**Analysis supported by the Canadian Propane Association**

# GHG emissions intensity of propane produced in Canada

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# Project scope

- The purpose of this engagement is to develop an estimate of the GHG intensity of western Canadian sourced propane. IHS Markit would describe the market circumstances that leads a propane molecule from production through to arrival at the Alberta market hub in Fort Saskatchewan, Alberta as well as delivered to Sarnia, Ontario. This analysis assumes the origin of production is the Montney basin in Western Canada.

- There are three main components to this analysis:

1. A breakdown of major sources of propane in western Canada and Ontario as well as natural gas production to provide a view of the importance of Montney as source of western Canadian propane.
2. Description of the stages of propane marketing, and thus GHG emissions sources starting with upstream extraction for natural gas in which the propane is embedded, natural gas processing where the natural gas liquids are separated from the natural gas, transportation to Fort Saskatchewan as well as Sarnia, Ontario where the NGL stream is fractionated into a saleable specification propane product.
3. A GHG emissions intensity estimate of each stage in the process culminating in a total GHG intensity estimate for the average intensity of propane in western Canada in Fort Saskatchewan as well as western Canadian sourced propane delivered to Sarnia, Ontario.

# Project scope (continued)

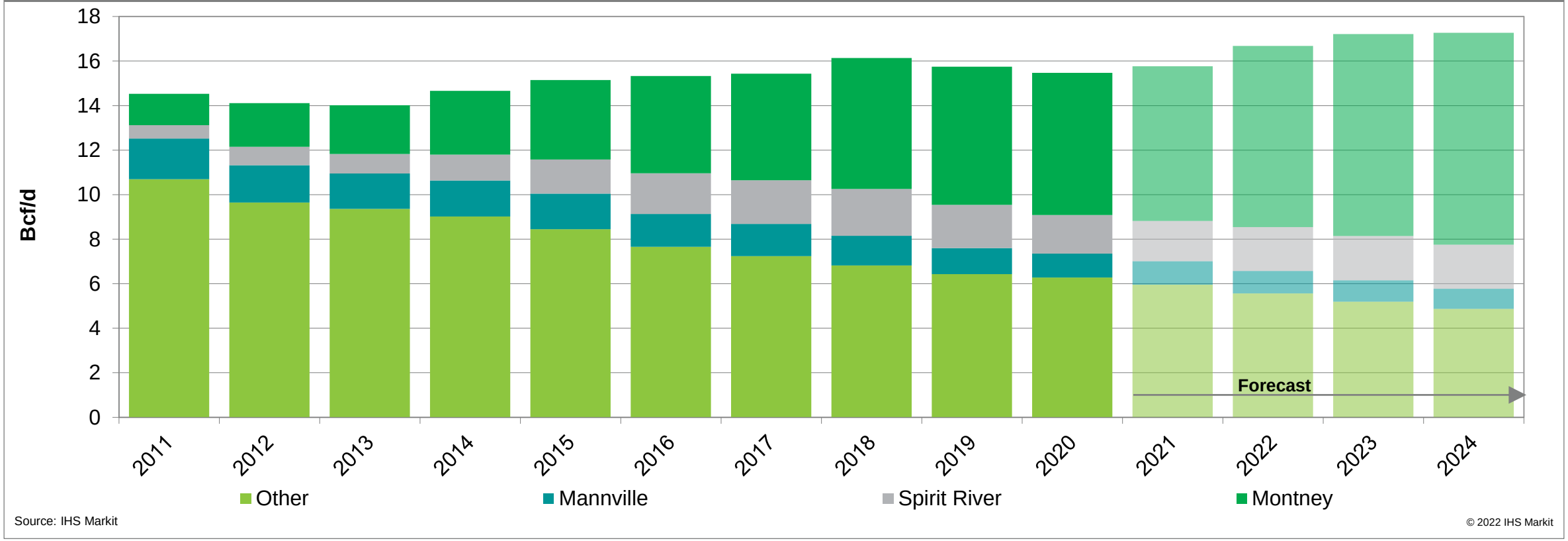
- Qualitative description of partial life-cycle process involved in the production of propane
  - Description of processes involved in propane production beginning with liquids-rich natural gas production in western Canada, gas processing, natural gas liquid transport to the Fort Saskatchewan, Alberta by pipeline for fractionation, as well as natural gas liquid transport from western Canada by long distance pipeline and rail to Sarnia, Ontario for fractionation.

- Development of quantification of GHG emissions of each stage of the single most representative pathway for marketable propane from western Canada in Fort Saskatchewan, Alberta as well as marketable propane sourced in western Canada delivered to Sarnia, Ontario. This includes the following stages:
  - An assessment of weighted average upstream GHG intensity of drilling and completion and production from the largest propane source region which was identified at the Montney.
  - Upstream initial natural gas processing to natural gas liquids stream.
  - Long-distance transport of natural gas liquids to Fort Saskatchewan, Alberta by pipeline and well as long-distance transport of natural gas liquids to Sarnia, Ontario by the dominant pipeline and rail route.
  - Assessment of the average fractionation process emissions to produce propane from the natural gas liquids stream.

- IHS Markit worked with the Canadian Propane Association to identify of the most recent representative year and singular pathways for propane from initial production through various stages of processing and transportation to Fort Saskatchewan, Alberta and Sarnia, Ontario.

# Despite low natural gas prices, gas supply has remained resilient – with nearly all growth coming from the Montney

## Canadian natural gas production by play



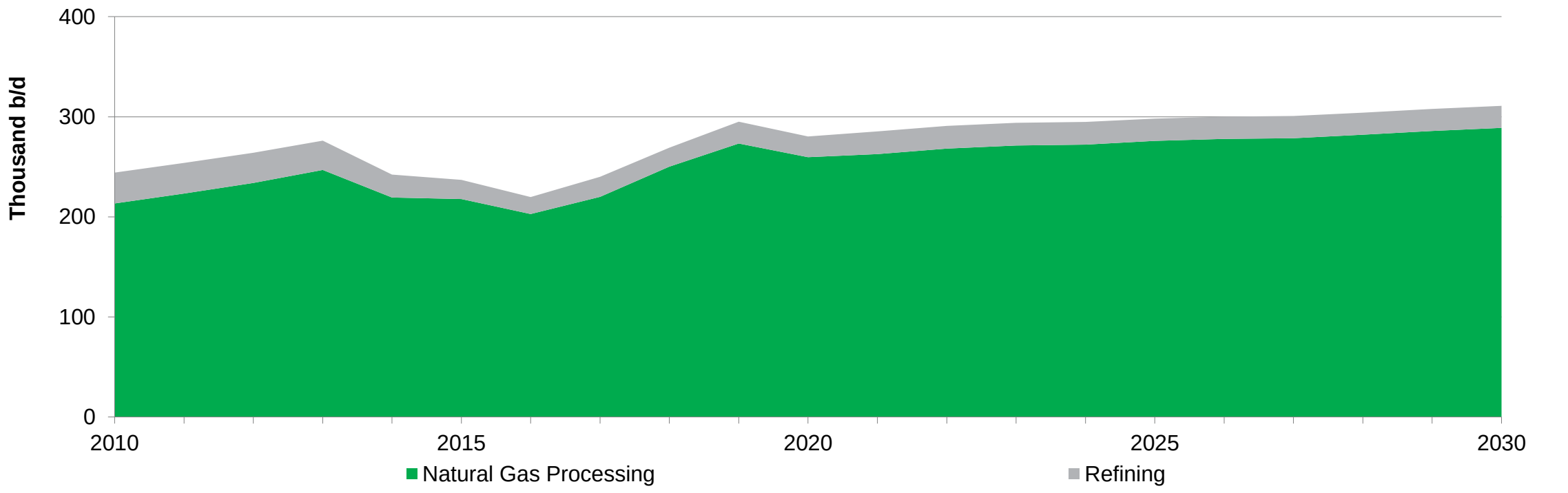

Source: IHS Markit



**The Montney has remained the focus for production due to a high liquid-rich content, offsetting declines in other drier gas plays; an ever-increasing share of Canadian propane will be sourced from the Montney**

# Propane production from natural gas accounts for 92-93% of total propane produced in Canada…

## Canada propane production



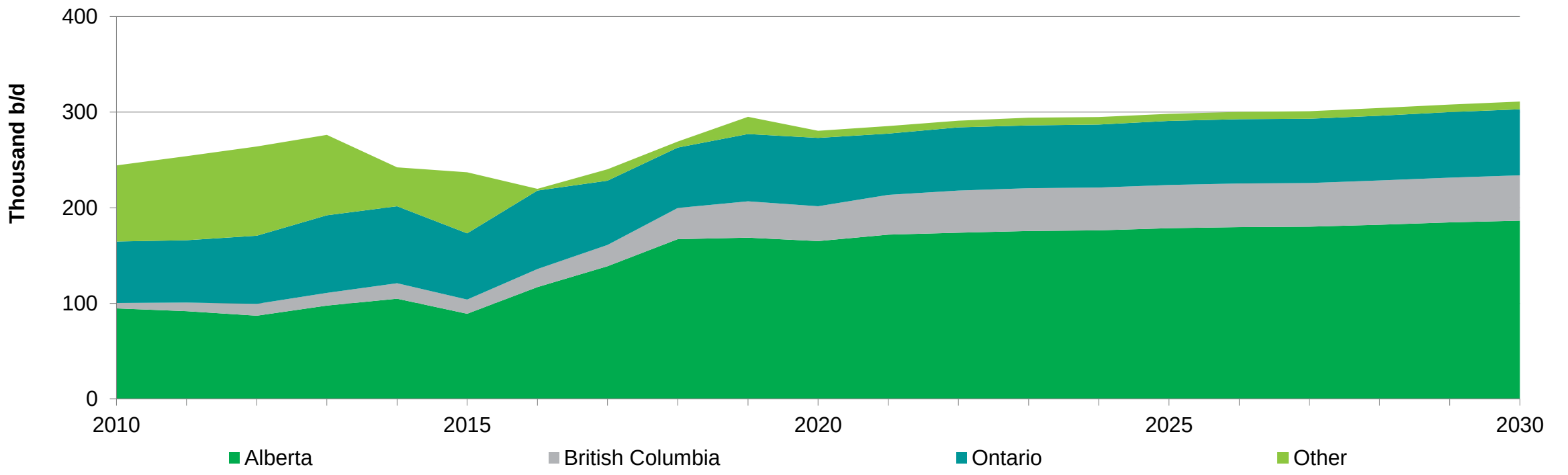

Source: IHS Markit



**… therefore, when developing a methodology to estimate propane emissions it is important to focus on volumes sourced from natural gas processing / fractionation facilities**

# Most Canadian propane comes from natural gas produced in Western Canada, including Ontario production

## Canada propane production by region

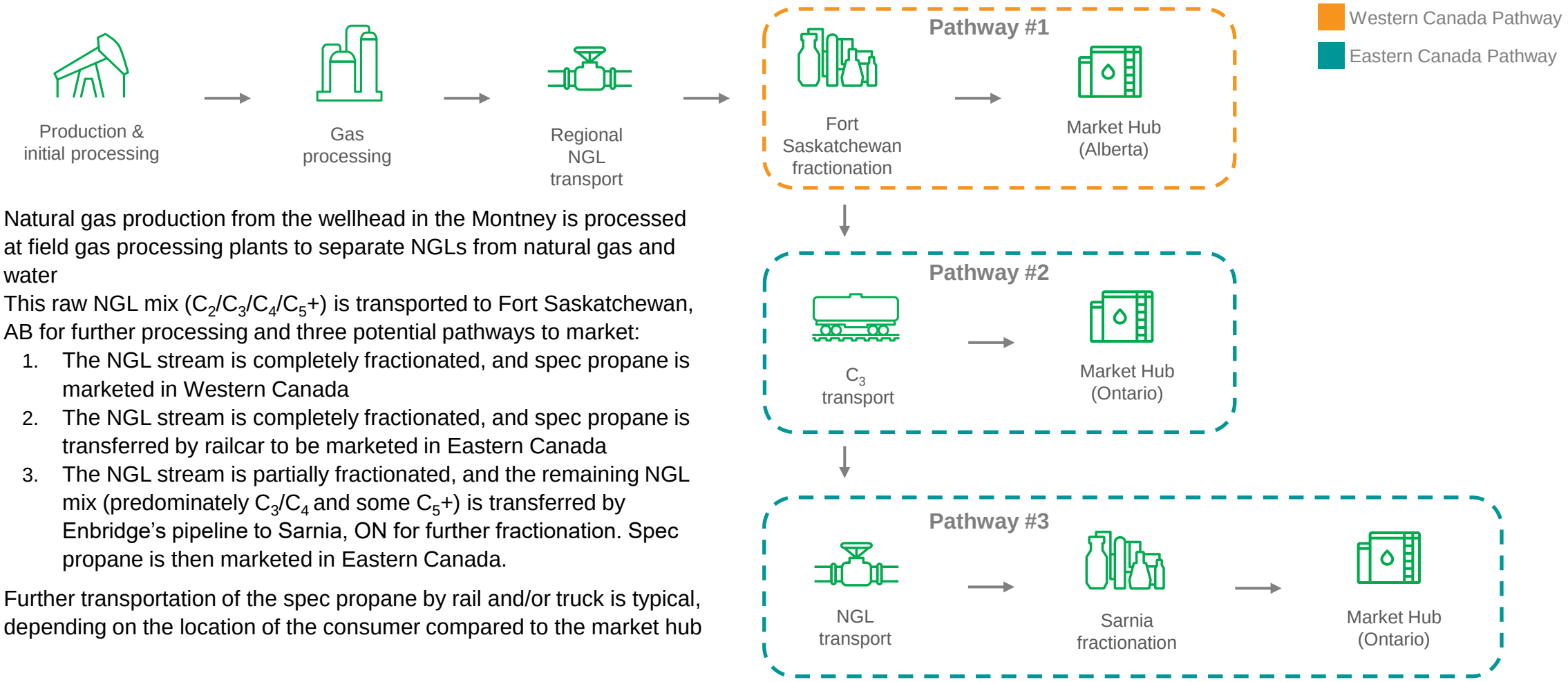



Source: IHS Markit



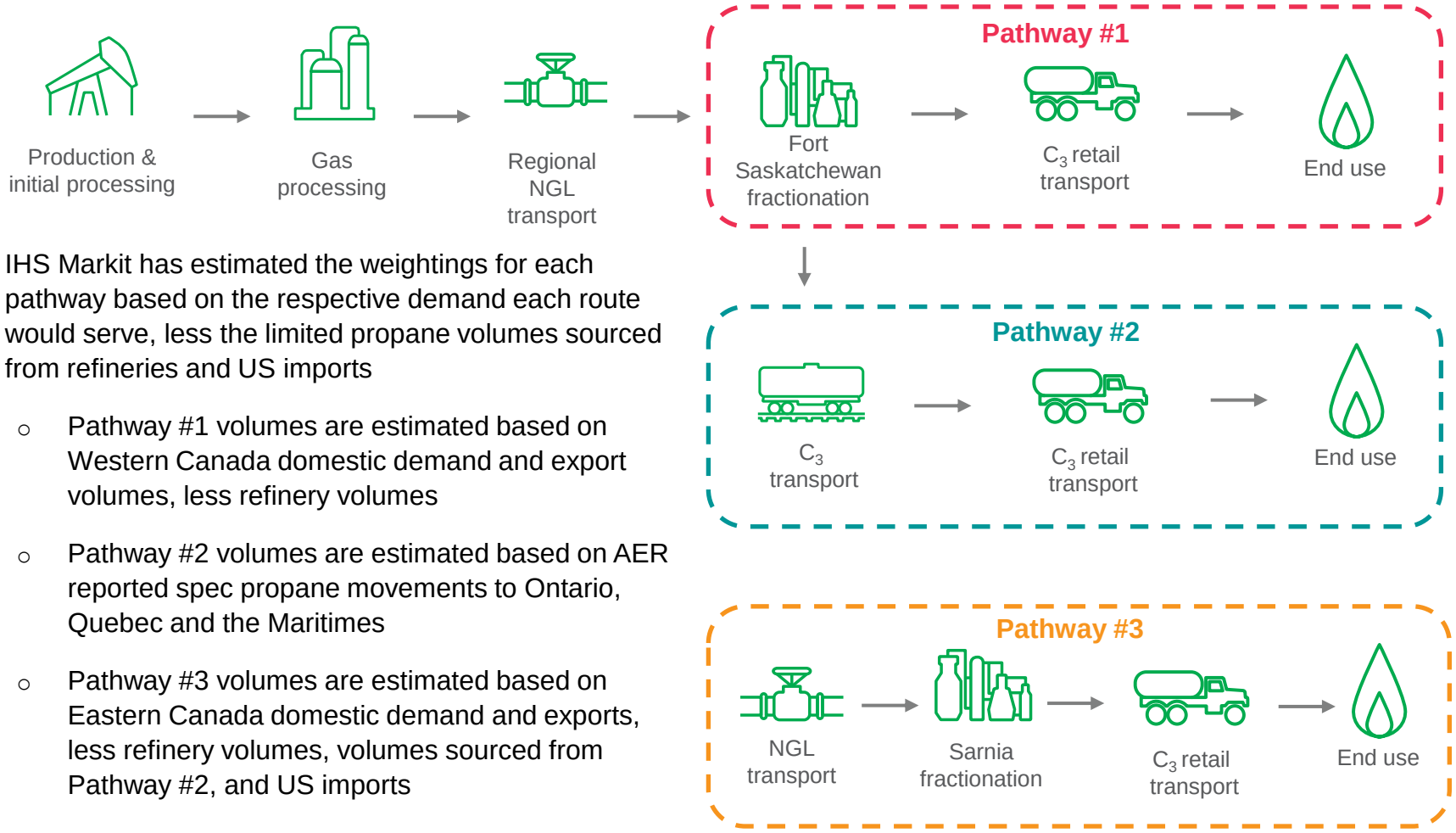
**Propane volumes produced in Ontario are originally sourced from Western Canada and transported to Sarnia, Ontario for fractionation as mixed NGLs along Enbridge's Line 1 and Line 5 pipelines**

# There are three pathways for propane from the wellhead in Western Canada to reach key market hubs across Canada




- Natural gas production from the wellhead in the Montney is processed at field gas processing plants to separate NGLs from natural gas and water
- This raw NGL mix ($C_2$/$C_3$/$C_4$/$C_5$+) is transported to Fort Saskatchewan, AB for further processing and three potential pathways to market:
  1. The NGL stream is completely fractionated, and spec propane is marketed in Western Canada
  2. The NGL stream is completely fractionated, and spec propane is transferred by railcar to be marketed in Eastern Canada
  3. The NGL stream is partially fractionated, and the remaining NGL mix (predominately $C_3$/$C_4$ and some $C_5$+) is transferred by Enbridge's pipeline to Sarnia, ON for further fractionation. Spec propane is then marketed in Eastern Canada.
- Further transportation of the spec propane by rail and/or truck is typical, depending on the location of the consumer compared to the market hub

# Volumes for the three pathways are estimated based on the propane demand each route would serve; majority of propane demand in the West




- IHS Markit has estimated the weightings for each pathway based on the respective demand each route would serve, less the limited propane volumes sourced from refineries and US imports
  - Pathway #1 volumes are estimated based on Western Canada domestic demand and export volumes, less refinery volumes
  - Pathway #2 volumes are estimated based on AER reported spec propane movements to Ontario, Quebec and the Maritimes
  - Pathway #3 volumes are estimated based on Eastern Canada domestic demand and exports, less refinery volumes, volumes sourced from Pathway #2, and US imports

## 2019 Pathway Volumes

**Pathway #1 Total: ~215,200 bpd**
**77%**

**Pathway #2 Total: ~5,300 bpd**
**2%**

**Pathway #3 Total: ~60,000 bpd**
**21%**

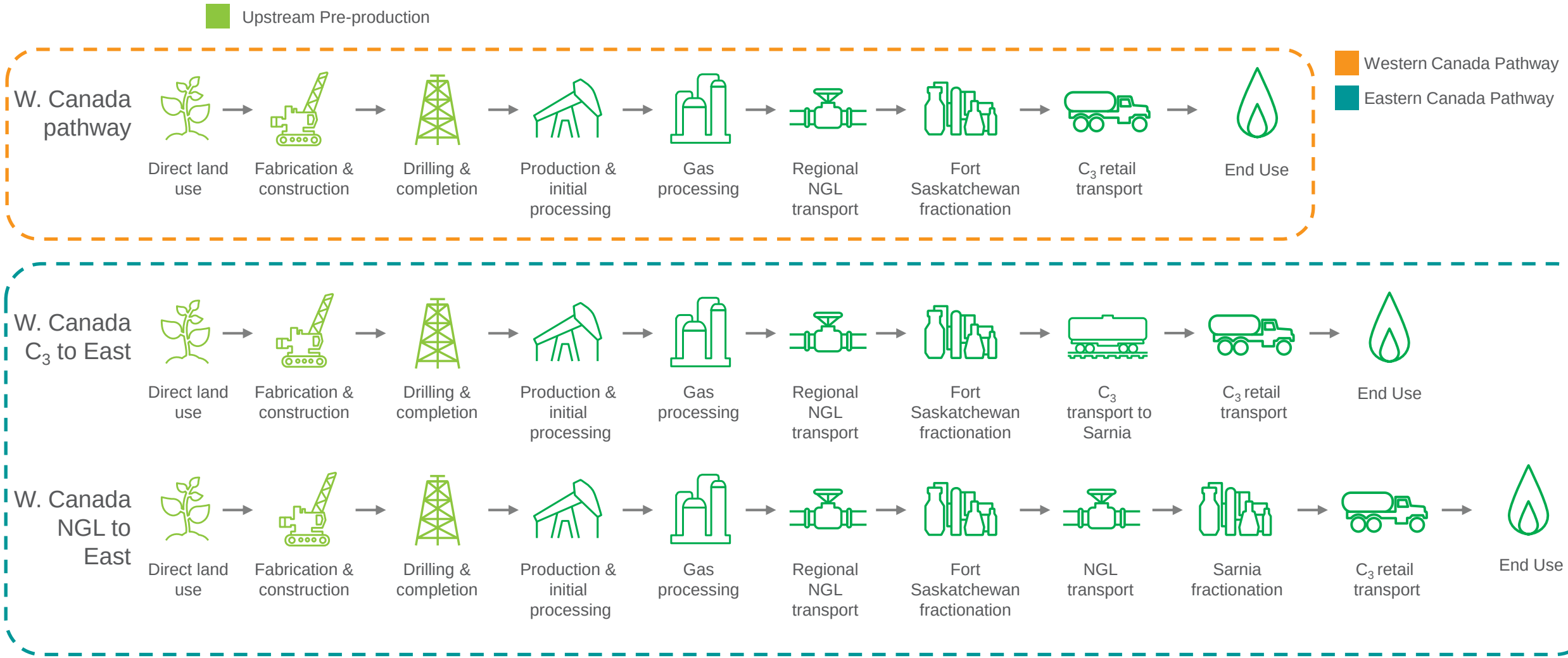


Source: IHS Markit, AER, Government of BC, Government of Saskatchewan, Statistics Canada, CER, EIA

# GHG emissions intensity methodology

# GHG emission pathways for Canadian propane in 2019

IHS Markit / S&P Global considered two markets and three pathways in the analysis



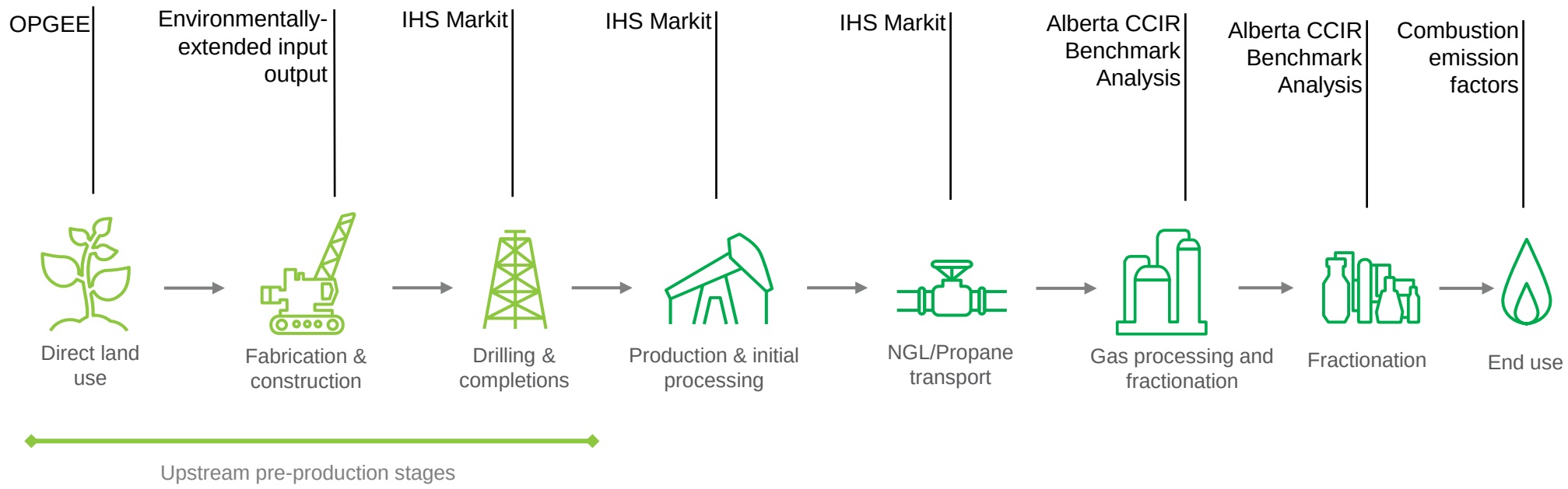



Note: $C_3$ retail transportation will assume a common or average distance for the purpose of estimating propane emissions

# IHS Markit GHG emission intensity analysis

GHG emissions estimates were developed for the various life-cycle segments outlined below

## Life-cycle stages included in IHS Markit / S&P Global analysis




Source: IHS Markit



**GHG estimation for this analysis follows published guidance included in *The Right Measure, A guidebook to crude oil life-cycle GHG emissions estimation***



The Right Measure, A guidebook to crude oil life-cycle GHG emissions estimation. Published by IHS Markit / S&P Global. (March 2022). Available for download https://ihsmarkit.com/products/right-measure.html

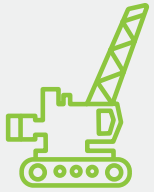
# Pre-production sources of emissions

## Land-use Change and Fabrication & Construction

- Due to the relatively low materiality (share of full life-cycle value) and high uncertainty associated with quantification, IHS Markit / S&P Global adopted simplified approaches for estimating land-use change and fabrication & construction emissions. (Refer to *The Right Measure** for additional information.)
- Pre-production sources of emissions are amortized over the lifetime production of the wells.

**Land-use change (LUC)**

- Leveraged published factors from open-source tool, Oil Production Greenhouse Gas Estimator (OPGEE)**
- For the Montney:
  - Land use type: Mixture of forested, grasslands, and crop land
  - Development intensity: Moderate
- Montney land use change emissions: 1.3 $gCO_2e/MJ$



**Fabrication & construction**

- In a recent public study called *The Right Measure**, IHS Markit / S&P Global published estimates for fabrication and construction emissions for onshore conventional and unconventional assets.
  - Onshore: conventional 0.4 $gCO_2e/MJ$
  - Onshore: unconventional 0.1 $gCO_2e/MJ$
- In 2019, the breakdown of operation wells in the Montney:
  - Conventional wells: 21%
  - Unconventional wells: 79%

* The Right Measure, A guidebook to crude oil life-cycle GHG emissions estimation. Published by IHS Markit / S&P Global. (March 2022). Available for download https://ihsmarkit.com/products/right-measure.html

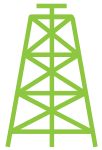
** OPGEE is a well-known, open-source, Microsoft Excel–based tool developed at Stanford University to estimate GHG emissions associated with upstream drilling, development, production, and transport of crude oil for processing. "The Oil Production Greenhouse gas Emissions Estimator," Version 2.0, Stanford University, https://eao.stanford.edu/opgee-oil-production-greenhouse-gas-emissions-estimator

# Pre-production and Upstream Production emissions

IHS Markit's North American Upstream Emissions Analytics was leveraged to provide upstream emissions in this analysis

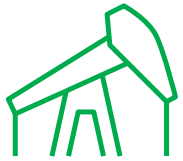
IHS Markit's North American Upstream Emissions Analytics:

- Contains GHG emissions estimates for every month of life, for every well in North America since 2001.
- Layered on top of existing well data, over 150 calculations per well are used to derive estimates of GHG emissions and emissions intensities associated with drilling, completions, and production activity.



## Drilling & Completion

- Model accounts for GHG emissions associated with:
  - Diesel consumption (based on drill days, frac fleet, frac pumps, etc.)
  - Venting associated with mud degassing
  - Flaring during well testing
- Drilling & completions emissions are EUR-amortized over the life of each well



## Upstream Extraction & Production

- Model accounts for GHG emissions associated with:
  - Energy for lifting
  - Venting, flaring, and fugitive sources
  - Wells assumed to start on natural lift, progress to gas lift then electric submersible pumps (ESPs)
- Based on 2019, emissions are allocated to oil and gas based on energy content

**Analysis includes discrete estimates for 7,992 wells in the Montney (the totality of the play)**

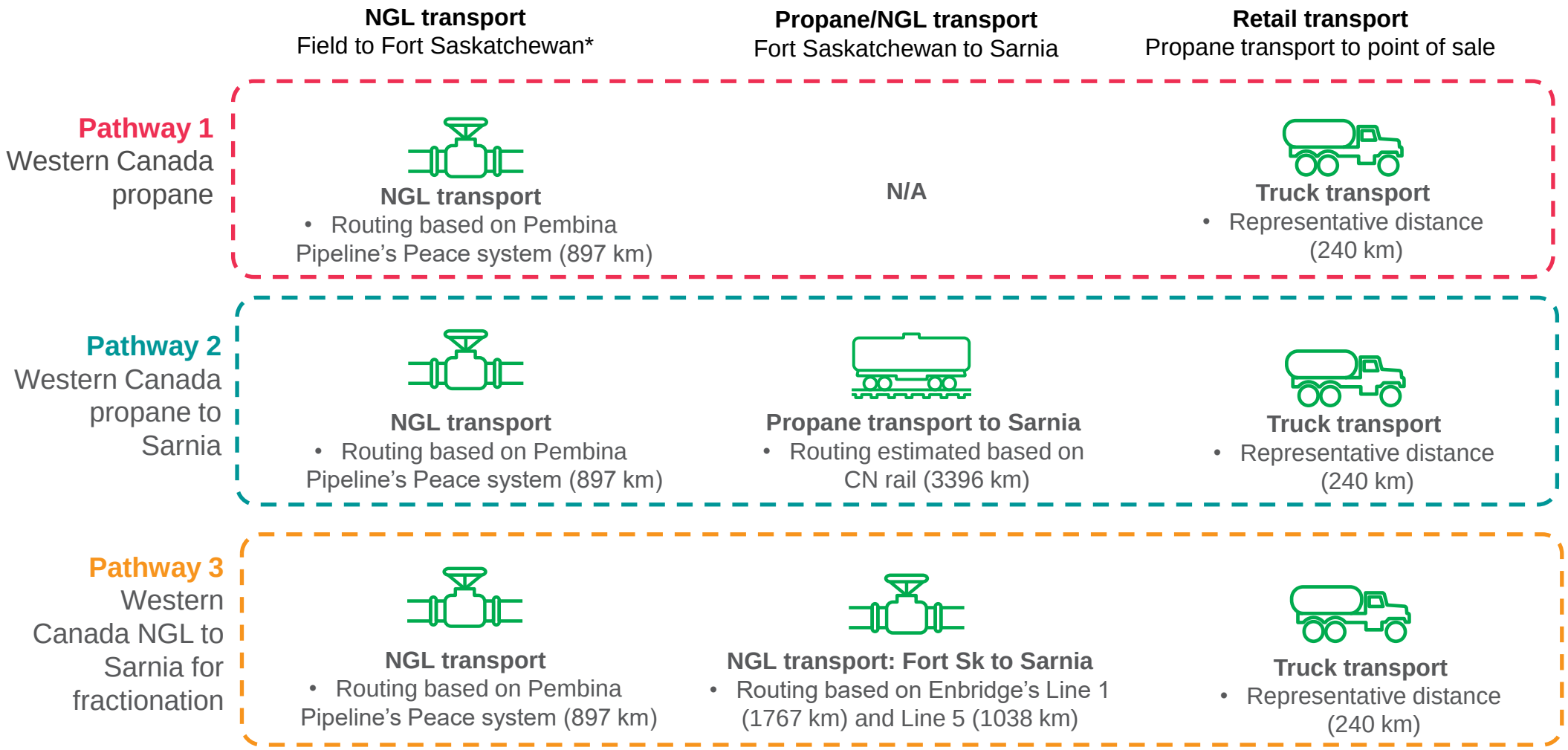
Note: EUR = Estimated Ultimate Recovery



Additional detail on the upstream emissions estimation methodology can be found in the appendixes to The Right Measure, A guidebook to crude oil life-cycle GHG emissions estimation. Published by IHS Markit / S&P Global. (March 2022). Available for download https://ihsmarkit.com/products/right-measure.html

# NGL and propane transport

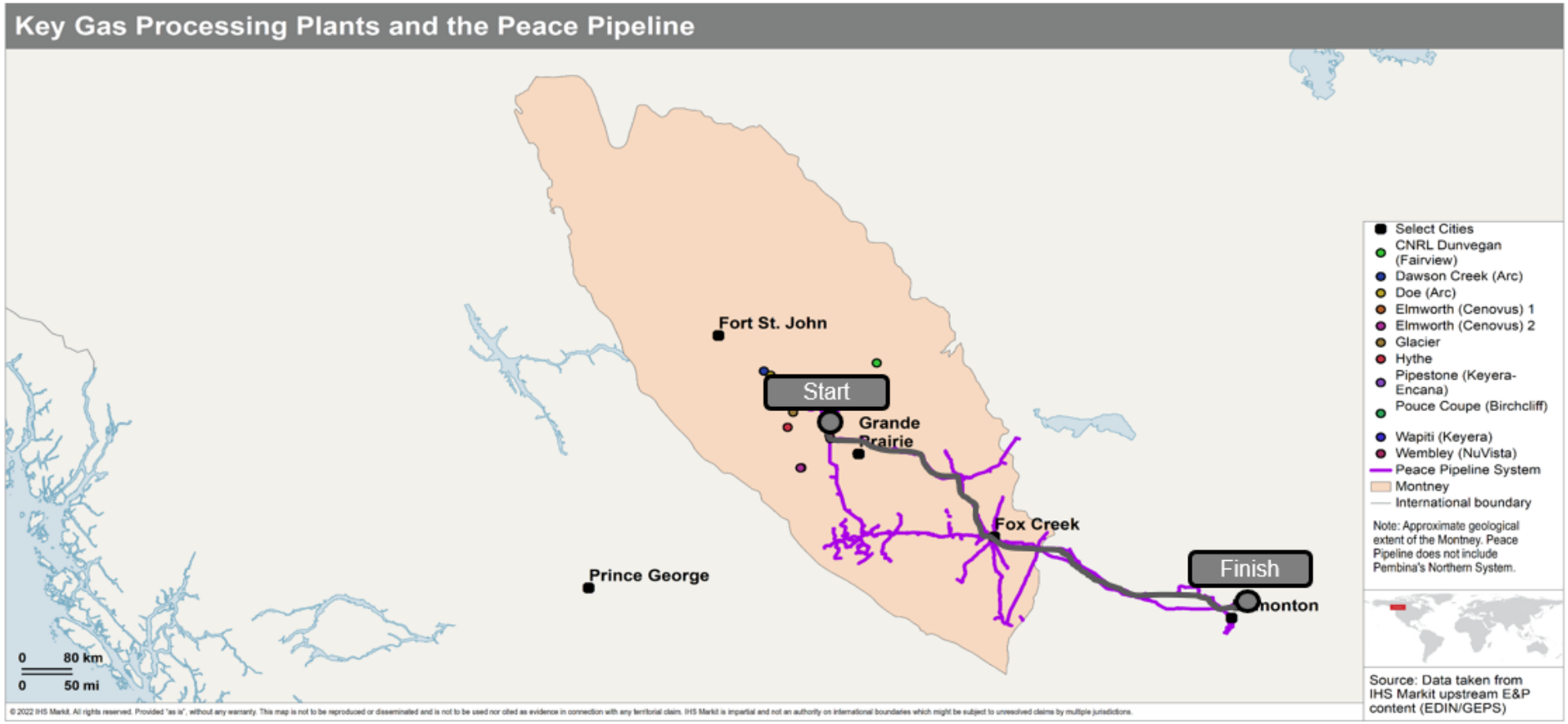
## Overview of IHS Markit's modelling approach






Note: * Includes distance from field gas processing plant to Pembina Pipeline's Peace system (~41km)

# Pembina Pipeline's Peace system carries NGL mix from the Montney to fractionators in Fort Saskatchewan




- IHS Markit analyzed approximately 300 gas processing plants located in/near the Montney play
- Of these facilities, a subset were identified in the heart of the Montney located between Fort St. John, BC and Grand Prairie, AB
- The 10 largest and key gas processing facilities in this region were then used to calculate the approximated distance to Pembina's Peace Pipeline System (~41 km) and the distance to Fort Saskatchewan along the pipeline (~856 km)

Source: Pembina Pipeline

# Enbridge pipeline details – Line 1 and Line 5

## Line 1

- Line 1 is an 18–20-inch pipeline carrying light crude, refined products and NGL with a capacity of 237,000 barrels per day
- It originates at the Enbridge Edmonton terminal and terminates at Superior, Wisconsin
- Length of pipeline is 1,098 miles or 1,767 kilometers

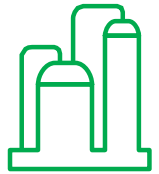

## Line 5

- Line 5 is a 30-inch pipeline carrying light oil and NGL products with a capacity of 540,000 barrels per day
- It originates at the Superior terminal in Wisconsin and terminates at Sarnia, Ontario
- Length of pipeline is 645 miles or 1,038 kilometers


Source: Enbridge

# Gas Processing

## Overview of IHS Markit's modelling approach



- IHS Markit leveraged the public natural gas processing benchmarks developed for the Carbon Competitiveness Incentive Regulation (CCIR) in 2018*.
    - Based on 29 Alberta gas processing facilities who voluntarily shared data by process
- Gas processing GHG emissions have been allocated by energy to propane based on gas analyses from the Montney.
    - Propane accounts for 8% of produced gas (by energy).

**Natural Gas Processing**

| Module | GHG emissions factor - propane share ($kgCO_2e$/bbl propane) |
|---|---|
| Inlet Compression | 5.4 |
| Dehydration | 0.4 |
| Amine Sweetening | 5.0 |
| Total Refrigeration | 3.0 |
| Flaring, venting, fugitives | 0.7 |
| $CO_2$ Plant | 2.1 |
| Sulphur plant | 0.0 |
| **Total gas processing** | **16.6** |

Note: See appendix for Montney gas composition used in analysis.

Source: Government of Alberta, IHS Markit



*Gas processing and fractionation GHG emissions are estimated based on the average module intensities (100% production weighted average) from the Carbon Competitiveness Incentive Regulation *Benchmarks for Processing Natural Gas*, Government of Alberta, https://www.alberta.ca/assets/documents/cci-natural-gas-processing-benchmarks-presentation.pdf

# Fractionation

## Overview of IHS Markit's modelling approach

- Like gas processing, IHS Markit / S&P Global leveraged CCIR natural gas processing benchmarks

**Fractionation**

| Module | GHG emissions factor - propane share ($kgCO_2e/bbl$ propane) |
|---|---|
| Fractionation | 6.6 |

Note: See appendix for Montney gas composition used in analysis.

Source: Government of Alberta, IHS Markit



*Gas processing and fractionation GHG emissions are estimated based on the average module intensities (100% production weighted average) from the Carbon Competitiveness Incentive Regulation *Benchmarks for Processing Natural Gas*, Government of Alberta, https://www.alberta.ca/assets/documents/cci-natural-gas-processing-benchmarks-presentation.pdf

# End use of propane

## Overview of IHS Markit's modelling approach

- It was assumed that all propane is combusted in stationary applications for its end use.

| End use (combustion) | GHG emission factors | | |
|---|---|---|---|
| | ($gCO_2e/L$) | LHV basis ($gCO_2e/MJ$) | HHV basis ($gCO_2e/MJ$) |
| Propane | 1,544 | 66 | 61 |

Source: Canada's National Inventory Report 2019, GREET

# Results

# IHS Markit estimates of GHG emissions intensity of Canadian propane

Results are presented on both a lower and higher heating value (LHV and HHV) basis.

In units of grams of carbon dioxide equivalent per megajoule of energy from propane on a lower heating value (LHV) basis ($gCO_2e/MJ$ LHV)

**GHG emission intensities of Canadian Propane**
($gCO_2e/MJ$ LHV)

| Pathway | Pathway Share | Land-use change | Fabrication and construction | Drilling and completions | Upstream production | Gas processing | Fractionation | Transport | End use | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Pathway #1 (Propane to western Cdn market hub) | 77% | 1.3 | 0.1 | 0.3 | 2.5 | 4.5 | 1.8 | 1.7 | 66 | **78** |
| Pathway #2 (Propane to Eastern Cdn market hub) | 2% | 1.3 | 0.1 | 0.3 | 2.5 | 4.5 | 1.8 | 3.0 | 66 | **79** |
| Pathway #3 (NGL to Sarnia for fractionation) | 21% | 1.3 | 0.1 | 0.3 | 2.5 | 4.5 | 1.8 | 5.0 | 66 | **81** |
| **Canadian Propane** | **100%** | **1.3** | **0.1** | **0.3** | **2.5** | **4.5** | **1.8** | **2.4** | **66** | **79** |

Source: IHS Markit



In units of grams of carbon dioxide equivalent per megajoule of energy from propane on a higher heating value (HHV) basis ($gCO_2e/MJ$ HHV)*

**GHG emission intensities of Canadian Propane**
($gCO_2e/MJ$ HHV)

| Pathway | Pathway Share | Land-use change | Fabrication and construction | Drilling and completions | Upstream production | Gas processing | Fractionation | Transport | End use | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Pathway #1 (Propane to western Cdn market hub) | 77% | 1.3 | 0.1 | 0.3 | 2.5 | 4.5 | 1.8 | 1.7 | 61 | **73** |
| Pathway #2 (Propane to Eastern Cdn market hub) | 2% | 1.3 | 0.1 | 0.3 | 2.5 | 4.5 | 1.8 | 3.0 | 61 | **74** |
| Pathway #3 (NGL to Sarnia for fractionation) | 21% | 1.3 | 0.1 | 0.3 | 2.5 | 4.5 | 1.8 | 5.0 | 61 | **76** |
| **Canadian Propane** | **100%** | **1.3** | **0.1** | **0.3** | **2.5** | **4.5** | **1.8** | **2.4** | **61** | **74** |

Source: IHS Markit



*Note: Environment & Climate Change Canada (ECCC) in Clean Fuel Regulations (CFR) Specifications for Fuel Life Cycle Assessment (LCA) Model Carbon Intensity (CI) Calculations references results per MJ of energy from propane on a HHV basis. Direct comparisons are complicated due to differences in estimation methodology and the results on this slide are not comparable to those included in the Clean Fuel Regulation.

# IHS Markit estimates of GHG emissions intensity of Canadian propane

In units of kilograms of carbon dioxide equivalent per barrel of propane ($kgCO_2e$/bbl of propane)

**GHG emission intensities of Canadian Propane**
($kgCO_2e$/bbl propane)

| Pathway | Pathway Share | Land-use change | Fabrication and construction | Drilling and completions | Upstream production | Gas processing | Fractionation | Transport | End use | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Pathway #1 (Propane to western Cdn market hub) | 77% | 5.0 | 0.5 | 1.1 | 9.5 | 16.6 | 6.6 | 6.1 | 245 | **291** |
| Pathway #2 (Propane to Eastern Cdn market hub) | 2% | 5.0 | 0.5 | 1.1 | 9.5 | 16.6 | 6.6 | 10.7 | 245 | **295** |
| Pathway #3 (NGL to Sarnia for fractionation) | 21% | 5.0 | 0.5 | 1.1 | 9.5 | 16.6 | 6.6 | 18.5 | 245 | **303** |
| **Canadian Propane** | **100%** | 5.0 | 0.5 | 1.1 | 9.5 | 16.6 | 6.6 | 8.9 | 245 | **294** |

Source: IHS Markit

# Comparing the results to ECCC's Clean Fuel Regulations Carbon Intensity for propane

- Comparison of LCA estimates between studies is challenging as there are differences in the basis of the estimation and it can be difficult to make like-for-like comparisons.
- For the purposes of comparison to Environment and Climate Change Canada's *Clean Fuel Regulations (CFR) Specifications for Fuel Life Cycle Assessment (LCA) Model Carbon Intensity (CI) Calculations*, IHS Markit / S&P Global made the following adjustments:
  - Removed IHS Markit / S&P Global estimates of Land-use Change emissions and Fabrication and Construction emissions.
  - Using units of $gCO_2e/MJ$ (HHV-basis)
- The IHS Markit / S&P Global estimates of the GHG emissions intensity of Canadian propane are -4% to +1% when compared to the ECCC CFR estimate.

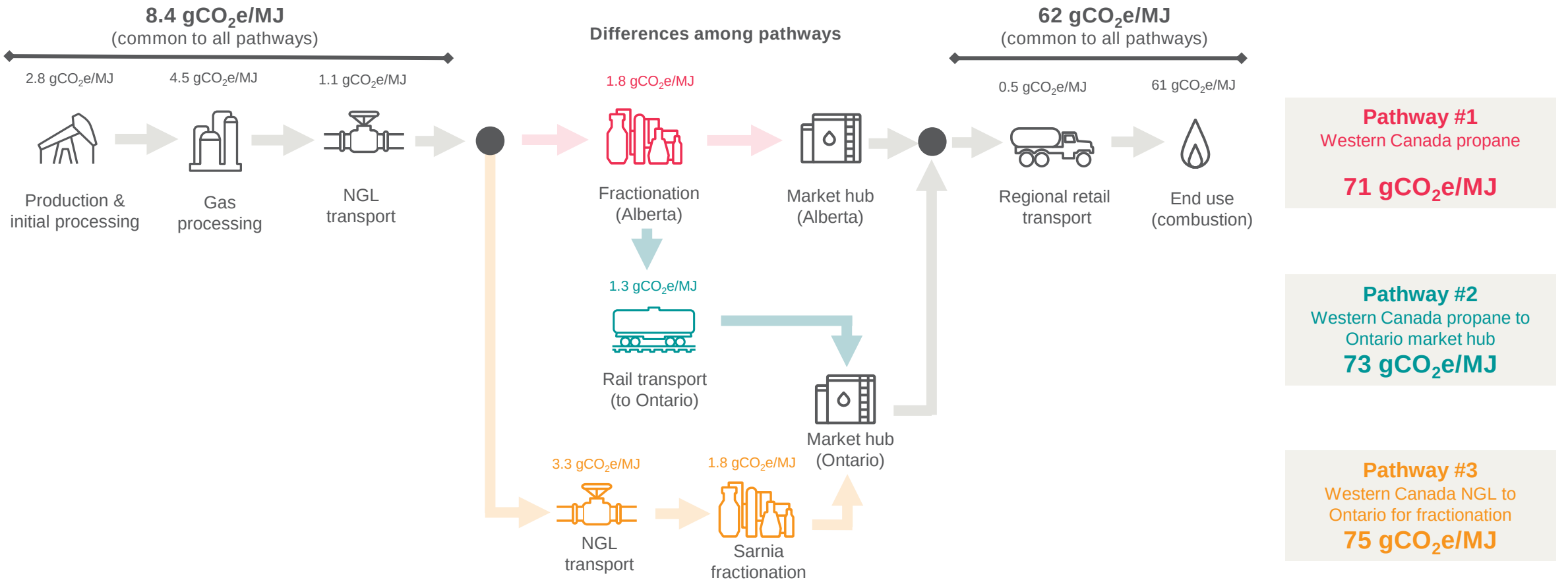
**GHG emission intensities of Canadian Propane ($gCO_2e/MJ$ HHV)**

| Pathway | Pathway Share | Drilling and completions | Upstream production | Gas processing | Fractionation | Transport | End use | Total | % difference |
|---|---|---|---|---|---|---|---|---|---|
| Pathway #1 (Propane to western Cdn market hub) | 77% | 0.3 | 2.5 | 4.5 | 1.8 | 1.7 | 61 | 71 | -4% |
| Pathway #2 (Propane to Eastern Cdn market hub) | 2% | 0.3 | 2.5 | 4.5 | 1.8 | 3.0 | 61 | 73 | -2% |
| Pathway #3 (NGL to Sarnia for fractionation) | 21% | 0.3 | 2.5 | 4.5 | 1.8 | 5.0 | 61 | 75 | 1% |
| **Canadian Propane** | **100%** | **0.3** | **2.5** | **4.5** | **1.8** | **2.4** | **61** | **72** | **-3%** |
| **ECCC Canadian Propane** | | | | **13** | | | **61** | **74** | |

Note: ECCC value for Canadian Propane is from CFR Specifications for Fuel Life Cycle Assessment (LCA) Model Carbon Intensity (CI) Calculations. Direct comparisons of life-cycle analyses are complicated due to differences in estimation methodologies. The S&P Global / IHS Markit values in the table have been adjusted to support a comparison to the ECCC value; however, differences in the basis of estimation may remain.

Source: IHS Markit, ECCC

# Life-cycle GHG intensity estimates of Canadian propane in 2019*




**Canadian propane: 72 $gCO_2e/MJ$**
(volume-weighted average)



*Life-cycle GHG estimates included in this slide exclude land-use change and fabrication & construction emissions.

# Shedding light on quality using the Data Quality Metric (DQM)

The DQM includes five individual indicators, capturing both the reliability and representativeness of the data

- The development of life-cycle GHG estimates often necessitates the use of imperfect information.
- DQM assessments are intended to be informative, supporting further understanding of the reliability and representativeness of the data used to develop GHG estimates.
- The DQM assessment and aggregation process results in a two-letter score, ranging from A to F, for each life-cycle stage as well as for the full life-cycle values.

**Data Quality Metric assessments for full life-cycle estimates of Canadian propane**

| | Land-use change | | | Fabrication and | | | Drilling and completions | | | Upstream production | | | Gas processing | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GHG intensity | DQM score | | GHG intensity | DQM | | GHG intensity | DQM | | GHG intensity | DQM | | GHG intensity | DQM | |
| Pathway | $gCO_2e/MJ$ | Data Rel. | Data Rep. | $gCO_2e/MJ$ | Data Rel. | Data Rep. | $gCO_2e/MJ$ | Data Rel. | Data Rep. | $gCO_2e/MJ$ | Data Rel. | Data Rep. | $gCO_2e/MJ$ | Data Rel. | Data Rep. |
| Pathway #1 | 1.3 | F | F | 0.1 | F | D | 0.3 | D | A | 2.5 | C | B | 4.5 | C | C |
| Pathway #2 | 1.3 | F | F | 0.1 | F | D | 0.3 | D | A | 2.5 | C | B | 4.5 | C | C |
| Pathway #3 | 1.3 | F | F | 0.1 | F | D | 0.3 | D | A | 2.5 | C | B | 4.5 | C | C |
| **Canadian Propane** | **1.3** | **F** | **F** | **0.1** | **F** | **D** | **0.3** | **D** | **A** | **2.5** | **C** | **B** | **4.5** | **C** | **C** |

Note: DQM = Data Quality Metric; Data rel. = Data reliability; Data rep. = Data representativeness. Data Quality Metric assessments have been completed bsed on full life-cycle GHG estimates of propane (HHV-basis).

Source: IHS Markit



**Data Quality Metric assessments for full life-cycle estimates of Canadian propane**

| | Fractionation | | | Transport | | | End use | | | Full life-cycle | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GHG intensity | DQM | | GHG intensity | DQM | | GHG intensity | DQM | | GHG intensity | DQM | |
| Pathway | $gCO_2e/MJ$ | Data Rel. | Data Rep. | $gCO_2e/MJ$ | Data Rel. | Data Rep. | $gCO_2e/MJ$ | Data Rel. | Data Rep. | $gCO_2e/MJ$ | Data Rel. | Data Rep. |
| Pathway #1 | 1.8 | C | C | 1.7 | D | C | 61 | C | A | 73 | C | A |
| Pathway #2 | 1.8 | C | C | 3.0 | D | C | 61 | C | A | 74 | C | A |
| Pathway #3 | 1.8 | C | C | 5.0 | D | C | 61 | C | A | 76 | C | A |
| **Canadian Propane** | **1.8** | **C** | **C** | **2.4** | **D** | **C** | **61** | **C** | **A** | **74** | **C** | **A** |

Note: DQM = Data Quality Metric; Data rel. = Data reliability; Data rep. = Data representativeness. Data Quality Metric assessments have been completed bsed on full life-cycle GHG estimates of propane (HHV-basis).

Source: IHS Markit



For additional information on the Data Quality Metric, including the pedigree matrix used for DQM assessments, the aggregation process and detailed examples, refer to *The Right Measure*.

# Appendix

# Common assumptions and factors

IHS Markit / S&P Global used the following densities, LHVs, and HHVs for propane and NGLs in the analysis.

## Propane and NGL properties

| Fluid | Density ($kg/m^3$) | Lower Heating Value (LHV) (MJ/kg) | Higher Heating Value (HHV) (MJ/kg) |
|---|---|---|---|
| Natural Gas Liquids (NGL) | 669 | 35 | 38 |
| Propane | 507 | 46 | 50 |
| Butane | 585 | 40 | 43 |
| isobutane | 560 | 38 | 41 |
| Pentane | 626 | 45 | 49 |
| Hexane | 655 | 44 | 47 |
| Methane | 1 | 50 | 56 |
| Ethane | 1 | 19 | 19 |
| Hydrogen | 9.E-02 | 118 | 139 |

Source: GREET, NIST Chemistry WebBook



IHS Markit / S&P Global used Global Warming Potentials from the IPCC's Fifth Assessment Report (100-year timeframe) and the following electricity grid system GHG emissions intensities in the analysis.

## Global Warming Potentials (GWPs)

| Gas | | GWP |
|---|---|---|
| Carbon Dioxide | $CO_2$ | 1 |
| Methane | $CH_4$ | 28 |
| Nitrous Oxide | $N_2O$ | 265 |

Source: IPCC Fifth Assessment Report (AR5)



## Electricity Grid System Emissions Intensities in 2019

(metric tons $CO_2e$/MWh)

| | |
|---|---|
| **Canada** | |
| Alberta | 0.67 |
| British Columbia | 0.02 |
| Manitoba | 1E-03 |
| Saskatchewan | 0.71 |
| **United States** | |
| MROW (MRO West) | 0.57 |

Sources: US EPA, ECCC

# Upstream drilling, completions, and production

- The average gas composition produced from the Montney is included in the table on this slide.
- The lift mechanism changes over the life of each well and has been modelled assuming:
  - First six months of operation: natural lift
  - Months 6-8 of operation: gas lift
  - Remainder of operational life: electric submersible pumps
- Upstream flaring
  - Assumed 2% of produced gas is flared, based on provincial averages
- Upstream venting/fugitives:
  - Assumed 0.2% of produced gas is released to atmosphere

**Montney Gas Composition**

| Substance | | Mol % |
|---|---|---|
| Methane | $C_1$ | 79.8 |
| Ethane | $C_2$ | 8.1 |
| Propane | $C_3$ | 3.3 |
| Isobutane | $iC_4$ | 0.6 |
| Normal butane | $nC_4$ | 0.9 |
| Isopentane | $iC_5$ | 0.3 |
| Normal pentane | $nC_5$ | 0.3 |
| Hexane | $C_6$ | 0.2 |
| Heptane | $C_7$ | 0.2 |
| Octane | $C_8$ | 0.1 |
| Nonane | $C_9$ | 0.0 |
| Decane | $C_{10}$ | 0.0 |
| Hydrogen | $H_2$ | 0.0 |
| Helium | He | 0.0 |
| Nitrogen | $N_2$ | 0.7 |
| Carbon dioxide | $CO_2$ | 3.2 |
| Hydrogen sulfide | $H_2S$ | 2.4 |

Source: IHS Markit Accumap

# Transportation of NGL and propane

## Basis for GHG estimation, assumptions, and factors

**IHS Markit hydrocarbon transport model** relies on published energy intensities of various modes of transport with the following inputs:

- Mode of transport
- Fuel source
- Distances
- Fluid properties

### Energy intensities by transport mode

(J/kg-km)

| Mode of Transport | Outbound trip (to destination) | Return trip (to origination) |
|---|---|---|
| Pipeline | 292 | 0 |
| Rail | 197 | 0 |
| Truck | 647 | 514 |

Source: GREET



### Value chain transportation of Canadian propane by pathway

| Pathway | Leg | Product | Mode | Distance (km) | Fuel source |
|---|---|---|---|---|---|
| **Pathway #1** (Propane delivered to western Cdn market hub) | 1 | NGL | Pipeline | 897 | Electricity |
| | 2 | Propane | Truck | 240 | Diesel |
| **Pathway #2** (Propane delivered to Eastern Cdn market hub) | 1 | NGL | Pipeline | 897 | Electricity |
| | 2 | Propane | Rail | 3,396 | Diesel |
| | 3 | Propane | Truck | 240 | Diesel |
| **Pathway #3** (NGL to Sarnia for fractionation) | 1 | NGL | Pipeline | 897 | Electricity |
| | 2 | NGL | Pipeline | 3,708 | Electricity |
| | 3 | Propane | Truck | 240 | Diesel |

Source: IHS Markit

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