's residents and businesses" (State of Michigan 2019).

Given the amount of information already compiled on this subject, **PSC's study sought to leverage existing research and to expand on the collective understanding of how Michigan can prepare itself in the event of future propane supply disruptions.** This study does not attempt to address the questions related to the operation or safety of Enbridge's Line 5, nor does it consider the potential impacts of various spill scenarios. Instead the study focuses on the options available to supply the state with required propane volumes under three potential supply disruption scenarios.

In consultation with the U.P. Energy Task Force, PSC identified the following scenarios to serve as the basis for the evaluation of propane supply alternatives.[1]

- The first scenario considers the possibility of **a supply disruption of Enbridge's Lakehead System that delivers natural gas liquids (NGL) from Edmonton, Alberta, to Superior, Wisconsin, via Line 1.** This scenario assumes that Line 5 would not continue operating and would ultimately result in the loss of NGL and crude oil deliveries to propane production facilities and refineries in Superior, Wisconsin; Rapid River, Michigan; Detroit, Michigan; Sarnia, Ontario; Toledo, Ohio; and other downstream facilities. In addition, this scenario would restrict petroleum shipment from Michigan's northern Lower Peninsula to markets via Line 5. The potential impact of this scenario would jeopardize 51.4 percent of Michigan's current propane supplies.

- Scenario two also considers **a potential disruption of an Enbridge pipeline, Line 5 in this case**. Line 5 runs from Superior, Wisconsin, across Michigan's Upper Peninsula, under the Straits of Mackinac, and into Sarnia, Ontario. A disruption of Line 5 would eliminate the flow of NGLs to the Rapid River processing facility, interrupt shipments of Michigan petroleum production, and cut off crude oil and NGL deliveries to refineries and processing facilities in Detroit, Sarnia, Toledo, and other downstream facilities. Under this scenario, 46 percent of Michigan's propane supplies could potentially be impacted.

- The third scenario examines the impact of a weather-related supply disruption on propane supply and consumption. This scenario is modeled after the polar vortex event that took place during the 2013–2014 winter season. During this event, regional temperatures plunged to nearly 20 percent below ten-year averages. Additional supply-related challenges exacerbated the challenge posed by increased demand and resulted in dramatically higher propane demand across the country, but especially in the Midwest. Propane prices spiked during this period, leaving providers and customers to grapple not only with associated price hikes, but also supply shortages. In an extreme weather scenario, Michigan's demand would increase during winter months and current supply options could be inadequate to meet increased customer demand. In addition, regional supply constraints could result in higher delivery costs to meet customer needs.

PSC identified several sensitivities to consider while analyzing these scenarios that would potentially impact short- and long-term effects on propane supplies. The first sensitivity examines the potential for energy efficiency to reduce propane consumption in the long run and reduce the state's overall propane demands. Modeled on existing efficiency programs for natural gas customers, this sensitivity assumes annual investment in energy efficiency and savings potential for propane customers. The second sensitivity is based on the role seasonal temperatures play in driving propane consumption. This sensitivity integrates variability in temperature that could potentially impact statewide propane consumption to account for growing unpredictability of weather and abnormal

[1] PSC's assessment of these alternatives does not consider the nonpropane impacts these scenarios could have, such as the potential impact lost crude oil supply would have on other petroleum products, alternative fuel sources for meeting energy needs, or other environmental costs.

weather patterns. A third sensitivity included in this analysis considers how optimizing propane storage volumes through the use of customers' existing propane storage tanks could help mitigate supply disruptions and insulate customers and retailers from price volatility.

Summary of Results

PSC identified a number of robust and diverse alternative supply options for delivery to the Michigan market. These include sourcing from multiple supply hubs, with primary reliance on supply from Edmonton, Alberta, and Conway, Kansas, transported by rail, pipeline, and truck. Rail routes **from Edmonton to delivery sites in Michigan are the most cost-effective option, especially when propane is procured with a long-term focus on meeting demand throughout the year and using storage as needed to optimize price.** In addition to sourcing propane directly from a major supply hub like Edmonton, PSC found several propane storage terminals in neighboring states where shipments via various pipelines can be accessed and subsequently delivered to Michigan. The best terminal options vary depending on the distance from specific delivery points.

The modeling approach developed for this study provides an opportunity to evaluate the cost impacts and potential trade-offs associated with different procurement and storage configurations, such as purchasing propane stores during nonheating months. Depending on hub prices, the cost of incremental storage capacity can be an effective strategy for supplying propane.

Through the modeling exercise, PSC estimated costs for hundreds of different supply alternatives for selected delivery locations in Michigan. PSC identified the top four priority supply options based on cost. Given the quantity of propane required to mitigate the impacts of potential supply disruptions and the geographic dispensation of propane demand across Michigan, a single supply alternative would likely not be able to supply the quantities required. Based on this finding, PSC used a portfolio approach to calculate the impact of the different scenarios and sensitivities, finding an approach that would leverage the lowest-cost options for each delivery point to meet the needs of Michigan customers and provide supply diversity to mitigate risk. Sensitivities around energy efficiency and utilization of customer storage analyzed in conjunction with the scenarios provide options for reducing the impact of supply disruptions as well. Sensitivities related to extreme weather show the compounding effects of supply disruptions and variability in demand for propane.

While PSC's analysis identified some alternative supply options with prices comparable to those offered at the Rapid River and Sarnia hubs, the overall impact from the scenarios modeled illustrates that wholesale propane prices will likely increase in the event of supply disruptions. While this study focuses on wholesale propane pricing, it is recognized that these increases on the wholesale level would be amplified at the retail level.

Overview of Michigan's Existing Propane Market

Though propane represents a relatively small percentage of Michigan's overall energy use, it is an important component of the state's energy supply, supporting vital functions for commercial, industrial, agricultural, and residential customers. The majority of propane consumption is used as fuel for space heating; water heating; cooking; drying clothes; and fueling gas fireplaces, grills, and backup electrical generators. Additionally, propane is used in agricultural operations for heating livestock housing and greenhouses, drying crops, controlling pests and weeds, and powering farm equipment. Other commercial applications include fuel for forklifts, electric welders, and other equipment. Propane is also used in transportation for a number of different vehicles, such as cars, school buses, and delivery vans. Other nonfuel uses of propane include use in petrochemical feedstocks or in the production of propylene (U.S. EIA n.d.c).

While propane plays an important role in meeting the state's energy needs, the industry is not subject to the same degree of state regulatory oversight as the electric or natural gas industries. As such, the State has had limited visibility into planning, procurement, or pricing strategies employed by the propane industry to meet the needs of Michigan consumers (MPSC 2019). Given the State's limited regulatory role, concerted efforts have been made in recent years to establish a better understanding of Michigan's propane market and identify ways that the State can ensure adequate supply and appropriate prices. In order to plan for and respond to potential risks facing Michigan's propane market, this report provides an overview of this market as a baseline for evaluating alternative supply scenarios.

Propane Supply and Demand

Though marketed to end users as an independent product, propane is just one of the many hydrocarbon chains in the family of hydrocarbon gas liquids (HGLs). HGLs are produced as a biproduct of natural gas processing or crude oil refining and are comprised of ethane, propane, normal butane, isobutane, and natural gasoline, as well as refinery olefins, including ethylene, propylene, butylene, and isobutylene. Propane is also commonly classified under the terms natural gas liquids (NGLs) or liquified petroleum gases (LPGs).[2] NGLs are a narrower subset of HGLs and include natural gas plant liquids and liquified refinery gases. LPG is used to describe a somewhat more limited group of HGLs, primarily propane, normal butane, and isobutane and excludes ethane and olefins (U.S. EIA n.d.b). HGL production through natural gas processing are separated from dry gas products in order to meet required specifications for transportation and sale.[3] Similarly, to produce consumer grade petroleum products, crude oil refineries separate out HGLs, including propane, as part of their production processes (U.S. EIA n.d.a).

Once HGLs are extricated from the original source, there are additional processing steps necessary to produce propane or other marketable products. These products are separated from HGLs through the fractionation process to produce propane, ethane, and butanes that meet the needs of end-use customers. The fractionation process separates different products from the HGL mix based on the different boiling point for each product. Lighter products like ethane and propane are the products fractionated and represent the largest percentage of HGL products, as shown in Exhibit 1.

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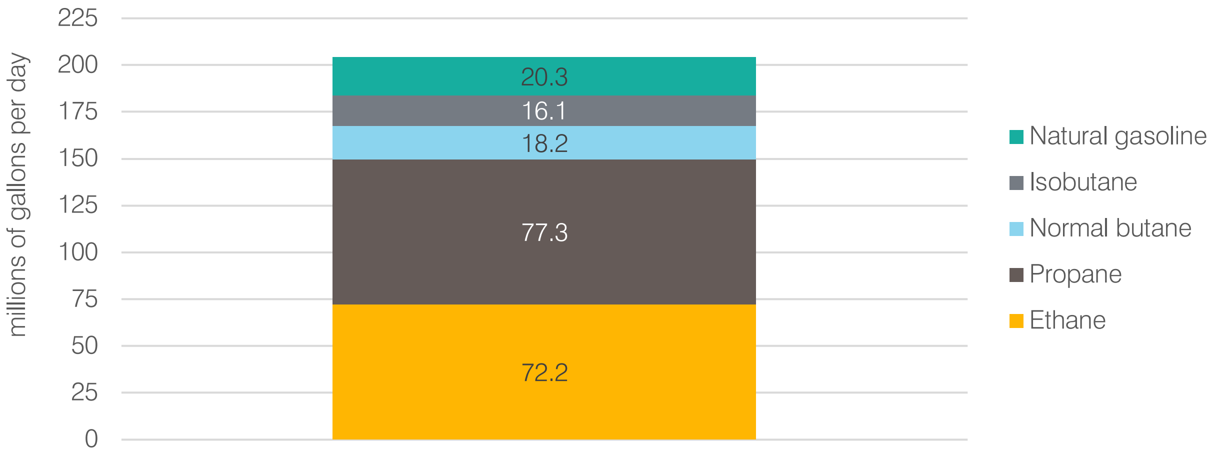
[2] These terms are used throughout this study in accordance with the terms use by an underlying data set or source.

[3] Dry gas refers to the consumer-grade natural gas that is left after the liquefiable hydrocarbons and nonhydrocarbon gases have been removed (U.S. EIA n.d.b).

EXHIBIT 1. U.S. Daily Average Supply and Disposition of Natural Gas Liquids, 2018



Source: U.S. EIA September 2019

Each product fractionated from HGLs has different end uses and thus different customer bases. Propane is the second most commonly used HGL product nationally and the only product that is predominately used as fuel for residential and commercial customers (U.S. EIA November 12, 2019). Ethane, like propane, is sometimes used as fuel, but the majority of ethane and other products from the HGL stream are consumed in industrial processes and as feedstock for petrochemical industries. A description of NGL products and their uses are shown in Exhibit 2.

EXHIBIT 2. Attributes of Natural Gas Liquids

NGLs	Chemical Formula	Uses	Product End Use	End-use sectors
Ethane	C_2H_6	Petrochemical feedstock for ethylene production, power generation	Plastics, antifreeze, detergents	Industrial
Propane	C_3H_8	Fuel for space heating, water heating, cooking, drying, and transportation; petrochemical feedstock	Fuel for heating, cooking, and drying; plastics	Industrial (includes manufacturing and agriculture), residential, commercial, and transportation
Butanes: normal butane and isobutane	C_4H_{10}	Petrochemical and petroleum refinery feedstock, motor gasoline blending	Motor gasoline, plastics, synthetic rubber, lighter fuel	Industrial and transportation
Natural gasoline (pentanes plus)	Mix of C_5H_{12} and heavier	Petrochemical feedstock, additive to motor gasoline, diluent for heavy crude oil	Motor gasoline, ethanol denaturant, solvents	Industrial and transportation

Lighter — Heavier

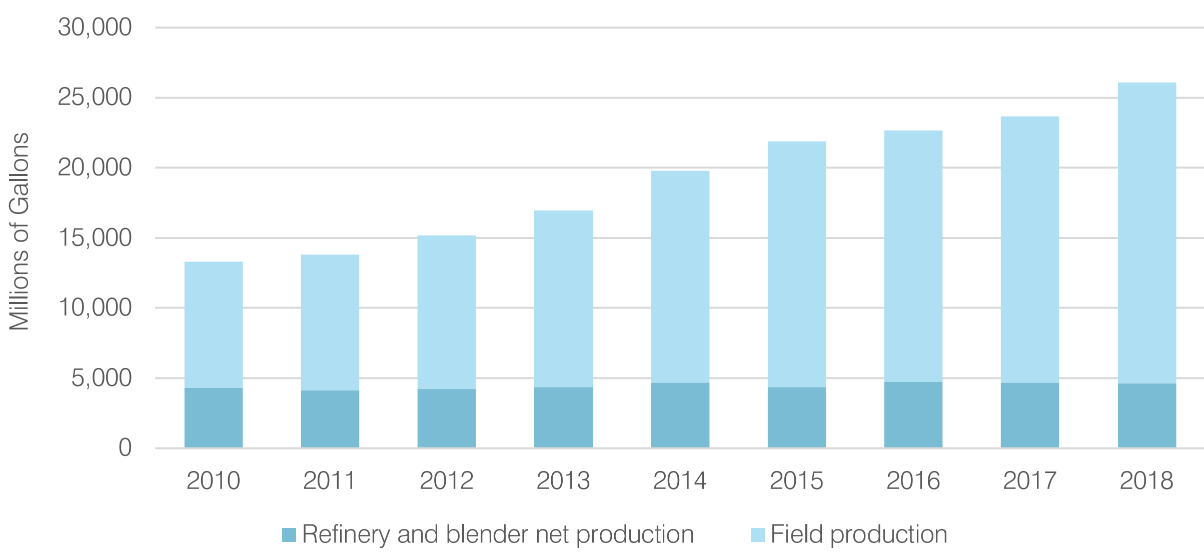
Source: U.S. DOE 2018

Production

Since HGL and propane production depend on other processes, it is not possible to increase their production without also expanding natural gas or crude oil production. Domestic production of crude oil, natural gas, and subsequently HGLs have all been on the rise in recent years. From 2000 to 2018, crude oil production increased 88 percent, natural gas production grew by 54 percent, and production of natural gas plant liquids grew 119 percent (U.S EIA January 30, 2020; U.S. EIA January 31, 2020a; U.S. EIA December 2019).

Domestic propane production has nearly doubled since 2010, growing from 13.3 billion gallons in 2010 to over 26 billion gallons in 2018. This growth has been driven in large part by a substantial increase in field production of propane from natural gas processing plants.[4] Natural gas processing accounted for 82 percent of propane production nationwide in 2018 (U.S. EIA January 31, 2020c). Annual propane production is shown in Exhibit 3.

EXHIBIT 3. U.S. Propane Production, 2010–2018



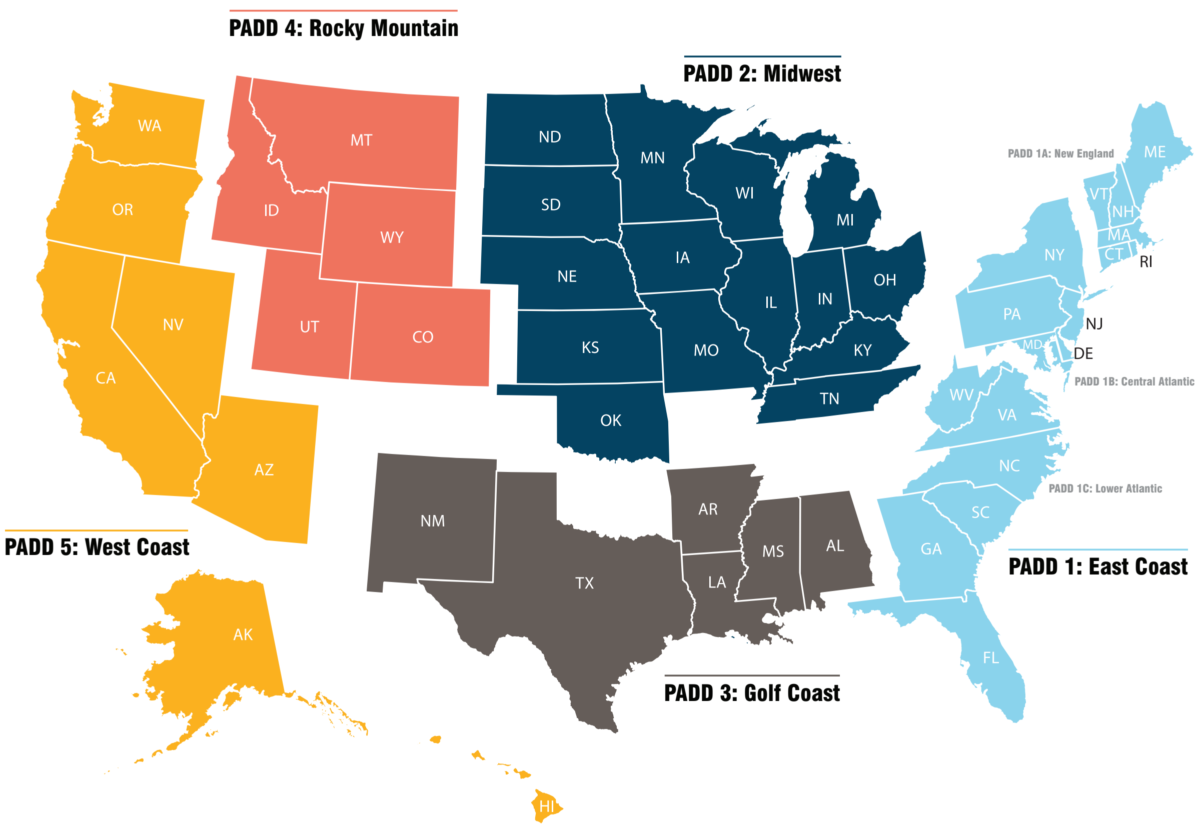
Source: U.S. EIA January 31, 2020c

[4] Field production includes NGLs produced from natural gas processing plants.

Regional Propane Production

Propane supply and disposition is not reported at the state level in publicly available datasets. Instead, this information is reported at the regional level for the five Petroleum Administration for Defense Districts (PADDs). Michigan is part of PADD 2, or the Midwest region, and includes Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin (U.S. EIA n.d.d). A map of these districts is provided in Exhibit 4.

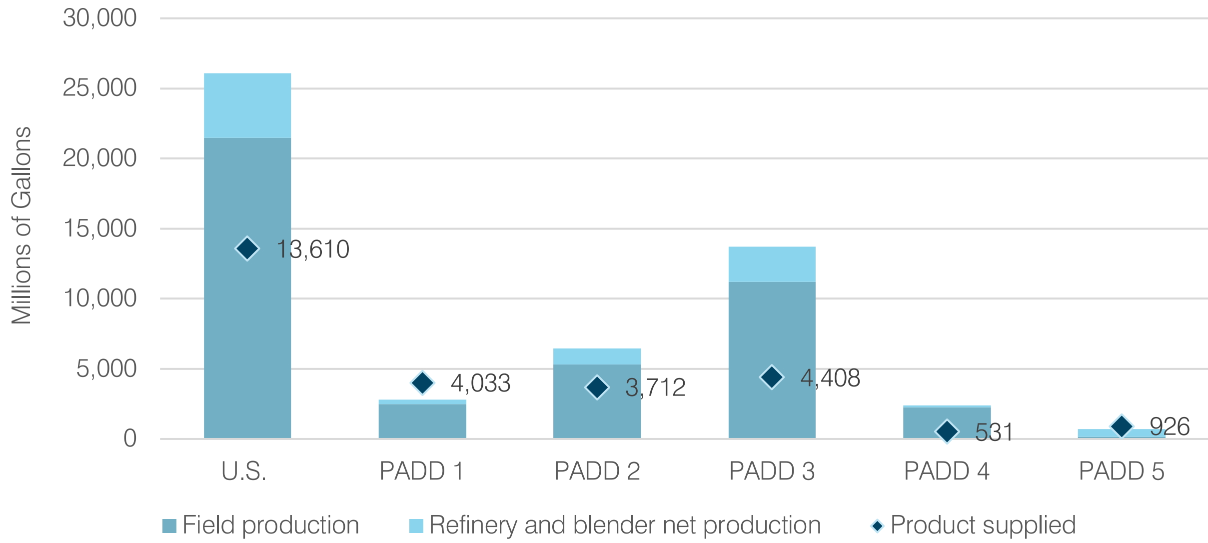
EXHIBIT 4. Petroleum Administration for Defense Districts



Source: U.S. EIA n.d.d

PADD 2 produces 6.455 billion gallons of propane, or 24.7 percent of U.S. production, the second-highest volume of the five PADDs. Only PADD 3 produces more propane, with 52.5 percent of total U.S. production—more than double PADD 2's production. Of the five PADDs, only PADDs 2, 3, and 4 produced more propane than they supplied to customers in 2018. As noted above, the majority of U.S. propane production comes from field production at natural gas plants. Only PADD 5 has more propane production from refineries and blenders than natural gas plant field production (U.S. EIA January 31, 2020c). Propane production by PADD is shown in Exhibit 5.

EXHIBIT 5. Propane Production, by PADD and by Source, 2018



Note: Percentages included in the chart indicate the portion of total U.S. production from each PADD.
Source: U.S. EIA January 31, 2020c

Michigan Propane Production

While PADD 2 has substantial propane production capacity, Michigan has just three facilities that produce propane—one natural gas processing plant, one fractionator, and one refinery. Together, these three facilities produce an estimated 77.3 million gallons of propane per year.

- The Lambda Energy Resources natural gas plant located in Kalkaska, Michigan, extracts propane from wet natural gas produced in the northern Lower Peninsula.[5] The plant is capable of producing over 44,100 gallons of propane per day, or 16.1 million gallons per year (MPSC September 2019).
- The state's only fractionation facility, located in Rapid River, Michigan, in the central Upper Peninsula, is owned and operated by Plains Midstream Canada. The Rapid River facility draws NGLs directly from Enbridge Line 5 and has a gross production capacity of 315,000 gallons per day (Plains Midstream Canada 2019). Estimated actual daily production from Rapid River is approximately 84,000 gallons and annual production is 30.6 million gallons (MPSC August 2019).
- Michigan's only refinery, Marathon Petroleum Corporation's Detroit facility, is the third source of propane production in the state. Crude oil is supplied to Marathon's refinery via a number of sources, including Enbridge Lines 78 and 5. The refinery produces an estimated 84,000 gallons of propane per day, which equates to 30.6 million gallons per year (MPSC September 2019).

[5] EIA defines wet natural gas as "a mixture of hydrocarbon compounds and small quantities of various nonhydrocarbons existing in the gaseous phase or in solution with crude oil in porous rock formations at reservoir conditions. The principal hydrocarbons normally contained in the mixture are methane, ethane, propane, butane, and pentane" (U.S. EIA n.d.b).

Ontario Propane Production

In addition to domestic propane production, Michigan also draws on propane produced in Ontario, Canada. Like the Rapid River facility, the propane production facilities in Sarnia, Ontario, are owned by Plains Midstream Canada and receive NGLs directly from Enbridge's Line 5. The facility has the operating capacity to produce 4.4 million gallons of propane per day (Plains Midstream Canada 2019). The estimated total production from Sarnia is nearly 1 billion gallons per year (MPSC August 2019).

Other Regional Propane Production

Propane Processing Capacity

Another propane processing facility served by Enbridge's Lakehead system, is located in Superior, Wisconsin. Superior is approximately 100 miles from the far western border of the Upper Peninsula. Operated by Plains Midstream Canada, the Superior facility has the capacity to produce 420,000 gallons of propane per day (Plains Midstream Canada 2019).

One of the larger propane processing facilities in the region, the Aux Sable plant in Channahon, Illinois, (approximately 50 miles southwest of Chicago) is situated at the terminus of the Alliance Pipeline. The Alliance Pipeline does not deliver NGLs, instead shipping wet natural gas from British Columbia, Alberta, and North Dakota directly to the Aux Sable facility. The plant has the capacity to produce over 5.5 million gallons per day of NGL consumer-grade products, including ethane and propane. PSC was not able to identify specific production volumes of propane from this facility. Assuming 30 percent of NGL products extracted are in the form of propane, the output from Aux Sable is 1.65 million gallons per day (Pembina Pipeline Corporation 2019). During interviews with companies contacted for the study, some noted that they do procure propane supplies from this facility to various locations in Michigan.

Refinery Capacity

There are other sources of propane production in close proximity to Michigan, including a number of oil refineries that produce propane as a biproduct of the refining process. Refineries process crude oil and other unprocessed petroleum products into refined petroleum products like gasolines, diesel fuel, asphalt, and others (U.S. EIA n.d.b). There are 13 refineries operating in Michigan and neighboring states. Based on assumptions for propane production as a percentage of refineries' total capacity, PSC estimates that these 13 facilities produce 665 million gallons of propane annually. There are an additional 14 operating refineries in PADD 2. Using the assumed rate of propane production, the 27 total refineries in PADD 2 produce 1.053 billion gallons of propane per year, aligning with the U.S. Energy Information Administration's (EIA's) data for propane production from PADD 2 refineries in 2018, which totaled 1.124 billion gallons.

EXHIBIT 6. Operating Capacity of PADD 2 Refineries and Annual Propane Production Estimates, 2019 (Million Gallons)

State	City	Company	Total Operable Capacity	Estimated Propane Production
Illinois	Joliet	ExxonMobil	3,658	61
	Robinson	Marathon Petroleum Corporation	3,756	62
	Lemont	PDV Midwest Refining	2,748	46
	Wood River	WRB Refining	5,120	85
Indiana	Whiting	BP Products	6,592	109
	Mount Vernon	CountryMark Cooperative	442	7
Michigan	Detroit	Marathon Petroleum Corporation	2,146	36
Minnesota	Saint Paul	Flint Hills Resources	4,906	81
	Saint Paul	St. Paul Park Refining	1,510	25
Ohio	Toledo	BP-Husky Refining	2,376	39
	Lima	Lima Refining Company	2,713	45
	Canton	Marathon Petroleum Corporation	1,426	24
	Toledo	Toledo Refining Company	2,649	44
Total			**40,042**	**665**

Note: Production from Marathon's Detroit refinery is also discussed in the section of this report titled Michigan Propane Production. Propane production estimates are based on a 1.66 percent average propane yield rate from crude oil production (MPSC September 2019). Actual propane production will vary by refinery and time of year.
Source: U.S. EIA January 1, 2019

Supply and Disposition

Though propane production has risen in the U.S. over the past decade, the national landscape for propane supply and disposition has also changed as new supply configurations and greater emphasis on exports have altered what happens to propane after production. In addition to tracking propane production, the U.S. EIA tracks imports and exports, movement of product between regions, and propane stocks. Supply and disposition vary regionally; the characteristics of each PADD's propane supplies are as follows.

- PADD 1: East Coast does not produce enough propane to meet its needs on an annual basis and relies on shipments from other regions and, to a lesser extent, imports. Despite relying on imports and shipments from other regions, PADD 1 is the second-largest exporter of propane.
- PADD 2: Midwest has more than enough production to meet its annual supply needs and ships a significant amount of propane to other PADDs. PADD 2 receives the most propane imports, most coming from Canada and has limited propane exports.

- PADD 3: Gulf Coast is by far the largest propane producing region and has the most product supplied. PADD 3 also receives the most propane shipments from other regions and is responsible for over 90 percent of all exports.
- PADD 4: Rocky Mountain produces more propane than it ultimately supplies. The region does not receive a large amount of imports and had zero exports in 2018. The largest share of PADD 4 propane is supplied to other regions.
- PADD 5: West Coast does not produce enough propane to supply the volumes required and relies on imports and shipments from other regions to meet nearly one quarter of its needs, though exports from PADD 5 were almost equal to imports in 2018.

Exhibit 7 provides further insight into how the propane market functions and the overall flow of product.

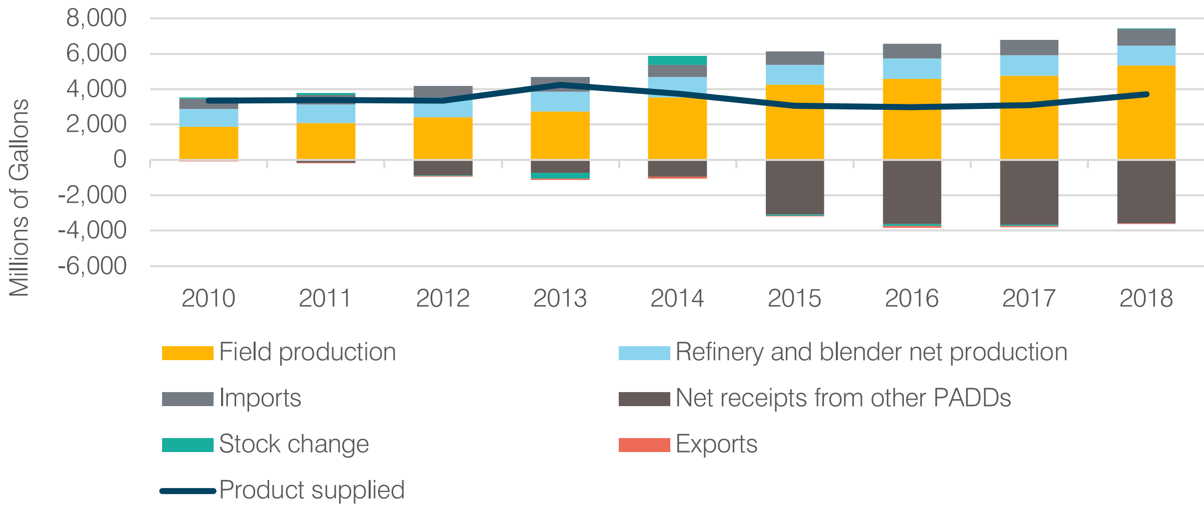
EXHIBIT 7. Propane Supply and Disposition, 2018 (Millions of Gallons)

	Field Production	Refinery and Blender Net Production	Imports	Net Receipts from Other PADDs	Stock Change	Exports	Product Supplied	Ending Stocks
PADD 1	2,497	324	569	1,537	6	889	4,033	251
PADD 2	5,331	1,124	928	-3,569	35	68	3,712	869
PADD 3	11,217	2,483	0	3,903	31	13,164	4,408	1,439
PADD 4	2,276	127	166	-2,042	-4	0	531	59
PADD 5	155	561	470	170	-2	432	926	59
U.S.	21,476	4,620	2,133	0	65	14,553	13,610	2,677

Note: Columns do not add up to U.S. totals due to rounding.
Source: U.S. EIA November 29, 2019

Review of propane supply and disposition for PADD 2 over time reveals propane market changes. In 2010, PADD exports and shipments to other regions were just over 1 percent of total product supplied and the region's propane production and imports were in alignment with supply needs (U.S. EIA. November 29, 2019). However, since 2010, PADD 2 production has more than doubled and imports have increased by 63 percent. The increased volume of propane in PADD 2 is not serving increased need for supply, which has remained relatively consistent in the last nine years, instead the main change has been in the flow of propane from PADD 2 to other regions (see Exhibit 8).

EXHIBIT 8. PADD 2 Propane Supply and Disposition, 2010–2018

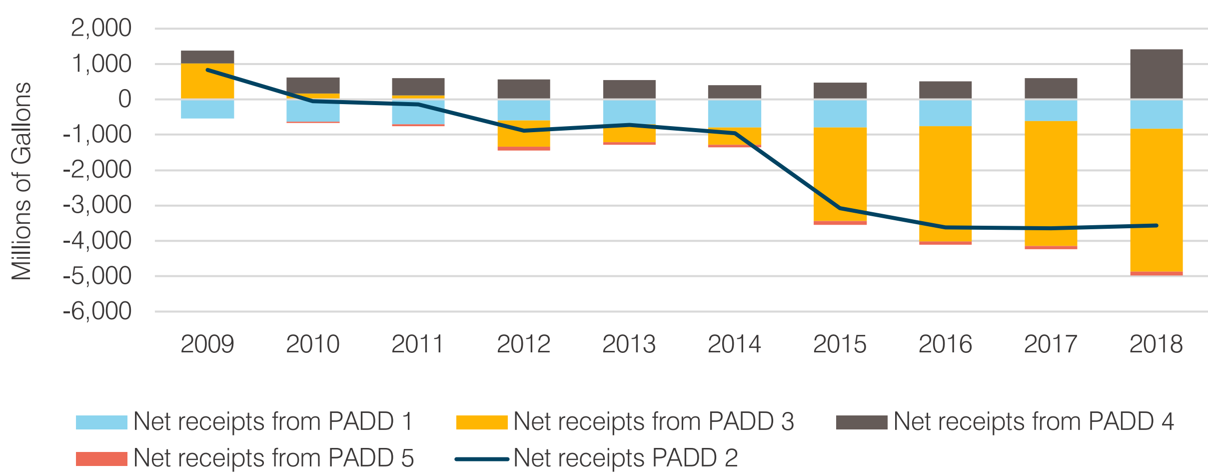


Source: U.S. EIA. November 29, 2019

Regional Supply and Disposition

PADD 2 is the largest exporter of propane to other regions of the country, supplying 3.57 billion gallons to other PADDs in 2018. PADD 2 propane shipments to other regions have increased dramatically since 2010. PADD 3 is by far the largest recipient of propane shipments from PADD 2, receiving 4.03 billion gallons in 2018. The majority of this increase is due to reconfiguration of pipelines to move propane from PADD 2 into PADD 3. Pipelines accounted for over 88 percent of propane shipments from PADD 2 to PADD 3 in 2018. PADD 2 is also a net exporter of propane to PADD 1 and PADD 5. Exhibit 9 breaks down net propane receipts in PADD 2 (U.S. EIA January 31, 2020d).

EXHIBIT 9. PADD 2 Net Receipts of Propane, by Pipeline, Tanker, Barge, and Rail from Other PADDs

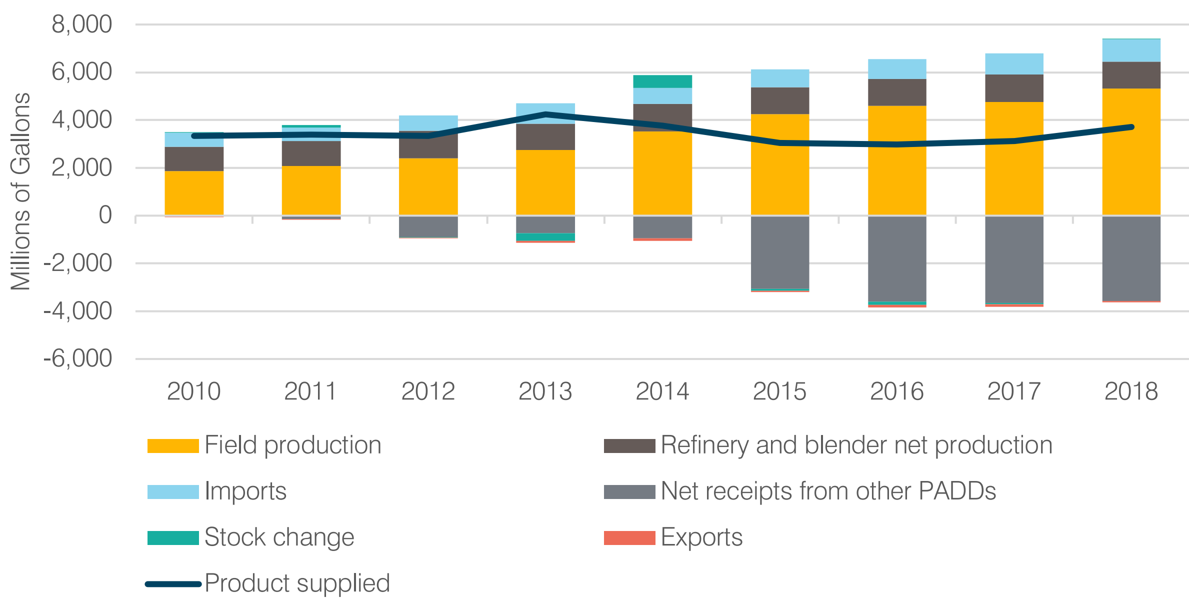


Source: Source: U.S. EIA January 31, 2020d

Imports and Exports

While domestic propane consumption has been increasing, there has been little change in the amount of propane supplied to consumers in the U.S., which has increased by only 4 percent since 2010. The vast majority of the U.S.'s increased propane production is being exported. Since 2010, the propane exports have increased nearly eightfold with more than 14 billion gallons exported in 2018. Propane imports have increased over the same time period, but the growth remains relatively small in comparison to the growth in exports (U.S. EIA January 31, 2020c).

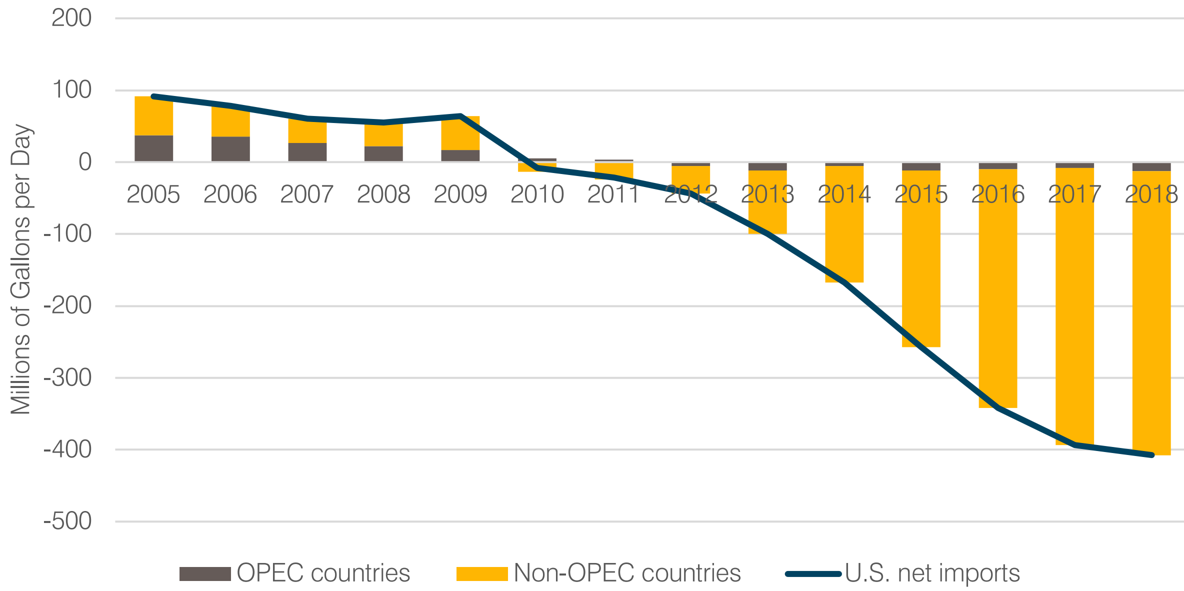
EXHIBIT 10. U.S. Propane Supply and Disposition, 2010–2018



Source: U.S. EIA January 31, 2020c

Net propane imports from 2005 to 2018 further show the shifting landscape of domestic propane supplies (Exhibit 11). Prior to 2010, the U.S. was a net importer of propane, with the largest share of propane imports coming from Canada. Canada was responsible for 73.7 percent of net propane imports per year from 2005 to 2010. Since 2010, the U.S. has become a net exporter of propane, with exports rising from 8 million gallons per day to 407 million gallons per day in 2018. The five largest export markets for propane are Japan, Mexico, Korea, China, and the Netherlands (U.S. EIA November 29, 2019).

EXHIBIT 11. Net Propane Imports, 2005–2018



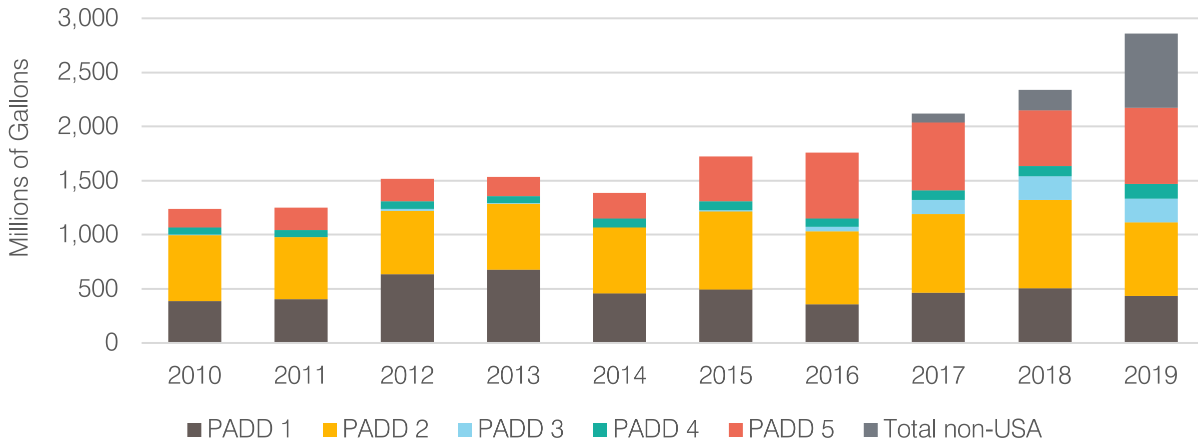
Note: OPEC stands for the Organization of the Petroleum Exporting Countries.
Source: U.S. EIA. November 29, 2019

Canadian Imports

While the U.S. has generally been exporting more propane each year, propane imports from Canada have also grown during the same time period, increasing 75.2 percent since 2010. Imports have increased to every region in the U.S., but the largest increases have come from imports to PADDs 3 and 5. Though imports of Canadian propane to the U.S. have grown consistently over the last decade, since 2017 there has been an sharp increase in propane exports to markets outside of the U.S. In 2019, Canada exported 690 million gallons of propane to non-U.S. markets, up from less than 100 million gallons two years prior. Over the same period, NGL exports from Canada to the U.S. have also increased at a similar rate (Canada Energy Regulator 2019; Canada Energy Regulator n.d.).

The increase in Canadian exports to non-U.S. markets is part of a concerted effort to open Canada's substantial energy resources to new markets. In 2019, Canada completed its first west coast export terminal in British Columbia, enabling Canadian companies to move propane from production centers in Alberta to premium markets like Japan. The CEO of AltaGas, owner of the newly completed terminal, explained the company's strategy to investors in an October 2019 earnings call, saying, "Our fundamental assumption, underlying our midstream strategy, is that the marginal molecule of natural gas and natural gas liquids in Canada will need to be exported, not to the U.S., but to Asia" (Canadian Press 2019).

EXHIBIT 12. Propane Exports from Canada, 2010–2019



Source: Canada Energy Regulator 2019; Canada Energy Regulator n.d.

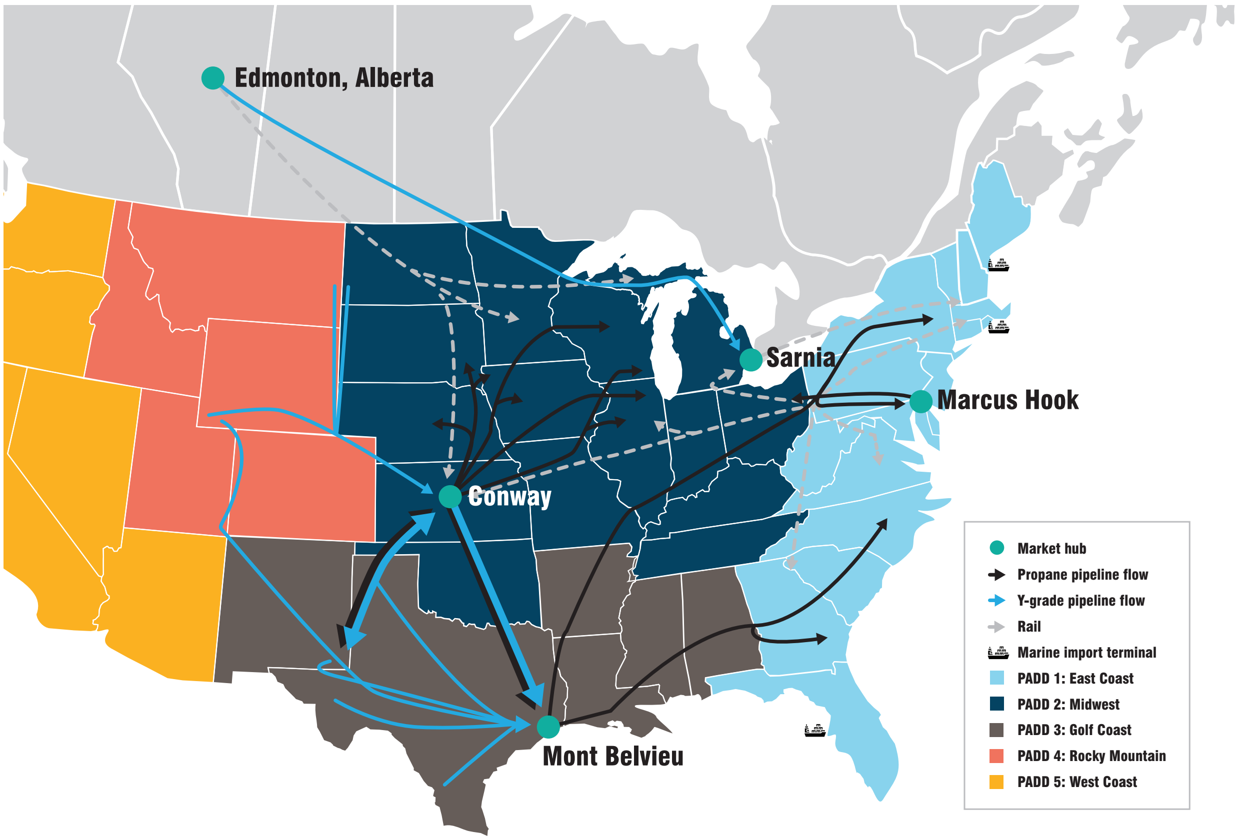
Transportation Modes

Propane is transported across North America through a series of connected supply pathways, including pipelines, rail, trucks, barges, and tankers. The U.S. EIA tracks shipments of propane by the delivery method when products move between PADDs but there is no publicly available data set that tracks the movement of propane within a region or by truck. According to data reported by the U.S. EIA, over 85 percent of all propane movements between PADDs in 2018 were handled via pipeline, rail shipments made up 14 percent of propane movements, and barge and tanker movements made up the remaining 1 percent (U.S. EIA January 31, 2020d).

Though pipelines are the dominant shipment source for propane between regions within the U.S., they account for a much smaller proportion of propane imports from Canada. In 2018, pipeline imports from Canada were 10 percent of total import volumes. The share of Canadian imports via pipeline has fallen since 2015, both in terms of the proportion of shipments and total volumes shipped (CER March 15, 2019). This is primarily due to the reversal of the Cochin pipeline, which went into effect in July 2014. From 1979 to 2014, the Cochin pipeline moved propane from Alberta, Canada, through the Midwest and ultimately to Windsor, Ontario. Growing production of Canadian tar sands in recent years led to increased need for condensate to serve as a diluent for the petroleum being produced and drove pipeline operators to reconfigure the Cochin line to bring condensate from Illinois to production regions in Alberta. New propane supply pipelines from Canada have not replaced Cochin's capacity, which has limited propane movement by pipeline (CER June 2019). Over the same period, propane imports via rail have more than doubled, accounting for the shift in pipeline infrastructure and growing propane production and making up 84 percent of all Canadian imports in 2018 (CER March 15, 2019).

While data for propane movements within PADDs is limited, review of propane pipeline routes provides some insight into the current propane transportation configuration. As shown in Exhibit 13, there are a number of pipelines that move NGLs and propane across the country, but the general movement of NGL and associated products in the U.S. is configured around two primary hubs—Mont Belvieu in Texas and Conway, Kansas.

EXHIBIT 13. U.S. Propane Supply Movements



Note: Y-grade is another term that refers to raw, unseparated HGLs.
Source: U.S. EIA November 12, 2019

Mont Belvieu, Texas

The largest of the U.S. propane hubs is Mont Belvieu, Texas, located near Houston. Mont Belvieu draws NGL supply from producers across Texas as well as Colorado, New Mexico, Utah, and Wyoming and produces propane along with other NGL products. The production capacity at Mont Belvieu and the surrounding area is a large portion of PADD 3's propane production, which accounts for over half of the U.S.'s annual production. In recent years, new pipeline capacity has been added between Mont Belvieu and Conway, Kansas, which has led to greater propane imports from PADD 2 into PADD 3 and contributed to significant growth in international exports from PADD 3 since 2014.

Though many supply changes for PADD 3 in recent years have focused on propane exports, the region shipped an average of 800 million gallons of propane to the PADD 1 from 2014 to 2018. These volumes are delivered to PADD 1 primarily through two pipelines. The Dixie Pipeline transports propane from Texas, Mississippi, and Louisiana to the southeast U.S. up to North Carolina. The second pipeline, TE Products Pipeline Company (TEPPCO), runs from Mont Belvieu through southern Missouri, Illinois, Indiana, and Ohio to reach markets in Pennsylvania and New York. This pipeline primarily serves customers in the northeastern U.S.

Conway, Kansas

Conway, Kansas, is another major source of propane in the U.S., receiving unprocessed NGLs from production in the Rockies and North Dakota and also receiving product via rail from Canadian producers and the Utica and Marcellus shale formations in Pennsylvania and Ohio. Increasingly, Conway has begun to ship propane and NGLs to Mont Belvieu, but the hub still serves as a major supply source within PADD 2, serving states across the plains and the upper Midwest through a number of pipeline systems. The two primary pipeline systems delivering from Conway are ONEOK North Pipeline and the Mid-America Conway North Pipeline. Together these pipelines provide propane to regional distribution points in Illinois, Iowa, Missouri, Nebraska, South Dakota, and Wisconsin.

Other Propane Production Resources

While propane supply in the U.S. has historically been oriented around Mont Belvieu and Conway, NGL production in the Appalachian region—which covers western New York state, western Pennsylvania, and West Virginia—has increased dramatically in recent years (U.S. EIA February 2020). Since 2010, natural gas plant liquid production in the Appalachian region has increased more than 1,700 percent—from 309 million gallons to 7.6 billion gallons in 2018. The increased production from the Appalachian region represents the largest increase in production of any region in the country, but this region still comprised just 11.4 percent of all NGL production in the U.S. for 2018. All of PADD 1, including the Appalachian region, accounts for half the production from PADD 2 and 20 percent of the production in PADD 3 (U.S. EIA February 28, 2020).

The majority of the increase in NGL production from the Appalachian region has been in the form of ethane; however, propane production has increased by over 1,000 percent. These increases are a result of increased production of the Utica and Marcellus shale formations that are accessible through new exploration and extraction technologies. The U.S. EIA's *Annual Energy Outlook 2019* anticipates that production of propane and other NGLs from the Appalachian region will continue to grow through 2050 but that production levels will begin to level off around 2025 (U.S. EIA January 31, 2019h).

Though propane production from the Utica and Marcellus shale formations is expected to continue to grow, the region has limited pipeline capacity to move product to markets. This is likely due to the relatively recent emergence of production activity in the region. Existing NGL pipelines that currently ship propane within the region include:

- The TEPPCO pipeline, which originates in Mont Belvieu, Texas, and travels through the Appalachian region delivering propane into upstate New York.
- The Mariner East pipelines, which move propane, ethane, and other products from western Pennsylvania to the Marcus Hook facility on the Eastern Seaboard.

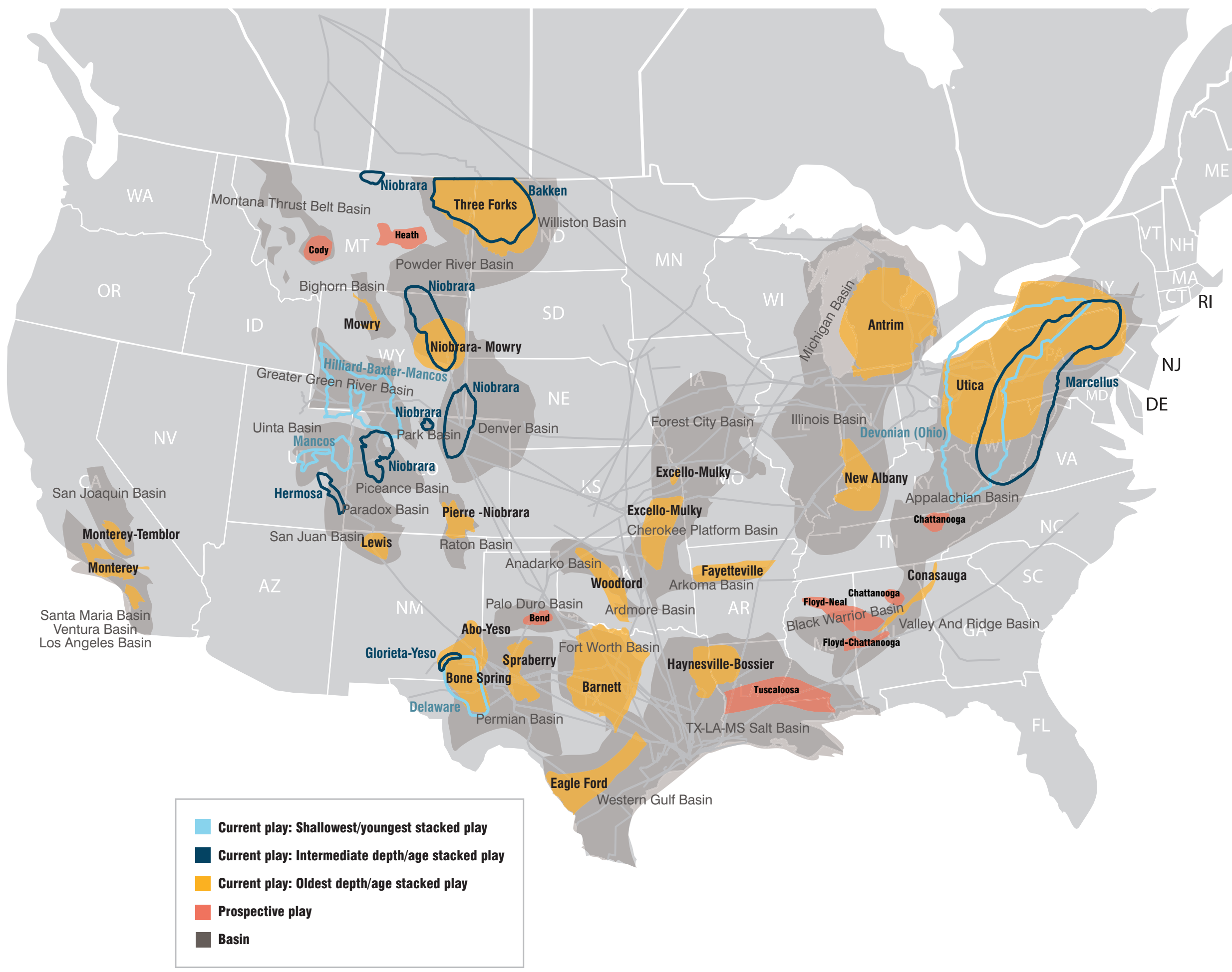
Other pipelines in the region move NGLs but do not currently ship propane. Instead, these pipelines move ethane and other products to markets outside of the Appalachian region. The pipelines include:

- The Appalachia-to-Texas Express pipeline, which ships ethane from the region to petrochemical industries in Texas.
- Marathon's Cornerstone pipeline, which ships natural gasoline and condensate from eastern Ohio to refineries in Ohio and Michigan.

- The Mariner West pipeline, which originates in western Pennsylvania and supplies ethane to facilities in Sarnia, Ontario.
- The Utopia East pipeline, which reconfigured the western-most portion of the former Cochin pipeline that was reversed in 2014 and now ships ethane from facilities in western Ohio to Michigan. (U.S. DOE 2017)

A map depicting active shale plays and existing HGL pipeline infrastructure is provided below (Exhibit 14).

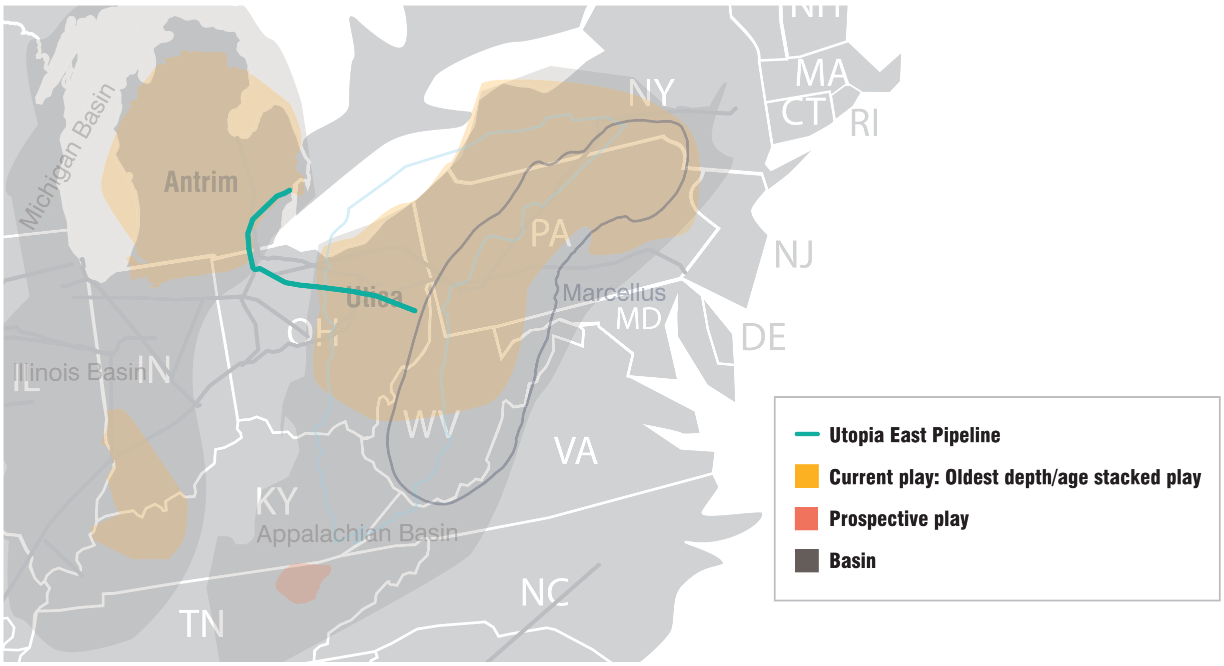
EXHIBIT 14. Active Shale Plays and HGL Pipelines



Source: U.S. EIA n.d.c

The Utopia East pipeline represents the best potential source for propane delivery to Michigan from the Appalachian region (Exhibit 15). Beginning operations in January 2018, the pipeline currently only ships ethane, though it is configurable to ship propane and ethane mixtures. The pipeline's current capacity is 2.1 million gallons per day and can be expanded by more than 1 million gallons per day if needed for a total capacity of 3.15 million gallons per day (Kinder Morgan n.d.). This expansion would likely require a long-term commitment to the pipeline's operation but could potentially be a source of propane for Michigan consumers.

EXHIBIT 15. Utopia Pipeline Map



Source: U.S. EIA n.d.c

Michigan Propane Demand

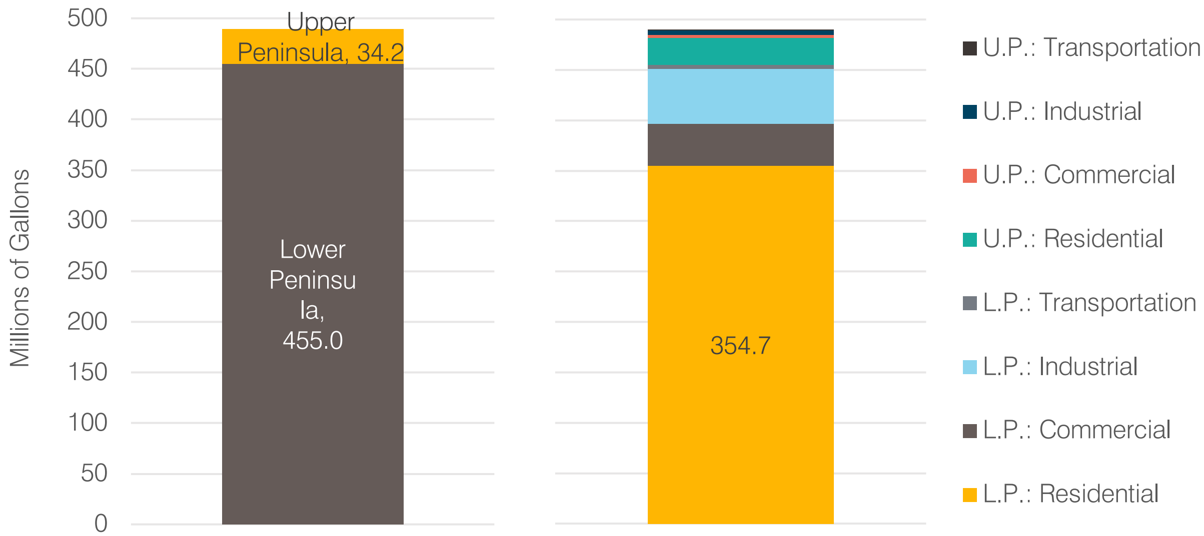
Unlike energy sources such as electricity and natural gas, there is limited public reporting of propane consumption by end use or sector. The Propane Education and Research Council's (PERC's) *Annual Retail Propane Sales Report* is one of the only sources that breaks down odorized propane sales/consumption for each state by sector. This report is compiled through an annual survey of participating retail propane companies as well as other publicly available sources. According to PERC's most recent *Annual Retail Propane Sales Report,* Michigan is one of largest consumers of propane. In 2017, Michigan ranked second in total propane sales (first in residential consumption), with 489 million gallons consumed, comprising 6 percent of the country's total propane demand. Of the ten largest propane-consuming states, five (including Michigan) are located in the Midwest. The Midwest combined for nearly 38 percent of all propane sold in 2017 and 59 percent of total sales were to residential customers (ICF and PERC 2019). Exhibit 16 breaks down Michigan's propane sales by end-use sector for 2017.

EXHIBIT 16. U.S. Retail Propane Sales Summary, by State and Sector, 2017 (Millions of Gallons)

State	Residential	Commercial	Agriculture	Industrial	Cylinder Markets	Transportation	Total
Michigan	367	45	26	6	14	30	489
Percentage	75%	9%	5%	1%	3%	6%	100%

Source: ICF and PERC 2019

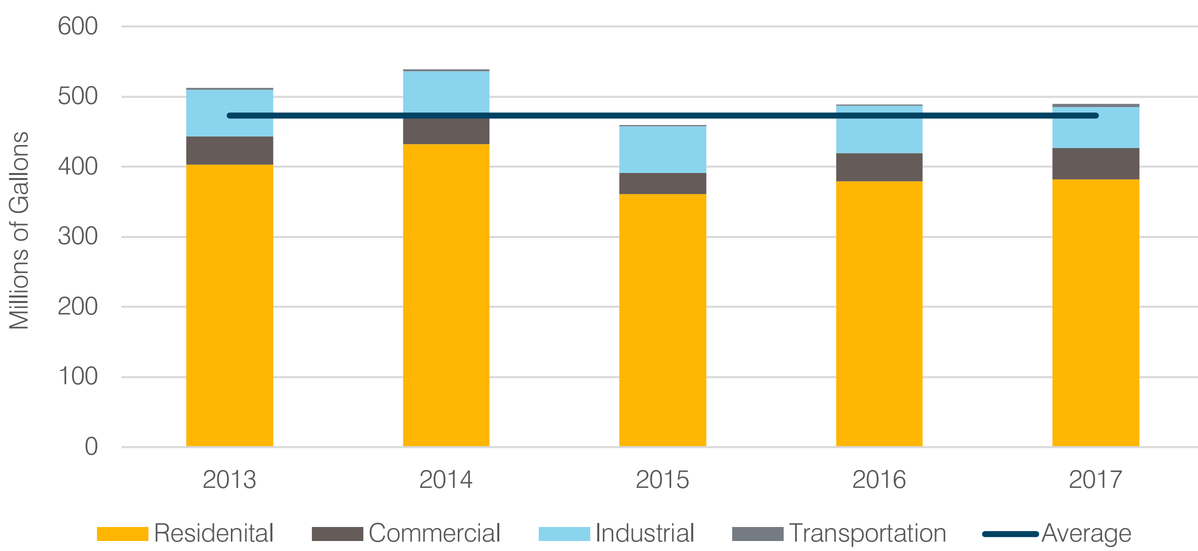
EXHIBIT 17. Michigan Propane Consumption, by Peninsula and End-use Sector, 2017



Source: ICF and PERC 2019

The estimates provided by PERC's annual report align with those provided by the U.S. EIA's State Energy Data System (SEDS), which tracks energy statistics at the state level for production, consumption, prices, and expenditures. U.S. EIA's tracking of propane consumption started in 2010, and since that year, Michigan has consumed an annual average of 473 million gallons of propane. In 2017, Michigan's total propane consumption was 489 million gallons (U.S. EIA June 28, 2019).

EXHIBIT 18. Michigan Propane Consumption, by Sector, 2010–2017



Source: U.S. EIA June 28, 2019

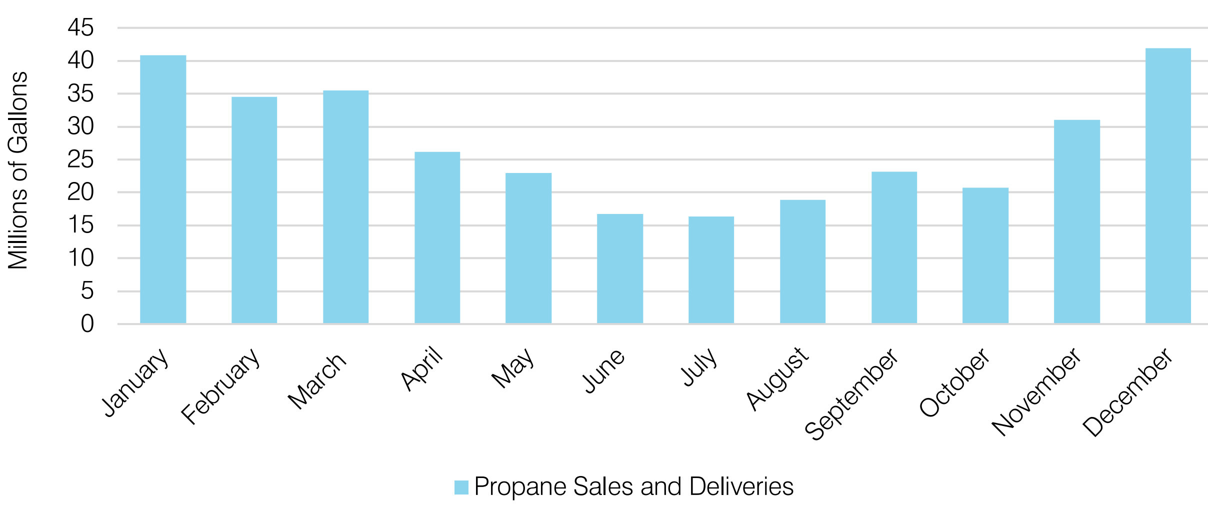
Monthly Consumption

While PERC and U.S. EIA estimates for annual consumption provide important information for Michigan's propane demand, they do not give the full picture of propane supply, as they do not illustrate the variability in propane demand from month to month. Given that a major end use of propane is space heating, the seasonal variation in temperature plays a role in driving propane demand during winter months. The U.S. EIA has one source that provides a better view into the seasonality of propane demand in the state, which offers monthly information on the sale and delivery of propane by prime supplier.[6] This data set does not provide the complete picture of propane consumption for the state of Michigan because it only accounts for a propane supplier "that produces, imports, or transports selected petroleum products across state boundaries and local marketing areas, and sells the product to local distributors, local retailers, or end users" (U.S. EIA n.d.b).

The U.S. EIA's sales and deliveries by prime supplier dataset accounts for 328.7 million gallons of propane in Michigan during 2017, a gap of over 150 million gallons compared to the 489 million gallons of consumption referenced by PERC and the U.S. EIA's SEDS (U.S. EIA January 23, 2020a). Still, this data set provides a useful point of reference, as it shows the variability and trends in propane sales throughout the year.

Propane sales during the heating season—commonly defined as October through March—were nearly 205 million gallons compared to 124 million gallons during the remaining six months of the year. December and January were the peak sales months for 2017, with 25 percent of annual sales during these two months.

EXHIBIT 19. Propane Sales and Deliveries, by Prime Supplier, 2017



Source: U.S. EIA January 23, 2020a

[6] A prime supplier is "a firm that produces, imports, or transports selected petroleum products across state boundaries and local marketing areas and sells the product to local distributors, local retailers, or end users" (U.S. EIA n.d.b).

Residential Propane Consumption

The residential sector represents over 75 percent of total propane demand in Michigan, the majority of which is consumed for home heating. While Michigan's residential propane consumption is high, it makes up only a fraction of the fuels used for home heating in the state, or 8.3 percent according to the most recent data provided by the U.S. Census Bureau (U.S. Census Bureau n.d.b). Michigan also has a high penetration of natural gas use in home heating, with 76.5 percent of households relying on utility gas for home heating needs. While natural gas is the most common home heating fuel in both Michigan and nation as a whole, Michigan has a much higher percentage of households using natural gas, compared to 48.1 percent of households nationally (U.S. Census Bureau n.d.a; U.S. Census Bureau n.d.b).

Overall, the proportion of households using propane for home heating has decreased in both Michigan and the United States since 2010, with an 8.3 percent decrease in Michigan and 7.4 percent decrease nationally (Exhibit 17) (U.S. Census Bureau n.d.a; U.S. Census Bureau n.d.b).

EXHIBIT 20. Household Heating Fuel Demand, Michigan and United States, 2018

	Michigan			United States		
	2018 Estimate	**2018 Share**	**Percentage Change 2010–2018**	**2018 Estimate**	**2018 Share**	**Percentage Change 2010–2018**
Total	3,909,509	100%		119,730,128	100%	
Utility gas	2,988,839	76.5%	-0.3%	57,596,266	48.1%	1.0%
Bottled, tank, or LPG	323,130	8.3%	-8.3%	5,689,915	4.8%	-7.4%
Electricity	374,024	9.6%	38.2%	46,038,234	38.5%	17.8%
Fuel oil, kerosene, etc.	44,640	1.1%	-43.2%	5,895,731	4.9%	-27.0%
Coal or coke	1,151	0.0%	12.4%	123,905	0.1%	-8.4%
Wood	121,949	3.1%	15.2%	2,283,400	1.9%	1.5%
Solar energy	809	0.0%	19.9%	148,118	0.1%	289.7%
Other fuel	36,433	0.9%	38.4%	588,881	0.5%	21.8%
No fuel used	18,534	0.5%	67.0%	1,365,678	1.1%	33.2%

Note: LPG refers to propane in this case. Calculations for percentage change are based on estimated household heating fuel use in 2010 and 2018.
Source: U.S. Census Bureau n.d.a; U.S. Census Bureau n.d.b

Household propane consumption in Michigan varies from county to county, with rural counties having a higher proportion of their population relying on propane. For example, Michigan's largest county in terms of population, Wayne County, has the smallest proportion of households using propane for home heating, at 0.9 percent. Meanwhile, there are 31 counties that have more than 25 percent of households served by propane and 18 counties where the proportion is greater than 30 percent. A complete breakdown of propane consumption by county is provided in Appendices A and B.

There are also differences in household propane use between the Upper and Lower Peninsulas. The U.S. Census Bureau estimates that there are 323,130 households that utilize propane as their primary heating source in Michigan, and approximately 300,057 of those residents, or 92.9 percent of all Michigan propane households, live in the Lower Peninsula. Approximately 23,073 residents, or 7.1 percent of Michigan propane households, live in the Upper Peninsula. Though representing the majority of propane households in the state, propane serves a smaller proportion of households in the Lower Peninsula than in the Upper Peninsula, serving 7.9 percent and 18.6 percent respectively (Exhibit 21) (U.S. Census Bureau n.d.b).

EXHIBIT 21. Household Heating Fuel Demand by Peninsula, 2018

	Total Households	Bottled, Tank, or LPG	Share
Michigan	3,909,509	323,130	8.3%
Upper Peninsula	124,148	23,073	18.6%
Lower Peninsula	3,785,361	300,057	7.9%

Source: U.S. Census Bureau n.d.b

Based on the U.S. EIA's estimates for residential propane consumption and the U.S. Census Bureau's estimates for households using propane as their primary source for home heating, the average household in Michigan consumes 1,180 gallons per year (Exhibit 22).

EXHIBIT 22. Average Annual Household Propane Consumption

Total Residential Propane Consumption, 2017	381,444,000	Gallons
Number of Residential Propane Consumers, 2018	323,130	Households
Average Propane Consumption per Household	1,180	Gallons

Source: U.S. Census Bureau n.d.b; U.S. EIA June 28, 2019

The majority of households that use propane for home heating in Michigan own their home (87 percent), compared to a smaller number of renters (13 percent). Across all home heating fuels, only electricity (61 percent) is higher among renters than owners. These figures are similar by peninsula. In the Upper Peninsula, homeowners make up the overwhelming share (90 percent) of propane users, compared to renters (10 percent), a slightly higher ratio than in the Lower Peninsula, where 86 percent of propane users are homeowners, compared to 14 percent of renters. (U.S. Census Bureau n.d.b).

Weather

As a significant proportion of propane is used in the residential sector for space heating, temperature plays an important role in determining consumption levels. The colder the outside temperature, the more fuel most households consume to keep their homes at the desired temperature. The Climate Prediction Center at the National Weather Service tracks a variety of weather-related variables, including variations in temperature, and reports degree day statistics on a monthly basis. Heating degree day (HDD) statistics are commonly used in the energy industry; they measure the difference between the average daily temperature and the base temperature of 65˚F. For example, if the average daily temperature was 32˚F, then the number of HDDs ascribed to that day would be 33. Daily HDDs are added together to establish weekly, monthly, or annual HDD statistics (National Weather Service n.d.).

In 2019, Michigan had the 13th most HDDs of any state, with a total of 6,998. The national average for HDDs in 2019 was 5,230. HDDs vary from year to year based on actual observed temperatures. Data for HDDs is available from 1919 to 2019. Analysis of this data illustrates that Michigan has experienced fewer HDDs in recent years. The ten-year average for HDDs from 2010 to 2019 had the fewest HDDs of any decade where records were available, and the last three decades have had the fewest HDDs for the entire period. A breakdown of average HDDs for the past 100 years is provided in the Exhibit 23(National Weather Service n.d.).

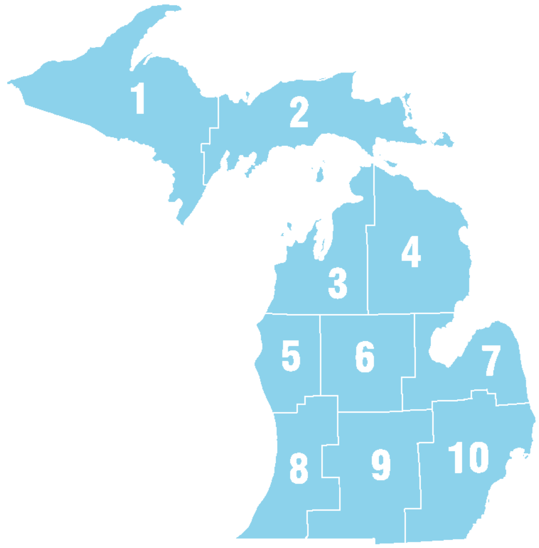
EXHIBIT 23. Average Heating Degree Days, Michigan

Time Period	Average HDDs
1920–1929	7,391.9
1930–1939	7,109.1
1940–1949	7,165.0
1950–1959	7,131.0
1960–1969	7,288.2
1970–1979	7,280.3
1980–1989	7,143.8
1990–1999	6,884.0
2000–2009	6,729.0
2010–2019	6,658.8
1919–2019	7,078.1

Note: PSC calculated averages using monthly HDD totals for each year from 1919 to 2019.
Source: National Weather Service n.d.

Just as HDDs vary from year to year and state to state, they also vary from month to month and by location. The National Oceanic and Atmospheric Administration (NOAA) divides Michigan into ten climate divisions and makes HDD statistics available for each division. The Upper Peninsula is divided into two regions—the Western Upper (1) and Eastern Upper (2). The remaining seven regions divide the Lower Peninsula into the Northwest (3), Northeast (4), West Central (5), Central (6), East Central (7), Southwestern (8), South Central (9), and Southeastern (10) regions (Exhibit 21).

EXHIBIT 24. U.S. Climate Divisions, Michigan



Source: NOAA n.d.

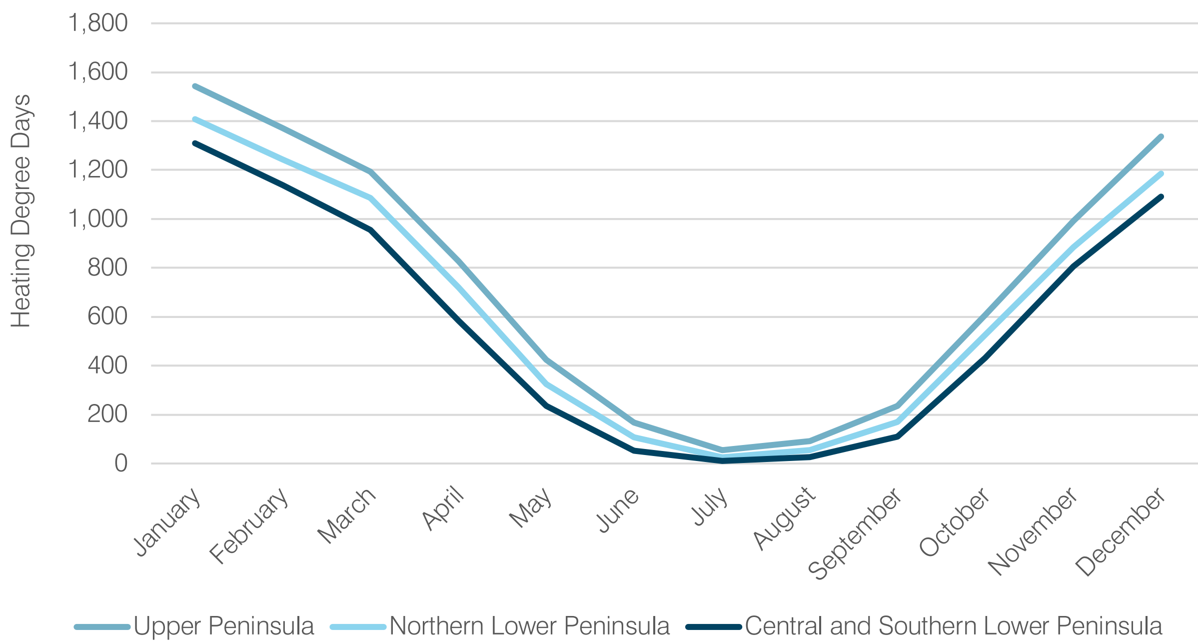
There are notable variations between Michigan's ten climate divisions. The Western and Eastern Upper Peninsula divisions reported 29.9 percent and 35.7 percent more HDDs during the 2010 to 2019 time period than the statewide average (National Weather Service n.d.). Similarly, the two climate divisions in the northern Lower Peninsula were also colder than the statewide average, but the variation was less than half of what was experienced in the Upper Peninsula. Exhibits 25 and 26 break down HDDs for all climate divisions in the state.

EXHIBIT 25. Michigan Heating Degree Days, by Region, 2010–2019 Average

Region		Average HDDs
Statewide		6,658.8
1	**Western Upper Peninsula**	9,037.7
2	**Eastern Upper Peninsula**	8,650.0
3	**Northwest Lower Peninsula**	7,628.8
4	**Northeast Lower Peninsula**	7,835.8
5	**West Central Lower Peninsula**	7,065.3
6	**Central Lower Peninsula**	7,133.8
7	**East Central Lower Peninsula**	6,866.7
8	**Southwest Lower Peninsula**	6,417.6
9	**South Central Lower Peninsula**	6,577.3
10	**Southeast Lower Peninsula**	6,439.8

Source: National Weather Service. n.d.

EXHIBIT 26. Monthly Heating Degree Days, by Region, 2010–2019 Average

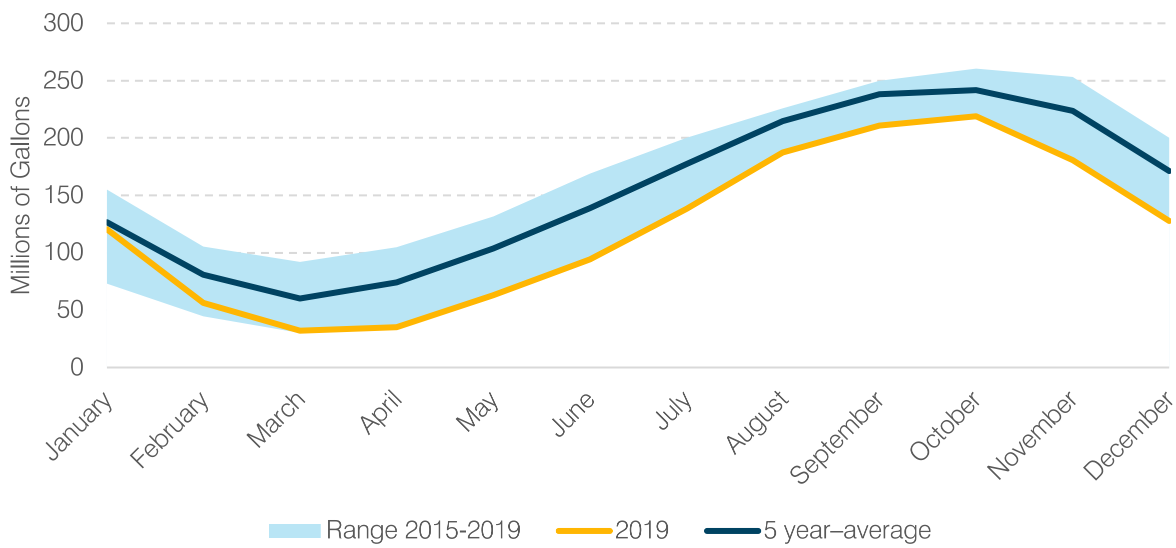


Source: National Weather Service. n.d.

Storage

Given the seasonal nature of propane demand, especially in states like Michigan with high numbers of HDDs, storage is a key aspect of managing propane supply and ensuring that there are adequate stocks available when they are needed most. Michigan has vast HGL storage resources between underground storage capacity and bulk storage tanks, totaling more than 600 million gallons. Companies rely on the state's storage capacity throughout the year, building up propane storage starting in April and throughout the summer to prepare for seasonal heating demands. Michigan's storage volumes typically peak in September or October, just as customer demand starts to respond to cooler temperatures. From 2015 to 2019, the average peak storage volume occurred in October and totaled 238 million gallons of storage. The low point of propane storage volumes in Michigan occurred in March, with an average of 74 million gallons in storage from 2015 to 2019. Propane storage levels in 2019 were at the low end of the five-year average for Michigan. Exhibit 27 illustrates monthly propane storage volume changes in Michigan.

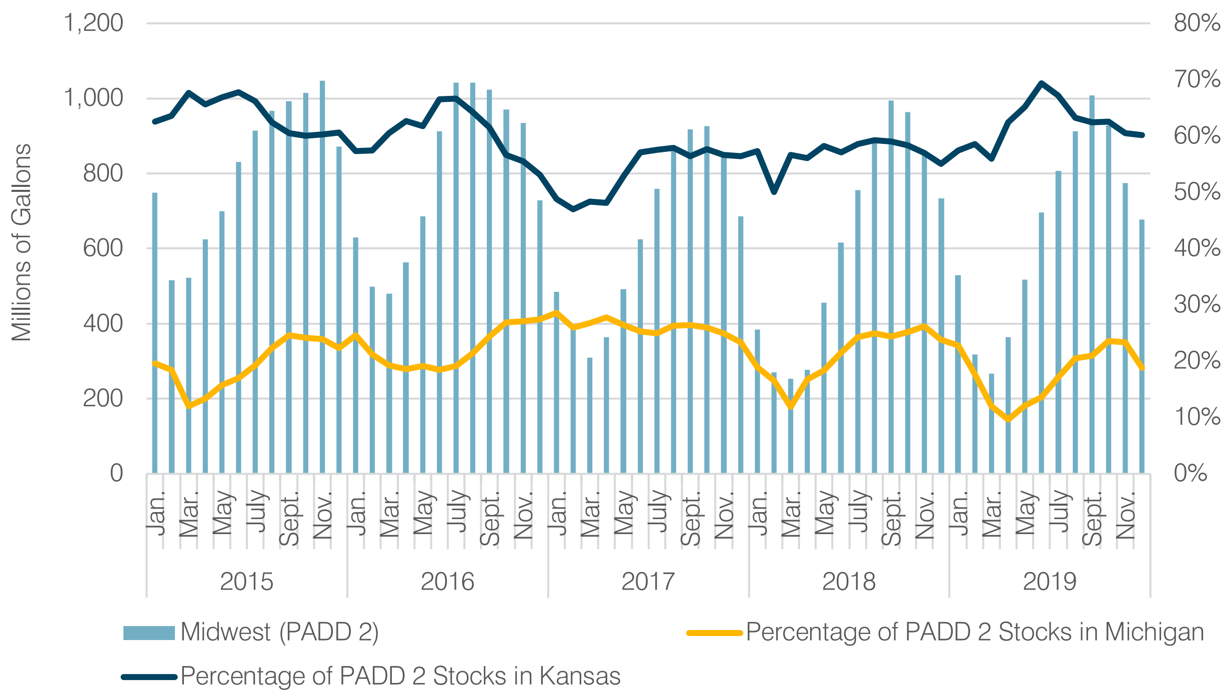
EXHIBIT 27. Propane Stocks at Refineries, Bulk Terminals, and Natural Gas Plants, Michigan, 2015–2019



Source: U.S. EIA January 31, 2020e

Michigan has historically been a top state for propane storage, with the third-largest annual storage volumes behind only Texas and Kansas. The state stored an average of over 185 million gallons per year from 2014 to 2018, representing 23.3 percent of all propane stored in PADD 2 on an annual basis. Propane storage in Kansas and Michigan accounts for over 80 percent of PADD 2 volumes.

EXHIBIT 28. Propane Storage Volumes, by Month, PADD 2 and Michigan, 2015–2019



Source: U.S. EIA January 31, 2020e

Underground Storage

Michigan's unique underground rock formations and caverns provide it with the capability to store large volumes of HGLs. Michigan has over 585 million gallons of HGL storage capacity, of which 99.9 percent is underground (MPSC September 2019). There is additional underground storage capacity located between Sarnia and Windsor, Ontario, totaling 785 million gallons. Exhibit 29 provides a breakdown of these facilities, their locations, and storage volumes.

EXHIBIT 29. Hydrocarbon Gas Liquids Storage Capacity, Aboveground and Underground (Gallons)

Owner/Operators	Location	Underground Storage	Aboveground Storage
Plains Midstream	St. Clair, Michigan	84,000,000	162,288
DCP Midstream	Marysville, Michigan	336,000,000	359,940
Marathon Petroleum	Woodhaven, Michigan	73,710,000	149,940
Plains Midstream	Alto, Michigan	54,600,000	449,988
Sunoco Logistics	Inkster, Michigan	33,600,000	119,994
Plains Midstream	Kincheloe, Michigan	0	119,994
Plains Midstream	Rapid River, Michigan	0	359,940
Lambda Energy Resources	Kalkaska, Michigan	170,100	1,530,060
Michigan Total		**582,080,100**	**3,252,144**

Owner/Operators	Location	Underground Storage	Aboveground Storage
Plains Midstream	Windsor, Ontario	197,400,000	
Plains Midstream	Sarnia, Ontario	243,600,000	
Alberta Ltd.	Corunna, Ontario	218,400,000	
Suncor Energy Products	Sarnia, Ontario	49,560,000	
Imperial Oil	Sarnia, Ontario	76,440,000	
Sarnia, Ontario Total		**785,400,000**	

Source: MPSC September 2019

Aboveground Tank Storage

Michigan's Bureau of Fire Services regulates both above- and underground storage tanks, gas stations, trucking companies, generator tanks, and any petroleum or hazardous substance tank over 110 gallons. This includes storage for liquified petroleum gases.[7] According to Michigan's Administrative Rules, any LPG storage tanks larger than 2,000 gallons are required to be permitted by the State of Michigan (Michigan Department of Licensing and Regulatory Affairs 2014). Since the State requires registration of LPG storage tanks, it is possible to assess the size and distribution of this storage. One limitation with this dataset is that it does not differentiate between LPG products and determining the portion of storage that is devoted to propane is unknown. However, using data from the U.S. EIA that details LPG product supplied by each PADD, it is possible to establish what proportion of LPGs supplied come from propane. From 2013 to 2018, propane accounted for 67.3 percent of all LPG products supplied in PADD 2. PSC then applied this proportion to the LPG storage tank data to calculate the volume of propane tank storage in Michigan.

Based on this calculation, PSC estimates that of the approximately 18 million gallons of LPG storage in Michigan, 12.1 million gallons is used for propane storage.[8] The majority of the aboveground propane storage is found in the Lower Peninsula, which is consistent with the overall distribution of residential propane customers. The Upper Peninsula has over 1.5 million gallons of aboveground propane storage. Exhibit 30 shows the overall capacity of aboveground storage and tank sizes.

[7] Liquified petroleum gases are a subset of hydrocarbon gas liquids. The U.S. EIA defines LPGs as a "group of hydrocarbon gases, primarily propane, normal butane, and isobutane, derived from crude oil refining or natural gas processing. These gases may be marketed individually or mixed" (U.S. EIA n.d.c).

[8] Comparing this figure to survey results compiled by MPSC staff as a part of the 2019 Statewide Energy Assessment confirms that this number is reasonable, if not conservative. Staff's survey included responses from 18 Michigan propane providers who reported serving up to 38 percent of residential customers in the state. These same respondents indicated that they own 11.4 million gallons of bulk propane storage capacity. It is possible that the aboveground storage included in Exhibit 29 is also included in the data provided by the Bureau of Fire Services, which could potentially lead to double counting. Even if this is the case, PSC still believes that this assumption is reasonable, given the MPSC staff's survey results.

EXHIBIT 30. Estimated Aboveground LPG Tank Storage (Gallons)

	Number of Tanks						
	Total	<2,000	2,000–29,999	30,000–90,000	Unknown Size	Total Known Capacity	Propane Capacity
Statewide	1,844	1,156	261	406	21	18,069,676	12,153,479
Lower Peninsula	1,680	1,078	233	350	19	15,769,488	10,606,396
Upper Peninsula	164	78	28	56	2	2,300,188	1,547,083

Note: PSC calculated the five-year average of LPG supplied to the Midwest and calculated the percentage of this total supply that propane represented (67.3 percent). PSC multiplied the total storage volume by the percentage of propane supplied.
Source: Data provided by Bureau of Fire Services, Storage Tank Division, Department of Licensing and Regulatory Affairs.

Customer-level Storage

Another component of Michigan's propane storage capacity is residential customer propane tanks. The average size of a residential propane tank is 500 gallons and each 500-gallon tank can hold up to 400 gallons of propane. Based on the U.S. Census Bureau's estimates for the number of residential propane customers, PSC calculated that Michigan has an additional 128 million gallons of tertiary propane storage. The distribution of this storage capacity is directly related to the distribution of residential customers. Exhibit 31 breaks down of customer-level storage by peninsula.

EXHIBIT 31. Estimated Customer-level Propane Storage (Gallons)

	Total Households	Households Using Propane	Propane Storage
Statewide	3,888,646	320,680	128,272,000
Upper Peninsula	123,995	22,568	9,027,200
Lower Peninsula	3,764,651	298,112	119,244,800

Source: U.S. Census Bureau n.d.a; U.S. Census Bureau n.d.b

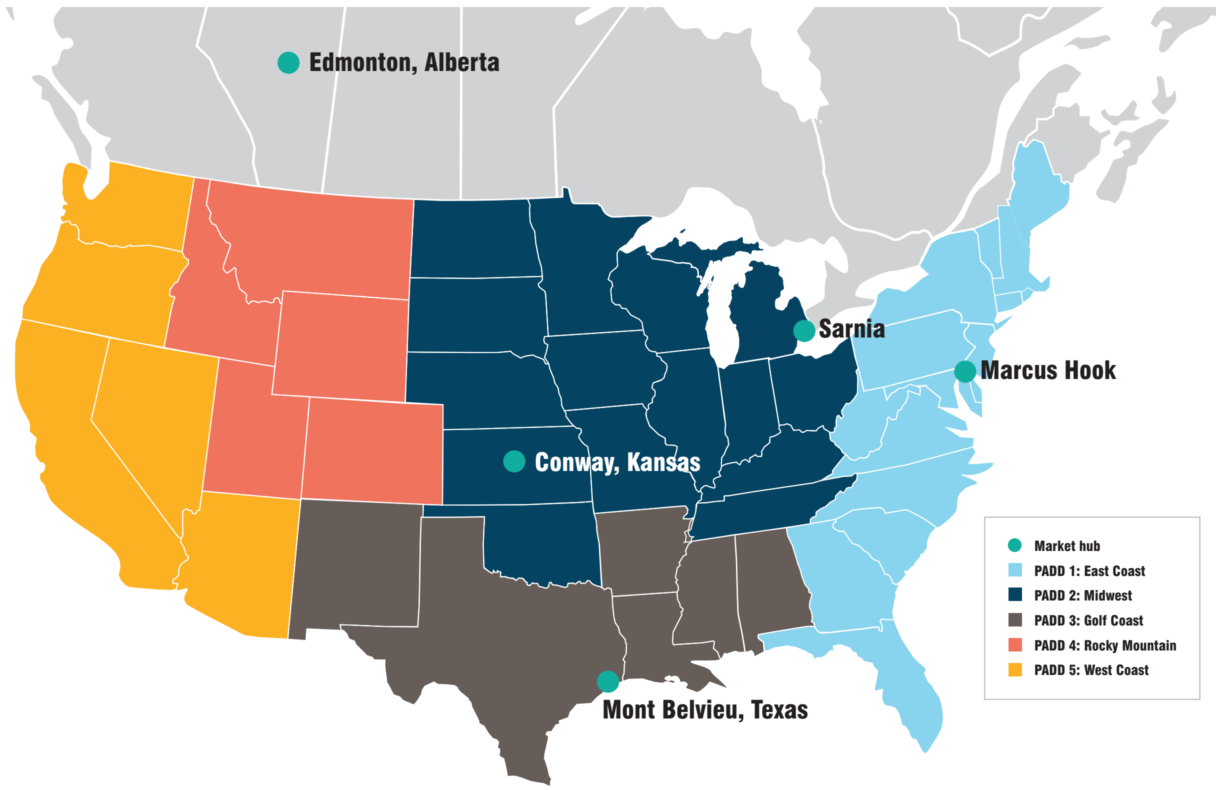
Propane Prices

Propane prices are not regulated, instead prices are based on market dynamics and reflect variability in supply and demand over time. Historical pricing information is available at three different levels—hub prices, wholesale prices, and retail prices. These prices reflect the costs incurred at various levels of the industry, such as the cost of production, transportation, storage, and distribution, plus profit margins for companies.

Hub Prices

There are three primary propane hubs in North America—Edmonton, Alberta; Conway, Kansas; Sarnia; Ontario; and Mont Belvieu, Texas. There is no official designation for what constitutes a propane market hub—these sites were selected based on the amount of propane they produce, store, and distribute.[9]

EXHIBIT 32. North American Major Propane Market Hubs

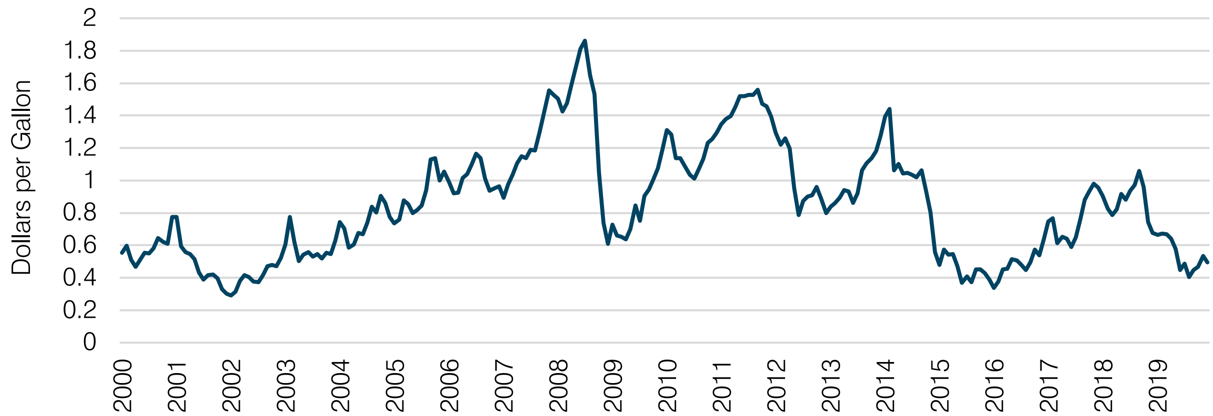


Source: U.S. EIA November 13, 2019

There is limited public information available for propane hub prices, as the U.S. EIA only provides historical pricing data for Mont Belvieu, Texas. Propane prices have varied considerably during the last 20 years, with the lowest price observed being $0.372 per gallon in July 2002. The highest price over a 20-year period also occurred during July; in 2008, hub prices reached $1.862 per gallon. Prices have not reached the same level since 2008, but there have been other instances where prices have approached or exceeded $1.50 per gallon. From April through November 2011, hub prices were above $1.45 per gallon and exceeded $1.50 per gallon from May to August. During the polar vortex of the winter of 2013–2014, prices again approached these levels, peaking in February 2014; however, high prices did not persist for the same duration as in 2011. Despite significant price volatility from 2007 to 2015, since 2015, prices have stabilized, only eclipsing the one-dollar-per-gallon mark during September 2018. Exhibit 33 displays historical propane prices for Mont Belvieu.

[9] Additionally, these locations were discussed in the greatest detail during the U.S. EIA's November 13, 2019, presentation to the U.P. Energy Task Force.

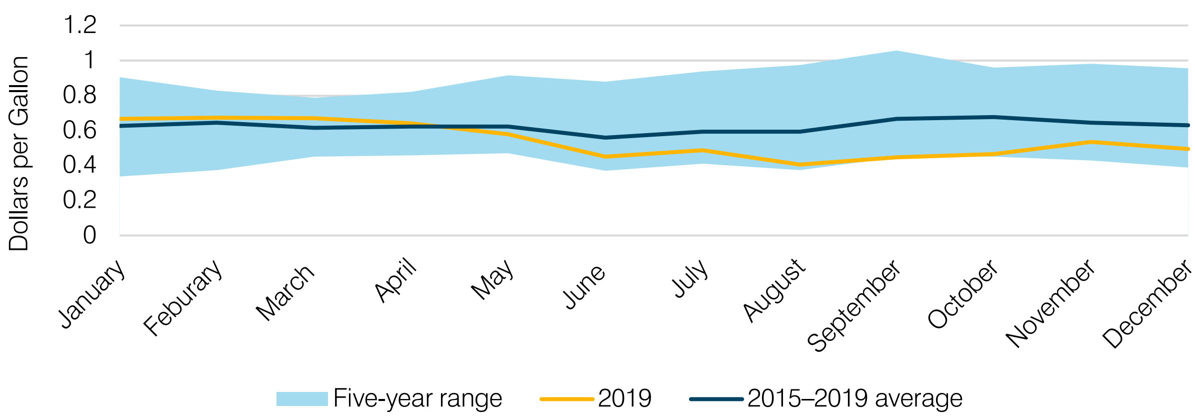
EXHIBIT 33. Propane Hub Prices, Mont Belvieu, 2000–2019



Source: U.S. EIA January 23, 2020b

Though propane prices in the last five years have had less-substantial price spikes than in previous years, prices have still varied over time. From 2015 to 2019, prices were highest during 2017 and 2018, reaching average annual prices of $0.764 and $0.878 per gallon. In 2019, prices returned to levels in line with 2015 and 2016 prices and were below five-year monthly prices for most of the year. Mont Belvieu pricing data from 2015 through 2019 is provided in Exhibit 34.

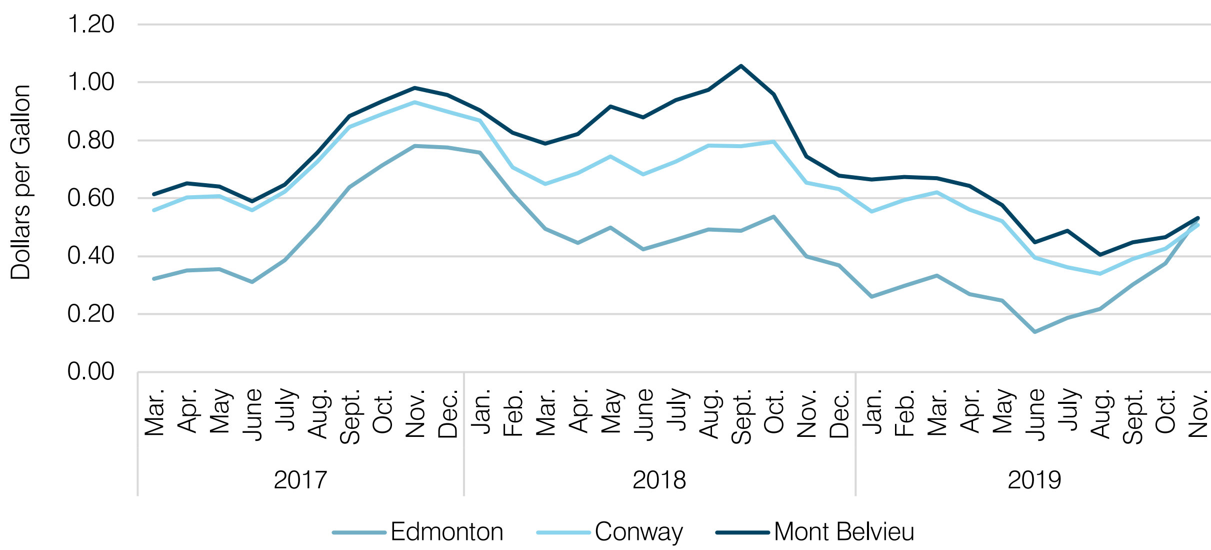
EXHIBIT 34. Propane Hub Prices, Mont Belvieu, 2015–2019



Source: U.S. EIA January 23, 2020b

Additional propane hub pricing information was provided by the U.S. EIA in their November 13, 2019, presentation to the U.P. Energy Task Force; however, this data only includes pricing from March 2017 through November 2019. Though somewhat limited, this data provides insight to a rebalancing of propane supplies in North America. Edmonton, another major source of propane and NGL production, has historically been priced below Mont Belvieu and Conway because the region did not have other alternative markets for its propane production. As shown above in the discussion of Canadian imports, the U.S. was the only major trading partner for propane. Because of this, Edmonton facilities had to ship their propane to U.S. customers and were forced to keep local spot prices low in order to compete with other U.S. propane sources, such as Mont Belvieu and Conway. As new export opportunities on Canada's west coast have opened access for propane trade with premium markets in Asia and elsewhere, Edmonton no longer needs to price itself below other markets to be competitive and its spot price has converged with the other major propane hubs (Exhibit 35). More time will be needed to determine if this trend will persist. The U.S. EIA's most recent *Winter Propane Market Update* shows that Edmonton prices have fallen below Conway and Mont Belvieu in the first months of 2020 (U.S. EIA February 20, 2020b).

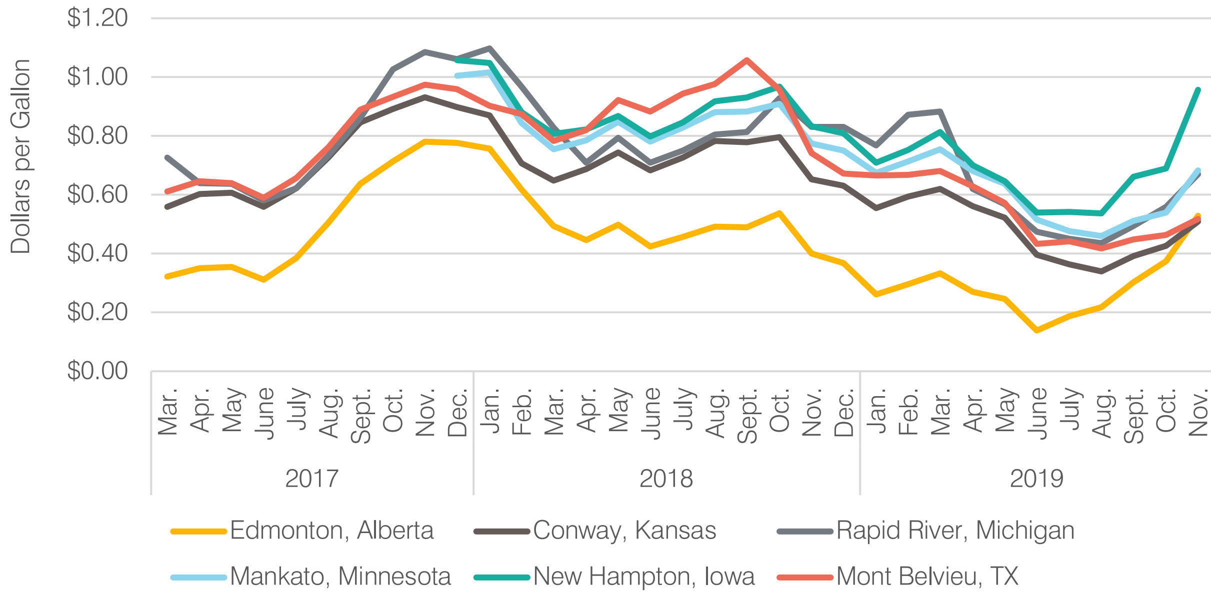
EXHIBIT 35. Propane Hub Prices, Monthly, 2017–2019



Source: U.S. EIA January 23, 2020b; U.S. EIA November 13, 2019

While Mont Belvieu was consistently the highest-priced major hub from 2017 through 2019, data provided by the U.S. EIA illustrates that it was also higher than spot prices for three locations in the Midwest region—Mankato, Minnesota; New Hampton, Iowa; and Rapid River, Michigan—from April to October 2018. As Mont Belvieu prices declined into 2019, prices at these three locations exceeded Mont Belvieu during 2019 by approximately $0.08 per gallon.

EXHIBIT 36. Annual Propane Spot Prices



Source: U.S. EIA January 23, 2019. b and Accessed from U.S. EIA November 13, 2019

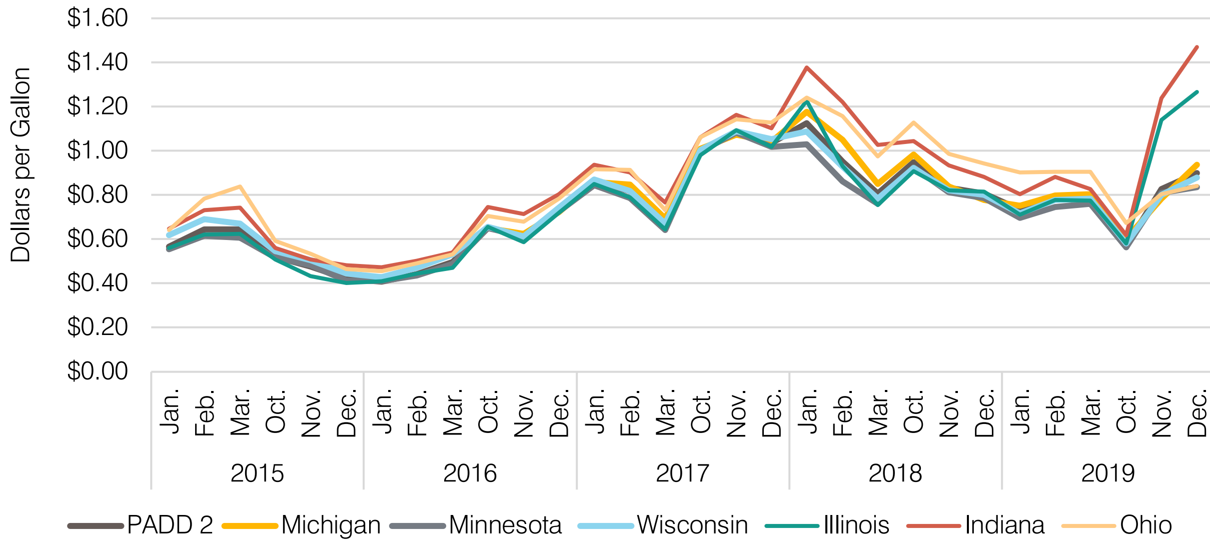
Wholesale Prices

Wholesale propane prices are tracked by the U.S. EIA through the State Heating Oil and Propane Program (SHOPP) which relies on weekly survey data collected by states and compiled by the U.S. EIA for analysis. This information allows the administration to provide weekly updates for wholesale and retail propane and heating oil prices. All PADD 2 states participate in this program for propane, providing a rich data set of propane pricing in the region. Data for Michigan is available starting in October 2016. Data for other PADD 2 states is available through October 2013 (U.S. EIA October 2014).

Overall, wholesale price data for states neighboring Michigan in PADD 2 illustrates that propane prices for the region follow similar patterns. The average monthly price differential for Michigan, Illinois, Minnesota, and Wisconsin compared to PADD 2 was less than $0.03 per gallon. Wholesale prices in Michigan and Illinois' were $0.02 higher than the PADD 2 average. Minnesota and Wisconsin's prices were lower than the PADD 2 average, and Indiana and Ohio had the greatest price difference from PADD 2, with prices higher by an average of $0.14 and $0.10 per gallon, respectively (U.S. EIA February 20, 2020b).

Similar to the trend observed in spot prices, wholesale prices were slightly higher in 2017 and 2018, but declined in 2019. Indiana and Illinois are notable exceptions to declining price trends in 2019. Between the end of October and the third week of November, wholesale prices for Indiana and Illinois spiked, and by January 2020, prices had fallen back in line with historical performance (U.S. EIA February 20, 2020b). Factors contributing to this included delay in grain harvests compounded by a wet fall across the Midwest that led to greater propane demand for crop drying (U.S. EIA November 13, 2019).

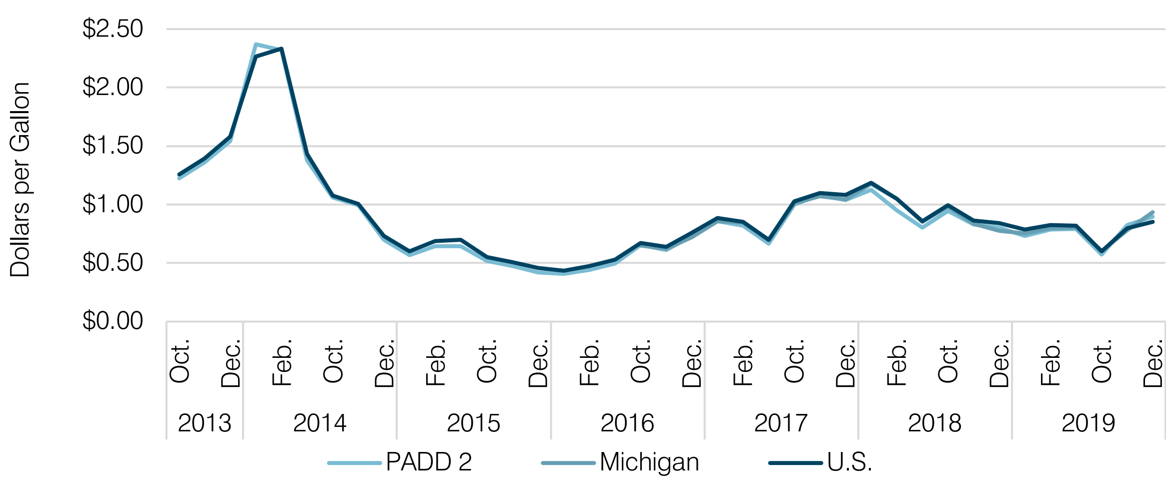
EXHIBIT 37. Monthly Wholesale Propane Prices, 2015–2019



Source: U.S. EIA February 20, 2020b.

While wholesale propane prices have been relatively stable for the past five years, that has not always been the case. During winter 2013–2014, driven by persistent cold temperatures and a confluence of supply issues, wholesale propane prices across the country and in PADD 2 reached $3.987 per gallon for the week of January 27, 2014, and average prices during January and February exceeded $2.35 per gallon (Exhibit 38). This problem was not localized to the Midwest; however, because the region has 36 percent of the country's homes that are heated by propane and temperatures were 19 percent colder than the ten-year recorded average, demand sharply exceeded available supplies, leaving providers and customers paying much more for propane (U.S. EIA March 2014).

EXHIBIT 38. Weekly Wholesale Propane Prices, 2013–2019

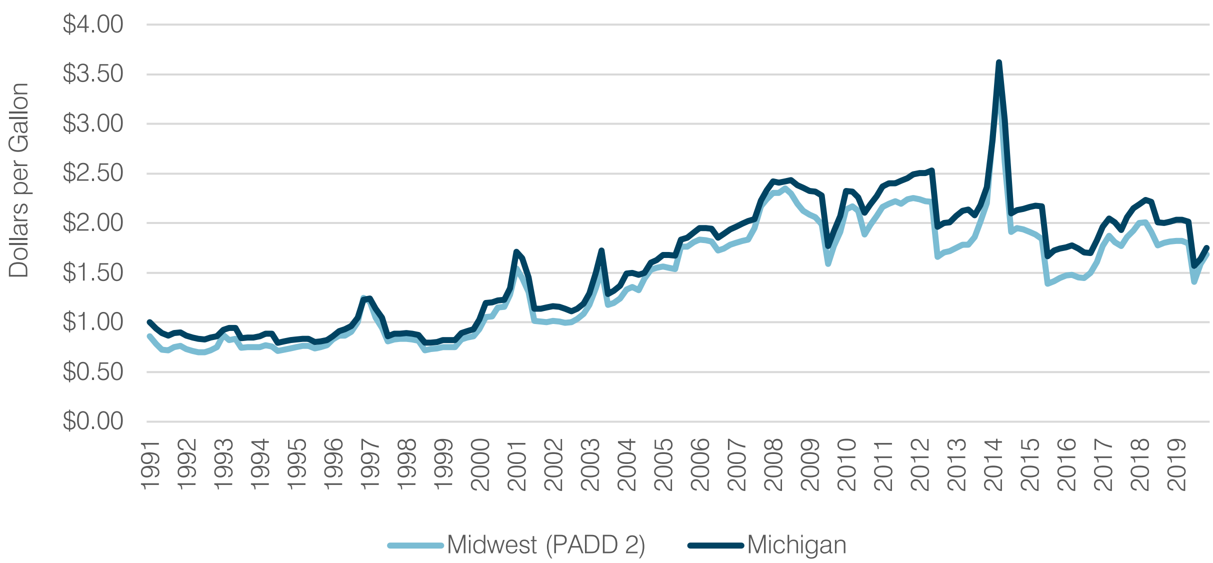


Source: U.S. EIA February 20, 2020b

Residential Prices

Residential propane prices in Michigan have increased by over 72 percent since 1990, rising from $1.015 per gallon in October 1990 to $1.752 in December 2019. For PADD 2 overall, residential propane has increased 76.6 percent over the same time period. Residential propane in Michigan was on average 9 percent higher than PADD 2. Residential pricing data also exhibits the price spike that occurred during January and February 2014, due to the 2013–2014 polar vortex. Prices during February 2014 were 70 percent higher than the previous year and nearly 67 percent above February 2015 (U.S. EIA February 20, 2020a).

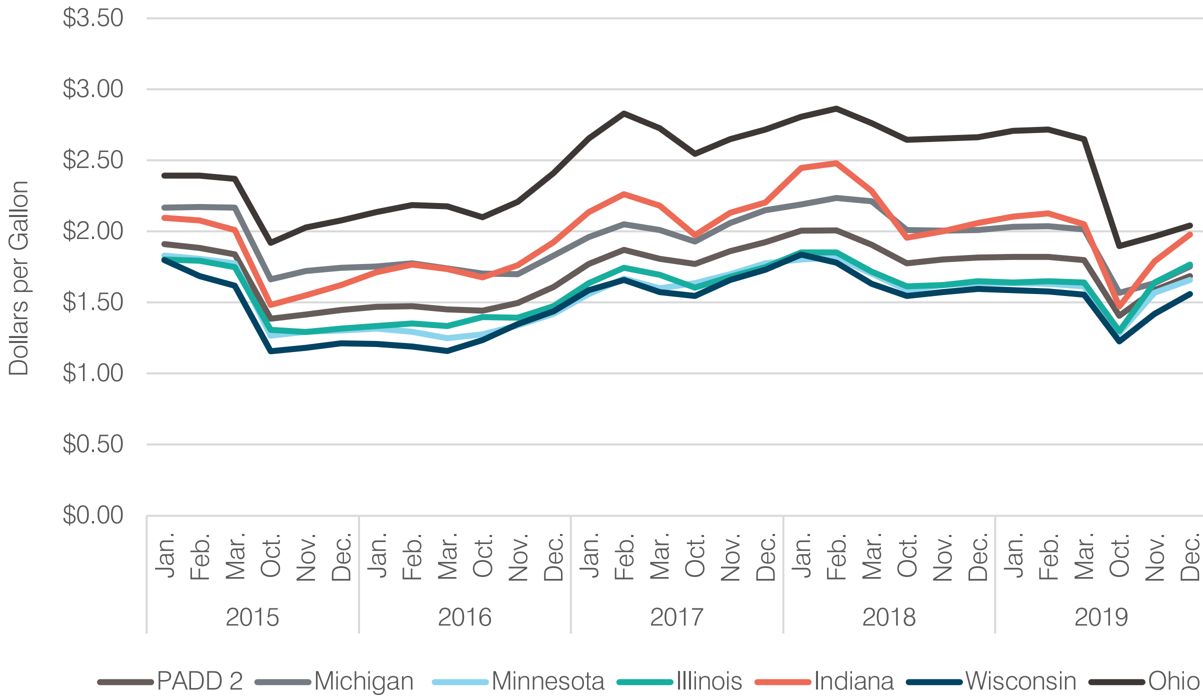
EXHIBIT 39. Residential Propane Prices, 1991–2019



Source: U.S. EIA February 20, 2020a

Michigan has consistently had higher residential propane prices when compared to PADD 2 and the average of neighboring states. From 2015 to 2019, Michigan residents paid an average $0.22 per gallon more than general PADD 2 residential prices. When compared to neighboring states, Michigan customers paid at least $0.10 per gallon more. Of the five states compared, only Ohio had consistently higher residential prices than Michigan. Minnesota, Wisconsin, and Illinois had the lowest residential propane prices, averaging $0.16 less than PADD 2 for the time period examined (U.S. EIA February 20, 2020a). Exhibit 40shows residential prices.

EXHIBIT 40. Monthly Residential Propane Prices, 2015–2019



Source: U.S. EIA February 20, 2020a

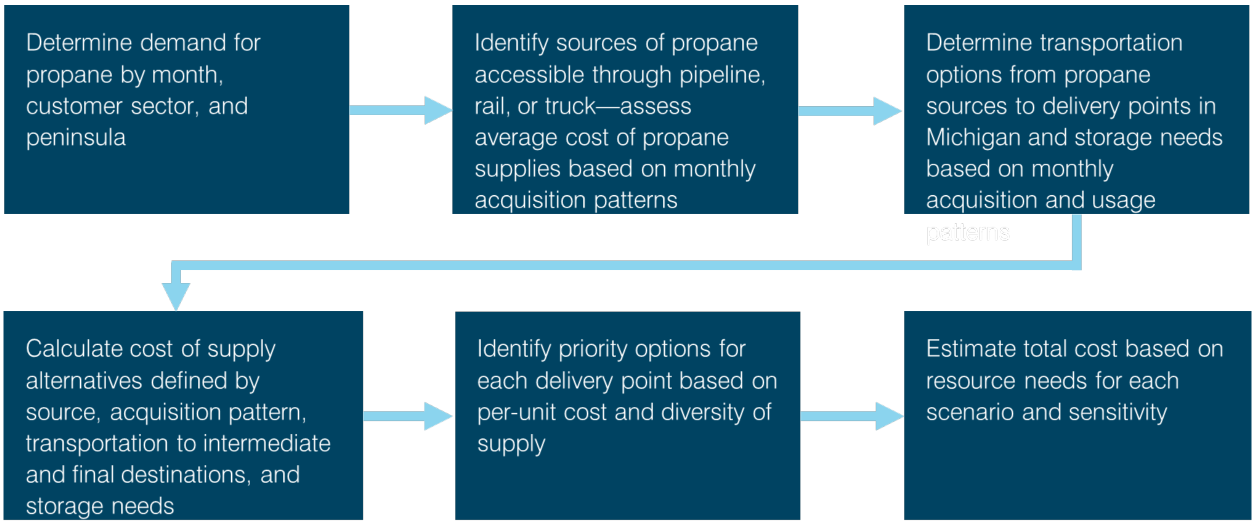
Michigan Propane Supply Modeling

Modeling is an essential tool used across industries for evaluating a range of potential outcomes based on a set of underlying assumptions. A well-designed model supports better, more accurate decision making when the long-term impact of a decision can be difficult to understand. PSC developed a modeling framework for assessing propane supply alternatives based on the current composition of the State's propane supply system. The modeling parameters consider the current sources of Michigan's propane supply, demand for propane by customer type and location, pipeline capacity (export and import), other transportation modes for propane supply, existing propane processing and fractionation capacity and location, existing and operational storage capacity and location, and the costs associated with supply and transportation.

Modeling Approach

PSC developed a modeling approach to identify the costs of various supply alternatives and the total cost associated with supply alternatives to meet the need in each scenario examined. This modeling approach is based on PSC's calculations for expected propane demand, available propane supply alternatives, costs associated with supply alternatives and delivery options, and the impact of different scenarios on supply availability. PSC's approach is illustrated in Exhibit 41. The following sections further describe each step.

EXHIBIT 41. Modeling Process



Source: PSC modeling approach

Modeling Parameters

PSC's modeling parameters were developed through review of existing research, analysis of available data sources, participation in U.P. Energy Task Force discussions, interviews with key industry participants, and examination of relevant secondary sources. Assumptions used in the development of modeling parameters were vetted by PSC's project team, MPSC staff, task force members, and in some cases external industry experts. The following section details modeling parameters used as the basis of PSC's analysis. The underlying assumptions, calculations, and references for these modeling parameters and assumptions are provided in separate technical summary.

Michigan Propane Demand

Propane use is highly dependent on weather; the largest use of propane is related to space heating in residential, and to a lesser extent, commercial buildings.

PSC began its analysis of the weather dependency of propane use by examining propane consumption by sector and the ways propane is used by each sector. Exhibit 42 shows the overall consumption by sector and describes how much of sector consumption is affected by weather and the demand for space heating.

EXHIBIT 42. Weather-dependent Propane Use, by Sector

Sector	Sector Share of Propane Consumption	Share of Consumption Weather Dependent	Percentage of Total Propane Consumption Weather Dependent
Residential	78%	70%	55%
Commercial	9%	60%	5%
Industrial	12%	0%	0%
Transportation	1%	0%	0%
Total	**100%**		**60%**

Source: PSC calculations based on data from U.S. EIA

As noted, residential consumption accounts for 78 percent of the state's propane use. Of that, approximately 70 percent is used for space heating (U.S. EIA March 2018). Other uses include water heating, clothes drying, and cooking. Similar end-use data for the commercial sector is not available; PSC used estimates of natural gas use in the commercial sector to estimate the proportion of propane used for space heating (U.S. EIA March 2016). Propane is used in industrial applications to make plastics, run machinery, cut metal, and for process heat. Industrial propane use accounts for approximately 12 percent of the state's propane use and includes agricultural applications. For example, crop drying can be impacted by weather, and heavy rain during the harvesting season can increase the amount of propane used; however, agricultural and industrial uses are not impacted by heating degree days.

In addition to using an estimation of consumption by end-use, PSC ran a regression analysis to estimate the portion of propane use that depends on weather. This formula looked at propane use as a function of weather using actual consumption and average heating degree days for Michigan from 2010 to 2018. The model was specified as:

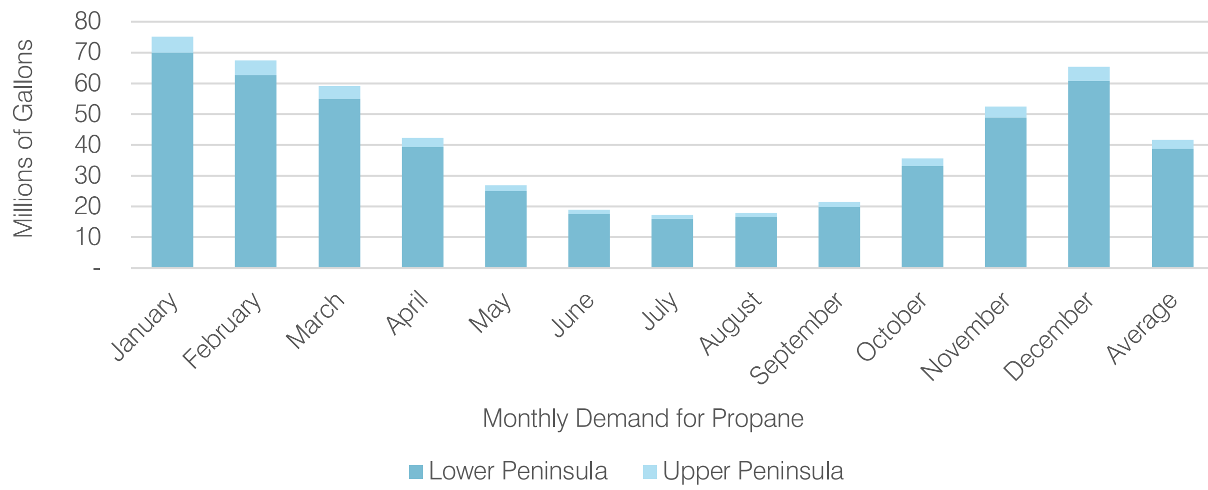
$$\text{Propane consumption} = \beta_0 + \beta_1 * \text{HDDs}$$

β_0 is the non-weather-dependent consumption.

β_1 is the increase in propane consumption for each HDD measured.

Once β_0 and β_1 were calculated, PSC substituted average HDDs for actual HDDs to calculate a weather-normalized demand curve by month. Based on average HDDs, the calculated weather-dependent propane consumption was estimated to be 59 percent and non-weather-dependent propane usage was estimated to be 41 percent. Due to the weather-dependent nature of propane consumption, PSC estimated monthly weather-normalized propane demand. This estimated demand curve exhibits substantial seasonal variation in propane demand that correlates with the observed number of HDDs throughout the year. Projected propane demand is highest during winter months, peaking in December, January, and February. The weather-normalized monthly propane demand is shown in Exhibit 43.

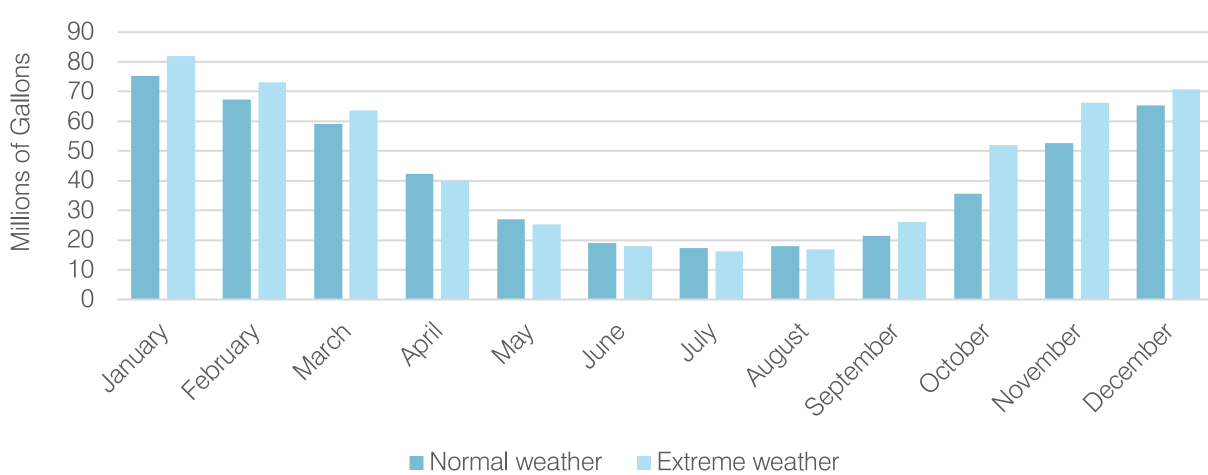
EXHIBIT 43. Weather-normalized Monthly Propane Demand



Source: PSC calculations

To estimate the impact of extreme cold weather, PSC calculated expected consumption assuming a 20 percent increase in the number of HDDs above the ten-year average. This is consistent with weather events experienced during the 2013–2014 polar vortex, during which HDDs for the heating season were 18.7 percent higher than the 2010–2018 average. Under extreme weather conditions, annual consumption of propane is projected to increase by 10 percent and peak month consumption (January) is projected to rise by 15 percent. Consumption in the Upper Peninsula is projected to increase by 18 percent under extreme weather as shown by the observation that the U.P. already experiences more HDDs than the rest of the state on average. Exhibit 44 compares the projected monthly consumption of propane under normal weather and under extreme weather.

EXHIBIT 44. Extreme Weather Monthly Propane Demand



Source: PSC calculations

Michigan Propane Supply

Determining the sources of Michigan's propane supply is an important step in assessing the impacts of different supply disruptions. Since there is limited ability to track where propane deliveries to customers originate from, analysis must rely on a series of assumptions to establish a baseline for Michigan's current propane supply. These assumptions are based on various sources of information that detail imports into the state, known propane production capacities in Michigan and neighboring states, and the movement of propane within the region. While this analysis represents PSC's best attempt to identify sources of propane supply for Michigan based on available information, there are limitations that make it impossible to quantify with certainty how much of Michigan's propane supplies come from different sources.

Supply Sources

Michigan is home to three facilities that produce propane—Plains Midstream's Rapid River terminal, Lambda Energy Resources' Kalkaska gas processing plant, and Marathon's Detroit refinery. These facilities have a combined annual output of 77.4 million gallons. For the purposes of this analysis, PSC assumes that all of the propane produced at these facilities is sold within the state.

Sarnia, Ontario, has substantial propane production capacity and is one of the closest sources of propane supply for Michigan. Sarnia propane production is directly tied to Michigan through a series of pipelines that cross the Detroit River into the state, supplying propane and other products to storage capacity in Marysville and St. Clair, Michigan. Because propane deliveries from Sarnia flow through designated pipelines, it is possible to track how much propane is imported into Michigan. The average annual volume shipped into Michigan from Sarnia amounts to approximately 224 million gallons. For the purposes of this analysis, PSC assumes that all of the propane shipped from Sarnia into Michigan is sold within the state. Combined, these four sources provide 301.5 million gallons of propane to Michigan, equating to just over 60 percent of the state's weather-adjusted demand.

While identifying specific origins for the remaining sources of propane supplies for Michigan presented an obstacle because of the inability to track shipments from state to state or from an individual facility, for the sake of this analysis, PSC assumed that a portion of Michigan's propane supplies are procured from the propane fractionation facility in Superior, Wisconsin. Nearly half of the Upper Peninsula's population lives within 200 miles of Superior, Wisconsin. While the Rapid River facility represents a closer source of propane for many U.P. customers, the proximity of the Superior facility combined with the fact that Rapid River does not produce enough propane to meet the entirety of the U.P.'s demand means Michigan customers likely receive at least some product from Superior. The Rapid River facility supplies an estimated 87.6 percent of all Upper Peninsula propane demand. For the sake of this analysis, PSC assumed that half of the remaining 12.4 percent of propane not sourced from the Rapid River is supplied from Superior, Wisconsin, totaling 2,170,000 gallons per year. This represents 6.2 percent of propane supplied to the U.P. and less than 6 percent of the total production from the Superior facility.

The remaining 196.3 million gallons of propane supply in Michigan is assumed to come from several different sources in neighboring states, including Wisconsin, Minnesota, Illinois, Indiana, and Ohio. PSC was unable to identify the amount of propane supplied per state or facility. Exhibit 45 details assumptions for Michigan's propane supply.

EXHIBIT 45. Michigan Propane Supply Sources (Gallons)

Facility	Owner	Location	Annual Production	Percent of Michigan's Supply
Rapid River Fractionator	Plains Midstream Canada	Rapid River, Michigan	30,660,000	6.13%
Kalkaska Gas Processing Plant	Lambda Energy Resources	Kalkaska, Michigan	16,096,500	3.22%
Detroit Refinery	Marathon Petroleum Corporation	Detroit, Michigan	30,660,000	6.13%
Ontario Facilities	Plains Midstream Canada	Sarnia, Ontario	224,093,940	44.82%
Superior Fractionator	Plains Midstream Canada	Superior, Wisconsin	2,170,000	0.43%
Total Identified Propane Supply Sources			**303,680,440**	**60.74%**
Other Propane Supply Sources in Neighboring States			196,319,560	39.26%
Total Propane Supply and Demand			**500,000,000**	

Note: Columns may not total due to rounding. PSC assumes that approximately 80 percent of propane produced at the Ontario facilities is sourced from Line 5 (see Appendix E).
Sources: Plains Midstream Canada 2019; Enbridge 2019; MPSC September 2019; MPSC August 2019; and U.S. EIA January 31, 2020f

Due to Michigan's unique geography and the different levels of propane demand for the Upper and Lower Peninsula, PSC apportioned propane supplies for each Peninsula. For purposes of this analysis, PSC assumes that all propane produced at Rapid River is consumed in the Upper Peninsula and that any remaining propane supplies necessary to meet demand come from Minnesota, Wisconsin, or via direct rail from Canada. According to PSC's, analysis Rapid River accounts for 87.6 percent of demand in the Upper Peninsula. For the Lower Peninsula, this analysis assumes that propane produced at facilities in Kalkaska, Detroit, and Sarnia are used exclusively within the Lower Peninsula. These facilities represent 58.2 percent of all propane consumed in the Lower Peninsula. Exhibit 46 shows the complete propane supply picture for the Upper and Lower Peninsulas.

EXHIBIT 46. Michigan Propane Supply Sources, by Peninsula (Gallons)

Upper Peninsula Propane Supply Sources

Facility	Owner	Location	Annual Production	Percentage of Peninsula's Supply
Rapid River Fractionator	Plains Midstream Canada	Rapid River, Michigan	30,660,000	87.60%
Superior Fractionator	Plains Midstream Canada	Superior, Wisconsin	2,170,000	6.20%
Other Propane Supply Sources in Neighboring States			2,170,000	6.20%
Total Upper Peninsula Propane Supply/Demand			**35,000,000**	

Lower Peninsula Propane Supply Sources

Facility	Owner	Location	Annual Production	Percentage of Peninsula's Supply
Kalkaska Gas Processing Plant	Lambda Energy Resources	Kalkaska, Michigan	16,096,500	3.50%
Detroit Refinery	Marathon Petroleum Corporation	Detroit, Michigan	30,660,000	6.60%
Ontario Facilities	Plains Midstream Canada	Sarnia, Ontario	224,093,940	48.20%
Other Propane Supply Sources in Neighboring States			194,149,560	41.80%
Total Lower Peninsula Propane Supply/Demand			**465,000,000**	

Note: PSC assumes that approximately 80 percent of propane produced at the Ontario facilities is sourced from Line 5 (see Appendix E).
Sources: Plains Midstream Canada 2019; Enbridge 2019; MPSC September 2019; MPSC August 2019; and U.S. EIA January 31, 2020f

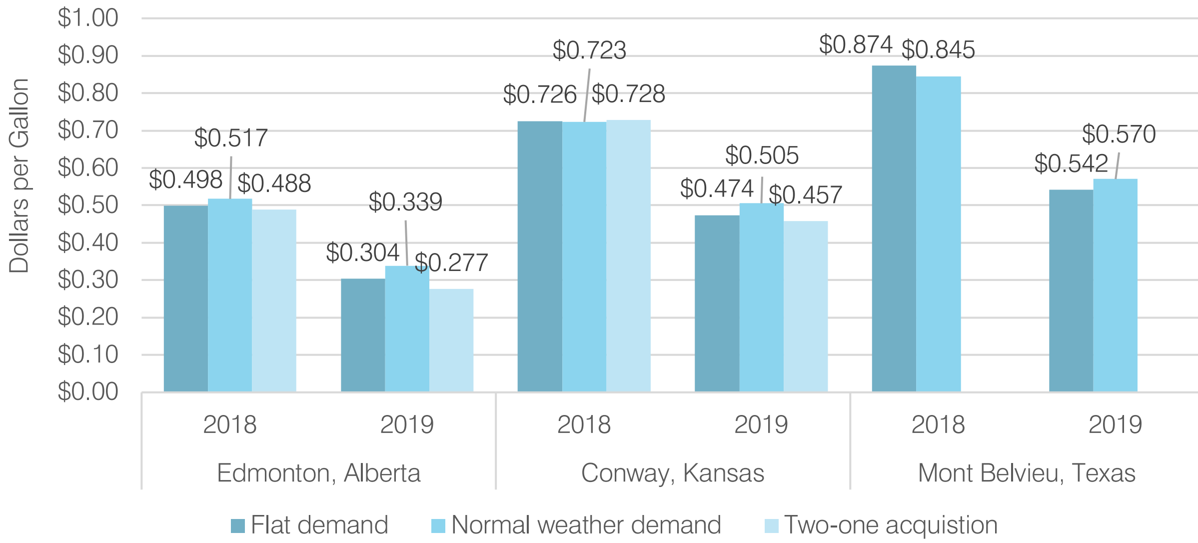
Alternative Supply Sources

PSC considered three hub locations for its modeling efforts, including Edmonton, Alberta; Conway, Kansas; and Mont Belvieu, Texas. For each hub location, there is variation in price from month to month, with some of the price variation related to seasonal fluctuations in demand. For purposes of modeling, PSC considered three acquisition patterns, including:

- Flat demand: Propane would be procured in equal amounts each month and the commodity cost of different supply alternatives would reflect the average hub price across all months of the year.
- Normal weather demand: Propane would be procured in a pattern consistent with monthly demand for propane or just in time, meaning more propane would be acquired in winter months when consumption is higher and less in summer months when consumption is lower.
- Two-one acquisition: To transport propane by rail, rail operators may require two shipments in each summer month for every shipment contracted during winter months. Since rail is only an option for shipments from Edmonton and Conway, the impact of this acquisition pattern is only calculated for these locations.

Exhibit 47 shows the variation in pricing by hub location and acquisition pattern using 2018 and 2019 monthly hub prices. Based on 2019 monthly prices, the average cost per gallon of propane from Edmonton varies from 33.9 cents per gallon when purchased consistent with monthly consumption, 30. 4 cents (or approximately 10 percent less) when purchased in even increments across all months, and 27.7 cents per gallon (or 20 percent less than the cost when purchased just in time). Flat demand, or average prices, were 35 to 40 percent lower in 2019 compared to 2018 across all locations.

EXHIBIT 47. Hub Prices by Location and Acquisition Pattern



Source: U.S. EIA January 23, 2020b; U.S. EIA November 13, 2019

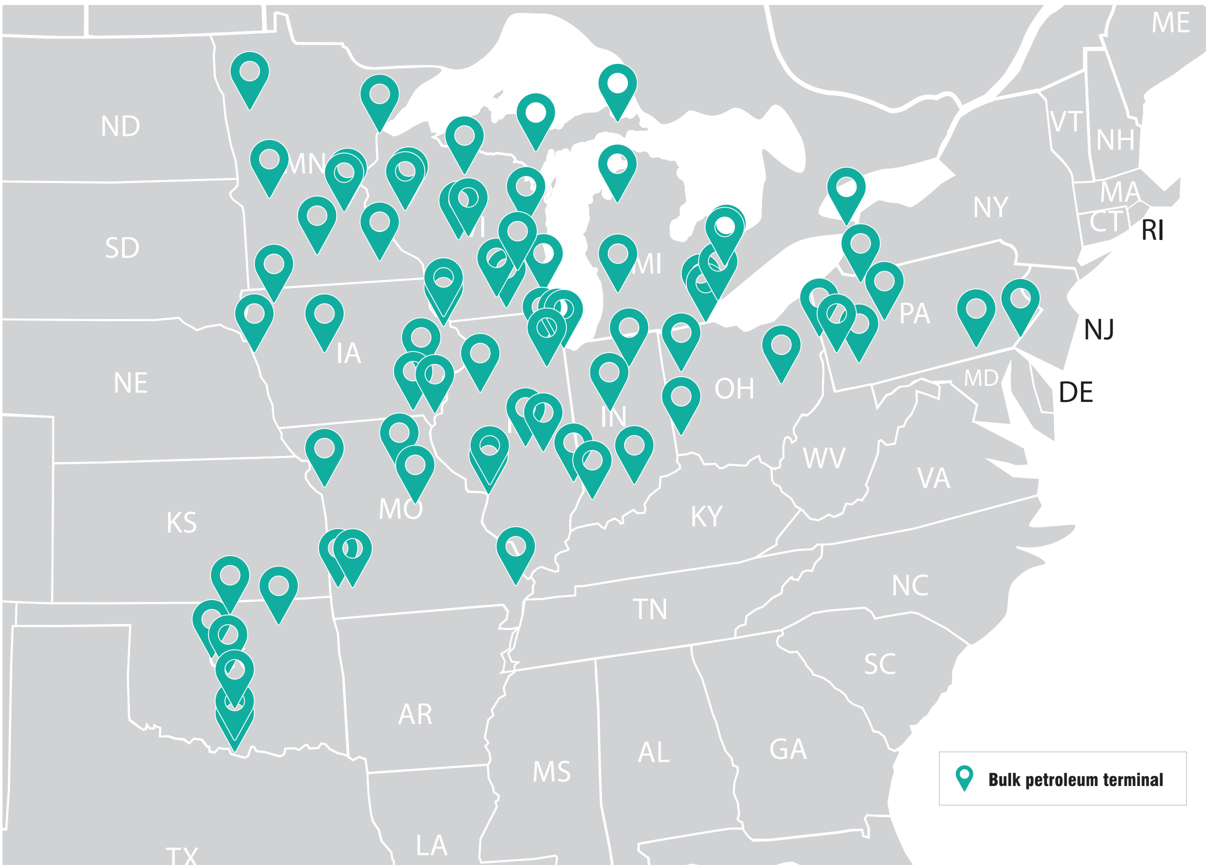
As Michigan only has a few in-state sources of propane production and depends on propane supply from other states and Canada to meet its needs, propane retailers already have to look to resources in other states for propane supplies. The need for supplies from other states will be even greater when considering the impact of potential disruptions to Michigan's current supply. PSC's modeling framework was designed to identify the lowest-cost alternative supply options for Michigan. To do this, PSC created a propane delivery model that incorporates wholesale propane prices at regional supply hubs, transportation options from these major sources of supply, and existing bulk storage terminals located in neighboring states that have NGL storage.[10]

To identify bulk terminals, PSC first consulted publicly available information from the U.S. EIA. The list of published bulk storage terminals available through the administration includes nearly 1,500 sites throughout the country; however, the data set does not provide relevant information for the types of products served or transportation options available (U.S. EIA February 2020). Instead, PSC compiled a list of petroleum terminals from the *2018 Petroleum Terminal Encyclopedia*, published by OPIS/STALSBY. This resource includes over 1,600 storage facilities in North America. Additionally, it provides more detailed information for petroleum terminals than the U.S. EIA does, including the products served, methods for supply and off-loading facilities, any pipelines serving a terminal, and storage capacity in some cases.

[10] The U.S. EIA defines bulk storage terminals as facilities "used primarily for the storage and/or marketing of petroleum products, which [have] a total bulk storage capacity of 50,000 barrels or more and/or [receive] petroleum products by tanker, barge, or pipeline" (U.S. EIA n.d.b).

PSC coded terminal information for nearly 400 petroleum terminals in the following states and provinces: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Ohio, Oklahoma, Ontario, and Pennsylvania. Analysis of this data yielded, 86 terminals that serve propane and/or NGL products within close proximity to Michigan: 12 in Illinois, nine in Indiana, nine in Iowa, two in Michigan, nine in Minnesota, six in Missouri, six in Ohio, nine in Oklahoma, four in Ontario, eight in Pennsylvania, and 12 in Wisconsin.

EXHIBIT 48. Map of Selected Supply Terminals



Note: Map includes Alto, Rapid River, Kincheloe, and Kalkaska facilities, which were not contained in the original data set.
Source: Coates 2018

Delivery Points

Reflecting propane needs across the state, PSC identified five different delivery points, meaning locations to which propane is delivered within the state, for evaluating the cost of various propane supply alternatives.[11] Delivery points were selected to ensure that cost calculations reflect the variable distances from alternative supply options to different regions of the state. In an effort to maximize use of existing propane storage infrastructure, each of the selected delivery points has existing propane storage and transportation options. The five delivery locations included in this analysis are listed in Exhibit 49.

EXHIBIT 49. Delivery Points and Storage Volumes (Gallons)

Facility	Owner	Location	Region	Underground Storage Capacity	Aboveground Storage Capacity
Rapid River Terminal	Plains Midstream	Rapid River, Michigan	Central Upper Peninsula		359,940
Kincheloe Storage Terminal	NGL Supply Co.	Kincheloe, Michigan	Eastern Upper Peninsula		119,994
Kalkaska Gas Processing Plant	Lambda Energy Resources	Kalkaska, Michigan	Northern Lower Peninsula	170,100	1,530,060
Alto Storage Terminal	Plains Midstream	Alto, Michigan	Western Lower Peninsula	54,600,000	449,988
Marysville Storage Terminal	DCP Midstream	Marysville, Michigan	Eastern Lower Peninsula	336,000,000	359,940
St. Clair Storage Terminal	Plains Midstream	St. Clair, Michigan	Eastern Lower Peninsula	84,000,000	162,288

Note: Given that Marysville and St. Clair are in such close proximity to each other, PSC treated them as a single delivery point for this analysis.
Source: MPSC September 2019

Another variable taken into consideration when evaluating alternative propane supply routes is the transportation mode for delivery to selected locations. Trucking is an option for all five delivery points, and every site, with the exception of Rapid River, has access to rail. Only Marysville and St. Clair are served by pipelines that currently ship propane.

[11] Given the close proximity of Marysville and St. Clair, Michigan, the two locations were treated as a single delivery point for this analysis. This is also noted for Exhibit 49, which separates the two locations for granularity of data.

EXHIBIT 50. Transportation Options for Delivery Points

Facility	Transportation Options
Rapid River Terminal	Truck
Kincheloe Storage Terminal	Rail and truck
Kalkaska Gas Processing Plant	Rail and truck
Alto Storage Terminal	Rail and truck
St. Clair/Marysville Storage Terminals	Pipeline, rail, and truck

Source: MPSC August 2019; Plains Midstream Canada 2019; DCP Midstream, pers. comm.

Transportation Cost Assumptions

The next step in the development of modeling parameters involved identifying the costs associated with transporting and storing necessary propane supplies. PSC's analysis focused on establishing per-unit costs for propane transportation via truck and rail that could be applied to all supply alternatives and account for the variable costs associated with the distance traveled. Rail and trucking were the primary modes of transportation considered for final delivery to supply points in Michigan, due to the lack of propane supply pipelines into the state, except for pipelines connecting Sarnia and Southeast Michigan.

Rail

Shipment of propane by rail has increased steadily since 2010, both in terms of rail imports from Canada and movement of propane by rail within the U.S. During 2018, more than 2 billion gallons of propane were shipped from PADD 2, more than double the volume shipped from PADD 2 in 2014 (U.S. EIA January 31, 2020g.). The consistent and expanding shipment of propane from Canada reflects the overall growth in the production of NGLs in western Canada and the need to move these products to end users. The increasing use of rail to move propane supplies is also evidence of limited pipeline capacity to bring product to market and suggests that rail can be a feasible supply option for propane. What determines the viability of rail as a supply option is the cost and availability. Four of the delivery points identified in this study (Kincheloe, Alto, Kalkaska, and Marysville) have existing rail connections, making rail an available option throughout the state.

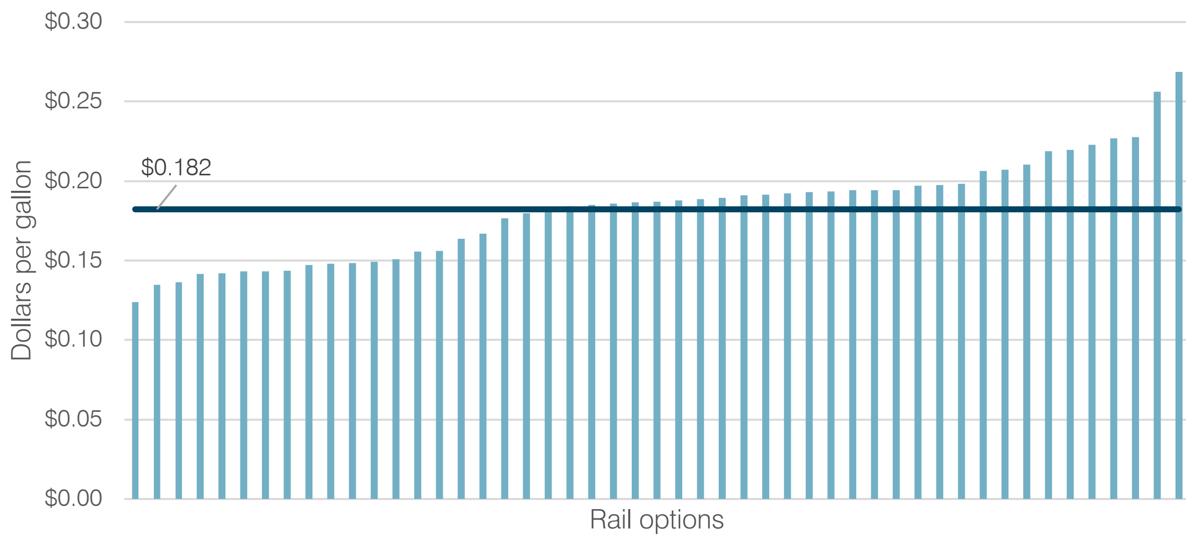
Using the three major hubs as the origin point, PSC identified transportation pathways to delivery points in Michigan, the ownership of various segments of routes, and the distance traveled for each segment of a route. Since class-one rail carriers do not serve one of the delivery points—Kalkaska, Michigan—PSC was not able to identify variable costs for this alternative using the Surface Transportation Board's Railroad Cost Program.[12] Because there are several potential routes that shippers could take to reach delivery locations, PSC constructed more than one rail delivery route for several locations. PSC calculated associated costs for each of the 49 potential rail routes from Edmonton, Conway, and Mont Belvieu to include in the modeling of alternative supply source.

PSC calculated the per-car and subsequently per-gallon costs associated with each supply route. The least-costly rail option in terms of variable cost was $0.124 per gallon. The highest-cost option was nearly

[12] The Railroad Cost Program is part of the Surface Transportation Board's Uniform Railroad Costing System which allows users to estimate the costs of providing specific railroad services (STB 2011).

$0.30 per gallon. The average for the 49 delivery routes was $0.182 per gallon, as shown in Exhibit C4 in Appendix C.

EXHIBIT 51. Range of Variable Costs for Rail Options, per Gallon



Source: PSC calculations

The range of cost options from the three hubs indicates that variable rail shipment costs can be a determining factor in the cost-effectiveness of rail alternatives. The hub with the lowest-average variable cost for supply routes was Edmonton, which came in at $0.151 per gallon. This is despite having the longest overall distance travelled. Options from Conway had the next lowest average distance and came in less than $0.01 per gallon higher than routes from Edmonton. Variable costs from shipping via rail from Mont Belvieu were the most expensive on average. All of the rail supply alternatives from Mont Belvieu had average variable costs that were greater than the average cost option.

EXHIBIT 52. Average Variable Cost and Distance for Rail Alternatives

Origin Hub	Average Distance (Miles)	Average Cost (Dollars per Gallon)
Edmonton	1,621.0	$0.151
Conway	1,355.1	$0.173
Mont Belvieu	1,579.7	$0.203
All Options	1,530.4	$0.182

Source: PSC calculations

A full discussion of cost assumptions for rail is provided in Appendix C.

Truck

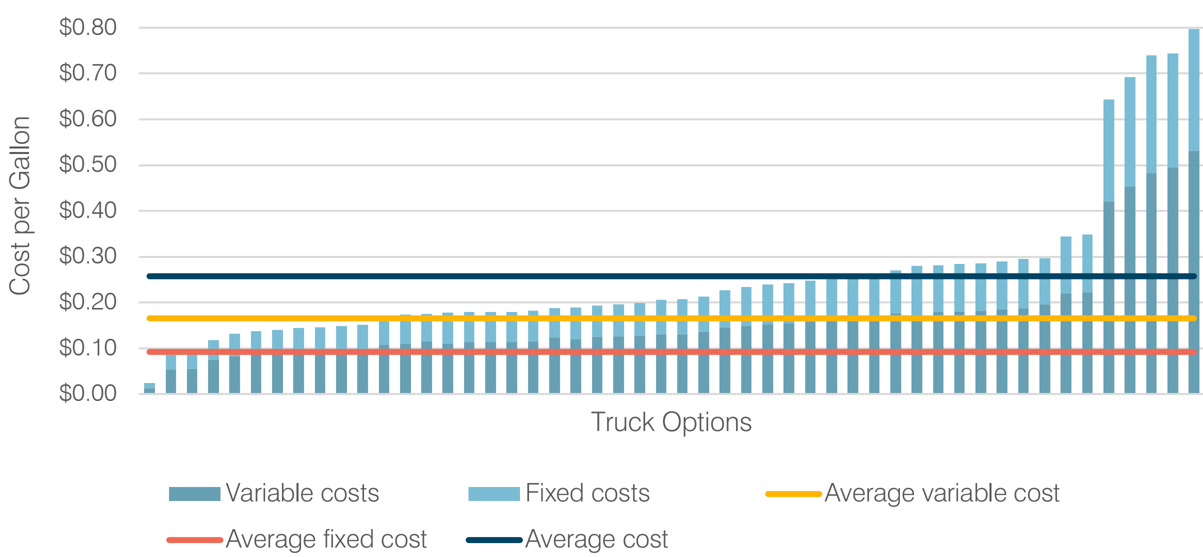
There is limited public information available related to trucking propane; however, it is clear from existing infrastructure configurations that trucking would be an increasingly important component of propane delivery in the event of supply disruption. The Rapid River terminal relies exclusively on trucking for distributing its propane production, and every other delivery point examined in this study relies on trucking to move product at some point. Using trucks to move propane has the advantage of being adaptable to changing conditions in a way that fixed infrastructure assets like rail and pipelines are not. Trucks carry smaller volumes of fuel and are typically used for more localized supply options and propane delivery between points within the state; however, use of trucking for propane transport into the state will likely increase under the scenarios considered.

PSC analyzed trucking routes from ten locations (nine terminals and one hub) to the five Michigan delivery points. Some of the origin points for trucking options included existing bulk terminals in the region. In total, PSC identified more than 50 routes between these origin and delivery points as well as their associated distances and transit time estimates.

PSC determined the cost of propane trucking for each of the routes identified based on a comprehensive cost analysis that included fixed costs, variable costs per mile, and variable hourly costs. These types of costs were also broken down into capital costs associated with truck and trailer ownership; incremental storage to accommodate increased volumes; additional transloading equipment; as well as variable costs for fuel, maintenance, insurance, and labor. A full discussion of cost assumptions for trucking is provided in Appendix D.

Using these estimates, PSC calculated the variable and fixed costs per gallon of propane shipped for each route. Exhibit 53 provides the range of fixed and variable costs for the possible routes for a single truck operating at full capacity. Average variable costs are $0.17 per gallon and average fixed costs are $0.09 per gallon. The highest-cost options represent truck transport from Edmonton, Alberta. Because of long cycle time from this location, relatively few gallons are delivered, which increases costs per gallon.

EXHIBIT 53. Range of Variable and Fixed Costs for Truck Options, per Gallon



Source: PSC calculations

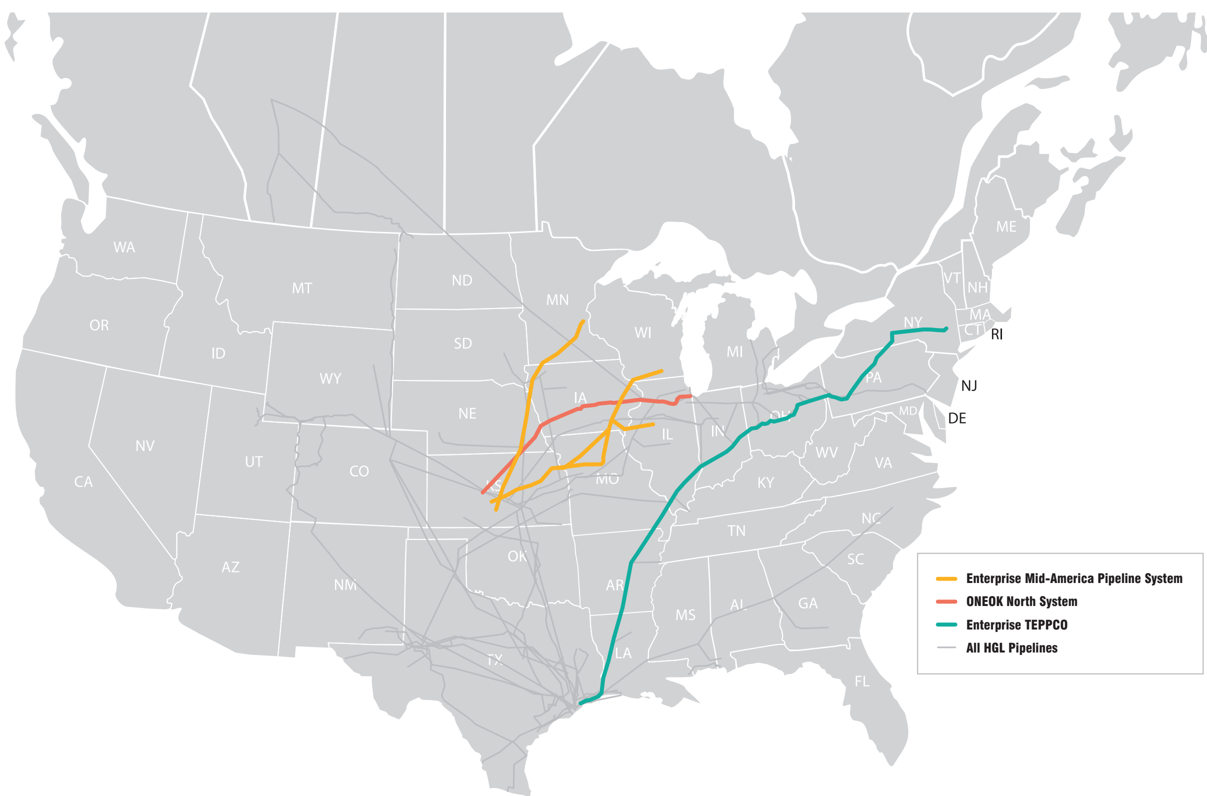
PSC's analysis is based on a single truck; however, some fixed-cost components, including transloader equipment, storage, and overhead, could be spread across a fleet of trucks, reducing the fixed costs allocated to each gallon delivered. Increasing fleet size to ten trucks would reduce average truck transport costs from $0.26 per gallon to $0.019 per gallon.

Pipeline

Propane supplies in North America are structured around several regional hubs that have sizeable production and storage facilities. In addition, these hubs are the epicenters of propane supply pipelines for the continent. Pipelines make up the vast majority of propane supply movements in the U.S., as they can ship large volumes long distances and operate at near continuous rates. Though there are advantages to pipelines, they cannot address every propane supply need. There are only three propane product pipelines that bring product into the Midwest and within proximity of Michigan—the TEPPCO pipeline out of Mont Belvieu, Texas; the Mid-America Conway North Pipeline system from Conway, Kansas; and the ONEOK North Pipeline out of Kansas (see Exhibit 54).

Each of these pipelines has several delivery points in PADD 2 and neighboring states from which Michigan could potentially access propane. Published pipeline tariffs provide the location of destination points along pipelines and the cost associated with shipment. PSC reviewed tariffs for the three pipelines and developed a list of potential supply points and their associated costs. These supply points are integrated into the supply options evaluated in the modeling process.

EXHIBIT 54. Hydrocarbon Gas Liquids Pipelines Map



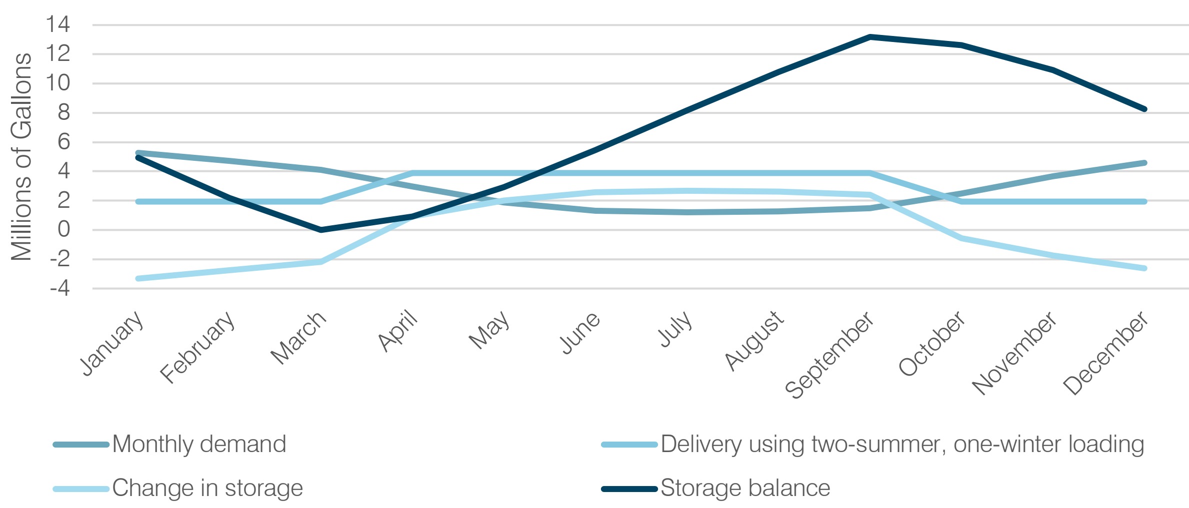
Source: U.S. EIA n.d.c

Storage Cost Assumptions

Storage capacity is a factor for consideration when determining acquisition patterns for gas purchasing. Because of monthly variation in hub prices, it may be advantageous to purchase propane in off-peak times, generally nonheating months, to benefit from lower fuel prices. Further, supply shipped by rail may have specific delivery requirements—e.g., some rail providers require two shipments in summer months for every shipment provided in winter months. In order to accommodate propane acquisition that varies from the consumption pattern, storage is required. To determine the storage capacity requirements, PSC examined how supplies would be drawn from or added to storage if propane were delivered in equal amounts each month or in a ratio of two to one in nonheating and heating months.

Assuming propane deliveries follow the two-to-one ratio, the Upper Peninsula would receive 3.89 million gallons per month from April through September and 1.94 million gallons per month from October to January. This results in a gradual increase in propane storage volumes beginning in April and a peak storage volume of 13.19 million gallons in September. As demand increases during the winter months, storage volumes gradually decline through March. Procuring supply using this alternate propane acquisition pattern would require at least 13 million gallons of storage. PSC estimates that the current storage capacity in the Upper Peninsula is approximately 10.8 million gallons, of which 1.5 million gallons is aboveground tank storage at the retail level and 9.2 million is in the form of customer propane tanks. Exhibit 55 shows the implications of this propane procurement strategy and the monthly changes in demand, deliveries, and storage volumes.

EXHIBIT 55. Upper Peninsula Storage Needs, Two-to-one Delivery Ratio (Millions of Gallons)



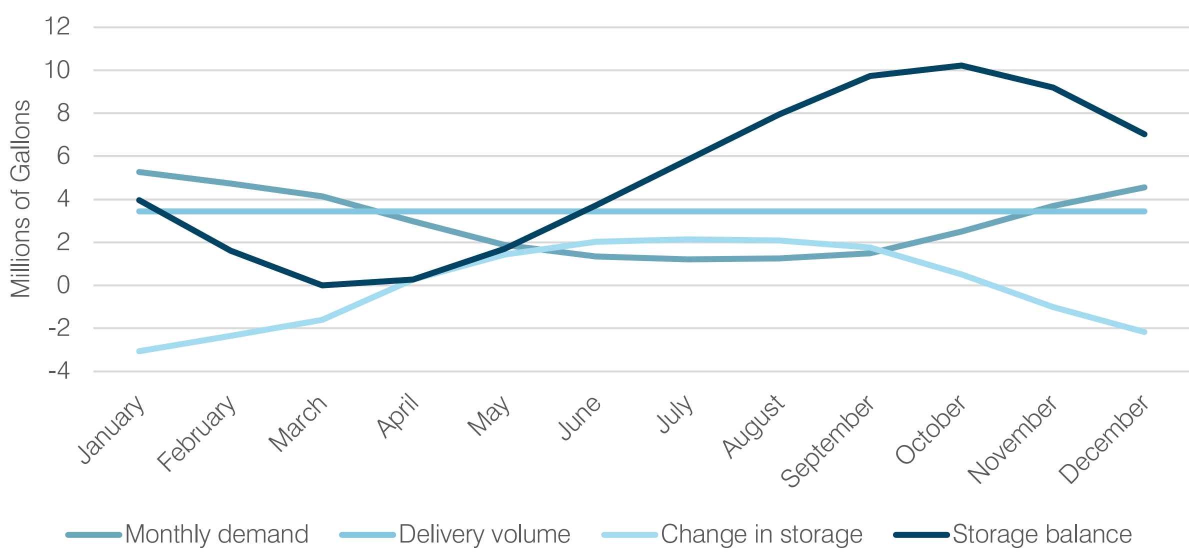
Month	Monthly Demand	Delivery Volume	Change in Storage	Ending Storage Balance
January	5.27	1.94	-3.32	4.96
February	4.72	1.94	-2.77	2.19
March	4.13	1.94	-2.19	0.00

Month	Monthly Demand	Delivery Volume	Change in Storage	Ending Storage Balance
April	2.97	3.89	0.92	0.92
May	1.89	3.89	2.00	2.93
June	1.33	3.89	2.56	5.48
July	1.21	3.89	2.68	8.16
August	1.25	3.89	2.64	10.80
September	1.50	3.89	2.39	**13.19**
October	2.49	1.94	-0.55	12.64
November	3.68	1.94	-1.73	10.91
December	4.57	1.94	-2.63	8.28

Source: PSC calculations

In the alternative supply scenario considered where propane is delivered at a flat rate for each month, PSC observed similar trends to those exhibited in the two-to-one delivery ratio alternative. To meet the total propane demand in the Upper Peninsula, deliveries would need to be 3.44 million gallons per month. Storage volumes would increase steadily from April to October, but the peak storage volume would be only 10.22 million gallons in the peak month (October). Though the Upper Peninsula would need less storage capacity in this alternative, Exhibit 56 shows the implications of this propane procurement strategy and the monthly changes in demand, deliveries, and storage volumes.

EXHIBIT 56. Upper Peninsula Storage Needs, Equal Monthly Deliveries (Millions of Gallons)



Month	Monthly Demand	Delivery Volume	Change in Storage	Storage Balance
January	5.27	3.44	-3.06	3.96

Month	Monthly Demand	Delivery Volume	Change in Storage	Storage Balance
February	4.72	3.44	-2.36	1.61
March	4.13	3.44	-1.61	0.00
April	2.97	3.44	0.27	0.27
May	1.89	3.44	1.42	1.69
June	1.33	3.44	2.02	3.71
July	1.21	3.44	2.14	5.85
August	1.25	3.44	2.10	7.95
September	1.50	3.44	1.77	9.72
October	2.49	3.44	0.50	**10.22**
November	3.68	3.44	-1.02	9.19
December	4.57	3.44	-2.17	7.02

Source: PSC calculations

Each of these procurement alternatives would potentially require additional storage capacity to meet propane demand. The bulk of storage volume in the Upper Peninsula, 85 percent, is in the form of customer propane tanks, and as such, storage use possibilities are limited. According to a survey of propane providers conducted by the MPSC as part of the 2019 Statewide Energy Assessment, 55 percent of customers are enrolled in programs that allow their propane provider to fill their propane tank as needed, referred to as a keep-full or courtesy-fill program. This enables customer-level storage resources to act as distributed storage and thus to be used as part of providers' procurement strategies. Assuming 55 percent of customers in the Upper Peninsula are enrolled in a keep-full program, up to 5 million gallons of customer storage could be utilized to ensure adequate propane storage volumes. The limitation of customer-level storage is that overall propane volumes could be adequate but individual customers who are purchasing propane on an as needed basis could potentially be vulnerable to supply issues.

Given potential storage needs to ensure adequate propane supplies, PSC estimated incremental storage volumes and associated costs for the Upper Peninsula. Looking at a range of storage expansion scenarios PSC ended up with three options, a low, medium, and high storage expansion. These scenarios reflect the levels of storage additions required based on reliance on alternate procurement patterns and utilization of retail and end-user storage as described below:

- **Low-storage option:** Under this option, there would be higher reliance on just-in-time propane delivery and utilization of retail and customer-level storage.
- **Medium-storage option:** Under this option, there would be reliance on combination of just-in-time and flat demand acquisition of propane or utilization of retail and customer-level storage.
- **High-storage option:** Under this option, incremental bulk storage is used to allow increased purchase of propane during nonheating months and ensure supply availability during heating months.

The low storage scenario results in 1.5 million gallons of new storage. The medium storage scenario would add 4.75 million gallons, and the high scenario would increase storage by 8 million gallons. Storage investment alternatives and associated costs are shown in Exhibit 57 Underlying calculations for storage costs are provided in Appendix F.

EXHIBIT 57. Upper Peninsula Storage Investment Costs Across Low, Medium, and High Scenarios

Storage Expansion Scenarios		Low	Medium	High
A.	New U.P. storage required (millions of gallons)	1,500,000	4,750,000	8,000,000
B.	Number of new storage tanks required (90,000 gallon)	16.67	52.78	88.89
C.	Estimated cost of one 90,000-gallon storage tank at 15 percent amortization rate over 20 years	$1,106,103	$1,106,103	$1,106,103
D.	Total estimated storage cost (B x C)	$18,435,054	$58,377,671	$98,320,288
E.	Storage costs per gallon (D/20 years/32.5 million gallons)	$0.150	$0.085	$0.028

Source: PSC calculations

Other Assumptions

There were a number of limitations to PSC's analysis of propane supply alternatives, including data availability, companies' willingness to provide certain information, and regulatory oversight of the industry. Due to these limitations, PSC has had to make a number of assumptions about propane supply dynamics and business decisions to assess propane supply alternatives. These assumptions have been vetted through conversations with industry participants, MPSC staff, and publicly available information. These assumptions were ultimately selected by PSC for the purposes of this analysis and are detailed below.

Focus on Propane Delivery

Given the limited propane processing capacity in the state and the intent of this analysis to identify alternative supplies of propane to meet customer needs, PSC did not consider alternatives that involved supply of NGLs or other feedstock to Michigan consumers. PSC assumed that without additional investment in propane production facilities, Michigan would rely on propane delivery from out of state and any investment in new production capacity would not be available to address short-term supply needs.

Propane Supply Availability

As profiled above, propane production has been growing across the continent in recent years. At the same time, propane demand has remained relatively flat, which has led producers to look for alternative markets for their products, predominantly exports to Asia, Europe, and Central and South America. Given current production levels, PSC assumes that North America will have adequate propane supplies available to meet Michigan demand. The limitation is the ability to cost-effectively transport product and to compete with greater demand from export markets.

Propane Supply Sources

The vast majority of propane produced in North America comes from three regional hubs in Edmonton, Alberta; Conway, Kansas; and Mont Belvieu, Texas. There are other sources of propane closer to Michigan, such as propane processing in the Chicago area, refineries in the region, or natural gas field processing in Ohio and Pennsylvania; however, price information is not available for these sources. Given the amount of propane produced and stored at these three hub locations, as well as the availability of price data for these locations, PSC assumes that these will be the primary sources of alternative propane supplies for Michigan.

Available Pipeline Capacity

PSC identified three pipelines that deliver propane into the region, the TEPPCO pipeline, Mid-America Conway North Pipeline, and ONEOK North Pipeline. While PSC was able to determine the products delivered, delivery points, total volume shipped, and associated prices, it was not possible to identify whether these pipelines had additional capacity to supply propane necessary to meet Michigan's needs. As such, PSC assumed that it would be possible to procure a portion of Michigan's propane needs from these pipelines.

Rail Supply Availability

Rail plays an important role in propane movements into the U.S. from Canada, between PADDs, and within regions. PSC assumes that existing rail capacity will be able to accommodate increased propane movements necessary to facilitate propane supply alternatives considered in this analysis. However, there are several potential limitations to relying on rail for propane supplies. Railroad strikes, protests impacting supply movements, and capacity constraints all impacted rail shipments in 2019. Additionally, rail, though able to move large volumes, does not have the same ability to deliver continuous supplies in the same manner that pipelines can. Other concerns about timeliness of rail shipments and the availability of rail delivery points are also potential challenges.

Propane Production from Refineries

The alternative supply scenarios examined in this report, impact more than propane supply. If disruptions occur to the infrastructure included in scenarios one and two, there will also be a disruption in the delivery of crude oil to refineries in Ontario, southeastern Michigan, and northern Ohio. As these refineries also produce propane as biproduct of crude oil refining, there are potential impacts to propane supplies from these sources. PSC assumes that propane production levels from these facilities will not be impacted as a result of the scenarios considered because the facilities will be able to access crude oil supplies from alternative sources. This analysis does not consider any alternatives for crude oil supply.

Propane Production from Utica and Marcellus Shale Plays

Extensive NGL resources are available from the Utica and Marcellus shale plays in eastern Ohio and the Appalachian region. Currently, pipeline infrastructure for delivering propane from this region to Michigan is limited, but trucking and rail could be supply options. However, PSC is limited in considering these resources in the model of alternatives because there is no spot price data available for this region. As such, these options have not been considered in this assessment. The expansion of the Utopia East pipeline could also be an option in the long term for shipping propane to Michigan, but this infrastructure would require additional investment and time.

Continued Operation of Superior Wisconsin

The Superior propane fractionator is supplied by Enbridge Line 1; however, the facility is not large enough to consume all of the NGL volume transported on the pipeline. Instead, NGLs continue to flow from Superior through Michigan on Line 5. For this analysis, PSC assumes that the Superior, Wisconsin, facility would continue operation in the event of a Line 5 closure and would continue to be supplied by Line 1 or receive NGLs from another source in Western Canada or the North Dakota region.

Reconfiguration of Rapid River

Of the three scenarios considered for this analysis, Line 5 and the Rapid River facility are impacted in two of them. This analysis does not consider alternative sources of NGL supplies to serve Rapid River and assumes that the facility would cease operating as a propane producer. However, given its central location and existing infrastructure, PSC assumes that Rapid River can continue to play a role in the propane supply picture for the Upper Peninsula by serving as a storage hub for propane delivery. Additional investment in rail capacity could potentially resupply the facility with NGL feedstock, but these considerations are beyond the scope of this analysis.

Propane Storage Capacity

The rebalancing of propane supplies will most likely require investment in infrastructure either to accommodate different transportation methods or supply configurations. PSC assumes that all alternative supply options considered would require some level of investment in storage capacity to facilitate changing delivery patterns associated with supply alternatives.

Propane Supply Scenarios

In consultation with EGLE, the MPSC, and U.P. Energy Task Force, PSC identified several propane supply scenarios that would alter Michigan's current propane supply configuration. These scenarios do not represent every potential disruption that Michigan could face and were not selected based on a formal assessment of risks facing the state's propane supply. Instead, these scenarios were developed based on direction provided in Governor Whitmer's executive order 2019-14, the input of task force members, findings from PSC's research, and information compiled through interviews with industry participants. Though not comprehensive, this set of scenarios and the subsequent analysis of alternatives provides a framework for reviewing other potential supply disruptions the state could face.

PSC's analysis of propane supply alternatives is based on addressing several potential disruptions to Michigan's propane supplies. The three supply scenarios selected for inclusion in this analysis were viewed as the most likely disruptions and those that would have the greatest impact on Michigan's propane supplies. Each of these scenarios and the applicable sensitivities have a quantifiable impact on Michigan's propane supply. Before defining the extent of the impact for each scenario considered, PSC worked to establish reasonable assumptions for the current state of propane supplies in Michigan. Underlying calculations for propane supply are provided in Appendix E.

Scenario One: Supply Disruption on Enbridge's Line 1

Enbridge's Lakehead system is a series of petroleum pipelines that transport products from Edmonton, Alberta, to Superior, Wisconsin, and subsequently on to markets in the Midwest and Eastern Canada. The Lakehead system transports a variety of products that are part of the supply chain for propane, including crude oil and NGLs. Crude oil and NGLs are transported on Enbridge's Line 1 from Edmonton to Superior and subsequently on Line 5 from Superior to the Rapid River fractionator and ultimately onto Sarnia. Line 1 has the capacity to ship 9,954,000 gallons or 237,000 barrels of crude oil and NGLs per day, of which approximately 33 percent is NGL and the remaining portion is crude oil. Line 5 has more than double the capacity of Line 1 and ships 21,000,000 gallons or 540,000 barrels of crude oil and NGLs per day. NGLs make up approximately 16 percent of the total volume shipped on Line 5 (Enbridge 2019).

The NGLs shipped via Lines 1 and 5 are the source for several propane fractionation facilities, including Superior, Wisconsin; Rapid River, Michigan; and Sarnia, Ontario. Together the propane production facilities served by Lines 1 and 5 represent 5.1 million gallons per day of gross operating capacity (Plains Midstream Canada 2019). Total propane production from these facilities supplied to Michigan customers amounts to 60.74 percent of Michigan's statewide propane consumption. This represents over 93.8 percent of the Upper Peninsula's propane supplies. PSC assumes that only a portion of propane imported from Sarnia is derived from NGLs delivered by Line 5.[13] Of the 224,093,940 gallons delivered to Michigan from Sarnia each year, PSC estimates that 199,428,558 million gallons or 89 percent are sourced from Line 5. The cumulative propane supplies jeopardized by an outage on Line 1 results in shortfall of 256,923,940 million gallons of propane for the state of Michigan, the equivalent to 46.5 percent of statewide supplies and 42.9 percent of the Lower Peninsula's propane supplies.

In addition to NGLs, Line 5 carries over 17.5 million gallons of crude oil per day, serving refineries in Lower Michigan, Ontario, and Ohio (Enbridge pers. comm.). While a portion of this product will end up as propane, the vast majority is refined for other petroleum products. PSC's analysis does not assume a direct impact on Michigan's propane supplies as a result because refineries supplying propane to Michigan will be able to source alternative crude oil supplies from locations out of state and produce roughly the same amount of propane.

EXHIBIT 58. Impact of Scenario One: Supply Disruption on Enbridge's Line 1

Facility	Owner	Location	Annual Production	Percentage of Peninsula's Supply
Rapid River Fractionator	Plains Midstream Canada	Rapid River, Michigan	30,660,000	87.6%

[13] PSC could not verify that Sarnia receives feedstock for propane production from other sources in addition to Line 5. Shipments of NGLs to Sarnia via Line 5, provided by Enbridge, and the net imports from Sarnia to Michigan, provided by the U.S. EIA form the basis of this assumption. If Sarnia sourced NGLs exclusively from Line 5, the Plains Midstream Canada facility located in Sarnia would have a capacity utilization rate of 72 percent (comparing rated capacity to actual production). PSC assumed that Sarnia operated at a higher capacity rate (95 percent) for the development of supply assumptions, which would indicate that only a portion of production from the region is supplied by Line 5. Using a lower capacity factor assumption would increase the proportion of propane imported from Sarnia that is attributable to Line 5. PSC's analysis includes calculations for supply impacts of a conservative assumption and an assumption that Line 5 is the only source of supply to Sarnia. Plains Midstream Canada did not return repeated requests to provide input on these assumptions. PSC's approach is a conservative estimate of Line 5's contribution to Michigan's propane demand and is in line with other estimates. A complete discussion of supply assumptions is provided in Appendix E.

Facility	Owner	Location	Annual Production	Percentage of Peninsula's Supply
Superior Fractionator	Plains Midstream Canada	Superior, Wisconsin	2,170,000	6.2%
Total Upper Peninsula Propane Supply Impact			**32,830,000**	**93.8%**
Ontario Facilities	Plains Midstream Canada	Sarnia, Ontario	199,428,558	42.9%
Total Lower Peninsula Propane Supply Impact			**199,428,558**	**42.9%**
Total Statewide Propane Supply Impact			**232,258,558**	**46.5%**

Source: PSC calculations

Scenario Two: Supply Disruption on Enbridge's Line 5

Enbridge's Line 5 transports light crude oil and NGLs from Superior, Wisconsin, through Michigan to Sarnia, Ontario. The total capacity of Line 5 is 540,000 barrels or 22,680,000 gallons per day. Enbridge estimates that 21,000,000 gallons of combined product is shipped per day. NGLs represent nearly 16 percent of the total volume shipped on Line 5 (Enbridge 2019).

Line 5 supplies NGLs to the Rapid River facility in the Upper Peninsula and the Sarnia complex in Ontario. Combined, Rapid River and Sarnia have over 4.7 million gallons per day (Plains Midstream Canada 2019). The cumulative propane supplies jeopardized by an outage on Line 5 results in shortfall of 230.1 million gallons of propane for the state of Michigan, the equivalent to 46 percent of statewide supplies. These facilities represent 87.6 percent of supplies for the Upper Peninsula and 42.9 percent of the Lower Peninsula's supplies.

In addition to NGLs, Line 5 carries more than 17.5 million gallons of crude oil per day, serving refineries in Lower Michigan, Ontario, and Ohio (Enbridge pers. comm.). While a portion of this product will end up as propane, the vast majority is refined for other petroleum products. PSC's analysis does not assume a significant impact on Michigan's propane supplies as a result of a potential reduction in propane productions from refineries drawing crude oil from Line 5.

EXHIBIT 59. Impact of Scenario Two: Supply Disruption on Enbridge's Line 5

Facility	Owner	Location	Annual Production	Percentage of Peninsula's Supply
Rapid River Fractionator	Plains Midstream Canada	Rapid River, Michigan	30,660,000	87.6%
Total Upper Peninsula Propane Supply Impact			**30,660,000**	**87.6%**
Ontario Facilities	Plains Midstream Canada	Sarnia, Ontario	199,428,558	42.9%
Total Lower Peninsula Propane Supply Impact			**199,428,558**	**42.9%**
Total Statewide Propane Supply Impact			**230,088,558**	**46.02%**

Source: PSC calculations

Scenario Three: Weather-related Supply Disruption

As propane demand fluctuates seasonally based on the need for space heating or for other weather-related end uses, such as grain drying, it is vital to consider the role weather can play in creating potential disruptions to propane supply. There are numerous examples in recent years that highlight the impact weather can have in driving propane demand from month to month. Given the variable impact weather can have, it makes sense to consider a scenario where extreme weather creates challenges for meeting propane supplies.

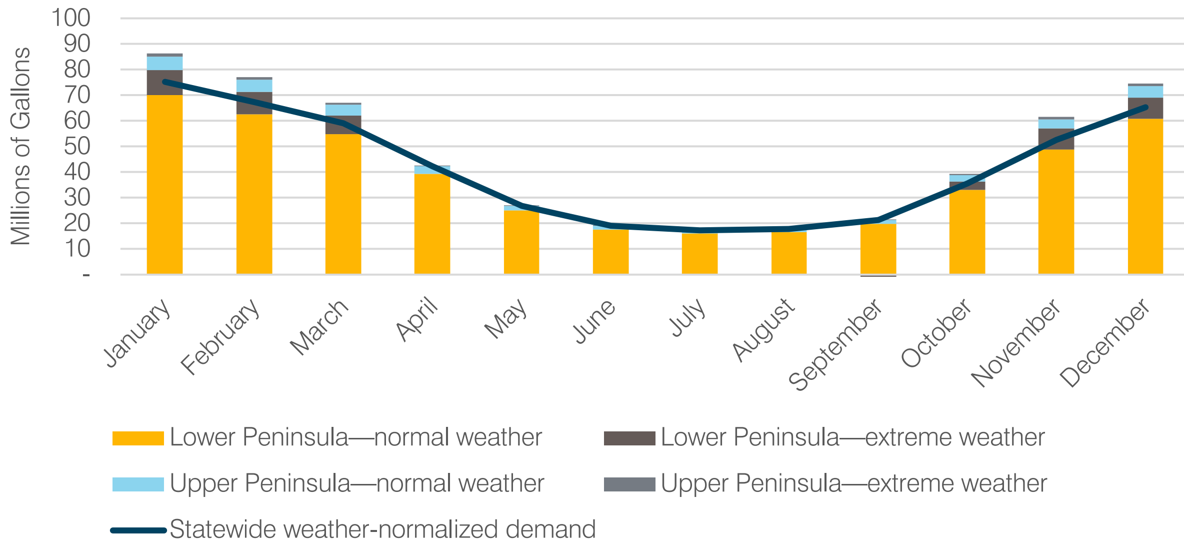
The basis for this scenario is formed by the experience of the polar vortex that occurred during the winter of 2013–2014. Winter temperatures for the Midwest and across the country were well below average, which led to increased consumption for home heating fuels. Across the energy sector, supply issues threatened energy production and delivery, and propane users in the Midwest were strongly affected. One of the main reasons for this was the fact that 36 percent of all households that depend on propane are in the Midwest and two key elements of propane supply into the region were not operating. The Cochin pipeline, which until March 2014 carried propane from western Canada into the Midwest, was reversed, decreasing supply options, and a Line 5 outage limited regional propane supply.[14] Another part of the challenge was the extreme cold, with temperatures nearly 20 percent lower than the average for the previous ten years. Customers used more propane to combat the cold, which stressed storage volumes and distribution centers across the region. Hub, wholesale, and residential prices all rose between January and February 2014, and it took the industry months to replenish storage levels. Government officials and propane providers took a close look at how to guard against a similar event in the future.

Scenario three does not incorporate the exact same confluence of events that led to the dramatic propane price spikes across the Midwest in early 2014. Instead, this scenario looks at the impact similar weather conditions would have on Michigan propane demand and the alternatives that are available for Michigan consumers to access propane supplies. Because the 2013–2014 polar vortex experience was brought on by a series of events, PSC will also look at how extreme weather coupled with other supply-related impacts would impact Michigan consumers, this is discussed in the following section related to sensitivities analysis.

As modeled for this analysis, an extreme weather scenario that results in a 20 percent increase in HDDs will lead to a 10 percent increase in annual propane consumption in Michigan. The seasonal nature of propane demand combined with cold weather events occurring during winter months means that impacts on propane consumption during winter months will be substantially higher than at other times. In the Upper Peninsula, propane demand is estimated to increase 22 percent each month from November through March. Demand in the Lower Peninsula also increases as a result of colder temperatures, rising more than 13 percent during winter months. The impact of this scenario on monthly demand is shown below in Exhibit 60.

[14] Though the Cochin pipeline continued shipping propane to U.S. markets until Mach 2014, the pipeline was operating at approximately 50 percent of its historical capacity starting in April 2013, while existing pump stations were reconfigured to reverse the pipeline's flow (Harvest Land Cooperative 2012).

EXHIBIT 60. Impact of Scenario Three: Weather-related Supply Disruption



Source: PSC calculations

Modeling Sensitivities

The sensitivities included in this analysis, represent different assumptions for ways that external factors can impact supply scenarios and enable an additional layer of scrutiny for evaluating the short- and long-term impacts of potential disruptions on Michigan's propane supply needs.

Demand Reduction Through Conservation

One sensitivity included in the analysis of propane supply alternatives is the potential for reducing propane consumption through enhanced investment in energy efficiency for customers. Energy-efficiency programs have consistently demonstrated that they can yield long-term savings for customers as they eliminate energy waste and reduce overall energy consumption. These programs are not yet as widespread for customers who depend on deliverable fuels. PSC's sensitivity will consider what energy-efficiency savings measures deployed on a statewide basis could do to lower total propane demand and the impact these investments could have on the supply alternatives being considered. PSC demand reduction sensitivity is based on demonstrated performance in natural gas energy-efficiency program delivery and assumes that the state can achieve 1.5 percent annual demand reductions for a ten-year period.

Weather

PSC's weather-dependent propane demand assumes that Michigan's heating needs will be consistent with past experience (based on a weighted average for HDDs during a ten-year period). However, there is sometimes significant variability in weather and subsequently home heating needs. PSC determined that applying a sensitivity to the analysis for propane supply alternatives would help the state be better prepared in the case of a propane supply disruption. PSC has developed two different weather sensitivities that will be layered with the analysis of supply scenarios—one for above-average seasonal heating demands and one for below-average heating demand. These scenarios will impact the monthly propane consumption for Michigan households and drive different supply considerations for propane providers. In the case of a colder-than-average heating season, propane consumption during affected months could rise as much as 17 percent statewide.

For the extreme weather scenarios, PSC utilized the regression model used to create a weather-normalized monthly demand curve, increasing HDDs by 20 percent for the severe weather case and decreasing HDDs by 15 percent for the mild-weather scenario. Overall consumption is estimated to increase by 10 percent in the severe weather case and decrease by 7 percent in the case of mild weather.

Customer Storage Optimization

Propane consumption is a highly seasonal industry. As discussed above, 40 percent of the state's propane demand is not weather dependent, meaning that more than 40 percent of propane consumption is for space heating or other weather-related end uses. Given the variability in propane consumption customers, retailers and propane marketers rely on storage to safely and reliably deliver propane when it is needed. There are 320,680 households in Michigan that use propane for their primary space heating needs, which equates to 8.2 percent of all households (U.S. Census Bureau 2018). Assuming the average household has a 500-gallon tank holding 400 gallons of propane, the total available storage capacity for Michigan's households is nearly 150 million gallons.[15] This is equal to 38 percent of total residential propane consumption.

One way to better prepare for propane supply disruptions is through the optimization of all storage resources, which includes customer-level storage. According to a survey of propane providers conducted by the Michigan Public Service Commission in 2019, 55 percent of retail customers are enrolled in programs that allow their provider to fill their tank automatically.[16] In these cases, propane retailers can ensure that customers have enough fuel to meet their needs, filling tanks throughout the nonheating season. There is an added advantage to this practice that potentially allows customers to access lower wholesale prices during off-peak times.

For this scenario, PSC assumed that an additional 25 percent of residential customers participate in prefill programs. By filling customers' storage in advance of the heating season, retailers can reduce the need to procure propane during periods of high demand and utilize other storage resources to ensure adequate supply. Customers with full tanks at the beginning of the heating season would have sufficient supply to last between October to the first of December. Tanks would need to be refilled in early December to ensure adequate supply through the peak heating season. PSC assumed that customer storage for the average consumer in the Upper Peninsula is sufficient for 50 days of peak consumption if fully utilized. While customer storage does help to mitigate supply disruption impacts, PSC identified additional need for bulk storage for many of the supply alternatives.

[15] This number does not factor in households that have propane tanks for nonprimary space heating or who have different-sized tanks.

[16] The survey collected responses from 18 providers who collectively serve 122,302 customers or 32.1 percent of households in the state.

Modeling Results

Supply Alternatives

PSC modeled supply alternatives using a supply curve approach, meaning costs were calculated for multiple options based on combinations of sourcing from three hubs across the U.S. and Canada, different transportation routes and modes, and delivery to five targeted delivery points in the state.[17] For each combination of hub, transportation mode, and delivery point, PSC assessed different propane procurement patterns that impact hub price and the need for storage at or near the delivery points. Over 170 permutations were considered for each delivery point. After the costs associated with each supply alternative and delivery point were calculated, PSC identified the lowest-cost options to use in developing the supply curve. Separate supply curves were constructed by ranking options based on per-unit cost and selecting the four lowest-cost options for each delivery point. These supply options were then examined further to assess the robustness and applicability of each option.

The following exhibits document the priority options for each delivery site. For each option, the components of cost, including fuel, transportation, and storage, are shown.

Supply Options for Delivery to the Western Upper Peninsula

PSC's analysis shows that the Rapid River facility is responsible for the majority of propane supplies in the Upper Peninsula. According to pricing data from EIA, average spot market prices for Rapid River were $0.79 per gallon in 2017, $0.83 per gallon in 2018, and $0.60 per gallon in 2019. The four lowest-cost alternatives identified for propane delivery to Rapid River range from $0.64 to $0.82 per gallon. The lowest-cost alternative for propane supply to the Western Upper Peninsula is propane purchased in Edmonton, Alberta, that is shipped via rail to Escanaba, Michigan, and subsequently transported to Rapid River by truck. This option was the closest to the spot price observed at Rapid River for 2019, at $0.04 more per gallon. PSC compared the sum of cost components for priority options to spot market prices observed at Rapid River. PSC recognizes this may not reflect an exact comparison for Rapid River because spot market prices include unobservable costs, such as operational costs, facility maintenance, and profit margins. Given that Rapid River's operational characteristics would change under this scenario (e.g., by no longer producing propane), it is reasonable to assume that there could be additional costs for the continued operation or reconfiguration of the Rapid River facility. However, the comparison between spot market prices and alternative supply options is useful in establishing a floor for expected price impacts. PSC calculated that the potential incremental costs to maintain operation of Rapid River would be in line with current calculated price spread, less than $0.12 per gallon, based on the following formula.

[17] While PSC modeled supply alternatives from Mont Belvieu, Texas, none of the options fell into the top priorities for each delivery point.

$$
\begin{aligned}
&Price\ Spread\ at\ Rapid\ River\ (\$0.12) \\
&\quad = 2019\ Propane\ Spot\ Price\ for\ Rapid\ River\ (\$0.60) \\
&\quad - 2019\ Propane\ Spot\ Price\ at\ Edmonton\ (\$0.386) \\
&\quad - 2019\ Line\ 5\ Transportation\ Cost\ from\ Edmonton\ to\ Rapid\ River\ (\$0.0853)
\end{aligned}
$$
[18]

One factor contributing to this option's higher costs is the need for increased storage capacity to handle propane deliveries from rail. PSC assumed that rail deliveries would be contracted using a two-to-one ratio, resulting in more propane being received in summer months and necessitating the development of incremental storage capacity to accommodate this supply configuration.

The other low-cost options considered were at least $0.18 per gallon higher than 2019 spot prices at Rapid River and reflect the higher price for fuel from Conway, Kansas. These three options would utilize existing pipeline capacity to bring propane from Conway to intermediate storage terminals in Wisconsin, Iowa, and Minnesota, with transport from these locations to Rapid River via truck. Review of these supply options illustrates the cost advantage of pipeline transportation. There is very little difference in the cost of transportation to intermediate locations and the majority of the cost spread is from the trucking transportation to the final delivery point. This demonstrates that the longer the distance travelled via truck the higher the total cost of that supply option. The complete cost breakdown for priority supply options is provided in Exhibit 61.

[18] PSC could not identify the explicit costs contained in the price spread for Rapid River, though it was assumed the formula accounts for operations, maintenance, overhead, and a profit margin. PSC was also unable to identify a source for NGLs sourced from Edmonton, Alberta, and substituted the price of propane, but any cost increase or decrease in the commodity price paid for product delivered to Rapid River will affect the price spread (CER February 2020). Rapid River's spot price was calculated from U.S. EIA data (U.S. EIA November 13, 2019). The transportation cost associated with Line 5 comes from published tariffs for the pipeline (Enbridge 2020).

EXHIBIT 61. Priority Options for Delivery to Rapid River, Michigan (Dollars per Gallon)

		Costs				
Option	Acquisition Pattern	Commodity	Transport to Intermediate Location	Transport to Final Location	Storage	Total
Edmonton, Alberta, to Escanaba, Michigan (by rail), to Rapid River, Michigan (by truck)	Two-one	$0.2770	$0.1913	$0.0200	$0.1585	$0.6468
Conway, Kansas, to Janesville, Wisconsin (by pipeline), to Rapid River, Michigan (by truck)	Flat demand	$0.4739	$0.0856	$0.1400	$0.0897	$0.7892
Conway, Kansas, to Dubuque, Iowa (by pipeline), to Rapid River, Michigan (by truck)	Flat demand	$0.4739	$0.0738h	$0.1705	$0.0897	$0.8079
Conway, Kansas, to Inver Heights Grove, Minnesota (by pipeline), to Rapid River, Michigan (by truck)	Flat demand	$0.4739	$0.0735	$0.2498	$0.0299	$0.8272

Source: PSC calculations

Supply Options for Delivery to the Eastern Upper Peninsula

PSC was not able to access price information to compare supply options to the Kincheloe delivery point in the eastern Upper Peninsula; however, the Rapid River spot price is appropriate for comparison given how much of the Upper Peninsula's propane demand the location supplies. The four lowest-cost options for delivery to Kincheloe ranged from $0.62 to $0.88 per gallon. Compared to the 2019 spot price at Rapid River these alternative supply options were anywhere from $0.02 to $0.28 cents per gallon higher.

Unlike Rapid River, Kincheloe is served by rail and can receive propane shipments without needing to utilize trucking capacity. This provides a price advantage for Kincheloe's lowest cost-alternative, which relies on propane shipments from Edmonton, Alberta via rail. However, because Kincheloe has fewer storage volume deliveries to the facility and operates on a just-in-time basis, it experiences higher prices at the hub level because it cannot take advantage of purchasing at off-peak times. Despite paying higher commodity costs, low transportation and incremental storage costs help make this option competitive with spot prices from Rapid River for 2019.

The other top supply options for the eastern Upper Peninsula all come from Conway, Kansas, though by different transportation modes. The second lowest-cost option also relies entirely on rail transportation but originates in Conway. Though utilizing rail transportation, this alternative requires greater investment in storage to accommodate the configuration of deliveries, resulting in higher prices. The next-best options both are based on pipeline transport to intermediate destinations and trucking to the final delivery point. Each of these supply alternatives is at least 22 cents per gallon above 2019 spot prices at Rapid River, as shown in Exhibit 62.

EXHIBIT 62. Priority Options for Delivery to Kincheloe, Michigan (Dollars per Gallon)

		Costs				
Option	Acquisition Pattern	Commodity	Transport to Intermediate Location	Transport to Final Location	Storage	Total
Edmonton, Alberta, to Kincheloe, Michigan (by rail)	Normal weather (just-in-time)	$0.3387	$0.2528	$0.0000	$0.0299	$0.6214
Conway, Kansas, to Kincheloe, Michigan (by rail)	Two-one	$0.4571	$0.2111	$0.0000	$0.1595	$0.8277
Conway, Kansas, to East Chicago, Indiana (by pipeline), to Kincheloe, Michigan (by truck)	Flat demand	$0.4739	$0.1077	$0.1962	$0.0897	$0.8675
Conway, Kansas, to Janesville, Wisconsin (by pipeline), to Kincheloe, Michigan (by truck)	Flat demand	$0.4739	$0.0856	$0.2316	$0.0897	$0.8808

Source: PSC calculations

Supply Options for Delivery to the Western Lower Peninsula

Rail delivery of propane from Edmonton, Alberta, to Alto, Michigan is the lowest-cost option identified, at $0.64 per gallon. Under this supply alternative, supply would be delivered at the two-to-one ratio for summer and winter months, respectively. Incremental storage is required to accommodate the delivery of excess supply during nonheating months.

The next two priority options both originate in Conway, Kansas. Despite different delivery paths, the options are estimated at less than $0.01 difference in cost. The first option would entail delivery by rail to Alto on a schedule consistent with the monthly demand. Though the commodity cost is somewhat higher, it is offset by the elimination of the need to provide any incremental storage. Delivery of equal increments of propane each month from Conway via pipeline to East Chicago, Indiana, and then by truck to Alto comes in at almost exactly the same cost; the need for incremental storage to accommodate the delivery pattern is offset by lower commodity and transport costs.

The fourth priority option entails transportation from Edmonton, Alberta, by rail to Escanaba, Michigan, and transportation by truck to Alto. This option costs approximately $0.14 more per gallon than the first priority option, as the additional truck transport costs exceed the slightly lower rail cost for this option.

EXHIBIT 63. Priority Options for Delivery to Alto, Michigan (Dollars per Gallon)

		Costs				
Option	Acquisition Pattern	Commodity	Transport to Intermediate Location	Transport to Final Location	Storage	Total
Edmonton, Alberta, to Alto, Michigan (by rail)	Two-one	$0.2770	$0.2240	$0.0000	$0.1369	$0.6379
Conway, Kansas, to Alto, Michigan (by rail)	Normal weather (just-in-time)	$0.5053	$0.2447	$0.0000	$0.0000	$0.7500
Conway, Kansas, to East Chicago, Indiana (by pipeline), to Alto, Michigan (by truck)	Flat demand	$0.4739	$0.1077	$0.1238	$0.0459	$0.7513
Edmonton, Alberta, to Escanaba, Michigan (by rail), to Alto, Michigan (by truck)	Two-one	$0.2770	$0.1909	$0.1754	$0.1369	$0.7803

Source: PSC calculations

Supply Options for Delivery to the Northern Lower Peninsula

For delivery to Kalkaska, Michigan, again, the lowest-cost option originates in Edmonton, Alberta, and travels most of the distance to the final delivery point by rail. In this case, propane is delivered by rail to Escanaba, Michigan, and then transported by truck to Kalkaska.

The next two best options have very similar costs, and each originate in Conway, Kansas, and are transported to East Chicago, Indiana, to Kalkaska. In the first of the two options, delivery is made consistent with the consumption of propane in the state, i.e., more propane is delivered in heating months and less in months where there is little or no weather-driven propane consumption. For this alternative, commodity and transportation costs are higher than the next alternative, under which propane would be delivered in equal increments each month. The next alternative has lower expected commodity costs because of the greater volume of propane procured during off-peak periods. In addition, transportation costs are lower because the flat demand allows for using trucking resources at full capacity throughout the year, resulting in lower per-unit costs. These savings, however, are offset by the need for storage to meet variable demand for propane.

The fourth alternative would include propane from Conway, Kansas, transported by pipeline to Janesville, Wisconsin, and then delivery by truck to Kalkaska. The greater distance between Janesville and Kalkaska results in higher costs for transport from the intermediate to the final location. This accounts for the more than $0.06 per gallon cost difference over the second- and third-priority alternatives and a $0.15 premium over the lowest-cost alternative.

EXHIBIT 64. Options for Delivery to Kalkaska, Michigan (Dollars per Gallon)

Option	Acquisition Pattern	Costs Commodity	Transport to Intermediate Location	Transport to Final Location	Storage	Total
Edmonton, Alberta, to Escanaba, Michigan (by rail), to Kalkaska, Michigan (by truck)	Two-one	$0.2770	$0.1909	$0.1171	$0.1369	$0.7219
Conway, Kansas, to East Chicago, Indiana (by pipeline), to Kalkaska, Michigan (by truck)	Normal weather (just-in-time)	$0.5053	$0.1077	$0.1868	$0.0000	$0.7997
Conway, Kansas, to East Chicago, Indiana (by pipeline), to Kalkaska, Michigan (by truck)	Flat demand	$0.4739	$0.1077	$0.1369	$0.0910	$0.8096
Conway, Kansas, to Janesville, Wisconsin (by pipeline), to Kalkaska, Michigan (by truck)	Flat demand	$0.4739	$0.0856	$0.2222	$0.0910	$0.8728

Source: PSC calculations

Supply Options for Delivery to the Eastern Lower Peninsula

Propane supplies from Edmonton were the lowest-cost option identified for delivery to southeastern Michigan. This is primarily due to two factors. First, Edmonton has historically exhibited low commodity prices and continued to do so throughout the development of this analysis. Second, access to rail from Edmonton to Marysville makes it possible to avoid incremental costs associated with transloading and storage. The delivered price to Marysville was $0.65 per gallon. Compared to spot prices at Sarnia for 2019, the Edmonton supply alternative potentially offers a cost savings. Throughout 2019, the Sarnia hub was priced approximately $0.40 higher than Edmonton, meaning that any supply route from Edmonton that was priced at that level could be more cost effective.

The remaining three options all originate in Conway, Kansas. Two options rely on pipeline shipment to intermediate locations, in East Chicago, Indiana, and Dubuque, Iowa. Propane is subsequently shipped from these facilities to Marysville via truck. The third option relies on rail delivery from Conway to Marysville. Rail transportation costs from Conway to Marysville are closely aligned with the costs from Edmonton to Marysville, yet despite the similar transportation costs, the Conway alternative is $0.18 per gallon more due to higher commodity prices at Conway. These three alternatives exceed $0.80 per gallon and would represent a cost increase compared to 2019 prices at Sarnia. It is possible that substantial existing storage capacity at Marysville could be utilized to allow for alternate acquisition patterns, negating the need to add bulk storage capacity. In that case, costs for priority options to Marysville would drop by $0.0914 to $0.137 per gallon.

EXHIBIT 65. Priority Options for Delivery to Marysville, Michigan (Dollars per Gallon)

Option	Acquisition Pattern	Costs				
		Commodity	Transport to Intermediate Location	Transport to Final Location	Storage	Total
Edmonton, Alberta, to Marysville, Michigan (by rail)	Two-one	$0.2770	$0.2360	$0.00	$0.1370	$0.6501
Conway, Kansas, to East Chicago, Indiana (by pipeline), to Marysville, Michigan (by truck)	Flat demand	$0.4739	$0.1077	$0.1456	$0.0914	$0.8186
Conway, Kansas, to Marysville, Michigan (by rail)	Two-one	$0.4571	$0.2409	$0.000	$0.1370	$0.8351
Conway, Kansas, to Dubuque, Iowa (by pipeline), to Marysville, Michigan by truck	Flat demand	$0.4739	$0.0738	$0.2399	$0.0914	$0.8790

Source: PSC calculations

Other Supply Alternatives

The priority alternatives were selected from a wide range of supply alternatives that PSC identified and modeled. These supply alternatives drew on the same points of Mont Belvieu, Conway, and Edmonton, but they had different transportation pathways to delivery points in Michigan. The supply options examined illustrate the range of potential costs associated with propane supply alternatives and the myriad considerations for wholesalers and retailers running their businesses. The range of options considered for each delivery point is shown in Appendix G.

Scenarios and Sensitivities

For each of the scenarios and sensitivities laid out in this study, PSC calculated the impact on available propane supply in both the Upper Peninsula and the Lower Peninsula, i.e., the amount of propane that would need to be procured from alternative resources. Alternative supply resources were allocated between selected delivery points in Michigan. For the Upper Peninsula, PSC assumed that Kincheloe would receive 40 percent of supply and Rapid River would receive the remaining 60 percent. The allocation of deliveries in the Lower Peninsula is 30 percent to Alto, 30 percent to Kalkaska, and 40 percent to Marysville. These allocations were roughly determined based on proximity to customer demand, available storage, and historical supply patterns. The following section details propane needs for each scenario and sensitivity as well as the associated costs based on the supply alternatives discussed.

Scenario One Results

Scenario one would result in the greatest impact on Michigan's current propane supplies. The combination of lost production from Sarnia, Rapid River, and Superior facilities would jeopardize over 46.5 percent of the propane consumed by Michigan customers. In the base case for scenario one, the Upper Peninsula would need to procure nearly 33 million gallons of propane to replace the annual output of its lost supply. The total volume impacted in the Lower Peninsula would approach 200 million gallons on an annual basis.

Coupled with extreme cold weather, the impact of scenario one would be even more pronounced as consumption increases in reaction to cold temperatures. The proportional effect on the Upper Peninsula is greater under an extreme weather sensitivity. Not only would the state already be looking to replace more than 90 percent of the region's supply, but the deficit would increase as cold weather drives propane needs 20 percent higher.

In the long run, energy-efficiency investment can play a role in reducing propane consumption and help to lessen the impact of a supply disruption. PSC assessed the role annual savings targets could play in reducing overall consumption. Savings targets are typically set at 1 to 1.5 percent of total consumption per year. As such, this sensitivity would not have any impact in the short run before efficiency measures have been installed, but each year efficiency investments are prioritized and savings accumulate, the potential impact of a supply disruption decreases. In scenario one, PSC estimates that target energy-efficiency investment could achieve 1.25 percent savings. Energy-efficiency improvements that would reduce propane use often entail equipment upgrades and thermal envelope improvements, i.e., installation of insulation, window replacement, or infiltration reduction. These improvements have long-term impacts, with savings realized for 12 to 25 years (MPSC 2020).

Greater utilization of customers' storage will also help reduce the exposure to consequences of a supply disruption. Customer storage is also a cost-effective option in many cases because it utilizes existing capacity resources. By increasing customer participation in automatic fill-up programs, retailers can better optimize storage volumes and manage their other resources to prepare for winter heating months. In the case of scenario one, greater use of customer-level storage can help reduce the impact of a supply disruption by an estimate 14.7 percent from the base case.

EXHIBIT 66. Alternative Supply Needs for Scenario One: Supply Disruption on Enbridge's Line 1 (Millions of Gallons)

Location of Supply Delivery	Base	Sensitivity One–Severe Weather	Sensitivity Two–Energy-efficiency Reduction	Sensitivity Three–Customer Storage
Kincheloe, Michigan	13.13	15.63	12.61	10.88
Rapid River, Michigan	19.70	23.45	19.17	17.45
Alto, Michigan	59.83	72.96	58.09	50.91
Kalkaska, Michigan	59.83	72.96	58.09	50.91
Marysville, Michigan	79.78	97.28	77.45	67.88
Total	**232.27**	**282.27**	**225.41**	**198.02**

Note: Columns may not total due to rounding.

Source: PSC calculations

Relying on the portfolio of alternative propane supply options identified and the estimated impact on Michigan supply, PSC was able to calculate the estimated cost of each scenario and sensitivity. The costs for each scenario take into account the four lowest-cost supply alternatives and assume that 50 percent of supply can be procured from the lowest-cost resource, 30 percent from the second lowest-cost option, and 20 percent from the third lowest-cost resource.

The total cost of scenario one is estimated to be between $147 and $210 million per year. **The cost of the base case for scenario one is $173 million dollars, which totals approximately $0.745 per gallon of propane delivered. Compared to 2019 prices in Rapid River and Sarnia, this base case would result in higher costs for Michigan customers.** The lowest-cost scenario was based on the customer storage sensitivity, which decreased the amount of propane that would need to be procured and curbed the impact of the supply disruption. The energy-efficiency sensitivity would reduce propane supply costs by $5 million compared to the base case. The annual $5 million savings over the life of energy-efficiency measures installed has a present value between $35 and $45 million.[19] This amount could be invested cost-effectively to achieve savings of 1.25 percent of total annual propane consumption. The extreme cold weather sensitivity had the highest observed cost of all the scenario one options.

EXHIBIT 67. Supply Costs for Scenario One: Supply Disruption on Enbridge's Line 1 (Millions of Dollars)

Location of Supply Delivery	Base	Sensitivity One–Severe Weather	Sensitivity Two–Energy-efficiency Reduction	Sensitivity Three–Customer Storage
Kincheloe, Michigan	$9.6	$11.5	$9.2	$8.0
Rapid River, Michigan	$14.2	$16.9	$13.8	$12.6
Alto, Michigan	$42.5	$51.9	$41.3	$36.2
Kalkaska, Michigan	$46.9	$57.2	$45.5	$39.9
Marysville, Michigan	$59.8	$73.0	$58.9	$50.9
Total	**$173.1**	**$210.4**	**$168.0**	**$147.6**

Source: PSC calculations

Scenario Two Results

The results from scenario two are similar to the results observed in scenario one, as both scenarios include supply disruptions impacting Rapid River and Sarnia propane production. However, the overall impact on statewide supply in scenario two is slightly lower. In the base case for scenario two, 46 percent of Michigan's supply is impacted, resulting in the need to source 230 million gallons of propane from alternative supply points. Coupled with extreme cold weather, the impact of scenario two on the state's propane needs increases by 19 percent.

[19] Present value of $5,000,000 per year for 12 to 25 years calculated at a 10 percent discount rate.

The other sensitivities modeled with scenario two each dampen the impact of supply disruptions. Increased use of customer storage has the ability to reduce the supply impacts by more than 14 percent. Similarly, energy-efficiency would result in reduced consumption and lessen the impact of a disruption.

EXHIBIT 68. Alternative Supply Needs for Scenario Two: Supply Disruption on Enbridge's Line 5 (Millions of Gallons)

Location of Supply Delivery	Base	Sensitivity One–Severe Weather	Sensitivity Two–Energy-efficiency Reduction	Sensitivity Three–Customer Storage
Kincheloe, Michigan	12.26	14.76	11.74	10.01
Rapid River, Michigan	18.40	22.15	17.87	16.15
Alto, Michigan	59.83	72.96	58.09	50.91
Kalkaska, Michigan	59.83	72.96	58.09	50.91
Marysville, Michigan	79.78	97.28	77.45	67.88
Total	**230.10**	**280.10**	**223.24**	**195.85**

Note: Columns may not total due to rounding.
Source: PSC Calculations

The total cost associated with a scenario two disruption is estimated to be between $171 and $208 million annually. **Scenario two's base case is estimated to cost $171.6 million per year at $0.746 per gallon, similar to scenario one. This represents an increase from 2019 spot prices observed at Rapid River and Sarnia and would result in higher costs for Michigan customers.**

Increased use of customer storage provides the lowest overall costs of all scenario two options, as more-effective storage utilization can alleviate the need to access higher-cost supply alternatives, such as purchasing for just-in-time delivery during peak price periods. Over time, energy efficiency can have similar effects by reducing total consumption, yet these benefits would not be achievable in the short-term. Though these scenarios provide lower costs than the base case, they rely on the same propane supply alternatives and thus would also result in increased costs to consumers.

EXHIBIT 69. Supply Costs for Scenario Two: Supply Disruption on Enbridge's Line 5 (Millions of Dollars)

Location of Supply Delivery	Base	Sensitivity One–Severe Weather	Sensitivity Two–Energy-efficiency Reduction	Sensitivity Three–Customer Storage
Kincheloe, Michigan	$9.0	$10.8	$8.6	$7.3
Rapid River, Michigan	$13.3	$16.0	$12.9	$11.7
Alto, Michigan	$42.5	$51.9	$41.3	$36.2
Kalkaska, Michigan	$46.9	$57.2	$45.5	$39.9
Marysville, Michigan	$59.8	$73.0	$58.9	$50.9
Total	**$171.6**	**$208.8**	**$166.4**	**$146.02**

Note: Columns may not total due to rounding.
Source: PSC Calculations

Scenario Three Results

Unlike scenarios one and two, scenario three does not consider a disruption of propane production and delivery to Michigan. This scenario instead considers the impact variable weather would have on propane consumption and how changing consumption could potentially impact prices. During a year with extreme cold weather, propane consumption increases as customers operate space heating to maintain their homes at safe and healthy temperatures. Unseasonably warm weather will reduce propane consumption, which may result in underutilization of infrastructure built to meet normal or severe weather conditions. Exhibits 70 and 71 show the impact of severe or mild weather on propane consumption and costs.

EXHIBIT 70. Alternative Supply Needs for Scenario Three: Weather-related Supply Disruption (Millions of Gallons)

Location of Supply Delivery	Extreme Weather—Severe	Sensitivity One—Mild Weather
Kincheloe, Michigan	2.5	-1.7
Rapid River, Michigan	3.8	-2.6
Alto, Michigan	13.1	-9.4
Kalkaska, Michigan	13.1	-9.4
Marysville, Michigan	17.5	-12.6
Total	**50.0**	**-35.7**

Source: PSC calculations

EXHIBIT 71. Supply Costs for Scenario Three: Weather-related Supply Disruption (Millions of Dollars)

Location of Supply Delivery	Extreme Weather—Severe	Sensitivity One—Mild Weather
Kincheloe, Michigan	$2.2	-$1.5
Rapid River, Michigan	$3.1	-$2.1
Alto, Michigan	$10.2	-$7.3
Kalkaska, Michigan	$11.5	-$8.2
Marysville, Michigan	$15.4	-$11.1
Total	**$42.4**	**-$30.2**

Source: PSC calculations

For each of the locations, PSC estimated the cost of getting alternative supply by considering the priority options identified. PSC calculated a weighted average cost of alternative propane supplies, assuming 50 percent would come from the lowest-cost option, 30 percent from the next lowest-cost option, and 20 percent from the third lowest-cost option. In the event of extreme cold weather, PSC estimates that the additional costs associated with sourcing additional supplies would be between $37 and $42 million dollars. This calculation is based on the same supply alternatives and hub prices modeled for during normal weather conditions. Given the potential regional impacts of an extreme cold weather event, additional demands from out of state would likely impact market prices for propane, driving costs even higher. Examples like the 2013–2014 polar vortex illustrate how hub prices can react to increased seasonal demand. During this period, wholesale prices were over 50 percent higher than the same period in 2014–2015. To calculate the potential impact of an increase in hub prices, indicating regional extreme weather conditions, PSC assumed a 50 percent increase in the various hub prices during winter heating months. This resulted in increased costs for all of the supply options considered, ranging from 23 to 30 percent.

PSC also modeled the impact of seasonably warm weather that results in decreased demand for propane. For reductions in load resulting from milder weather, PSC's modeling estimates that costs savings will amount to approximately $30 million.

Impacts of Increased Reliance on Line 5

The nature of propane supply and disposition make it challenging to track the origin of propane deliveries to end use customers with certainty. One question that came up throughout this effort was how much of Michigan's propane supplies originate from Line 5. A commonly cited estimate is that approximately 55 percent of the state's propane supply is sourced from Line 5 (Enbridge n.d.). Scenarios one and two utilized a conservative estimate for the impact of disruptions considered on statewide propane supplies. This conservative estimate was based on an assumption that propane production facilities in Sarnia are able to operate at a 95 percent of their gross capacity. However, available data cannot confirm this capacity rate or the use of other sources of NGLs supplying the facility. Instead, PSC relied on data for the amount of NGLs shipped to the facility via Line 5 and the net imports from the facility into Michigan.

Recognizing the conservative estimate has the potential to understate the impacts of the scenarios modeled, PSC also calculated supply impacts and associated costs for scenarios one and two assuming that Line 5 is the only supply source for Sarnia propane production and that the total net propane imports from Sarnia facilities are derived from Line 5. Using this assumption, the impact of scenario one would be a 51.38 percent reduction in propane supplies. The estimated impact of scenario two would be slightly smaller, at 50.95 percent. Exhibit 72 shows the impact on alternative supply needs of scenario one using the higher estimated impact on statewide supply.

EXHIBIT 72. Alternative Supply Needs for Scenario One—High Case: Supply Disruption on Enbridge's Line 1 (Millions of Gallons)

Location of Supply Delivery	Base	Sensitivity One–Severe Weather	Sensitivity Two–Energy-efficiency Reduction	Sensitivity Three–Customer Storage
Kincheloe, Michigan	13.13	15.63	12.61	10.88
Rapid River, Michigan	19.70	23.45	19.17	17.45
Alto, Michigan	67.24	80.36	65.50	58.31
Kalkaska, Michigan	67.24	80.36	65.50	58.31
Marysville, Michigan	89.65	107.15	87.33	77.75
Total	**256.96**	**306.96**	**250.10**	**222.71**

Note: Columns may not total due to rounding.

Source: PSC calculations

The higher estimated contribution of Line 5 to production in Sarnia results in higher costs across all scenarios modeled. In each case, costs increase by at least $15 million; however, because production from Sarnia is consumed in the Lower Peninsula, cost in the Upper Peninsula remained the same. Exhibit 73 shows the cost of the anticipated supply needs.

EXHIBIT 73. Supply Costs for Scenario One—High Case: Supply Disruption on Enbridge's Line 1 (Millions of Dollars)

Location of Supply Delivery	Base	Sensitivity One–Severe Weather	Sensitivity Two–Energy-efficiency Reduction	Sensitivity Three–Customer Storage
Kincheloe, Michigan	$9.6	$11.5	$9.2	$8.0
Rapid River, Michigan	$14.2	$16.9	$13.8	$12.6
Alto, Michigan	$47.1	$56.3	$45.9	$40.8
Kalkaska, Michigan	$52.0	$62.1	$50.6	$45.1
Marysville, Michigan	$66.1	$79.0	$64.4	$57.4
Total	**$189.0**	**$225.8**	**$184.0**	**$163.8**

Note: Columns may not total due to rounding.
Source: PSC calculations

The results for scenario two are in line with those observed in scenario one. Exhibits 74 and 75 show the supply impacts and costs for the low case of scenario two.

EXHIBIT 74. Alternative Supply Needs for Scenario Two—High Case: Supply Disruption on Enbridge's Line 5 (Millions of Gallons)

Delivery Point	Base Case	Sensitivity One–Severe Weather	Sensitivity Two–Energy-efficiency Reduction	Sensitivity Three–Customer Storage
Kincheloe, Michigan	12.26	14.76	11.74	10.01
Rapid River, Michigan	18.40	22.15	17.87	16.15
Alto, Michigan	67.24	80.36	65.50	58.31
Kalkaska, Michigan	67.24	80.36	65.50	58.31
Marysville, Michigan	89.65	107.15	87.33	77.75
Total	**254.79**	**304.79**	**247.93**	**220.54**

Note: Columns may not total due to rounding.
Source: PSC calculations

EXHIBIT 75. Supply Costs for Scenario Two—High Case: Supply Disruption on Enbridge's Line 5 (Millions of Dollars)

Location of Supply Delivery	Base	Sensitivity One–Severe Weather	Sensitivity Two–Energy-efficiency Reduction	Sensitivity Three–Customer Storage
Kincheloe, Michigan	$9.0	$10.8	$8.6	$7.3
Rapid River, Michigan	$13.3	$16.0	$12.9	$11.7
Alto, Michigan	$47.1	$56.3	$45.9	$40.8
Kalkaska, Michigan	$52.0	$62.1	$50.6	$45.1
Marysville, Michigan	$66.1	$79.0	$64.4	$57.4
Total	**$187.5**	**$224.2**	**$182.4**	**$162.3**

Note: Columns may not total due to rounding.
Source: PSC calculations

Conclusions

Propane supports vital functions for Michigan residents and businesses in every county and corner of the state. However, this important energy source and those who depend on it could face supply challenges and higher prices as a result of disruptions in current supply configurations. The goal of this study was to assess the current state of Michigan's propane supplies, identify potential disruptions, and evaluate alternatives for meeting the state's propane needs. Through this effort, a better understanding of the propane industry and Michigan's part of that industry have emerged. This study highlights numerous supply alternatives, delivery strategies, and considerations that decision makers, industry participants, and customers can use to be more informed about the propane industry and better prepared to meet potential challenges.

The U.S has seen consistent growth in the production of NGLs over the past decade. At the same time, the U.S. has drastically increased the amount of propane it exports. This is largely due to limited growth in propane consumption from domestic consumers. The same is true for Canada. The U.S. historically was the sole importer of Canadian propane, but new investment in maritime export terminals are shifting propane supply dynamics on the continent. Still, **as U.S. production is projected to increase, adequate quantities of propane are expected to be available to meet the needs of domestic consumers.**

Though propane supply has increased across the continent over recent years, the picture of Michigan's propane supplies has remained relatively unchanged for over a decade. Aside from a few propane producers in the state which supply approximately 15 percent of demand, **Michigan relies on propane production from outside of its borders for the vast majority of its supply needs.** Michigan does not have access to necessary feedstock or production capacity to meet its own needs, so it draws on production in neighboring states and Canada to meet its needs. The bulk of this supply is sourced from Sarnia, Ontario, which heavily relies on Enbridge's Line 5. Additionally, one of the state's three propane production facilities is sourced by Line 5. PSC estimates that these combined facilities represent 46 percent of Michigan's propane supply. This reliance is even greater in the Upper Peninsula, where the Rapid River facility produces enough propane to supply an estimated 87 percent of demand. **While this configuration has historically ensured a consistent flow of propane into both peninsulas, more recently it has raised concerns about Michigan's potential overreliance on a single piece of infrastructure.**

Given the share of Michigan's propane supplies delivered via Line 5, the pipeline was identified as the most consequential source of a supply disruption facing Michigan. While this position forms the basis for the analysis conducted in this study, PSC sought to establish a methodology that was agnostic to the source of a supply disruption and instead could be utilized to evaluate supply alternatives for any potential supply disruption. **The modeling framework developed allows for consideration of almost any supply option for delivery to selected sites in Michigan.** Using estimated commodity costs at major hubs within the U.S. and Canada, costs of available transportation options, and associated storage costs, PSC identified alternative supply options and estimated costs that allow for comparison to historical prices at Rapid River and Sarnia.

For the five delivery points considered in the Upper and Lower Peninsulas, the lowest-cost option identified originates in Edmonton, Alberta. Edmonton has historically had the lowest prices of any hub in North America, as the region had limited options for transporting product to markets. The low commodity price at Edmonton enables propane to travel further distances and still be price competitive with other resources. The most competitive options from Edmonton are transported by rail either directly to the delivery site or to a site in the vicinity and then trucked to the final destination. Even with additional investment in storage capacity considered in the cost, Edmonton options proved competitive with observed prices at Rapid River and Sarnia. The limitation of relying on Edmonton is that rail is essentially the only option for moving product the entire distance. There are no options for pipeline transport, and the one option that used to ship propane from western Canada to the U.S. was reversed in 2014. Trucking supply from Edmonton to any point in Michigan is cost prohibitive. While rail can be a suitable transportation mode, overly relying on rail for propane deliveries comes with its share of risks. Additionally, Canadian companies have been investing heavily in the development of export terminals in British Columbia to export product to premium markets in Asia, which could potentially erode the discount that has been observed at Edmonton as suppliers can now access higher-value markets with their products. Still, **as long as Edmonton prices are low and rail operations are reliable, this option will be a cost-effective supply alternative.**

Constraints for rail delivery can be addressed through the use of alternate acquisition patterns that look to bring in more supply during nonheating months than in heating months, when more propane is in higher demand. Excess propane supplies delivered during nonheating months must be stored until time of use. While some propane can be delivered to customers in advance of use to be stored onsite, additional bulk storage would be needed to accommodate rail shipment patterns of propane.

The rest of the lowest-cost supply alternatives all originated in Conway, Kansas. Conway's commodity cost is not discounted in the same way that Edmonton's is, but the region has access to processing facilities, storage capacity, and a wide array of transportation options that make it competitive. Conway is the epicenter of the propane market in PADD 2. Several pipelines transport propane from Conway across the Midwest into nearby states, including Illinois, Iowa, Minnesota, and Wisconsin. Pipelines benefit from the ability to ship large volumes consistently and at low costs compared to other transportation modes. Out the 16 selected supply alternatives, 11 utilize pipeline capacity shipping from Conway. Pipelines deliver to intermediate storage terminals, which make it possible for trucks or rail to cost-effectively move product to the ultimate delivery point. The lowest-cost option from Conway using pipeline capacity was $0.75 per gallon from Conway to East Chicago, Indiana, with delivery to Alto, Michigan by rail. However, **because of the higher commodity cost at Conway, this option was still nearly $0.12 more per gallon than the Edmonton option.** Just as there are drawbacks to relying too heavily on rail, there are limitations to the extent that pipeline supply options can be used. While there is typically available capacity on pipelines from Conway, propane supply markets are operating near the margins and these pipelines will be put on allocations when demand gets too high, which will impact the ability to get desired product. Rail routes from Conway can also be cost-effective, though they were estimated to be between $0.12 and $0.20 per gallon more than rail from Edmonton and would potentially face the same challenges.

PSC did not identify any supply alternatives from Mont Belvieu, the largest exporter of propane in North America, that made it into the lowest-cost options. Commodity prices at Mont Belvieu averaged $0.06 per gallon higher per month than Conway in 2019. **Due to higher commodity prices and the fact that Mont Belvieu is further from Michigan than Conway, there were no competitive supply alternatives from this hub.** Mont Belvieu could provide an example of how access to export markets change pricing considerations for suppliers. Given the ability to reach higher-value markets abroad, there is little incentive to attempt to move product to domestic markets that might not be willing to pay the same cost premium. Infrastructure investment in recent years has enabled greater movement of product into the Mont Belvieu area, as suppliers look to support the sizeable petrochemical industry in the region and access valuable export markets.

Another potential source of propane that was identified as a viable supply alternative in this analysis was production from the Utica and Marcellus shale play. Located in close proximity to Michigan, this region has shown the largest growth in propane production in the U.S. in recent years. **Though still dwarfed by production in Conway and Mont Belvieu, there is sizeable and growing propane production capacity to access from the Utica and Marcellus shale play**. However, lack of spot pricing information for this region made it impossible to consider this option in the modeling exercise. Additionally, lack of spot market data signals that the market is still developing. **One potential consideration for accessing production from this region is the Utopia East pipeline carrying ethane into Michigan. The pipeline is built to support propane shipment and has the potential to increase its capacity if there is adequate market demand.**

Comparison of alternative supply options to the status quo for Michigan propane supplies highlights the important role pipelines play in delivering consistent and substantial quantities of propane in a cost-effective manner. **Propane spot prices for Rapid River and Sarnia, which are predominately supplied by Line 5, consistently offer the lowest-cost supply options for meeting Michigan's propane needs.** While cost-competitive alternatives exist, questions remain as to whether these options can deliver the same volume of products without interruption. **Though prices at Rapid River in 2019 were observed to be at or below the closest supply alternative—shipment from Edmonton via rail—there are few other available alternatives, which brings into focus issues related to market power and apparent lack of competitive forces in the Upper Peninsula's propane supply portfolio.**

Given the size of the propane market in Michigan, there is little that can be done in the short term to reduce the state's dependence on propane. There are a number of options that can begin to reduce propane consumption, should that be a goal, but these efforts will take time and resources. PSC modeled the impact energy efficiency can have on reducing propane consumption and determined that the impact of these policies in the short run cannot substantively reduce consumption to a level that will overcome potential supply disruptions. This is not to suggest that efficiency cannot be part of a broader set of solutions for helping customers reduce their energy bills and increase the comfort of their homes, only that the impact of energy efficiency is cumulative and will require careful planning to ensure that it is delivered effectively and equitably.

Similarly, use of existing customer storage resources presents opportunities for optimizing storage deployment, improving purchasing strategies, and better management of other supply components. By promoting increased levels of customer storage prior to the start of the heating season, retailers can reduce the number of fill-ups required during the heating season and potentially reduce the need to procure additional volumes in the event of a supply disruption or increased seasonal demand. Further, PSC modeled options that showed investment in new bulk storage could be offset by commodity and transportation cost savings.

Despite the number of possible alternative supply options, PSC's analysis found that supply disruptions will likely result in modest wholesale price increases, which would consequently affect Michigan consumers at the retail level. A robust dialogue between policymakers, propane suppliers, and industry experts can ensure the state is prepared for a range of potential scenarios and to mitigate the cost impact of potential events that could affect the supply or demand for propane.

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Appendix A: Household Heating Fuel by County, 2018

County	Peninsula	Total	Bottled, Tank, or LPG	Percentage
Alcona County	Lower	5,008	1,719	34.3%
Alger County	Upper	3,094	811	26.2%
Allegan County	Lower	43,000	7,069	16.4%
Alpena County	Lower	12,717	1,943	15.3%
Antrim County	Lower	9,805	3,366	34.3%
Arenac County	Lower	6,684	2,144	32.1%
Baraga County	Upper	3,036	642	21.1%
Barry County	Lower	23,840	5,935	24.9%
Bay County	Lower	43,891	4,072	9.3%
Benzie County	Lower	6,733	2,494	37.0%
Berrien County	Lower	63,908	4,380	6.9%
Branch County	Lower	16,506	3,620	21.9%
Calhoun County	Lower	53,659	3,598	6.7%
Cass County	Lower	20,855	5,260	25.2%
Charlevoix County	Lower	11,379	2,850	25.0%
Cheboygan County	Lower	11,201	1,784	15.9%
Chippewa County	Upper	14,046	2,943	21.0%
Clare County	Lower	12,406	4,479	36.1%
Clinton County	Lower	29,421	4,678	15.9%
Crawford County	Lower	6,047	2,636	43.6%
Delta County	Upper	15,949	2,968	18.6%
Dickinson County	Upper	11,087	1,501	13.5%
Eaton County	Lower	44,390	6,072	13.7%
Emmet County	Lower	14,510	3,354	23.1%
Genesee County	Lower	167,889	6,333	3.8%
Gladwin County	Lower	10,999	3,590	32.6%
Gogebic County	Upper	6,619	1,021	15.4%
Grand Traverse County	Lower	37,134	4,349	11.7%
Gratiot County	Lower	15,177	3,692	24.3%
Hillsdale County	Lower	17,904	5,762	32.2%
Houghton County	Upper	13,340	1,899	14.2%
Huron County	Lower	13,918	2,873	20.6%
Ingham County	Lower	112,200	6,563	5.8%
Ionia County	Lower	22,858	5,188	22.7%
Iosco County	Lower	11,631	2,000	17.2%

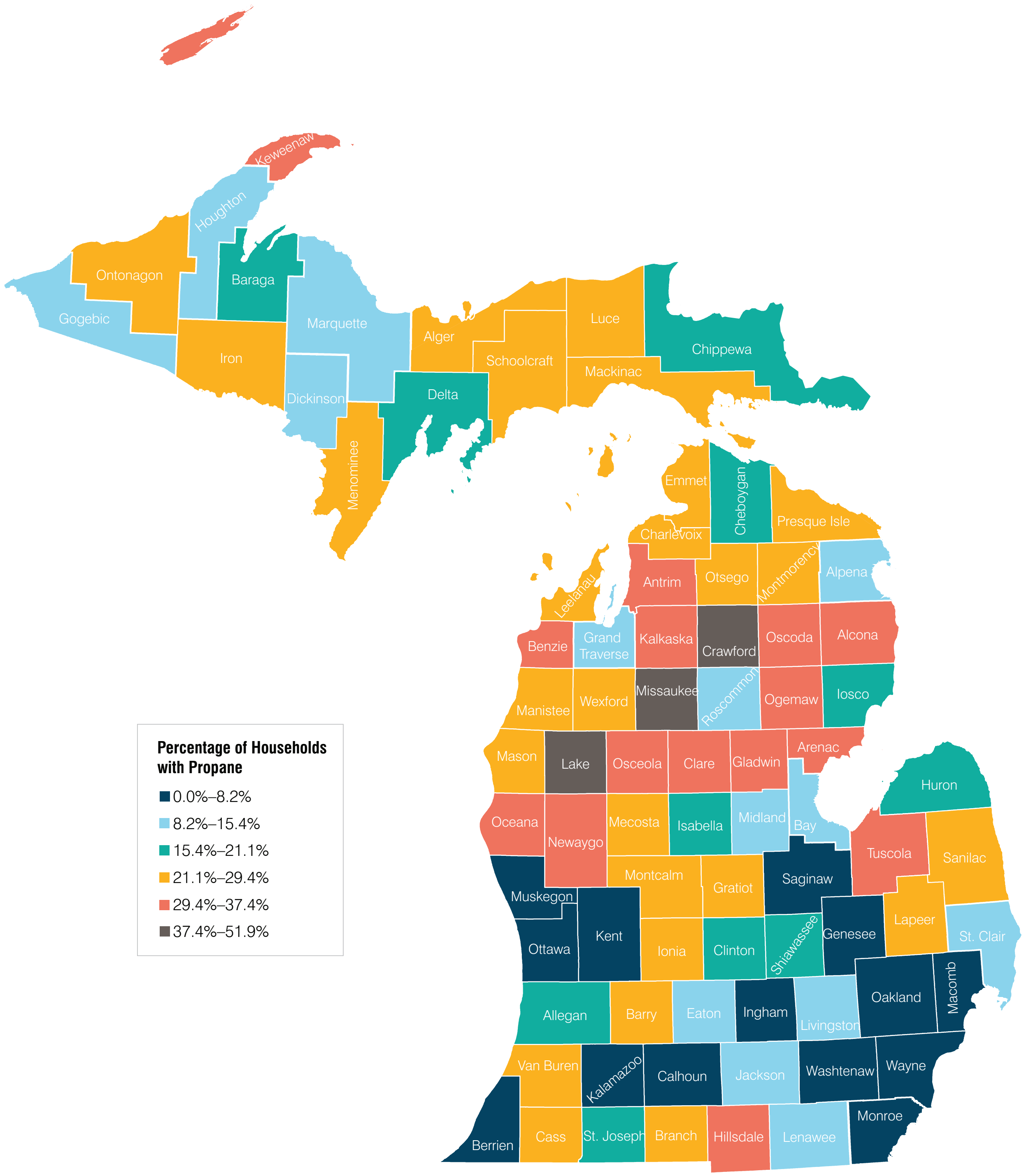
County	Peninsula	Total	Bottled, Tank, or LPG	Percentage
Iron County	Upper	5,327	1,339	25.1%
Isabella County	Lower	24,889	4,920	19.8%
Jackson County	Lower	61,696	7,052	11.4%
Kalamazoo County	Lower	102,809	5,923	5.8%
Kalkaska County	Lower	7,139	2,562	35.9%
Kent County	Lower	239,236	11,519	4.8%
Keweenaw County	Upper	1,081	357	33.0%
Lake County	Lower	4,517	2,346	51.9%
Lapeer County	Lower	33,320	7,517	22.6%
Leelanau County	Lower	9,152	2,530	27.6%
Lenawee County	Lower	38,222	5,180	13.6%
Livingston County	Lower	71,180	6,787	9.5%
Luce County	Upper	2,190	499	22.8%
Mackinac County	Upper	5,284	1,501	28.4%
Macomb County	Lower	343,592	4,672	1.4%
Manistee County	Lower	9,591	2,280	23.8%
Marquette County	Upper	26,203	3,361	12.8%
Mason County	Lower	12,115	3,192	26.3%
Mecosta County	Lower	15,858	4,172	26.3%
Menominee County	Upper	10,665	2,584	24.2%
Midland County	Lower	34,017	4,976	14.6%
Missaukee County	Lower	6,027	2,525	41.9%
Monroe County	Lower	59,279	4,524	7.6%
Montcalm County	Lower	23,761	6,995	29.4%
Montmorency County	Lower	4,195	968	23.1%
Muskegon County	Lower	65,619	5,407	8.2%
Newaygo County	Lower	19,007	6,340	33.4%
Oakland County	Lower	501,260	7,855	1.6%
Oceana County	Lower	10,157	3,596	35.4%
Ogemaw County	Lower	9,296	3,381	36.4%
Ontonagon County	Upper	2,876	794	27.6%
Osceola County	Lower	9,100	3,404	37.4%
Oscoda County	Lower	3,824	1,226	32.1%
Otsego County	Lower	9,886	2,392	24.2%
Ottawa County	Lower	101,223	5,030	5.0%
Presque Isle County	Lower	5,808	1,428	24.6%
Roscommon County	Lower	10,899	1,650	15.1%

County	Peninsula	Total	Bottled, Tank, or LPG	Percentage
Saginaw County	Lower	78,648	6,337	8.1%
Sanilac County	Lower	17,179	4,862	28.3%
Schoolcraft County	Upper	3,351	853	25.5%
Shiawassee County	Lower	27,741	4,948	17.8%
St. Clair County	Lower	64,805	6,694	10.3%
St. Joseph County	Lower	24,022	4,426	18.4%
Tuscola County	Lower	21,759	7,178	33.0%
Van Buren County	Lower	29,013	6,474	22.3%
Washtenaw County	Lower	140,210	5,355	3.8%
Wayne County	Lower	676,587	6,102	0.9%
Wexford County	Lower	13,053	3,529	27.0%
Total		**3,909,509**	**323,130**	**8.3%**
Total Upper Peninsula		**124,148**	**23,073**	**18.6%**
Total Lower Peninsula		**3,785,361**	**300,057**	**7.9%**

Source: U.S. Census Bureau n.d.b

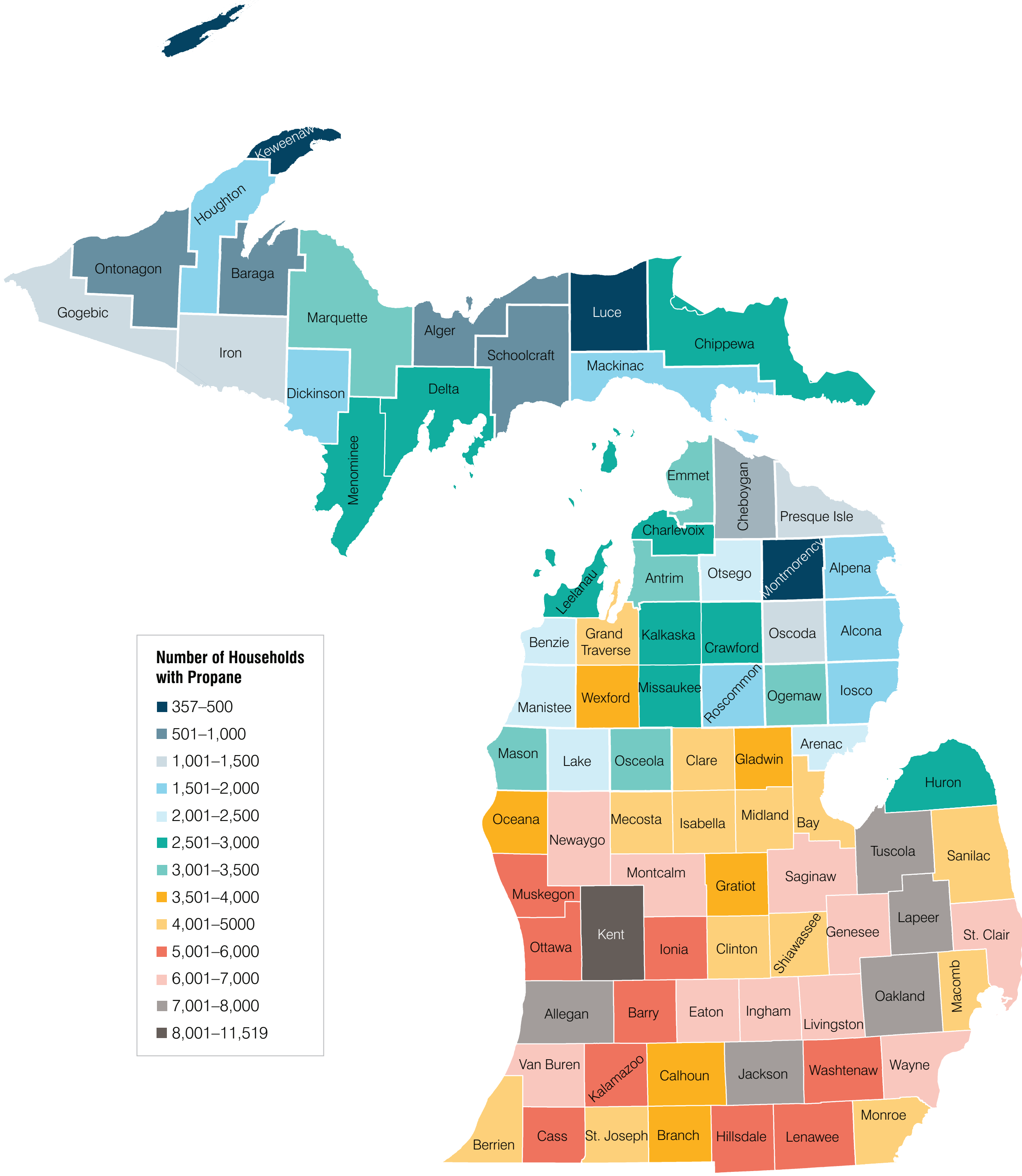
Appendix B: Map of Household Heating Fuel by County, 2018

EXHIBIT B1. Percentage of Households with Propane as Their Primary Heating Fuel



Source: U.S. Census Bureau n.d.b

EXHIBIT B2. Number of Households with Propane as Their Primary Heating Fuel, by County



Source: U.S. Census Bureau n.d.b

Appendix C: Rail Cost Calculations

PSC used the rail cost calculations presented in Dynamic Risk Assessment Systems' (Dynamic Risk's) 2017 analysis of alternatives to the straits pipeline prepared for the State of Michigan as a starting point for determining cost of rail shipments. Dynamic Risk's cost calculations were also integrated into analysis conducted by London Economics International (LEI) in a separate report released in 2018. These previous studies provide an underlying framework for developing rail cost estimates and a useful point of comparison for updated assumptions. PSC first reviewed the assumptions these studies used and worked to verify and update the inputs and assumptions as necessary. These assumptions are described below.

Fixed Costs

PSC identified several fixed costs associated with rail transportation alternatives from review of Dynamic Risk and other literature. These fixed costs include fixed operating and overhead costs associated with personnel, capital costs for incremental storage to facilitate increased delivery volumes, and additional transloading equipment necessary to accommodate greater numbers of railcars shipping propane. These fixed costs were included based on the following assumptions.

- Dynamic Risk assumed that the capacity of a railcar for shipping NGLs was 33,700 gallons. They also assumed that cars would not be filled to 100 percent capacity and estimated that each car would transport 31,500 gallons. According to a railcar leasing company interviewed by PSC, companies are prohibited from quoting the storage capacity of an average tank car, which varies by manufacturer (Trinity Rail pers. comm.). PSC was able to find one public source that quoted a railcar capacity of a Department of Transportation (DOT) 112J340-type tank car at 33,693 gallons, confirming Dynamic Risk's assumption (GBX n.d.).
- According to interviewed retailers, shippers commonly require that once a delivery is made, the recipient takes possession of the product and enables the railcar to return to service, within approximately 48 hours (Bowman Gas pers. comm.). If the propane storage car cannot be offloaded, there are additional costs associated with its use. PSC assumes that for delivery points in Michigan where rail capacity does not already exist, investment in transloading and storage will be necessary. Even in areas where rail capacity is already present, there is the potential the increased movement of propane via rail would necessitate increased storage and transloading equipment. Thus, the analysis treats these costs the same for each scenario.

Operating and Overhead Cost

PSC used Dynamic Risk's assumptions for other operating and overhead costs. Annual overhead costs for rail shipments were listed as $80,000 per year. For other operating costs, Dynamic Risk assumed that incremental overhead was equal to 0.3 person years, multiplied by 2,000 hours per year and $30 per hour, equating to $18,000 per year.[20]

[20] "Person year," referred to in Dynamic Risk's study as "man year," refers to the amount of work done by an individual throughout an entire year, typically expressed in the number of hours. For this analysis, PSC assumed that the required person years associated with rail transportation options was approximately 30 percent of an individual's full-time commitment.

Transloading Equipment Cost

PSC used the cost per unit estimate for transloading equipment ($100,000 per unit), as provided by Dynamic Risk. PSC was not able to identify sources to validate the cost assumptions for this equipment. Transloading equipment refers to the incremental investment needed to accommodate increased shipments of rail to locations without adequate rail capacity. Two transloading units were considered in these assumptions, one at the origin point and one at the delivery point. PSC replicated Dynamic Risk's calculations for the total investment costs associated with the financed purchase of transloading equipment using a 15 percent amortization rate and 20-year usable lifespan for equipment quoted by Dynamic Risk. The total cost associated with transloading equipment was $316,029 per unit or $632,059 for two units. The total annual cost associated with this investment was $31,603 for 20 years.

Storage Cost

PSC also used the cost-per-unit estimate for storage from Dynamic Risk. For one 90,000-gallon storage tank, Dynamic Risk listed the total capital cost at $350,000. PSC was not able to identify sources to validate the cost assumptions for this equipment. PSC calculated the total investment cost for storage using the 15 percent amortization rate from Dynamic Risk to develop cost estimates for the financed purchase of storage over their 20-year lifespan, which equals $1,106,103.25 per 90,000-gallon tank. Dynamic Risk assumed that three 90,000-gallon storage tanks would be necessary to accommodate increased shipment of propane. This incremental storage investment was not large enough to cover the total storage needed for the amount of product assumed to be shipped in the Dynamic Risk study, which confirms that these storage resources were not considered as the long-term storage solution for deliveries. Instead, PSC assumed that incremental storage additions as provided by Dynamic Risk are necessary to facilitate delivery of product which would be transferred to retailers for long-term storage or delivery to customers. The total annual cost estimate for incremental storage capacity at rail delivery points was $165,915 per year. PSC's fixed-cost assumptions are provided in Exhibit C1.

EXHIBIT C1. Fixed Rail Cost Assumptions, per Month

Cost Parameter	Cost
Total Storage Tank cost	$13,826
Total Transloading Equipment Cost	$2,634
Overhead and Incremental Overhead Cost	$8,167
Total Fixed Costs	**$24,627**

Source: PSC calculations

Though the annual fixed costs do not change unless additional infrastructure investment in equipment is required, the costs will vary on a per-unit basis depending on the utilization of a resource and the amount of product shipped. In determining rail cost estimates, PSC considered how fixed costs would be allocated based on different utilization rates. The rail transportation options examined require investments in infrastructure that are recovered through the sale of the commodities. As those infrastructure resources are more fully utilized, fixed costs are spread over more units and cost per commodity unit decreases.

To allocate fixed costs to the commodity units, PSC estimated volumes at different capacity factors to understand the impact of different utilization rates on per-unit fixed costs. The monthly fixed costs associated with rail are $24,627, which assumes new storage tanks totaling 270,000 gallons along with necessary transloading equipment and other overhead costs. If the facility handled 216,000 gallons per month (assuming that tanks are filled to 80 percent of their listed capacity), the fixed costs would be $0.11 per gallon. The more shipments processed during a month reduces the per-unit fixed costs. If the tanks were refilled and emptied two times per month, fixed costs would be $0.06 per gallon. Assuming three filling cycles per month, the per-unit fixed costs is $0.04, or $0.03 per gallon if there are four cycles.

Higher utilization of equipment invested in to deliver propane results in lower cost of supply. For the most part, priority options identified for each of the delivery sites included supply alternatives with high utilization rates. However, PSC saw value in understanding the cost impacts of other equipment utilization patterns. There is some relationship between utilization of fixed-cost resources and the supply pattern, e.g., just-in-time delivery of propane may result in varying levels of utilization over the year. In that case, higher delivery costs may be offset by reduced need for storage because propane is delivered only when needed.

Variable Costs

The variable-cost methodology utilized by Dynamic Risk and LEI was based on the total transit time for rail shipments from origin to delivery point. PSC was not able to identify a data source that would provide the total transit time for all of the scenarios considered. Canadian National Railway provides such a tool through their website, but PSC was unable to find similar tools for other class-one rail carriers, which made it impossible to calculate the variable rail costs using the same methodology as Dynamic Risk.

Instead, PSC used the Uniform Rail Costing System (URCS) provided by the Surface Transportation Board (STB) to establish variable costs for rail shipments. The URCS provides data from class-one rail carriers collected through annual sampling of carload waybills.[21] The STB provides a Railroad Cost Program that allows users to build train shipments and determine variable costs associated with a shipment. This tool utilizes data from 2018 that draws from actual reported shipping costs from class-one rail carriers. The Railroad Cost Program made it possible for PSC to calculate variable rail shipment costs for a wide number of supply pathways. The Railroad Cost Program requires a number of input parameters to calculate the variable cost of rail shipments. The required variables are discussed below

Railroad Company (Only Class-one Carriers)

As noted, the Railroad Cost Program only contains data for class-one carriers, and as such, PSC was only able to calculate variable costs for origin and delivery points served by these railroads. Of the delivery points identified for Michigan, Rapid River was the only location not served by rail. For this option, PSC assumed rail deliveries would be taken to Escanaba, Michigan, which is on a Canadian National Railway line with ultimate delivery to Rapid River via truck. Kincheloe was also served by Canadian National Railway. Alto and Marysville each have CSX lines running to their facilities. Only Kalkaska was not served by a class-one carrier, meaning that it was not possible to calculate rail delivery with the Railroad Cost Program. All of the supply hubs included in the model have class-one rail service. Edmonton is served by

[21] According to CSX's Railroad Dictionary, a waybill is "a shipping document prepared by a carrier at the point of origin showing the point of origin, destination, route, shipper, consignee, description of shipment, weight, charges, and other data necessary to rate, ship and settle" (CSX n.d.).

Canadian National Railway as well, and Mont Belvieu and Conway were served by BNSF Railway. PSC also reviewed the list of bulk petroleum terminals to assess how many were served by rail to identify alternative supply configurations to intermediate sources.

Distance Travelled

The variable cost of each rail route is driven in part by the distance travelled on each rail line. Only BNSF Railway had a public tool that allowed the distance between two points on their system to be calculated. Additionally, many of the potential delivery pathways crossed different rail carriers' lines, which meant that even a company-specific tool like BNSF's would not be able to supply distances in every case. Instead, PSC utilized the U.S. Department of Transportation Federal Railroad Administration's Web-based geographic information system application that displays rail lines for all class-one carriers and enables measurement of distances between points. PSC manually collected distances for rail line segments to establish the distances travelled for selected supply routes. PSC identified rail distances for 49 different supply routes for the modeling analysis.

Type of Segment

The type of rail segment refers to where a rail carrier fits in the movement of a shipment from origin to destination. In some cases, like shipment from Edmonton to Kincheloe, Canadian National Railway operates the entire stretch of rail lines from origin to destination and can originate a shipment and terminate the shipment without having to transfer to another carrier. In other cases, it takes several different rail carriers to transport product from origin to delivery point. In these types of shipments, the originating rail carrier will deliver product to another carrier that will receive and terminate the delivery at the end destination or potentially deliver it to the rail carrier. The various segment types ensure that the variable cost calculations consider the costs associated with transferring shipments at different points in the process and between carriers. These shipment segments are labeled as:

- **Originate and terminate:** This indicates this railroad moves the shipment from origin to destination—sometimes referred to as a local move.
- **Originate and deliver:** This indicates this railroad originates the shipment but will deliver it to another railroad—sometimes referred to as a forwarded move.
- **Receive and deliver:** This indicates this railroad receives the shipment from one railroad and will deliver it to another railroad—sometimes referred to as an overhead move.
- **Receive and terminate:** This indicates this railroad receives the shipment from one railroad and will move the shipment to the termination—sometimes referred to as a received move. (STB 2011)

Number of Cars

The number of cars included in a shipment is another important factor for calculating variable costs; however, PSC determined that the Railroad Cost Program's estimates for variable costs use a fixed number in calculating the cost of a shipment. Because of this, PSC chose to calculate the cost of shipping one car and subsequently the cost per gallon associated, while also considering cost variation due to shipment size.

Type of Car

The Railroad Cost Program provides a list of options for railcar type. PSC's analysis assumed that propane shipments would utilize a DOT 112J340-type tank car with a capacity of 33,700 gallons. In the Railroad Cost Program, this was entered as "Tank Car (>= 22,000 Gallons)."

Freight Car Ownership

There were two options for the ownership of a freight car available in the Railroad Cost Program—railroad or private. For the sake of this analysis, PSC used costs associated with railroad-owned cars.

Weight

The gross load of a 33,700-gallon propane tank car is 263,000 pounds, or 131.5 tons (GBX n.d.). PSC rounded this number up to 132 tons and utilized this for the assumed weight per car.

Commodity Type

The Railroad Cost Program provides a list of commodity types to choose from. For this analysis, PSC selected petroleum or coal products for the commodity type.

Shipment Charge

The shipment charge parameter is not required to calculate the variable costs, according to the STB. This variable is only required if trying to calculate the revenue-to-variable-cost ratio, which estimates the profitability of a shipment for the railroad (STB 2011). PSC did not enter a shipment charge for its calculations.

Shipment Size

The shipment size variable allows for consideration of costs for different-sized shipments. The Railroad Cost Program manual indicates how different shipment sizes should be utilized (see Exhibit C2).

EXHIBIT C2. Shipment Size

Shipment Size	Description
Single-car Movement	Select this option when calculating the variable costs for a small number of cars tendered under separate waybills (typically one to five cars).
Multiple-car Movement	Select this option when calculating the variable costs for six to 49 cars tendered under one waybill.
Unit Train Movement	Select this option when calculating the variable costs on a trainload basis (typically 50 or more cars).

Source: STB 2011

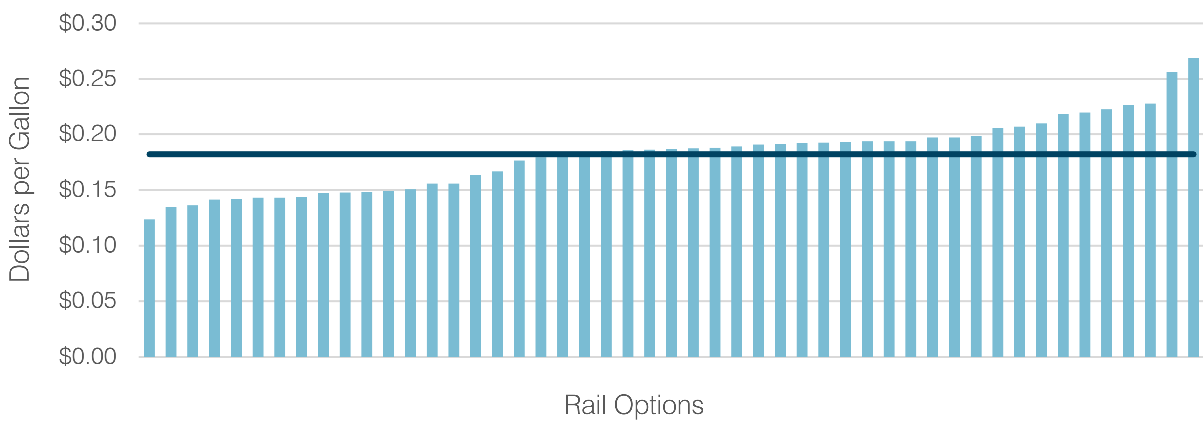
PSC elected to use the multiple-car movement shipment size for the basis of its calculations because it provided the widest range of shipment sizes.

Cost Calculations

The next step for calculating rail costs was to identify rail routes and associated costs to include in the modeling of alternative supply source. Using the three major hubs as the origin point, PSC identified transportation pathways to delivery points in Michigan, the ownership of various segments of routes, and the distance traveled for each segment of a route. Since class-one rail carriers do not serve Kalkaska, PSC was not able to identify variable costs for this alternative using the Railroad Cost Program. Because there are several potential routes that shippers could take to reach delivery points, PSC constructed more than one rail delivery route for several locations.

This analysis identified 49 different shipment routes from Edmonton, Conway, and Mont Belvieu. PSC calculated the per-car and subsequently per-gallon costs associated with each supply route. The least-costly rail option in terms of variable cost was $0.124 per gallon. The highest-cost option was nearly $0.30 per gallon. The average for the 49 delivery routes was $0.182 per gallon, as shown in Exhibit C4.

EXHIBIT C3. Range of Variable Costs for Rail Options, per Gallon



Source: PSC calculations

The range of cost options from the three hubs indicates that variable rail shipment costs can be a determining factor in the cost-effectiveness of rail alternatives. The hub with the lowest average variable cost for supply routes was Edmonton, which came in at $0.151 per gallon. This is despite having the longest overall distance travelled. Options from Conway had the next lowest average distance and came in less than $0.01 per gallon higher than routes from Edmonton. Variable costs from shipping via rail from Mont Belvieu were the most expensive on average. All of the rail supply alternatives from Mont Belvieu had average variable costs that were greater than the average cost option.

EXHIBIT C4. Average Variable Cost and Distance for Rail Alternatives

Origin Hub	Average Distance (Miles)	Average Cost (Dollars per Gallon)
Edmonton	1,621.0	$0.164
Conway	1,355.1	$0.173
Mont Belvieu	1,579.7	$0.203
All Options	1,530.4	$0.182

Source: PSC calculations

Appendix D: Trucking Cost Calculations

To establish costs associated with trucking, PSC followed the same approach it used for rail, first validating the calculations and sources used by the Dynamic Risk and LEI studies. Since Dynamic Risk did not include sources in their final report, PSC began by evaluating and updating the public sources used by LEI, including the key fixed- and variable-cost elements. Using the confirmed or updated fixed and variable costs, PSC calculated costs per gallon of propane based on shipping volumes and costs at capacity factors of 25 percent, 50 percent, 75 percent, and 100 percent. These calculations are described in the following sections.

Fixed Costs

PSC identified several fixed costs associated with trucking transportation alternatives from review of Dynamic Risk and other literature. These fixed costs include truck and trailer capital costs, fixed operating and overhead costs associated with personnel, capital costs for incremental storage to facilitate increased delivery volumes, and additional transloading equipment necessary to accommodate increased propane shipments via truck. These fixed costs were included based on the following assumptions.

Tractor Truck and Propane Trailer Capital Costs

PSC used the Dynamic Risk and LEI assumptions for the capital cost of a truck, $120,000, to which PSC then applied a 15 percent amortization rate for a total cost over the seven-year life of the vehicle of $194,511, which translates to $2,316 per month. PSC did the same for the cost of a propane trailer, $145,000, to which PSC then applied a 15 percent amortization rate for a total cost over the 15-year life of the trailer of $365,292, which translates to $2,029 per month. The total fixed cost of a tractor-trailer was $52,144 per year or $4,345 per month.

Operating and Overhead Cost

PSC used Dynamic Risk and LEI assumptions for other operating costs ($80,000 per year/$6,666 per month overhead and incremental overhead of 0.45 person years, multiplied by their assumption of 2,000 hours per year and $30 per hour to get $27,000 per year/$2,250 per month). PSC assumed that Dynamic Risk and LEI's assumptions did not apply to a single truck but to the cost of the overall fleet, and Dynamic Risk and LEI assumed a total fleet size of 55 trucks. PSC divided the estimated overhead cost by 55 to arrive at a per-truck overhead cost.

Transloading Equipment Cost

Transloading costs associated with trucking were assumed to be the same as those developed for rail. PSC used the cost-per-unit estimate for transloading equipment ($100,000 per unit), as provided by Dynamic Risk. Two transloading units were considered in these assumptions, one at the origin point and one at the delivery point. PSC replicated Dynamic Risk's calculations for the total investment costs associated with the financed purchase of transloading equipment using a 15 percent amortization rate and 20-year usable lifespan for equipment quoted by Dynamic Risk. The total cost associated with transloading equipment was $316,029 per unit or $632,059 for two units. The total annual cost associated with this investment was $31,603, or $2,634 per month.

Storage Cost

PSC took the same approach to estimating storage costs for trucking and for rail. PSC used the capital cost estimates for bulk storage tanks from Dynamic Risk. For one 90,000-gallon storage tank, Dynamic Risk listed the total capital cost at $350,000. PSC was not able to identify sources to validate the cost assumptions for this equipment. PSC calculated the total investment cost for storage using the 15 percent amortization rate from Dynamic Risk to develop cost estimates for the financed purchased of storage over their 20-year lifespan equal to $1,106,103 (or $55,305 per year for 20 years) per 90,000-gallon tank. Dynamic Risk assumed that three 90,000-gallon storage tanks would be necessary to accommodate increased shipment of propane. This incremental storage investment was not large enough to cover the total storage needed for the amount of product assumed to be shipped in the Dynamic Risk study, indicating that these storage resources were not considered as the long-term storage solution for deliveries. Instead, PSC assumed that incremental storage additions as provided by Dynamic Risk are necessary to facilitate delivery of product, which would be transferred to retailers for long-term storage or delivery to customers. The total annual cost estimate for incremental storage capacity at truck delivery points was $165,915 per year or $13,826 per month. PSC's fixed-cost assumptions are provided in Exhibit D1.

EXHIBIT D1. Fixed Trucking Cost Assumptions, per Month

Cost Parameter	Cost
Tractor Truck	$2,316
Propane Trailer	$2,029
Storage	$13,826
Transloading	$2,634
Overhead	$6,575
Total Fixed Costs	**$27,380**

Source: PSC calculations

Though the annual fixed costs do not change unless additional infrastructure investment in equipment is required, the costs will vary on a per-unit basis depending on the utilization of a resource and the amount of product shipped. In determining truck cost estimates, PSC considered how fixed costs would be allocated based on different utilization rates. The fixed cost of investment related to truck transport is recovered through the delivery of the commodities. As infrastructure resources are more fully utilized, fixed costs are spread over more units and cost per commodity unit decreases.

To allocate fixed costs to the commodity units, PSC estimated volumes at different capacity factors to understand the impact of different utilization rates. For example, fixed costs associated with trucking were estimated to be $27,380 per month. PSC assumed that operating at 100 percent utilization, a truck can deliver 8,800 gallons every day or 264,000 gallons per month. Allocation of the fixed costs across the volume transported results in fixed costs of $0.1037 per gallon. If the truck is only used at 25 percent capacity or delivers just 66,000 gallons per month, the fixed-cost allocation is $0.4148 per gallon. Part of PSC's analysis of alternative supply options included looking at the cost impact of different rates of utilization of delivery systems.

Higher utilization of equipment invested in to deliver propane results in lower cost of supply. For the most part, priority options identified for each of the delivery sites included supply alternatives with high utilization rates. However, PSC saw value in understanding the cost impacts of other equipment utilization patterns. There is some relationship between utilization of fixed-cost resources and the supply pattern, e.g., just-in-time delivery of propane may result in varying levels of utilization over the year. In that case, higher delivery costs may be offset by reduced need for storage because propane is delivered only when needed.

Variable Costs

Fuel-cost Estimates

PSC used U.S. EIA estimates for the retail price of No.2 Diesel Ultra Low Sulfur (0-15 ppm) for the past ten years, and then calculated the ten-year average cost of fuel over this time: $3.1935 per gallon. PSC calculated fuel costs per mile by dividing mileage by the assumed cost of fuel per gallon ($3.1935) by the number of miles travelled per gallon (7.9 miles). The estimated fuel cost for propane trucks is $0.4044 per mile.

Driver Wages and Benefits

To establish updated costs for driver wages and benefits, PSC used data provided by the Bureau of Labor Statistics (BLS). PSC used salary data from BLS's occupational employment and wages statistics for heavy and tractor-trailer truck drivers (Standard Occupational Classification system code 533032) for Michigan, which showed these wages at $20.89 per hour. For benefits, the BLS estimate for all workers of transportation and material-moving occupations nationwide for the second quarter of 2018 was $10.53 per hour. Adding these figures together, PSC established an hourly wage of $31.42 and used this number for the overall analysis.

Insurance and Other Fees

PSC used the Dynamic Risk and LEI assumptions for the insurance/license/fees of $0.09 per mile.

Other Maintenance Costs

PSC used Dynamic Risk and LEI's assumptions to calculate variable maintenance costs in the form of truck/trailer repairs and truck/trailer tires—$0.16 per mile and $0.04 per mile, respectively.

Other Assumptions

Volume of Propane per Tractor Trailer

PSC was not able to validate Dynamic Risk or LEI's assumptions for the common size of a propane trailer, as trailer sizes differ by supplier and requirements differ by state. PSC used 8,800 gallons for the assumed volume of a propane trailer (Crystal Flash pers. comm.). Though not the largest type of propane trailer operating in the state, this measurement does accommodate travel out of state, unlike other trailer types. PSC followed other assumptions used by Dynamic Risk and LEI with regard to terminal load/unload time (one hour each) and operating hours per day (trucks can operate up to 24 hours a day).

Distance Traveled and Time in Transit

For each truck route identified, PSC referenced Google Maps to determine the distance and time to travel from origin to destination. PSC specified a Monday at 9:00 AM departure time to determine accurate travel time under normal business day conditions.[22]

EXHIBIT D2. Variable Trucking Cost Assumptions

Cost Parameter	Cost
Diesel Fuel Costs, per Mile	$0.4044
Insurance and Other Fees, per Mile	$0.09
Truck and Trailer Repairs, per Mile	$0.16
Truck and Trailer Tires, per Mile	$0.04
Total Variable Costs, per Mile	**$0.69**
Driver Wages, per Hour	$20.89
Driver Benefits, per Hour	$10.53
Total Variable Costs, per Hour	**$31.42**

Source: PSC calculations

Cost Calculations

The next step in calculating trucking costs was to determine the number of cycles, i.e., round trips from terminal to delivery point that could be made in a time period (day, month, year) based on travel time between points and time for loading and unloading trucks. PSC selected ten terminals as the origin points for truck shipments with delivery to the five selected sites in Michigan, totaling 50 different routes. Assuming 24 hours of operation, PSC determined the maximum number of trips that could be made in a given day for each route and the total volume of propane shipped. Based on the number of cycles per day, PSC calculated the number of gallons per month that could be delivered with a single truck. The average cycle time for all routes was 1.55 deliveries per day, which results in 416,814 gallons delivered per month at full utilization. Exhibit D3 shows the number of cycles and delivery amounts for each route.

EXHIBIT D3. Number of Cycles per Day and Gallons per Month Delivery

Origin	Delivery Point	Cycles/Day	Gallons/Month
East Chicago, Indiana	Kincheloe, Michigan	1.47	393,254
	Rapid River, Michigan	1.53	409,306
	Alto, Michigan	3.00	802,560
	Kalkaska, Michigan	2.06	551,091
	Marysville, Michigan	1.95	521,664
Janesville, Wisconsin	Kincheloe, Michigan	1.36	363,423

[22] Google Maps is a Web mapping service that provides route planning, distance, and travel time based on real-time or typical traffic conditions. Information was accessed for the time range of December 1, 2019, through February 21, 2020.

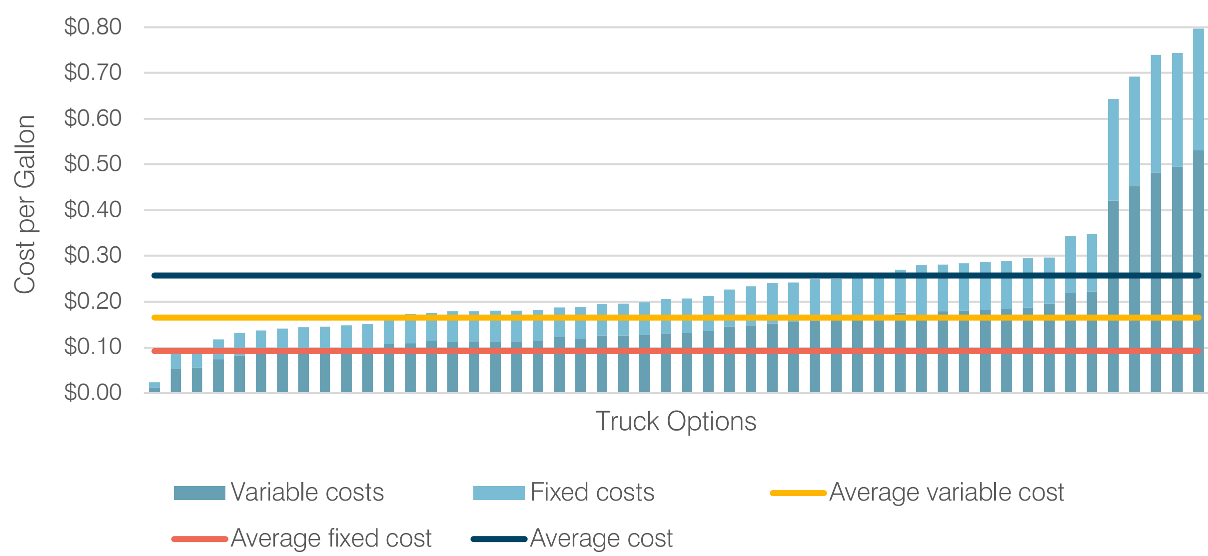
Origin	Delivery Point	Cycles/Day	Gallons/Month
	Rapid River, Michigan	1.89	506,880
	Alto, Michigan	1.89	506,880
	Kalkaska, Michigan	1.44	385,229
	Marysville, Michigan	1.33	356,693
Dubuque, Iowa	Kincheloe, Michigan	0.94	250,149
	Rapid River, Michigan	1.64	437,760
	Alto, Michigan	1.57	418,727
	Kalkaska, Michigan	1.26	337,920
	Marysville, Michigan	1.18	315,761
Coshocton, Ohio	Kincheloe, Michigan	1.18	315,761
	Rapid River, Michigan	1.09	292,727
	Alto, Michigan	1.87	500,297
	Kalkaska, Michigan	1.50	400,446
	Marysville, Michigan	2.07	553,490
Inver Heights, Minnesota	Kincheloe, Michigan	1.13	303,187
	Rapid River, Michigan	1.52	407,650
	Alto, Michigan	1.01	269,165
	Kalkaska, Michigan	1.00	266,299
	Marysville, Michigan	0.83	221,218
Rosemount, Minnesota	Kincheloe, Michigan	1.11	296,512
	Rapid River, Michigan	1.48	394,783
	Alto, Michigan	0.99	264,290
	Kalkaska, Michigan	0.97	260,748
	Marysville, Michigan	0.81	217,914
Lebanon, Indiana	Kincheloe, Michigan	1.11	297,015
	Rapid River, Michigan	1.20	320,971
	Alto, Michigan	1.95	521,849
	Kalkaska, Michigan	1.55	413,424
	Marysville, Michigan	1.60	428,603
Greensburg, Pennsylvania	Kincheloe, Michigan	0.96	256,546
	Rapid River, Michigan	0.85	226,952
	Alto, Michigan	1.36	362,876
	Kalkaska, Michigan	1.12	300,069
	Marysville, Michigan	1.55	413,424
Escanaba, Michigan	Kincheloe, Michigan	3.21	859,886
	Rapid River, Michigan	8.89	2,377,956
	Alto, Michigan	1.67	447,940

Origin	Delivery Point	Cycles/Day	Gallons/Month
	Kalkaska, Michigan	2.38	635,691
	Marysville, Michigan	1.59	426,138
Edmonton, Alberta	Kincheloe, Michigan	0.43	303,187
	Rapid River, Michigan	0.46	407,650
	Alto, Michigan	0.41	110,698
	Kalkaska, Michigan	0.40	107,008
	Marysville, Michigan	0.39	103,556

Source: PSC calculations

Using these estimates, PSC then calculated the variable and fixed costs per gallon of propane shipped for each route. Exhibit D4 shows the range of fixed and variable costs for the various routes for a single truck operating at full capacity. Average variable costs are $0.17 per gallon and average fixed costs are $0.09 per gallon. The highest-cost options represent transport from Edmonton, Alberta, via truck. Because of long cycle time, relatively few gallons are delivered, increasing fixed cost per gallon. High variable costs are driven by the distance and time required to travel.

EXHIBIT D4. Range of Variable and Fixed Costs for Truck Options, per Gallon



Source: PSC calculations

PSC's analysis is based on a single truck; however, some fixed-cost components, including transloader equipment, storage, and overhead, could be spread across a fleet of trucks, reducing the fixed costs allocated to each gallon delivered. Increasing fleet size to ten trucks would reduce average truck transport costs from $0.26 per gallon to $0.019 per gallon.

Appendix E: Michigan Propane Supply Calculations

The limited availability of data for tracking the origin of propane supply to Michigan customers requires reliance on various assumptions to illustrate the state's current propane supply picture. PSC's assumptions, detailed starting on page 46, are based on several calculations that attempt to overcome data limitations and quantify the importance of various supply sources to customers. This appendix provides those assumptions and calculations.

Rapid River

The Rapid River propane production facility receives all of its NGL feedstock from Enbridge's Line 5, which is shipped from Superior, Wisconsin. According to Enbridge estimates, roughly 17.5 percent of the products shipped on Line 5 are NGLs, averaging 82,844 barrels per day, or 3,479,488 gallons daily, from 2014 to 2019 (Enbridge pers. comm.). The facility's stated capacity is 7,500 barrels per day, or 315,000 gallons daily (Plains September 2019). The actual volume of NGLs received by Rapid River, as reported by Dynamic Risk for 2015–2016, states that the facility's actual capacity is closer to 3,000 barrels per day, or 129,231 gallons daily. Based on Plains Midstream Canada estimates, the propane content of the NGLs delivered to Rapid River is 65–70 percent of total volume. Assuming that the facility can extract propane totaling at least 65 percent of the volume of NGLs delivered to the facility, then the effective propane production is 2,000 barrels per day, or 84,000 gallons daily, which totals 30,660,000 gallons of propane annually. Based on PSC's estimated propane demand curve, this propane production amounts to 6.1 percent of statewide demand and 87.6 percent of the Upper Peninsula's demand. For this analysis, PSC assumes that all of the propane produced at Rapid River is consumed in the Upper Peninsula.

EXHIBIT E1. Rapid River Facility Propane Production Calculations

	Barrels	Gallons
Total Line 5 NGLs Shipped per Day	78,200	3,284,407
NGLs Withdrawn per Day	3,077	129,231
Propane Content in Line 5 NGL Mix	65%	
Propane Production per Day	2,000	84,000
Annual Propane Production	730,000	30,660,000
Percentage of Michigan Propane Supplied		**6.1%**
Percentage of Upper Peninsula Propane Supplied		**87.6%**

Source: PSC calculations

Kalkaska Gas Processing Plant

The Kalkaska gas processing plant is supplied from feedstock produced in the northern Lower Peninsula through DTE's Wet Header gas pipeline system (MPSC September 2019). The plant's owner, Lambda Energy Resources, reported to PSC that the facility can produce 2,500 barrels of propane per day, or 105,000 gallons daily. Annual propane production is estimated between 13 million and 15 million gallons (Lambda Energy Resources pers. comm.). According to the MPSC's 2019 *Michigan Statewide Energy*

Assessment, production from the Kalkaska facility was estimated at 1,050 barrels per day, or 44,100 gallons daily, totaling 16,096,500 gallons annually (MPSC September 2019). This estimate also aligns with PSC's. For this study, PSC elected to use the MPSC's production estimates. Based on these figures, the Kalkaska plant provides 3.2 percent of Michigan's total propane supply. PSC assumes that all of this supply is consumed in the Lower Peninsula, which equates to 3.5 percent of the peninsula's propane supply.

Detroit Refinery

Marathon's Detroit refinery is another source of propane supply for Michigan, producing the gas as a biproduct of crude oil refining processes. Crude oil is supplied to Marathon's refinery from a number of sources, including Enbridge's Line 78 and Line 5. The Detroit facility has a total refining capacity of 140,000 barrels per day of crude oil. The MPSC estimated that the rate of propane production from this refinery is 1.66 percent of its total capacity, equating to 2,324 barrels per day, or 98,868 gallons daily. This aligns with Marathon's own estimates (Marathon Petroleum Corporation pers. comm.). As the refinery's output varies seasonally, and some of the propane produced is consumed for its own industrial processes, PSC adopted a more conservative estimate of the refinery's production. For this analysis, PSC assumes that the facility would produce 2,000 barrels per day, or 84,000 gallons daily, which equates to 30.6 million gallons per year. This figure represents 6.1 percent of Michigan's total propane demand. PSC assumes that all of the propane from the Detroit refinery is delivered to customers in Michigan's Lower Peninsula, equating to 6.6 percent of the peninsula's demand.

Ontario Production

Like the Rapid River facility, Sarnia receives NGL product from Enbridge's Line 5 and is operated by Plains Midstream Canada. Plains Midstream Canada reports that the total production capacity of its Ontario facilities is 105,000 barrels per day, or 4,410,000 gallons daily (Plains Midstream Canada 2019). Assuming its Ontario facilities operate at 95 percent of their total capacity, they can produce up to 99,750 barrels per day, or 4,189,500 gallons daily. To determine the volume of propane production from the facility's expected capacity, PSC used the same assumption of 65 percent propane content used in its Rapid River calculations. Therefore, the total estimated propane production from Plains Midstream Canada's Ontario facilities is 64,838 barrels per day, or 2,727,175 gallons daily.

Though Line 5's supplies a sizeable portion of the feedstock for these facilities, PSC assumes that there are other sources. Enbridge estimates that Line 5 transports an average of 82,844 barrels, or 3,479,488 gallons, of NGLs per day (Enbridge pers. comm.). Of this volume, only 79,767 barrels, or 3,350,217 gallons, remain after withdrawals are made at Rapid River. This represents 79.9 percent of the assumed capacity of Plain Midwest's Sarnia facilities and would yield 51,849 barrels per day, or 2,177,641 gallons daily, of propane, totaling 794,839,038 gallons per year.

There is one other variable that helps determine the impact of Ontario production on Michigan. Plains Midwest facilities are connected via pipeline to storage capacity in St. Clair and Marysville, Michigan. Since these pipelines cross international boundaries, there is a record of propane shipments. Examination of these shipments from Ontario to Michigan shows that, from 2014 to 2018, net imports to Michigan from Ontario facilities were 14,618 barrels, or 613,956 gallons, per day (U.S. EIA January 31, 2020f). PSC assumes that all of the gallons delivered to Michigan from Sarnia are consumed in the state, equaling 224,093,940 gallons per year. This represents 44.8 percent of Michigan's total propane demand.

Assuming that the proportion of shipments from Ontario that can be traced to Line 5 equal the total volume of propane produced from Line 5 feedstock (79.9 percent), this would total 11,690 barrels per day, or 490,962 gallons, of propane originating on Line 5 being delivered to Michigan. Using these figures, the annual volume of propane originating from Line 5 is 179,201,188 gallons per year, which equates to 35.8 percent of Michigan's statewide supply and 38.5 percent of the Lower Peninsula's demand.

EXHIBIT E2. Ontario Propane Production Calculations

	Barrels	Gallons
Total Line 5 NGLs Shipped per Day	78,844	3,284,407
NGLs Withdrawn at Rapid River per Day	3,077	129,231
NGLs Shipped to Ontario Facilities per Day	75,123	3,155,176
Ontario Facilities Operating Capacity per Day	105,000	4,410,000
Ontario Facilities Capacity Utilization	95%	
Ontario Facilities Total Production per Day	99,750	4,189,500
Propane Content in Line 5 NGL Mix	65%	
Ontario Facilities Propane Production per Day	64,838	2,723,175
Percentage of Production Supplied by Line 5	75%	
Ontario Facilities Propane Production, Sourced from Line 5	48,830	2,050,865
Net Propane Imports from Ontario Facilities	14,618	613,956
Net Propane Imports from Ontario Facilities, Sourced from Line 5	11,009	462,380
Annual Propane Deliveries from Ontario Facilities	5,335,570	224,093,940
Annual Propane Deliveries from Ontario Facilities, Sourced from Line 5	4,018,299	168,768,558
Percentage of Michigan Propane Supplied		**44.8%**
Percentage of Michigan Propane Supplied, Sourced from Line 5		**33.8%**
Percentage of Lower Peninsula Propane Supplied		**48.2%**
Percentage of Lower Peninsula Propane Supplied, Sourced from Line 5		**36.3%**

Source: PSC calculations

Superior Production

The Superior propane production facility receives all of its NGL feedstock from Enbridge's Line 1, which is shipped from Edmonton, Alberta. According to Enbridge estimates, 80,000 barrels per day, or 3,360,000 gallons daily, from 2014 to 2019 (Enbridge pers. comm.). The facility's stated capacity is 10,000 barrels per day, or 420,000 gallons daily (Plains Midstream Canada 2019). The actual volume of NGLs received by Superior, as reported by Enbridge was 4,000 barrels per day. Based on Plains Midstream Canada estimates, the propane content of the NGLs delivered through Enbridge's Lakehead system is 65 to 70 percent of total volume. Assuming that the facility can extract propane totaling at least 65 percent of the volume of NGLs delivered to the facility, then the effective propane production is 2,600 barrels per day, or

109,200 gallons daily, which totals 39,858,000 gallons of propane annually. PSC estimated that the Superior facility contributes 2,170,000 gallons per year to Michigan propane consumption. This amounts to 6.2 percent of Upper Peninsula demand and 0.4 percent of the statewide demand.

EXHIBIT E3. Superior Facility Propane Production Calculations

	Barrels	Gallons
Total Line 5 NGLs Shipped per Day	80,000	3,284,407
NGLs Withdrawn per Day	4,000	168,000
Propane Content in Line 5 NGL Mix	65%	
Propane Production per Day	2,600	109,200
Annual Propane Production	949,000	39,858,000
Percentage of Michigan Propane Supplied		**0.43%**
Percentage of Upper Peninsula Propane Supplied		**6.2%**

Source: PSC calculations

Appendix F: Storage Calculations

PSC used Dynamic Risk's and LEI's cost-per-unit estimates for storage, which is $350,000 per 90,000-gallon tank. PSC also used each study's 15 percent amortization rate to develop cost estimates for the financed purchased of storage over the tank's 20-year lifespan, which is $1,106,103.25 per 90,000-gallon tank, or $12.29 per gallon.

PSC employed a different approach for estimating the amount of required storage. While PSC replicated Dynamic Risk and LEI's calculations using the three 90,000-gallon tank assumptions, it could not clarify the rationale used in assuming this amount of storage was sufficient. Instead, PSC calculated the number of 90,000-gallon tanks needed to meet demand at various levels, reviewing monthly propane demand in the Upper and Lower Peninsulas to identify the highest level of annual supply needed across two weather scenarios: normal weather (13.19 million gallons) and severe weather (16.60 million gallons). PSC examined these estimates across three different storage types—bulk, retail, and end-user storage—and focused on identifying the amount of bulk storage required.

To evaluate different levels of bulk storage investment, PSC used three capacity scenarios: 1.5 million gallons, 4.75 million gallons, and 8 million gallons. These scenarios represent the low end of bulk storage investment required: Low (normal weather with aggressive end-user storage, 1.5 million gallons), moderate (normal weather with moderate end-user storage/severe weather with aggressive end-user storage, 4.5 million gallons), and high (severe weather with moderate end-user storage, 8 million gallons.)

PSC calculated the number of tanks needed to meet these three demand levels, which is 16.67, 52.78, and 88.89 tanks, respectively. PSC then multiplied the number of tanks needed by the amortized cost per tank over 20 years, which totaled $18.4 million, $58.4 million, and $98.3 million, respectively. Lastly, PSC divided the total cost by 20 years and 365 days for daily cost, and then multiplied this figure by the number of days per month.

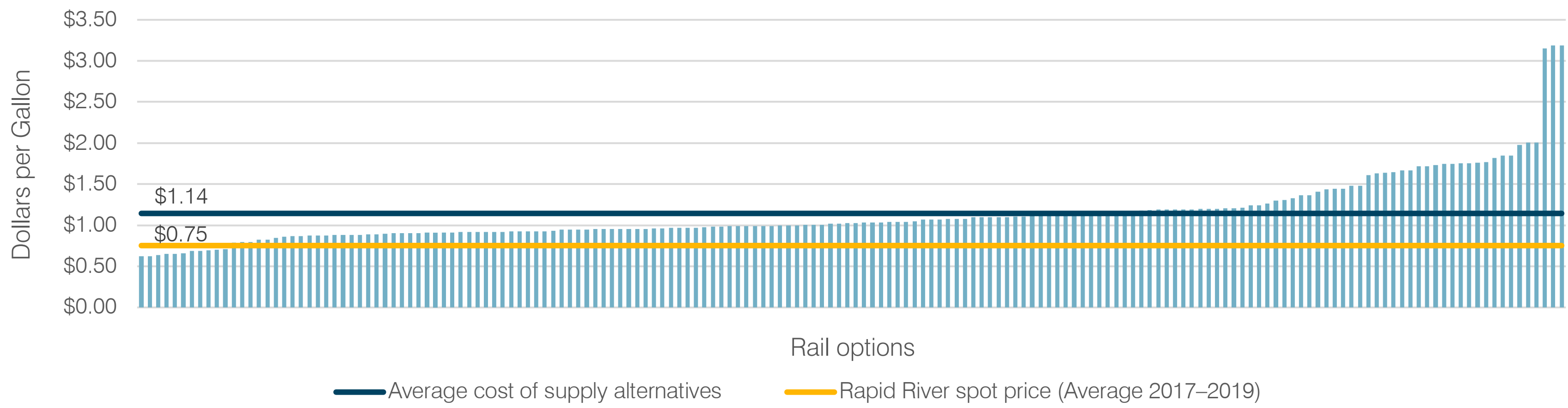
EXHIBIT F1. Upper Peninsula Storage Investment Costs Across Low, Medium, and High Scenarios

Storage Expansion Scenarios	Low	Medium	High
New Storage Required (Millions of Gallons)	1,500,000	4,750,000	8,000,000
New Storage Tanks Required (90,000 Gallons)	16.67	52.78	88.89
Estimated Storage Cost at 15% Amortization Rate (20 years)	$18,435,054	$58,377,671	$98,320,289
Monthly Storage Cost	$76,812	$243,240	$409,668
Monthly Storage Cost per Gallon Storage	$0.05	$0.05	$0.05
Storage Cost per Gallon Shipped Annually	$0.03	$0.08	$0.14

Source: PSC calculations

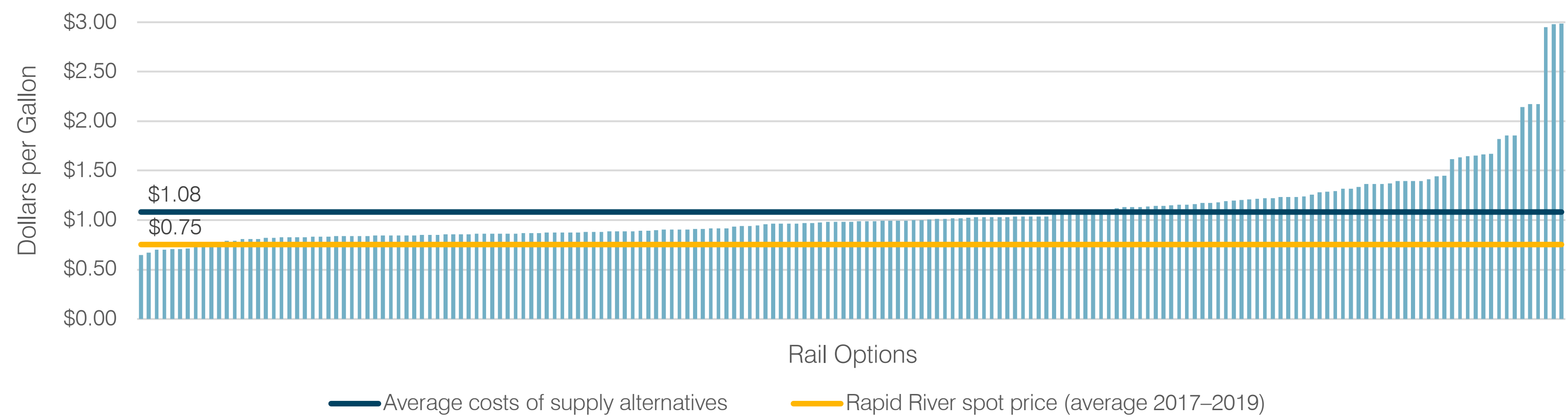
Appendix G: Supply Alternatives

EXHIBIT G1. Supply Alternatives with Delivery to Rapid River



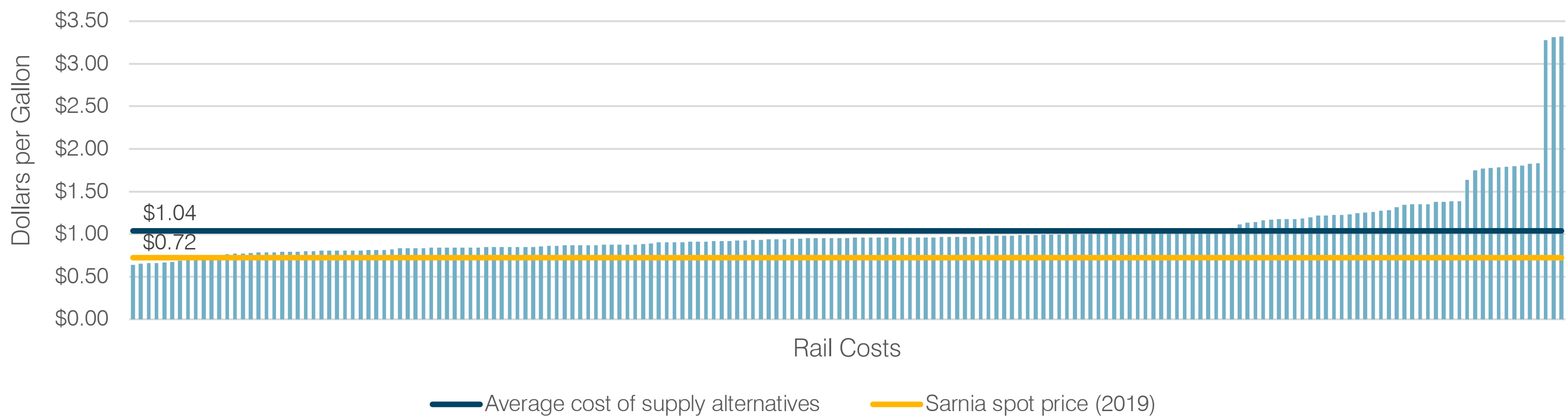
Source: PSC calculations

EXHIBIT G2. Supply Alternatives with Delivery to Kincheloe



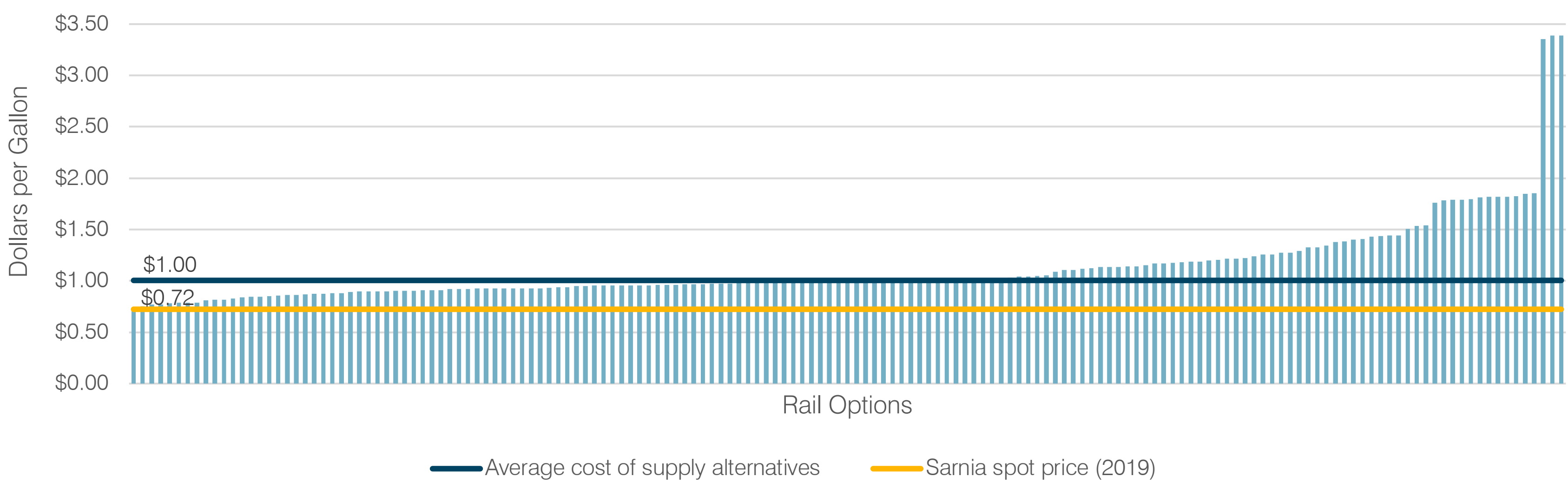
Source: PSC calculations

EXHIBIT G3. Supply Alternatives with Delivery to Alto



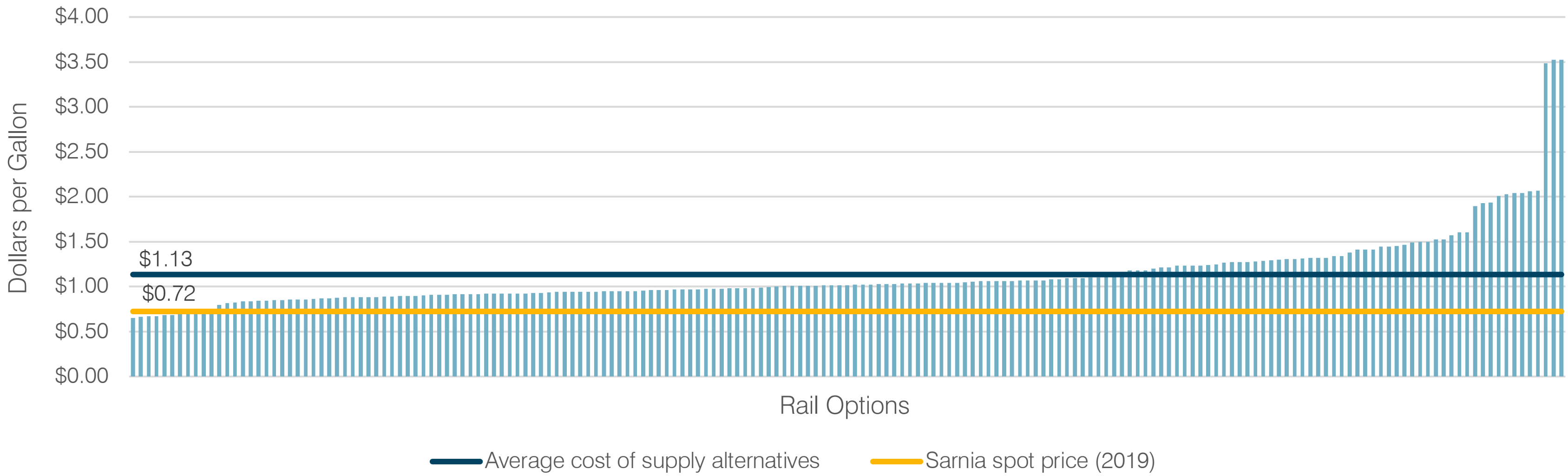
Source: PSC calculations

EXHIBIT G4. Supply Alternatives with Delivery to Kalkaska



Source: PSC calculations

EXHIBIT G5. Supply Alternatives with Delivery to Marysville



Source: PSC calculations

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