NATURAL GAS LIQUIDS (NGLs) IN NORTH AMERICA: AN UPDATE PART III – MARKET FUNDAMENTALS
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Executive Summary

This report follows the discussions of NGL sources and developments in upstream markets (Part I) as well as a detailed description of NGL infrastructure in North America (Part II). The purpose of this report is to present an overview of the main issues affecting NGL market fundamentals in North America including supply and demand, as well as pricing and economics.

Ethane supply in Canada has decreased since a peak reached in 2006 due to various factors including the suspension of ethane/ethylene service on the Cochin pipeline, the closure of Dow Chemical’s derivative facilities in Ontario (ON) and Alberta (AB), as well as lower gas export volumes making their way through the large gas re-processing or straddle plants in AB. Petrochemical demand has therefore been limited to available supplies, primarily in the Alberta market. Ethane extraction volumes however, have stabilized around 220 thousand barrels per day (kb/d) over the last few years.

Given various recent investment announcements, many of which have been partially motivated by the Government of Alberta’s Incremental Ethane Extraction Policy (IEEP), ethane recoveries in AB are expected to increase at the field level, as well as from oil sands upgrader off-gas extraction plants. Meanwhile, various ethane pipelines are being built to bring ethane supplies from nearby US shale basins to both the AB and ON petrochemical markets.

With the expected volumes of ethane availability, together with continued favorable pricing conditions, CERI believes there are opportunities for expansion of currently existing petrochemical facilities, or alternatively, the opportunity for new players to come into the Canadian market.

One lingering question surrounding future ethane availability is whether NGLs from liquefied natural gas (LNG) will remain in the Western Canadian Sedimentary Basin (WCSB), left in the LNG stream as heating value, or perhaps extracted but marketed elsewhere. CERI believes the answer lies at the crossroads of various economic and technical considerations.

Increased propane production in Canada is leading to overall increases in NGL production, meanwhile domestic demand has been growing rapidly led by increased demand in Alberta and Ontario across the mining, oil and gas extraction sector, propane use as a petrochemical feedstock, as well as propane energy use in the manufacturing sector.

Canadian propane exports to the US have fallen rapidly, in particular those heading to the US Midwest (PADD II), while increasing propane exports to the US East Coast (PADD I) have helped displace costlier international overseas LPG imports into the area. Meanwhile, more propane moves via rail from Canada to US markets than in the past, as markets continue to evolve in North America.
As propane supplies in North America continue to increase and propane prices remain relatively soft, various projects have been announced to absorb new propane barrels in North America either via LPG export terminals (over 1,000 kb/d of capacity) or propane de-hydrogenation facilities to produce on-purpose propylene (over 200 kb/d of feedstock required). As the market continues to evolve these new projects will be the key in balancing the North American market, and as more North American supplies reach the global LPG market they are sure to have an impact on future trade patterns and prices.

Butanes supply in Canada has been decreasing over time while domestic demand has fluctuated as less butane volumes become part of the refining pool, petrochemical use volumes fluctuated over time, but increasingly, butanes are used as a heavy oil and crude bitumen diluent for pipeline transportation purposes. As less butanes are available, and while domestic demand has fluctuated, butane exports to the US have followed a pattern much in line with that of propane exports where volumes continue to decline given increased production levels in the US.

Pentanes plus and condensate supply in Canada has increased rapidly over the last decades driven by strong demand for crude bitumen diluent. While domestic production volumes have declined, increased US and overseas imports have closed the demand gap, leading to a high degree of import dependence but also putting upward pressure on prices.

The surge of NGL production in the US following the shale gas revolution has resulted in markets for all NGL products being oversupplied domestically. The markets for propane, butane and pentanes plus, all rely on exports (to differing extents) to maintain balance in the market, while the market for ethane relies on rejection of ethane into the natural gas stream to ensure supply-demand balance.

While there are many new projects to increase domestic demand coming online to absorb some of this new supply, the rate of production is outstripping the rate that midstream and downstream sectors can respond with investment and infrastructure. Consequently, markets continue to rely on exports to maintain balance.

Within each region, however, the markets for NGLs are quite different.

Significant volumes are transferred from PADD to PADD, helping to match supply to unmet demand. While traditionally the Gulf Coast region (PADD III) was the center of NGL action in the US, other regions are increasingly emerging with potential to have increased market share. The game changing Marcellus and Utica plays in PADD I, along with the Bakken and Niobrara in the Midwest (PADD II) are set to bring on NGL supplies of significant volumes over the next few years.

This, along with continued strong supply in traditional Gulf Coast regions means that the previously mature and predictable US NGL market is now in a period of transition, as new sources of supply and demand transform the traditional market structure.
As supply of NGLs continue to increase and domestic demand sources reach their maximum, the US will increasingly rely on exports of products to balance these NGL markets. Currently, imports and exports of NGLs are dominated by trade with Canada, importing LPGs and exporting pentanes plus for use in the oil sands industry but also increasingly ethane for the petrochemical industry. As the NGL market develops it will be crucial for US producers to look further afield to find new markets for their products. Increasing exports will drive the globalization of NGL and petrochemical markets, helping to reduce regional price differentials and increase global competition across the NGL and petrochemical industries.

With an understanding of NGL market fundamentals in North America and the growing prospects of increased LPG exports to the global market and North American petrochemical industry expansion, Part IV of the NGL update will present an overview of global NGL markets and will discuss opportunities in these markets.
NGL Supply and Demand Balances in Canada

With an understanding of the upstream (Part I) and different sources of NGLs in Canada as well as the needed infrastructure to move NGLs to end-use markets (Part II), we can now discuss the markets for NGLs and how they are balanced in the context of supply and disposition (S/D) balances.

CERI developed an analytical framework for Canadian NGL S/D balances as presented in Figure 1.1. Within this framework, supply is comprised of domestic production from gas plants/gas production, refinery LPGs, and oil sands off-gas extraction plants SGLs; imports (primarily from the US), stock changes, and an estimated statistical adjustment that allows for increases or decreases in overall supply levels in order to match total disposition volumes.

**Figure 1.1: CERI NGL Supply and Disposition Framework**

Source: CERI

The disposition (or demand side) is primarily divided between domestic demand and exports. Domestic demand is divided into non-energy use and energy use categories. The energy

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1 The terms disposition and demand may be used interchangeably in this report. However, disposition is generally the sum of domestic demand in Canada from all sectors (and provinces/territories) plus exports to the US.
2 NGLs plus field/wellhead condensate.
3 Positive if there are net withdrawals as it adds to supply and negative if there are net stocks increases as it decreases overall supply in a given year.
4 In all cases this adjustment amounts to 10% or less of total supply thus giving a large level of confidence.
demand category is further disaggregated into the wholesale and retail sectors where applicable (primarily for C₃) (as seen in Figure 1.2).

**Figure 1.2: NGLs Domestic Demand**

What follows is a discussion of these balances for each NGL. The focus of this section will be on the S/D dynamics which brings into focus the relationship between upstream, midstream, and downstream. However, an important component of this section is also to elaborate more on the downstream (or demand side) as only some end-uses were discussed in the previous report (mainly, petrochemicals).

**Ethane**

Figure 1.3 displays the ethane S/D balance.

Starting with the supply side, traditionally, there have been three major sources of ethane in Canada including straddle plants, fractionators, and field plants in the WCSB (in that order). Over the last couple of years, new supply sources have developed including imports from the United States (US), but also increased extraction from SGLs in upgrader off-gases.

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5 Mainly an ethane/propane (E/P) mix from Conway delivered via the MAPL system into the Cochin system to ON. In the coming years, ethane deliveries from the US will come via the Vantage pipeline from ND (Williston Basin) to AB (mid-2014), as well as through the Mariner West (2014) and UTOPIA (2017) pipelines from the Marcellus/Utica NE US shale plays to ON.
Going forward, these emerging ethane supply sources will increase their share in the supply picture and will become more important as AB petrochemical producers aim to diversify their feedstock sources but also as the ON petrochemical producers switch their feedstock from heavy feeds to light NGL feeds.

Extracted ethane is used primarily by the petrochemical industry for the manufacturing of end-use products and thus it is allocated as domestic non-energy use demand on the disposition side. During the 1980s and 90s some ethane volumes were also used for enhanced oil recovery (EOR).

Ethane demand comes primarily from olefin crackers in AB. However, historically, ethane has moved from AB to ON to satisfy demand in the Sarnia market, while some ethylene has also moved from AB to ON, thus reflecting the ethylene capacity surplus position in AB. Ethane and ethylene transfers from AB to ON stopped around the 2007-08 timeframe as the Cochin pipeline was forced to stop deliveries, which in turn led to the closure of Dow Chemicals’ derivative plants in ON.

Additionally, the closure of some ethylene derivative facilities in AB by Dow Chemicals around the same time decreased the overall ethylene derivative capacity in the province and subsequently overall ethylene cracking demand levels.

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Maximum current possible demand for ethane in AB should be estimated not as the maximum ethylene cracking capacity (~260 kb/d) but rather as the maximum ethylene derivative plants’ capacity (~230 kb/d). This is the case as ethylene would not be produced unless it was turned into an ethylene derivative.

Given that over the last few years (2008-12) AB demand (~218 kb/d) has been below ethylene derivative capacity (~232 kb/d) and that some minor propane volumes have been cracked as a petrochemical feedstock (between 1-2 kb/d), CERI re-asserts the industry position that there is a feedstock shortage issue, albeit a smaller one than is usually perceived, and estimates the derivative-based ethylene crackers utilization levels are high (in the 90 percent range).

The top portion of Figure 1.4 illustrates the ethane gathering and delivery system in AB, while the bottom part of Figure 1.4 illustrates Canadian ethane supply from different sources between 2002 and 2012.

The Empress straddle (or re-processing) plants remain the single largest source of ethane to the AB petrochemical industry (between 90 - 100 kb/d), followed by the Cochrane straddle plant (~50kb/d). Ethane extraction from the Empress plants peaked around 2006-07 matching the peak in WCSB gas production and exports to the US. As exports to the US have declined, so have the volumes of gas passing through Empress and thus the amount of ethane extracted at that location. However, as previously discussed CERI estimates that even though less gas is making its way through Empress, there is more ethane in the gas which has in turn allowed the extraction volumes at Empress to stabilize around the 90-100 kb/d range.

This means that while gas throughput at Empress continues to decline, ethane extraction volumes have remained relatively flat over the last few years. Ethane extraction at Empress could stabilize/increase as more ethane was left in the gas stream. The actual data trend in 2011 pointed to an increase in ethane extraction at the straddle plants but in 2012 that trend reversed. This was the case not because less ethane was left in the gas or because less gas than anticipated made it to Empress, but rather the effect of a turnaround at the Joffre petrochemical site. As the petrochemical facilities shut down for maintenance, less ethane demand translated into less ethane extracted at the major supply sources. 2013 preliminary data (AER ST-3) indicate that ethane supply in AB reached 227 kb/d for the year.

This trend is apparent across all of the Empress plants. While some plants at Empress have undergone extraction efficiency improvements, the fact that all plants exhibit the same trend indicates that more ethane is being left in the sales gas stream over the last few years due to a series of economic and logistical barriers.

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8 In the original version of the NGLs report (Study No. 130) CERI predicted that from 2011 on (for the next few years) ethane extraction at Empress could stabilize/increase as more ethane was left in the gas stream. The actual data trend in 2011 pointed to an increase in ethane extraction at the straddle plants but in 2012 that trend reversed. This was the case not because less ethane was left in the gas or because less gas than anticipated made it to Empress, but rather the effect of a turnaround at the Joffre petrochemical site. As the petrochemical facilities shut down for maintenance, less ethane demand translated into less ethane extracted at the major supply sources. 2013 preliminary data (AER ST-3) indicate that ethane supply in AB reached 227 kb/d for the year.

9 This trend is apparent across all of the Empress plants. While some plants at Empress have undergone extraction efficiency improvements, the fact that all plants exhibit the same trend indicates that more ethane is being left in the sales gas stream.
Figure 1.4: Alberta Ethane Gathering and Delivery System (top), and Ethane Supply by Source (kb/d) (2002 - 2012) (bottom)

Sources: Image from AER. Data from AER, BCMNGD, and CERI estimates. Figure by CERI
This highlights the lack of a liquid spot market or a price discovery mechanism for ethane in AB and the fact that sales agreements need to be in place (with petrochemical producers/buyers) in order to be able to market and monetize the commodity.

Going forward, supported by the Government of Alberta’s Incremental Ethane Extraction Policy and the associated generated ethane sales agreements, a number of deep-cut field plants are expected to ramp up, be modified, or be built\(^{10}\) over the coming years. This means more ethane will be extracted at the field level (mainly as $C_2+$ mixes) and thus the amount of ethane produced at the fractionators\(^{11}\) is expected to increase.

As gas demand within the province is expected to continue to increase (led by power generation and oil sands activity), while exports to the US continue to decline, extracting ethane at the field level presents an opportunity for the midstream/petrochemical industry, while the existing straddle plants could decline in relevance.

Fractionators with de-ethanization capacity in AB are primarily fed via the Pembina Peace HVP system ($C_2+$ mixes from BC\(^{12}\) and AB) and the Brazeau system. Given that ethane output from fractionators was on a decline trend until 2008 and then stabilized while exhibiting an increasing trend over the last couple of years (2009-12), and given that $C_2+$ mix flows from BC to AB have been relatively steady, this indicates that more ethane extraction at the field level has taken place in AB over the last couple of years. Yet, since more ethane is also showing up at the straddle plants, not all of the available ethane is being extracted.\(^{13}\)

In BC, projects such as Spectra’s Dawson complex are being built with deep cut capabilities while both Pembina and Altagas have discussed the possibility of expanding extraction and fractionation capacity at the Taylor straddle plant. These projects could increase the amount of $C_2+$ mixes going to the AB fractionators over the coming years. However, the economics of deep-cut facilities in BC are somewhat different than those in AB given the IEEP incentives in AB, as well as the increased transportation and marketing costs incurred in BC versus AB.

Spec $C_2$ extraction at the field level in AB has remained relatively flat over the 2002 to 2012 timeframe with steady output from Shell’s Waterton and Jumping Pound complexes, while Imperial Oil’s Bonnie Glen plant was decommissioned around 2008. However, increases in extraction capabilities at Altagas’ Harmattan and Keyera’s Rimbey plants in the latter part of the decade made up for those lost volumes, keeping spec $C_2$ volumes around the 10-15 kb/d mark.

\(^{10}\) Including plants at Gordondale, Judy Creek, Musreau, Resthaven, Rimbey, Saturn, and Strachan, amongst others

\(^{11}\) Less ethane in the sales gas stream and decreasing sales gas volumes at export straddle plants could lead to significant declines in ethane extraction at the straddle plants unless the ethane content in the gas increases faster than the IEEP field extraction projects are built/exports continue to decline

\(^{12}\) $BC C_2+$ mixes come primarily from the Taylor straddle plant with some minor volumes coming from other field plants in NE BC

\(^{13}\) In fact, CERI estimates that only about 60% of the ethane available in the raw natural gas produced in the WCSB is extracted. This includes over 60 kb/d of ethane extracted at Channahon, ILL (shipped via Alliance)
Going forward, CERI will consider the Harmattan complex a straddle plant (a co-streaming operation since 2012), while the only expected increases in ethane extraction at the field level in AB are expected to come from the expansion/modification of the Rimbey plant. The only additional source of field spec ethane in Canada currently forecasted is the Mistral Energy/SaskEnergy straddle plant in SK which will transport its output through a tie-in to the Vantage pipeline.

Emerging sources of ethane in AB will include ethane extracted from SGLs primarily from the Williams projects (Suncor and CNRL upgraders) and the Aux Sable Heartland plant, but also US imports. Import volumes to AB could be significant given the level of development in the Williston basin (Bakken formation). The one common feature of these two emerging sources of ethane to AB is that they are not dependent on natural gas markets but rather crude oil production and thus provide needed feedstock diversification to petrochemical end-users.

Imports to ON from the US will come through the Mariner West and UTOPIA pipelines from the US NE Marcellus and Utica plays. The possible volumes coming from both these projects combined (in excess of 100 kb/d) compared to the ethane feed-based capacity of the Sarnia crackers (around 70 kb/d), together with NOVA’s announcement to expand ethylene cracking capacity in ON as well as debottlenecks, retrofits, and the possibility of building a new PE facility,\(^\text{14}\) indicates that not only the AB petrochemical industry is poised to expand but so will its counterpart in ON.

An interesting set of questions going forward includes: to what extent will ethane be left in the sales gas stream which is expected to feed BC’s LNG projects? Alternatively, to what extent can that ethane be economically extracted in the WCSB for sale in the AB petrochemical market?\(^\text{15}\) Will those volumes in fact be needed in AB given all the IEEP projects? CERI believes that the answers to these questions will depend on a complex interplay of gas composition and flows, technical/heating value specifications of LNG from buyers, and more importantly LNG/NGL pricing dynamics.

Clearly there are various and complex dynamics at play in regards to ethane supply and disposition in Canada. In preparing the outlook for ethane supply and disposition for Canada, CERI will consider the different natural gas outlook and natural gas composition together with all the changes that will affect the dynamics of field versus straddle plant level ethane extraction.


\(^{15}\) In regards to large integrated majors considering LNG projects in BC such as Chevron, Shell, or Exxon, the question could be one of leaving the ethane in the LNG versus extracting enough ethane to possibly feed their own ethane crackers
Furthermore, the impact that US imports will have on these dynamics will be important (pricing as an example), as will the issue of ethane staying in LNG or being extracted prior to LNG shipping.

**Propane**

Figure 1.5 displays the supply and disposition balance for propane while Figure 1.6 provides the breakdown of spec propane production in Canada by source and by region.

The supply side is primarily made of propane produced by gas plants and fractionators, followed by propane produced by refineries, off-gas plants, stock changes, and imports, in that order. Total supply has fluctuated through the 2002-12 timeframe with the highest supply levels recorded in 2012 at 248 kb/d compared to the lowest at 189 kb/d in 2010.

Propane production is almost evenly split between Western and Eastern Canada. While overall levels of propane production from gas plants/fractionators (83 percent of 2012 production) has increased over the last few years (186 kb/d by 2012), the highest level of propane production from these sources was in 2002, at close to 200 kb/d (195 kb/d). Output from refineries (13 percent of 2012 production) has decreased almost continuously at a compound annual decline rate (CADR) of about 2 percent between 2002 (37 kb/d) and 2012 (30 kb/d). Production from off-gas plants (4 percent of 2012 production) is estimated to have more than doubled from about 4 kb/d in 2002 to about 9 kb/d by 2012. Propane imports from the US have remained a small portion of the supply picture at less than 5 kb/d, but have increased from a low of 1 kb/d in 2009 to over 4 kb/d by 2012. Propane imports are directed primarily to AB and ON.

The disposition side offers a more dynamic and evolving picture.

While total Canadian propane production exhibited an overall declining trend until 2009 (at which point the trend reversed), domestic demand has increased almost uninterrupted between 2002 (85 kb/d) and 2012 (147 kb/d), all while exports to the US have been on a downward trend (which appears to have reversed in 2012). By 2012, domestic demand accounted for close to 60 percent of the total disposition (147 kb/d) (compared to 35 percent or 85 kb/d in 2002).

Domestic demand for propane is illustrated in Figure 1.7.

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16 Different ethane pricing mechanisms for ethane can be expected to develop for AB (gas plus) versus ON (Mt. Belvieu/Conway based netback/net forwards versus gas plus)
17 Includes: British Columbia (BC), Alberta (AB), Saskatchewan (SK), and Manitoba (MB)
18 Includes: Ontario (ON), Quebec (QC), New Brunswick (NB), Nova Scotia (NS), and Newfoundland (NFLD). The single largest production source in this region is the Sarnia fractionator which is fed with WCSB NGL mixes via the Enbridge system
19 Except for 2007
20 Except for 2003 and 2009
21 Net increase of 63 kb/d (or 43% growth) at a compound annual growth rate (CAGR) of six percent
At this point it is important to recall that from all NGLs, propane is the most versatile and thus it has a wide variety of uses. Its main use in Canada is for energy or fuel uses. CERI divides domestic energy demand into two major sub-categories including retail and wholesale categories.

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23 Table 128-0012, Supply and demand of natural gas liquids, and; Table 132-0001, Supply and demand for natural gas liquids and liquefied petroleum gases. Available at: [http://www5.statcan.gc.ca/cansim/a33?RT=TABLE&themeID=2026&spMode=tables&lang=eng](http://www5.statcan.gc.ca/cansim/a33?RT=TABLE&themeID=2026&spMode=tables&lang=eng)
The retail category includes propane use in the commercial/institutional, residential, transportation, and agriculture sectors (green bars in top portion of Figure 1.7). The wholesale category is comprised of propane use at the industrial level with the main users being the mining, oil and gas extraction sector, the manufacturing sector, and the construction sector, in that order (brown bars).

Last but not least, propane use can also be allocated to non-energy uses such as petrochemical feedstock and use for solvent floods\(^{24}\) (orange bars).

In 2012, AB, ON, and QC combined accounted for about 86 percent of total Canadian demand. On a per province basis, between 2002 and 2012, most of the growth in demand has been located in ON, AB, and BC (in that order) while most of the remaining regions have shown steady to decreasing demand trends.

\(^{24}\) Enhanced oil recovery (EOR)
Growth in domestic demand has been the highest across the wholesale category (net growth of 34 kb/d or 54 percent of domestic net growth), followed by the non-energy use category (net growth of 16 kb/d or 25 percent of domestic net growth volumes), and the retail category at a net growth of 12 kb/d (or 21 percent of domestic net growth volumes).

Across all domestic sectors, three sectors have contributed 80 percent of the growth in domestic demand including the mining, oil and gas extraction category (net growth of 26 kb/d), propane use as a petrochemical feedstock (+18 kb/d net), and propane use in the manufacturing sector (+7 kb/d net).

Propane use in the mining, oil and gas extraction sector as well as the manufacturing sector is primarily for the purposes of heating, equipment fuel, or power generation.

Two main determinants of fuel usage by a given sector in a geographical area are its availability/accessibility but also the price of propane as a fuel compared to other fuels or substitutes. As an example, remote locations in rural or undeveloped areas such as those where oil, gas or mining operations take place lack access to gas or electricity distribution infrastructure thus making portable liquid fuels such as propane, butanes, or diesel heating/furnace oil the most viable alternative to natural gas.

Figure 1.8 illustrates prices (on a $/GJ basis) for NGLs as well as those for substitutes such as natural gas and furnace oil.

As can be observed, up until the end of 2005 (when gas prices where high relative to oil prices), all these commodities traded in a close range in terms of $ per unit of energy ($/GJ). Thus, there was little incentive to substitute between types of fuel. After 2006, as crude prices increased rapidly and gas prices remained low in both relative and absolute terms, the spread between oil-based fuels (such as furnace diesel oil) and natural gas derived fuels (such as propane) increased significantly. This spread has remained wide, and continues to provide an incentive to substitute oil derived fuels to NGLs and natural gas.

A similar logic applies to the petrochemical industry. While the petrochemical industry is not concerned about the price of NGLs in terms of energy but rather volume (bbl) (input), given that propane use in the petrochemical industry occurs primarily in ON, and given that the energy density of propane and butanes is similar, thus in volume terms ($/bbl), propane remains a better priced alternative to butanes or heavier feeds (such as crude oil naphtha) as a petrochemical feedstock.

25 For more on propane uses in the oil and gas sector see: http://www.superiorpropane.com/external/bins/content_page.asp?cid=6-1579&lang=1
https://www.canwestpropane.com/sectors-we-service/oil-gas
26 For more on industrial propane uses see: http://www.superiorpropane.com/external/bins/content_page.asp?cid=6-1576&lang=1
https://www.canwestpropane.com/sectors-we-service/business/industrial
27 With some minor volumes used in AB and QC
While the feedstock choice largely depends on the value of ethylene and its co-products rather than solely on feedstock price, CERI estimates indicate that petrochemical users in Canada increasingly prefer propane over other heavier feedstocks as their input.

Favourable prices and availability are not the only reasons why propane use has increased in Canada. The level of activity in a given sector will dictate energy and fuel requirements. As an example, propane use in the residential sector increases at a given rate which is dictated by how many residences with propane heating systems are built or fuel switching from diesel to propane furnaces occur, as well as by factors such as how many BBQs are being used, which are in turn tied to economic activity, weather patterns, and demographics.

Thus, in regards to activity in the industrial sector, fuel requirements are largely driven by the level of activity in that sector. This point is illustrated in Figure 1.9 in regards to the petroleum industry.

The left portion of the figure illustrates propane use by the mining, oil and gas extraction sector together with production of crude oil (conventional and unconventional) in Canada. The right portion of the figure shows the correlation between these two sets of data.

The $R^2$ measure indicates that about 87 percent of the propane used in the mining, oil and gas extraction category can be explained by a given level of crude oil production volumes. Meanwhile, propane use in this category is the highest in AB (73 percent) followed by ON (12 percent),\textsuperscript{28} SK (10 percent), as well as BC and MB (5 percent combined).

\textsuperscript{28} Oil and gas extraction in Ontario is not significant; however, Ontario has a significant level of mining activity.
Propane use by the manufacturing sector is the highest in QC (30 percent of the total), followed by ON and AB (23 percent each), and BC and Atlantic Canada (at 23 percent combined).

While increased domestic demand growth has been the case in Canada, the same cannot be said about the US. Soft demand for propane in the US, coupled with substantial increases in output from gas plants (driven by shale gas development) and flat output from refineries, have led to an overall decrease in propane imports to the point that almost all US LPG imports are coming almost exclusively from Canada. This situation is much akin to what has been observed in natural gas markets as discussed in Part I.

Figure 1.10 displays exports of Canadian propane (and propylene29) to the US by PADD between 2002 and 2012.

Exports to the US have declined by close to 60 kb/d between 2002 (158 kb/d) and 2012 (99 kb/d). While back in 2002 exports to the US accounted for 65 percent of total Canadian propane disposition, by 2012 that share declined to 41 percent. In 2012, export to PADDs I (42 percent) and II (38 percent) combined accounted for 80 percent of Canadian exports to the US.

As can be observed in Figure 1.10, Canadian propane exports to PADD I (East Coast) declined steadily from a peak of close to 50 kb/d in 2003 to a low of about 24 kb/d in 2009, after which point export volumes started to increase, reaching 42 kb/d in 2012. Meanwhile, the largest drop in propane exports to the US has occurred in relation to PADD II (Midwest) which, back in 2002, accounted for 63 percent of Canadian exports (100 kb/d) but only 38 percent by 2012 (38 kb/d).

29 Assumes propylene produced at the Williams Off-Gas plant gets exported to the US (Midwest region primarily)
These trends are the result of a combination of factors (according to CERI’s analysis of EIA\(^\text{30}\) and Canadian data) which are affecting propane supply/demand and inter-regional flows across North America.\(^\text{31}\) These flows are represented in Figure 1.11.

This figure shows local propane supply (grey bars)\(^\text{32}\) versus local demand (red bars)\(^\text{33}\) for six regions in North America (top and bottom section of Figure 1.11) to illustrate which regions have a propane shortage or surplus position (green lines).\(^\text{34}\)

Meanwhile, the figures in between (middle section of Figure 1.11) illustrate the flows of propane from one area to another (colored bars). These flows serve the purpose of balancing the surplus/deficits in the different regions across North America.

CERI estimates indicate that the US East Coast (PADD I) is the third largest overall market for propane in the US (14 percent in 2012),\(^\text{35}\) after the US Gulf Coast (PADD III, 48 percent in 2012) and the US Midwest (PADD II, 28 percent in 2012). PADD I is in turn the second largest US propane heating/fuel (or energy use) market\(^\text{36}\) (20 percent in 2012) after the US Midwest (40 percent in 2012) (excluding petrochemical use).\(^\text{37}\)

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\(^{30}\)See: [http://www.eia.gov/petroleum/data.cfm](http://www.eia.gov/petroleum/data.cfm)

\(^{31}\)Includes: Two regions in Canada (West and East), and five P ADDs in the United States

\(^{32}\)Supply = Production from gas plants and refineries plus stock changes and adjustments

\(^{33}\)Demand = Production supplied (consumption/sales)

\(^{34}\)Supply minus Demand = Surplus (+) if local demand < supply, deficit (-) if demand > supply

\(^{35}\)CERI’s 2012 total US propane demand estimate is 898 kb/d

\(^{36}\)CERI’s 2012 US propane demand estimate for energy use (heating/fuel) is 638 kb/d. All petrochemical demand is assumed to occur in PADD III (US Gulf Coast)

\(^{37}\)For 2012, across Canada and the US (combined) propane petrochemical demand is estimated to account for about 28% (or about 290 kb/d) of total propane demand (or about 1,043 kb/d). Meanwhile the remaining 72% (or 752 kb/d) of propane demand corresponds to the heating/fuel (or energy use) segment of the propane market
Figure 1.11: North American Propane Supply and Demand Dynamics (kb/d) (2002 - 2012)

Source: Background images from EIA and RASC. Data from AER, BCMNGD, CERI estimates, NEB, and Statistics Canada. Figures by CERI

EIA, Gasoline and Diesel Fuel Update: [http://www.eia.gov/petroleum/gasdiesel/diesel_map.cfm](http://www.eia.gov/petroleum/gasdiesel/diesel_map.cfm)

PADD I however produced the lowest amount of propane volumes across all US regions in 2012. Although gas plant production has increased steadily between 2009 and 2012 driven by gas production and midstream infrastructure development in the Marcellus/Utica shale plays, the closure of various refineries in the region has meant lower production from refineries. With propane demand requirements well above production volumes in the region, there is a need for propane transfers from other PADDs (primarily PADDs III and II) as well as imports (from both Canada and overseas).

Canadian propane exports to PADD I have fluctuated through the 2002 to 2012 timeframe but the overall levels have remained much the same when comparing 2002 (41 kb/d) and 2012 (42 kb/d). The main implication of this trend is that PADD I has become a much more important market for Canadian propane as other US markets continue to shrink (PADD II, primarily) and by 2012 accounted for 42 percent of propane exports to the US compared to 26 percent in 2002.

Meanwhile, transfers from other US regions (primarily PADDs II and III) to PADD I have remained flat (PADD II) or declined (PADD III). LPG imports (propane and butanes combined) to PADD I peaked in 2006, from which point they have been on a continuous declining trend. Behind this trend there are some shifts occurring as pricier OPEC (primarily Algerian) and North Sea (Norway) supplies have been pushed out and replaced by better-priced Canadian imports. By 2012, LPG imports to PADD I were primarily sourced from Canada (89 percent) with minor volumes coming from Algeria (8 percent) and Norway (3 percent).

Propane prices further help explain these dynamics as illustrated in Figure 1.12.

This figure illustrates spot propane prices (blue bars) from different market sources (at the source), together with estimated transportation costs (red bars) to New York (one of the largest propane users in PADD I) to arrive to a delivered price (black dots) at New York (spot price plus transport cost estimate).

Furthermore, this figure illustrates residential propane prices (excluding taxes) in PADD IB or the Central-Atlantic region (red dots), which allows for the calculation of a gross marketing margin (green bars) as the difference between residential prices and delivered prices. The analysis is presented for average prices for the 2008 to 2009 time period (faded bars), versus the 2002 to 2013 time period (solid bars).

The point here is that if you were to be a propane marketer in the New York area and you had the option to get your supply from various sources, your end goal would be to maximize profit by obtaining propane at the lowest delivered costs in order to increase the marketing margin.

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40 EIA data also includes propylene and butylene
41 CERI estimates that by 2012 all overseas propane imports to PADD I have been replaced by Canadian sourced propane
42 A net margin would consider logistics, labor, storage, overhead and other costs associated with marketing the propane from a wholesale receipt point to the residential retail end-users
43 Alternatively, a propane producer will try to reach premium price propane markets such as those in PADD I as long as the received price exceeds the sum of production and marketing costs to enter that market
In the 2008 to 2009 timeframe, the gross marketing margin would have been as low as $62/bbl (for Edmonton-sourced propane) and as high as $69/bbl (Conway or Mt. Belvieu), or a $7/bbl margin difference, and therefore the marketer would have been mostly indifferent as to sourcing propane from any source (including Middle East or North Sea propane), while Edmonton propane would have been the least preferred option.

By 2012-13, the flow and pricing dynamics changed significantly. Margins were the highest for Conway propane ($89/bbl), followed by Mt. Belvieu propane, Edmonton and Sarnia propane, and the lowest for Middle East and/or North Sea propane ($58/bbl), and thus there was a significant spread between the highest and lowest margin ($31/bbl).

In regards to US inter-PADD flows this helps explain why more PADD II (Conway priced) propane is flowing to PADD I compared to PADD III (Mt. Belvieu) priced propane. In the international context, this explains that while most OPEC and North Sea sourced propane supplies have been backed out of the PADD I market, flows of Canadian sourced propane from both Western and Eastern Canada have increased.

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46 Hong Kong Electrical and Mechanical Services Department (HK EMSD), LPG Scheme: Auto-LPG Prices: [http://www.emsd.gov.hk/emsd/eng/sgi/lpg_pub_price.shtml](http://www.emsd.gov.hk/emsd/eng/sgi/lpg_pub_price.shtml)
48 Prices used here is the Saudi Contract price. In regards to North Sea or North West Europe (NEW) propane, between 2005 and 2013, prices have moved in tandem with Saudi prices and traded in a close range. See slide 14: [http://www.platts.com/IM.Platts.Content/ProductsServices/ConferenceandEvents/2013/pcc318/presentations/Michael_Lutz.pdf](http://www.platts.com/IM.Platts.Content/ProductsServices/ConferenceandEvents/2013/pcc318/presentations/Michael_Lutz.pdf)
This is consistent with the trend of Canadian propane exports increasingly moving by rail to US markets as exports travel to further markets to fetch better prices in order to access markets for which pipeline connections are not available (such as PADD I).

As PADD I propane production is expected to increase in the coming years given the activity levels in the Marcellus/Utica shale gas plays and an ongoing build-out of gas processing, fractionation, and transportation infrastructure in the area,\(^49\) Canadian propane marketers and producers as well as those from the US Midwest and Gulf Coast will be in direct competition with local northeast US suppliers. Given that demand for propane in PADD I has been declining over the last decade, external propane suppliers will be competing for a piece of the pie in a shrinking market. The Marcus Hook propane export terminal in Pennsylvania could provide some relief in this regard, but in order to remain competitive, Canadian propane prices will need to continue to be well below those of Mt. Belvieu and Conway and be able to compete on transport cost differentials.

In regards to PADD II, CERI estimates indicate that the US Midwest (PADD II) is the second largest overall market for propane in the US and the largest US propane heating/fuel market (excluding petrochemical use).

PADD II is also the second largest propane producing area in the US, yet it has traditionally required net inflows of propane from other US PADDs (mainly PADDs III and IV), as well as Canadian imports, in order to meet its own demand.

As demand for propane in PADD II has decreased over the last decade while propane production from gas plants (associated with shale gas development in the Woodford and Bakken shale plays) increased, PADD II’s propane net deficit has significantly narrowed resulting in reduced required inflows from other PADDs,\(^50\) but also Canadian imports.

This is a story that sounds too familiar when we recall those dynamics that have affected natural gas markets in North America, and, in turn, WCSB producers.

While propane exports to the US Midwest (PADD II) from both Western and Eastern Canada have fallen significantly, the data indicates that exports to this US region have fallen almost in tandem with exports via pipeline from both Western\(^51\) and Eastern\(^52\) Canada. This indicates that those states along the Cochin and Eastern System pipeline corridors — including Indiana, Iowa, Minnesota, North Dakota, and Ohio (mostly northern-tier states in PADD II) — are increasingly being served by intra-PADD supplies which are in turn displacing Canadian volumes.

\(^49\) However, this might be limited by the ability of industry to build enough storage capacity in the area allowing for proper management of seasonal demand fluctuations
\(^50\) CERI’s analysis of EIA data indicates that by 2012, PADD II net transfers of propane out to other US PADDs became positive indicating that PADD II sent out more propane to other PADDs (mainly III & I) than it receives. See also: http://www.eia.gov/oog/info/twig/twigarch/2013/131002/twigprint.html
\(^51\) Via Kinder Morgan’s Cochin pipeline: http://www.kindermorgan.com/business/products_pipelines/cochin.cfm
\(^52\) Via Plains Midstream’s Eastern System Pipeline: http://www.plainsmidstream.com/content/asset-map#
Some minor volumes of Canadian propane continue to move from Western and Eastern Canada via rail and truck.

In regards to PADD II, Canadian propane marketers and producers face similar challenges to those in PADD I. Furthermore, taking the Cochin pipeline out of propane service means that transportation costs to PADD II will increase as more volumes move via rail and truck. This could in turn put downward pressure on Edmonton prices in order to remain competitive against Conway prices. Alternatively, if more PADD II propane supplies continue to flow out to the US Gulf Coast (PADD III) because of better pricing supported by overseas US exports, Canadian supplies could fill a gap in the US Midwest market.

PADD V is mostly balanced via a combination of small import volumes from Canada and small exports to the overseas market.

PADD IV propane supplies exceed local demand which means they supply other PADDs such as III and II.

PADD III also produces propane volumes in excess of local demand which in turn leads to inter-PADD transfers to PADDs I and II, and increasingly, to the global LPG market.

Canadian propane exports to PADDs V (US West Coast) and IV (US Rockies) have remained relatively steady over the 2002 to 2012 timeframe at about 13 kb/d and 4 kb/d, respectively. Meanwhile, over the last few years Canadian propane volumes have increasingly targeted the PADD III area (US Gulf Coast) as Canadian producers and marketers look to expand their markets and possibly access the Gulf Coast’s LPG export infrastructure to get to global markets. These areas of the US combined (PADDs V, IV, and III) accounted for 20 percent of Canadian exports in 2012.

Over the last few years, the US has ramped up LPG exports rapidly, and by 2012, propane exports more than tripled to estimated levels of about 151 kb/d compared to 48 kb/d in 2002. This has, in turn, meant that North America has become a net propane exporter with net export volumes increasing quite rapidly since 2008.

The implications from this shift in the US LPG balance to WCSB producers cannot be understated.

While propane demand across the US has decreased in most regions, shale gas development across the Gulf Coast, Midwest, Rockies, and East Coast has led to a rapid increase in propane production from gas plants. This has, in turn, led to a back out of imports, starting with the ones sourced the furthest away and usually the costliest (similar to the case with light crude oil imports). While Canadian supplies have increased their share of total US imports, the US import segment is most likely a shrinking one under the continuation of the above-mentioned trends.

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53 The January to October 2013 average indicates that US propane/propylene exports have reached over 280 kb/d
54 Canada and the United States, excluding Mexico
This story is not much different than that of natural gas. The one important differing factor in the LPG/propane context is that US LPG exports have provided a relief valve to deal with surplus volumes in North America; while increased domestic demand in Canada has absorbed some of the decreasing US export volumes.

If these trends are to continue, North American LPG exports will continue to be the key to balance the local market. This is expected given proposed and in-service LPG export capacity well in excess of 1,000 kb/d, including close to 70 kb/d in Canada (targeting the Asia-Pacific market) as illustrated in Table 1.1.\(^\text{55}\)

### Table 1.1: North American Liquefied Petroleum Gases (LPG) Export Projects

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>Start-up Year</th>
<th>LPG Export Capacity (MMgal/yr)</th>
<th>LPG Export Capacity (kb/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In Operation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enterprise</td>
<td>Houston, TX</td>
<td>n/a</td>
<td>3,780</td>
<td>247</td>
</tr>
<tr>
<td>Targa</td>
<td>Galena Park, TX</td>
<td>n/a</td>
<td>1,764</td>
<td>115</td>
</tr>
<tr>
<td>Chevron (Acquired by Petrogas)</td>
<td>Ferndale, WA</td>
<td>n/a</td>
<td>460</td>
<td>30</td>
</tr>
<tr>
<td>Other</td>
<td>Miami, Norfolk, NY,</td>
<td>n/a</td>
<td>26</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Seattle, LA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Operating</strong></td>
<td></td>
<td></td>
<td>6,030</td>
<td>393</td>
</tr>
<tr>
<td><strong>Proposed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunoco Logistics (Mariner East)</td>
<td>Marcus Hook, PA</td>
<td>2014</td>
<td>600</td>
<td>39</td>
</tr>
<tr>
<td>Vitol</td>
<td>Beaumont, TX</td>
<td>2014</td>
<td>1,500</td>
<td>98</td>
</tr>
<tr>
<td>Phillips 66</td>
<td>Baytown, TX</td>
<td>2014</td>
<td>2,218</td>
<td>145</td>
</tr>
<tr>
<td>Enterprise (Expansion)</td>
<td>Houston, TX</td>
<td>2015</td>
<td>756</td>
<td>49</td>
</tr>
<tr>
<td>Targa (Expansion)</td>
<td>Galena Park, TX</td>
<td>2015</td>
<td>1,008</td>
<td>66</td>
</tr>
<tr>
<td>Sunoco Logistics (Mariner South)</td>
<td>Nederland, TX</td>
<td>2015</td>
<td>3,024</td>
<td>197</td>
</tr>
<tr>
<td>Williams/ Boardwalk</td>
<td>Moss Lake, LA</td>
<td>2016</td>
<td>7,358</td>
<td>480</td>
</tr>
<tr>
<td>Enterprise (Expansion)</td>
<td>Houston, TX</td>
<td>2016</td>
<td>3,528</td>
<td>230</td>
</tr>
<tr>
<td>Occidental</td>
<td>Corpus Christi, TX</td>
<td>2017</td>
<td>1,150</td>
<td>75</td>
</tr>
<tr>
<td><strong>Total Proposed US</strong></td>
<td></td>
<td></td>
<td>21,142</td>
<td>1,379</td>
</tr>
<tr>
<td><strong>Canada</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pembina Pipeline Corp.</td>
<td>Prince Rupert, BC</td>
<td>2016</td>
<td>620</td>
<td>40</td>
</tr>
<tr>
<td>Altagas Corp./ Petrogas/ Idemitsu Kosan</td>
<td>BC Coast</td>
<td>2017</td>
<td>400</td>
<td>26</td>
</tr>
<tr>
<td><strong>Total Proposed Canada</strong></td>
<td></td>
<td></td>
<td>1,020</td>
<td>67</td>
</tr>
<tr>
<td><strong>Total Proposed North America</strong></td>
<td></td>
<td></td>
<td>22,162</td>
<td>1,446</td>
</tr>
<tr>
<td><strong>Total Existing + Proposed North America</strong></td>
<td></td>
<td></td>
<td>28,192</td>
<td>1,839</td>
</tr>
</tbody>
</table>

Source: Data from Enterprise,\(^\text{56}\) ICF,\(^\text{57}\) Phillips 66,\(^\text{58}\) Sunoco Logistics,\(^\text{59}\) and Targa Resources.\(^\text{60}\) Table by CERI

\(^{55}\) Note that the Altagas/ Petrogas/ Idemitsu partnership recently acquired Chevron’s Ferndale, Washington (WA) LPG terminal which is estimated to have a capacity of 30 kb/d with pipeline, rail, and truck connectivity, but most importantly, import/ export capability. Thus, CERI expects that Canadian/ US LPG west coast exports are more likely to be coming out of this facility before the required infrastructure is built in the BC coast. Additionally, Sage Midstream is proposing to build an LPG export terminal in Longview, WA (undisclosed capacity as of the time of writing) which could also potentially serve as an outlet for Canadian volumes.


\(^{56}\) Enterprise Product Partners L.P., Goldman Sachs Global Energy Conference, January 2014; [http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9NTI5MDg2fENoaWxk5UQ9MjE2NTQ3fFR5cGU9MQ==&t=1](http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9NTI5MDg2fENoaWxk5UQ9MjE2NTQ3fFR5cGU9MQ==&t=1)
Another trend shaping LPG markets, in particular propane markets in North America, which warrants consideration from WCSB producers is the effect that changing petrochemical feedstock is having on petrochemical output. Given excess ethane availability in North America, prices have remained relatively low compared to other petrochemical feedstock choices. As this situation has developed, ethane has become the primary feedstock for olefin crackers across North America over the last few years.

Meanwhile, this has resulted in various announcements to re-purpose, expand/debottleneck, and even build green-field olefin cracker projects and derivative plants (including those in Canada), with the underlying premise of continued low cost ethane availability.61

On the output side, an increased share of ethylene being produced by ethane as opposed to propane and heavier feeds is translating into a lower overall by-product yield, including propylene. Given the outlook for this trend to continue as illustrated on Figure 1.13, it is expected that propylene production will continue to decline possibly creating supply issues to propylene-chain derivative plants in North America.

This has resulted in proposals to build various propane de-hydrogenation (PDH) plants in the United States and Canada in order to produce on-purpose propylene from propane, with the capacity to absorb over 200 kb/d of propane volumes. A list of these proposals is presented in Table 1.2.

Clearly, there are various and complex demand dynamics at play that are shaping the outlook for propane markets in North America. In the Canadian context, the supply outlook will be dictated primarily by the natural gas outlook, but also according to the evolution of midstream infrastructure.

Understanding how domestic demand will change over the coming years will be a key parameter in determining the amount of propane that is available for export markets. Given the scale of Ontario and Quebec markets in the Canadian context and their proximity to emerging Marcellus/Utica NGLs, it is important to consider how flows of propane within North America can change as infrastructure such as gas plants, fractionator, and NGL pipelines is completed.

60 Targa Resources, Barclays CEO Energy-Power Conference, September 2013: http://files.shareholder.com/downloads/NGLS/2886373239x0x690203/3c4291ca-3e05-431d-a414-6e314728e39a/130911_Barclays_CEO_ConferencevF.pdf
Figure 1.13: Effects of Light Feeds on North American Ethylene and Propylene Yields

Source: Williams Energy

Table 1.2: Propane De-hydrogenation (PDH) Plants in North America

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>Start-up Year</th>
<th>Output (tonnes/yr)</th>
<th>Output (t/d)</th>
<th>C3 Feed (t/d)</th>
<th>C3 Feed (kb/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PetroLogistics</td>
<td>Houston, TX</td>
<td>2010</td>
<td>582,400</td>
<td>1,596</td>
<td>2,026</td>
<td>25</td>
</tr>
<tr>
<td>PetroLogistics</td>
<td>Houston, TX</td>
<td>2014</td>
<td>582,400</td>
<td>1,596</td>
<td>2,026</td>
<td>25</td>
</tr>
<tr>
<td>Dow Chemical</td>
<td>Freeport, TX</td>
<td>2015</td>
<td>682,500</td>
<td>1,870</td>
<td>2,375</td>
<td>29</td>
</tr>
<tr>
<td>Enterprise</td>
<td>Chambers Co., TX</td>
<td>2015</td>
<td>623,350</td>
<td>1,708</td>
<td>2,169</td>
<td>27</td>
</tr>
<tr>
<td>C3 Petrochemicals</td>
<td>Alvin, TX</td>
<td>2015</td>
<td>582,400</td>
<td>1,596</td>
<td>2,026</td>
<td>25</td>
</tr>
<tr>
<td>Formosa Plastics</td>
<td>Point Comfort, TX</td>
<td>2016</td>
<td>728,000</td>
<td>1,995</td>
<td>2,533</td>
<td>31</td>
</tr>
<tr>
<td>Dow Chemical</td>
<td>USGC (TX/ LA)</td>
<td>2018</td>
<td>500,500</td>
<td>1,371</td>
<td>1,741</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total US</strong></td>
<td></td>
<td></td>
<td>4,281,550</td>
<td>11,730</td>
<td>14,897</td>
<td>185</td>
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<table>
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<th>Location</th>
<th>Start-up Year</th>
<th>Output (tonnes/yr)</th>
<th>Output (t/d)</th>
<th>C3 Feed (t/d)</th>
<th>C3 Feed (kb/d)</th>
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<td>Strathcona (AIH), AB</td>
<td>2016</td>
<td>500,500</td>
<td>1,371</td>
<td>1,741</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total Canada</strong></td>
<td></td>
<td></td>
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<td>1,371</td>
<td>1,741</td>
<td>22</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>4,782,050</td>
<td>13,102</td>
<td>16,639</td>
<td>207</td>
</tr>
</tbody>
</table>

Source: Data from ICF. Table by CERI

Having a clear understanding of the dynamics of flow changes and emerging supplies in the US will further create a clearer picture of what

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62 Williams Analyst Day, May 2013: http://b2icontent.irpass.cc/630%2F146005.pdf?AWSAccessKeyId=1Y51NDPSZK99KT3F8VG2&Expires=1389664421&Signature=vnSeZ8JYtwPzyfoXGxhK2pkXmM%3D
63 AIH refers to the Alberta Industrial Heartland which is Alberta’s NGL hub
64 Note that Williams has publicly mentioned the possibility of building PDH II and III plants in Alberta. These would be the same size as the proposed PDH I and could potentially absorb close to 70 kb/d of propane
opportunities there are for Canadian propane exports to the US to continue on a declining path or to remain at a certain level.

Last but not least, both LPG exports and PDH plants have the potential to create new markets for Canadian propane.

In the context of LPG exports, infrastructure will need to be built and investments will be needed, while the opportunity to fetch propane prices above and beyond the Edmonton benchmark will be dictated by transportation economics and world LPG prices. These are in turn dictated by world LPG fundamentals (supply and demand balances, as well as trade flows), for which the expected volumes of US LPG exports are sure to have an impact on.

In regards to PDH plants, these plants present the opportunity for incremental value added in Canada, yet the viability of these projects rests on the economics of propane versus propylene spreads. With all other dynamics and emerging demand sources at play, prices will be volatile and should not be taken for granted to remain at low levels.

Furthermore, it would be important to consider whether there are enough propane volumes in Canada to supply traditional and growing domestic demand, continued US exports, potential LPG exports, and a new propylene industry.

**Butanes**

Figure 1.14 illustrates the supply and demand balance for butanes in Canada. Total supply is the sum of butanes production (from gas plants, refineries, and off-gas plants), US imports, stock changes, and adjustments. Total disposition is the sum of domestic demand (all of which is classified as non-energy demand) and exports to the United States.

**Figure 1.14: Butanes Supply and Disposition Balance (kb/d) (2002-2012), and 2012 % Share of Disposition**

Source: Data from AER, BCMNGD, CERI estimates, NEB, and Statistics Canada. Figures by CERI
Supply volumes have fluctuated between the 123 kb/d (2008) and 96 kb/d (2005 and 2012) range. Domestic demand has been close to 100 kb/d (2008) and as low as 72 kb/d (2012), and by 2012 accounted for close to 75 percent of total disposition.

Figure 1.15 illustrates spec butanes production in Canada by source and by region.

**Figure 1.15: Butanes Production in Canada, by Source and Region (kb/d) (2002 - 2012) and 2012 % Share**

Source: Data from AER, BCMNGD, CERI estimates, NEB, and Statistics Canada. Figures by CERI

Production from gas plants in Western Canada has remained in the 60-70 kb/d range between 2002 and 2012 due to a combination of steady output from fractionators, increased output at the field level and lower production volumes at the straddle plants. Production from Eastern Canada refineries has declined, driven by refinery closures in Ontario and Quebec as well as a lighter crude slate in Atlantic Canada. Production from Eastern Canada gas plants has declined as less butanes leave the WCSB as an NGL mix via Enbridge (to the Sarnia fractionator) and as the Sable Offshore gas project’s output declines. Output from Western Canadian refineries has decreased given a switch in Alberta’s refineries to heavier and synthetic types of crudes. And last but not least, output from off-gas plants, although not a significant source of supply, has increased over the last few years.

Figure 1.16 illustrates domestic demand for butanes in Canada by end-use sector (top) and by region (bottom). The single largest use for butanes in Canada is as a refinery feedstock for gasoline blending, accounting for 39 percent (or 28 kb/d) of domestic demand in 2012. Demand for butanes as a refinery feedstock has fluctuated around the 40 kb/d mark between 2002 and 2012 with demand in 2012 being the lowest recorded since 2002, due to a significant drop in demand across both Western and Eastern Canada.
CERI believes there are various reasons for this trend including lower gasoline demand and thus lower gasoline production volumes. Furthermore, butanes blending in the gasoline pool are needed based on RVP requirements and thus, in this context, tied to changes in annual average annual temperatures. Last but not least, butane use across other end-use sectors (diluent, steam cracking) has increased rapidly over the last few years, exerting upward pressure on butane prices. If butanes are more expensive than other gasoline blending components then they will be substituted out of the gasoline pool.

The second largest domestic demand source for butanes in Canada is as a petrochemical feedstock (32 percent of domestic demand in 2012) including uses as a feedstock for steam crackers in Ontario but also for the production of iso-octane at the Alberta EnviroFuels (AEF) facility. Statistics Canada data and CERI’s analysis indicates that over the last few years, demand in AB has decreased while demand in ON has increased as butanes displace heavier steam cracker feeds (such as pentanes plus, refinery naphtha, and condensate).
Since 2005, butanes have increasingly been used in Western Canada as a heavy oil/crude bitumen diluent for pipeline transportation. This is the case primarily in Alberta and to a smaller extent in Saskatchewan. Limitations as to how much butane can be used as a diluent in a pipeline exist given the high vapour pressure of butanes compared to crude oil. By 2012, this use accounted for 27 percent of domestic demand for butanes (19 kb/d).

Last but not least, small volumes of butanes (2 percent in 2012) are used for solvent floods or enhanced oil recovery schemes in Western Canada.

On a regional basis, Eastern Canada accounted for 56 percent of domestic demand in 2012, with demand for butanes evenly split between refinery uses and petrochemical feedstock. In 2012, Western Canada accounted for 44 percent of domestic demand with 60 percent of those volumes being used as a diluent compared to 40 percent for all other uses combined (including refinery feedstock, petrochemical feedstock, and solvent floods).

Figure 1.17 illustrates Canadian butane exports to the US by PADD.

**Figure 1.17: Canadian Butane Exports to the US by PADD (kb/d) (2002 - 2012) and 2012 % Share of Total**

Butane exports to the US have decreased by 41 percent (-17 kb/d in net) between 2002 (42 kb/d) and 2012 (25 kb/d). In 2012, exports to PADD II accounted for 54 percent of Canadian butane exports to the US, followed by exports to PADD I (32 percent), with the remaining 14 percent allocated between PADDs V, IV, and III, in that order.

Similar to propane, Canadian butane exports to the US have decreased given a combination of various dynamics in the North American market which include lower LPG demand in the US, leading to lower LPG import requirements, coupled with increased supply from gas plant production, as well as increased domestic demand in Canada.
Figure 1.18 illustrates Canadian butane exports to the US by region, by transportation mode, and by PADD.

The first observation in regards to Figure 1.18 is that rail shipments have consistently accounted for between 80 and 90 percent of butane exports from Canada to the US. Pipeline exports – primarily via the Rangeland system to the US Rockies from Western Canada and via the Eastern System pipeline\textsuperscript{65} from Sarnia to Ohio (Upper US Midwest) – account for the majority of the remaining volumes, with truck transportation playing an almost non-existent role.

In regards to Western Canada, CERI estimates indicate that exports via pipeline have fallen in tandem with exports to PADD IV (Rockies) which indicate lower flows through the Rangeland pipeline system. Rail exports, primarily to PADDs II and V have also fallen substantially over the last few years.

In Eastern Canada, reduced exports by pipeline follow the trend of declining exports to PADD II, yet the overall level of exports indicate that exports to PADD II continue to move via rail (to farther away states).

The remaining export volumes from Eastern Canada move via rail primarily to PADD I with minor volumes targeting PADD III.

Butanes supply and demand dynamics are complex and resemble those around propane markets in North America. In regards to domestic demand, changes in gasoline blend components and overall gasoline production levels will dictate demand for butanes as a refinery feedstock. The competitiveness of butanes as a petrochemical feedstock against propane and naphtha will dictate changes in demand for butanes in that sector. Last but not least, in the Canadian context, activity and production levels in the heavy oil/oil sands industries together with possible limitations to butane use as a diluent will also need to be considered.

Given the outlook for increased NGLs/LPG production associated with shale gas development in the US, the market for Canadian butanes in the US could continue to shrink.

However, as the proposed and expanded North American LPG export terminals come to fruition, these facilities will provide a means to balance an oversupplied market in North America, but also a means for WCSB producers to enter the global LPG market and diversify their customer base.

\textsuperscript{65} Both systems are owned by Plains Midstream
Figure 1.18: Canadian Butane Exports from Western (Top) and Eastern (Bottom) Canada by Transportation Means (Left) and by PADD (Right) (kb/d) (2002 - 2012)

Source: Data from CERI, NEB, and Statistics Canada. Figures by CERI
Pentanes Plus

Figure 1.19 displays the supply and disposition balance for pentanes plus and condensate in Canada. For the purpose of this section and the overall report pentanes plus refers to the sum of pentanes plus (from gas plants) and field or wellhead condensate (associated with natural gas and crude oil production).

**Figure 1.19: Pentanes Plus Supply and Disposition Balance (kb/d) (2002 -2012), and 2012 % Share of Supply**

Supply is the sum of gas plant/fractionators pentanes plus output, field condensate, and off-gas plants’ olefinic condensate. Gas plant pentanes plus production (81 percent of total production in 2012) comes primarily from Western Canada, with minor and declining volumes coming from the Sarnia fractionator. This is the case as the primary market for pentanes plus in Canada is in the WCSB and thus there is no incentive to leave pentanes plus in NGL mixes heading to Sarnia.

WCSB gas plant’s pentanes plus production has fallen over time following lower gas production trends.

Field condensate (18 percent of 2012’s production) is also primarily sourced from Western Canada with small and declining volumes coming from the Sable Offshore Energy Project (SOEP) in Nova Scotia. Western Canadian field condensate is primarily produced in Alberta and British Columbia, both sources from which condensate production has increased over the last few years given WCSB producers’ focus on wet-gas or liquids-rich resources.

Olefinic condensate from off-gas plants accounts for 1 percent of total pentanes plus production.

Demand for pentanes plus in Canada is primarily for use as a diluent, for pipeline transportation purposes, by oil sands and heavy oil producers.
Other sources of demand include use in refineries for gasoline blending but also as a feedstock for petrochemical facilities such as ethylene crackers.

Diluent demand comes primarily from oil sands producers in Alberta, and to a smaller extent, heavy oil producers in Saskatchewan and Alberta. Use at the refinery and petrochemical level occurs primarily in Ontario and Quebec (Eastern Canada) while some refineries in Alberta were using small volumes of pentanes plus as part of their crude diet until 2007.

Figure 1.20 displays demand for pentanes plus in Canada.

**Figure 1.20: Pentanes Plus Demand in Canada by End-use (kb/d) (2002 - 2012)**

Source: Data from AER, BCMNGD, CERI estimates, EIA, NEB, and Statistics Canada. Figures by CERI

Demand for diluent in Canada has increased rapidly given increased production of crude bitumen (non-upgraded oil sands crude) as well as heavy oil production as seen in Figure 1.21.

Rapidly increasing diluent demand has far outpaced dwindling local supplies and has resulted in a rapid surge of diluent import requirements. These imports are estimated to come primarily from the US and include natural gasoline (pentanes plus) as well as different grades of condensate and naphtha (light and heavy) (as seen on Figure 1.22), all of which end up primarily at the condensate blend (CRW) diluent pool in Alberta, where they are blended with local diluent supplies to form a uniform diluent blend.

CERI estimates that as early as 2003 diluent import requirements have been the norm in Alberta. Between 2003 and 2007 most imports would have arrived via rail to the diluent pool, whether from the US or from overseas (via the Kitimat marine import terminal).

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66 Nova Chemicals has a condensate splitter in their Corunna site, yet their crackers are being re-tooled to use a primary NGL-based feed and the statistics indicate that by 2012 only minor volumes of heavy feeds were being used in Ontario. The Petro-Mont facility in Montreal used light crude, condensate, and pentanes plus as part of its feedstock slate prior to mothballing in 2008.
Starting in 2008-09, oil sands producers’ accessed US diluent sourced from as far away as the US Gulf Coast via tie-ins to Enbridge’s Southern Lights pipeline (which CERI estimates that by 2013 has been running at close to capacity).

In 2013, Enbridge announced that it will be expanding the Southern Lights pipeline capacity to reach 275 kb/d of capacity. In addition to the Southern Lights pipeline, starting in mid-2014 the Cochin pipeline will be placed in diluent service with the capacity to transport 95 kb/d of diluent from the US to the Alberta pool.

Together, these two pipelines will provide close to 400 kb/d of pipeline capacity to access increasing condensate supplies from the Eagle Ford as well as increasing natural gasoline or pentanes plus volumes associated with shale gas production in the US.

In addition to these pipelines, Enbridge’s Northern Gateway pipeline proposal to the British Columbia coast includes a parallel diluent return line with a capacity of 195 kb/d.

As previously discussed, the development of rail loading terminals for crude oil and oil sands crude in Western Canada will play a role in the development of the diluent market over the coming years. First, the terminals and rail cars can be used for hauling back diluent from the destinations to which the trains are targeting. Secondly, rail terminals with the ability to ship clean bitumen and rail-bit will mean that the future demand for diluent as a transportation agent will be reduced.

Diluent will be the main driver in regards to demand for pentanes plus going forward. How fast oil sands projects can continue to ramp up and whether they will use alternative means of transport to pipelines will shape the demand for diluent in Western Canada.

Furthermore, production and field upgrading technologies in the development of oil sands production could translate into lower demand for diluent than in a *business-as-usual* case of crude bitumen transported via pipeline.

Demand for pentanes plus in the refining and petrochemical sectors in Canada is expected to remain minimal.

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68 EIA US pentanes plus exports to Canada are used to illustrate US C5+ imports via pipeline. The difference between EIA crude oil exports to Canada and US crude oil imports as reported by the NEB are assumed to be condensate volumes given that EIA includes condensate as part of their crude oil statistics but the NEB makes a distinction between all types of imported crude streams. The difference between required imports is assumed to come primarily via rail from the US but also from overseas.
Total NGLs
Figure 1.23 illustrates the supply and disposition balance for NGLs in Canada.

Figure 1.23: Canadian NGL Supply and Disposition Balances (kb/d) (2002 - 2012) and 2012 % Share of Totals

Source: CERI

Domestic supply is the sum of local production (gas plants, fractionators, field level, refineries, and off-gas plants), stock changes and statistical adjustments. Total supply is the sum of domestic supply plus imports.

In 2012, domestic supply accounted for 76 percent of total supply, while imports, primarily diluent imports (91 percent of total NGLs imports), accounted for 24 percent of total supply.

Domestic supply has been on a continued decline trend from 2002 until 2010 at which point it started to once again increase, led by increasing NGLs extraction from gas plants. This trend is expected to continue as WCSB producers target NGLs-rich gas resources to increase profitability. Meanwhile, an ongoing wave of midstream investments, partly targeting increased ethane extraction as incented by the Alberta Governments’ Incremental Ethane Extraction Policy (IEEP), will connect producers with end-users across the WCSB and other markets for Canadian NGLs.

NGL imports have increased steadily since 2002, driven by diluent imports, but imports from all NGLs to Canada have increased since 2002, with ethane imports commencing in 2011 as seen in Figure 1.24.

Almost all imports of NGLs to Canada originate in various regions of the US (primarily the US Midwest, US Gulf Coast, and US Rockies), with some volumes of diluent imports coming from overseas (estimated to be in the 10 kb/d range).
Figure 1.24: Canadian NGL Imports (kb/d) (2002 - 2012)

Source: CERI

In the future, imports of ethane and pentanes plus to Canada are expected to continue to increase. This is the case given increased availability of US ethane (primarily from the Bakken and Utica/Marcellus shale plays) as a feedstock for Canadian petrochemical producers, but also ongoing midstream infrastructure projects being built to connect US NGL producers and Canadian end-users (including the Vantage, Mariner East, and UTOPIA pipelines). The same holds true in regards to US natural gasoline and condensate availability, coupled with strong demand for diluent by Canadian oil sands and heavy oil producers.

Imports of propane and butanes will be determined by the complex changes taking place in North American as well as world LPG market fundamentals, including production trends, demand dynamics, inter-regional trade, and pricing/economics.

Total disposition is the sum of domestic demand (86 percent of the total disposition in 2012) and exports. Domestic demand is sub-divided between non-energy demand (86 percent of domestic demand in 2012) and energy demand. Energy demand is then divided between the retail and wholesale end-use categories, which in 2012 were evenly split in their shares of energy demand. Exports are primarily to the US and in 2012 accounted for 14 percent of total disposition.

Non-energy NGL demand in Canada includes demand for diluent, as well as NGL uses as feedstock by the petrochemical industry (ethylene crackers, refineries, and an iso-octane plant), gasoline blending at refineries, and solvent flood agents for enhanced oil recovery (EOR).

Diluent (including pentanes plus, condensate, butanes, and naphtha) is used as a blending and transportation agent for crude bitumen and heavy oil in Western Canada. Its demand is mainly driven by the level of oil sands activity and the volumes transported primarily via pipeline, and to a certain extent, rail. Diluent demand accounted for 54 percent of Canadian NGL non-energy demand in 2012 and 46 percent of total NGL domestic demand in Canada.
Petrochemical demand in Canada (primarily ethane, but also some volumes of propane, butanes, and heavier feeds) is determined by a series of factors including demand for end-use products which is determined by overall consumer spending and economic activity; feedstock prices, as well as ethylene by-product prices amongst others. In 2012, petrochemicals demand accounted for 42 percent of NGLs non-energy demand and 36 percent of total NGLs domestic demand in Canada.

Various projects across Canada (mainly in Alberta and Ontario) are in the works to increase petrochemical capacity and thus production, driven by favourable NGL feedstock pricing and availability in North America (compared to other regions of the world) which have, in turn, been the result of increased shale gas development.
Tied to downstream or end-use investments, there are several midstream infrastructure projects planned or under construction including gas plants, pipelines, and fractionators, which serve to connect NGL producers with petrochemical end-users.

The viability and competitiveness of the petrochemical industry’s expansion in Canada (and North America) will be determined by the global demand for petrochemicals, continued local feedstock availability and price advantage, and the relative production costs of competitors worldwide.

Refinery blending is primarily determined by the butane requirements in the gasoline pool which are driven by octane and RVP requirements, government regulations, gasoline demand volumes, and pricing of gasoline blending substitutes. In 2012, refinery blending demand accounted for about 4 percent of both non-energy demand and total domestic demand for NGLs in Canada.

Solvent flood demand is driven by activity in EOR schemes in Western Canada. The volume of NGLs required for these schemes is not significant in the context of overall NGL demand and has declined over time.

Wholesale energy demand in Canada includes propane use by the mining, oil and gas extraction sector, the manufacturing sector, and the construction sector. Energy demand is determined by the level of activity in a given sector, economic activity, and according to substitute fuel prices.

Wholesale energy demand for propane has doubled between 2002 and 2012 in Canada, led by activity in the oil and gas sector. In 2012, wholesale energy demand accounted for 50 percent of energy demand and 7 percent of total NGL domestic demand in Canada.

Retail energy demand in Canada includes propane use by the commercial/institutional sector, followed by the residential, transportation, and agriculture sectors. Retail propane energy demand in Canada has grown by close to 30 percent between 2002 and 2012 given increases in the commercial/institutional sector.

By region, the most important demand areas in Canada are Alberta and Ontario, which together accounted for 96 percent of total NGL domestic demand in 2012.

Alberta’s largest NGL uses include ethane (and some minor propane volumes) in the ethylene cracking industry; propane at the industrial or wholesale level (oil and gas industry and manufacturing) and the retail level (commercial/institutional); butanes as a diluent, for gasoline blending and iso-octane production; and pentanes plus as a diluent.

Ontario’s largest demand sources include the petrochemical industry which uses a diversified mix of NGLs/heavy feeds including an ethane/propane mix, propane, butanes, pentanes plus and different ranges of naphtha; propane use in the manufacturing, commercial/institutional, and residential sectors, as well as butanes used for refinery blending.
Currently, NGL exports from Canada move to the US exclusively. As can be observed in Figure 1.26, PADDs II (Midwest), I (East Coast), and V (West Coast) are the largest markets for Canadian NGL exports. In 2012 these three US markets (combined) accounted for 94 percent of exports to the US. Meanwhile, LPGs, propane (79 percent) and butanes (20 percent) combined, accounted for almost all exports to the US.

**Figure 1.26: Canadian NGL Exports by PADD (Top) and by Type (Bottom) (kb/d) (2002 - 2012) and 2012 % Share of Total**

Rail is the primary means to transport Canadian LPGs to the US followed by pipeline and truck.

Between 2002 and 2012, LPG exports to the US declined by 41 percent (or -87 kb/d in net), due to a combination of increased US local production of NGLs from shale gas, as well as inter-PADD supplies reaching traditional markets for Canadian LPGs in the US. Meanwhile, demand has failed to keep up with the new production volumes. In most cases LPG demand has remained flat to declining in various regions of the US, leading to a back-out of overseas imports being displaced by Canadian LPGs which are slowly being squeezed out of the market.
This is the case being observed in regards to light crude and natural gas in the US. Those markets provide an indication of what is to come to Canadian LPG markets in the US and strengthen the case for market diversification whether through the creation or expansion of domestic markets, such as petrochemicals (ethylene and propylene), or via LPG exports to world markets and in particular the Asia-Pacific region.\(^69\)

While the inner workings of North American LPG markets are complex and dynamic, the main result is that North America as a whole (including Canada and the US) has reached an oversupply position over the last few years. As this situation continues to develop, LPG exports will be increasingly important in balancing the market and sustaining prices.

Entering the LPG market requires export infrastructure and contracts with buyers. With the announcement of various LPG export terminals to be expanded and constructed in North America, including two in Canada, understanding LPG world markets, and in particular, the Asia-Pacific market, will be an important task for WCSB producers.

Clearly there are various dynamics at play shaping the future of NGLs in Canada both at home and abroad. The following section discusses NGL balances in the US. Pricing and economics, considered the financial linkage between producers and end-users, will be discussed subsequently.

\(^{69}\) More on this in Part IV
NGL Supply and Demand Balances in the United States\textsuperscript{70}

**Ethane**

Ethane accounts for the largest portion of the NGL barrel in the US. Ethane is used almost exclusively as a petrochemical feedstock to produce ethylene, which in turn is a basic building block for plastics, packaging materials, and other consumer products. A limited amount of ethane can be left in the natural gas stream (ethane rejection) and is sold at a price based on its heating value.

For ethane to be extracted from the natural gas stream its value needs to be greater than the value of ethane as a fuel for heat plus the cost of extraction and marketing, otherwise it will be rejected.

Currently, the market for ethane in the US is oversupplied; some level of ethane rejection is occurring. While it is difficult to estimate this, some analysts suggest it could be between 200 and 250 kb/d.\textsuperscript{71}

The majority of ethane production occurs in PADD III, with smaller amounts being produced in PADDs II and IV. Currently, very little ethane is produced in PADD I (with most of it being rejected back into the natural gas stream), but as previously mentioned, this will change in the future, as infrastructure surrounding the Marcellus and Utica shale comes online.

Figure 2.1 illustrates US historical ethane production and demand by PADD.

Historical ethane demand is also dominated by PADD III, with some consumption coming from PADD II.\textsuperscript{72} The majority of petrochemical facilities (and consequently ethane demand) are located around the Gulf Coast. This location facilitates easier and more cost effective trade of petrochemical and derivative products.

Imports and exports of ethane are logistically challenging since – unlike other NGLs – ethane can only be economically transported by pipeline (currently). However, some NGL market players are looking at opportunities to export US ethane to the European petrochemical market (in liquid form), while leaving ethane in LNG presents another option for easing the current glut.

\textsuperscript{70}Note that the supply and demand (S/D) balances analytical framework for the US is somewhat different to that of Canada. This is the case mainly because of lack of data availability on a sector by sector basis at the demand level.\textsuperscript{71} Oil and Gas Journal, September 2013, Study: Glut of US ethane to remain; exports to balance propane, butane, [http://www.ogi.com/articles/2013/09/study-glut-of-us-ethane-to-remain-exports-to-balance-propane-butane.html](http://www.ogi.com/articles/2013/09/study-glut-of-us-ethane-to-remain-exports-to-balance-propane-butane.html)\textsuperscript{72} Primarily ethylene crackers in the Upper Midwest (Iowa and Illinois)
Historically, the US has had virtually no imports or exports of ethane, only transfers within the US. Again, this is changing as dedicated ethane pipelines are built from producing areas in the US to petrochemical facilities in Canada.

US petrochemical facilities are also able to absorb much of the increased supply of ethane as they switch away from other NGLs and heavier petroleum-based naphtha feedstock in ethylene crackers to lighter feedstock. Recent record low NGL prices have motivated petrochemical companies to maximize the amount of ethane and propane in their feedstock slate.  

Going forward, the main constraint on ethane availability in the US will remain on the demand side rather than on the supply side. When and where demand will expand at which rate will depend on infrastructure availability, re-tooling and expansion of currently existing ethylene crackers, and the possible building of new crackers, as well as possible overseas exports and increased exports to Canada (subject to capacity expansion and changing market dynamics).

**Propane**

Propane is a more versatile NGL, with uses ranging from residential heating to transportation fuel for forklifts, to petrochemical feedstock for ethylene and propylene production. Propane production, like natural gas production, comes mostly from PADD III. It is easier for gas plants to extract propane from the natural gas stream than it is to extract ethane. Consequently, PADDs I and V are able to extract more propane than ethane compared proportionally to other PADDs with fractionation capacity.

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Note: Includes refinery produced ethylene

Source: EIA data. Figures by CERI

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Figure 2.2: Historical Propane Supply and Demand by PADD, 2002-2012 and 2012 Demand % of Total

![Historical Propane Supply and Demand by PADD, 2002-2012 and 2012 Demand % of Total](image)

Note: Includes refinery produced propylene

Source: EIA data. Figures by CERI

Propane’s versatility in its uses also creates a more evenly balanced demand profile among the PADDs than ethane. PADD III still accounts for the largest share of propane demand since propane is used as a petrochemical feedstock, but PADDs I and II make up a significant portion of demand due to their colder winters and larger population centers.

The increased supply of propane has caused producers to look for alternative domestic markets for their products (as well as increasingly, exports), including the marketing of propane as an alternative vehicle fuel and for agricultural use. Figure 2.3 illustrates the average usage of propane in the US by sector.

Propane also has the advantage of flexibility in mode of transportation. Propane can be moved by pipeline, ship, train, or truck. Consequently, it is often used as a fuel for heating in remote areas, and its use is highly seasonal, peaking in the winter months. Figure 2.4 illustrates the seasonality of propane demand in the US.

While production of propane has been increasing over the past five years, consumer demand has been falling. Demand for propane is down in the petrochemical markets as it has been less competitive than ethane. While in the heating market, a shift to natural gas appliances is affecting demand levels throughout the country.

The result has been an increase in exports of propane; such that the US is now a net exporter of propane (see section below on exports of NGL products).
Figure 2.3: Use of Propane by Sector

Source: American Petroleum Institute, 2003 Sales of Natural Gas Liquids.

Figure 2.4: Seasonality of Propane Demand in the US

Source: EIA data. Figure by CERI

Butanes

Butanes are produced in much smaller quantities and are used mostly in refining (for gasoline blending or alkylation) or as petrochemical feedstock (mainly n-C₄).

Like ethane and propane, the supply of butane is dominated by PADD III. Growth in the supply of butane is in line with growth in raw-mix NGL supply.

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74 While the data for this particular figure is dated (2003), recent analysis from ICF and other industry analysts indicate that the percentage demand by sector remains relatively unchanged.
Demand for normal butane has fallen in recent years in the petrochemical sector as it is not as competitive as ethane for production of ethylene. However, butane is also used for other petrochemicals, including butadiene, used for making synthetic rubber for tires, belts and hoses, and demand for these products continues to rise.

The market for butane is typically balanced by increasing export demand from Mexico, South America and Europe.\(^\text{75}\)

**Pentanes Plus**

Pentanes plus components are used as ethanol denaturant, blend-stock for gasoline, chemical feedstock and, more recently, as diluent for the extraction and pipeline movement of heavy crude oils from Canada.

Supply of pentanes plus is again dominated by PADD III, given the number of gas processing plants in that region.

Demand for pentanes plus is also dominated by PADD III, given that the majority of demand stems from refineries and blenders, where it is used as a component in gasoline. Falling domestic demand for pentanes plus in the US has led to significant exports to Canada for use as diluent to facilitate bitumen production from oil sands.

\(^{75}\)Targa Resources, Third Quarter 2013 Reported Results & 2013 Investor & Analyst Conference, November 5, 2013
http://files.shareholder.com/downloads/NGLS/2923014341x0x703058/2f47d5ad-5ae6-40a5-8183-d76bac17551c/WEB_131101_2013_Targa_Investor_Presentation.pdf
Total NGLs

NGL demand in the US is also largely dominated by PADD III. This is due to the fact that the vast majority of petrochemical facilities and refineries – large users of NGL products – are located in PADD III. Demand in other PADDs can originate from a number of different sources, such as heating or refinery input. Figure 2.7 illustrates the historical demand and supply to each PADD in the US.
Another way to illustrate the NGL market is to examine the 2012 supply-demand components.

The total US NGL supply-demand balance for 2012 is illustrated in Figure 2.8 below.

![Figure 2.8: Total NGL Supply and Demand Balance, 2012](image)

Source: EIA data. Figures by CERI

The breakdown illustrates that on the supply side, domestic production of NGLs accounts for 95 percent of total supply, while imports account for the remaining 5 percent. On the demand side, the consumption of final NGL products accounts for 72 percent of total supply. Inputs to the refining process account for about 16 percent, exports account for about 10 percent and stock changes make up the remaining 2 percent.

While supply and demand of total US NGLs was in balance in 2012, this is not the case for each PADD, due to inter-PADD transfers as well as imports and exports. By looking at the supply-demand balance for each PADD we can track the flow of NGLs across and into and out of the US.

In PADD I, demand for NGLs significantly outweighed supply in 2012. Even with direct imports into the region, transfers from PADDs II and III were required to make up the remaining demand. Demand largely stems from residential, commercial, and industrial demand for propane heating.

While supply is currently constrained by infrastructure development, in the near future these bottlenecks will clear and the supply side will increase dramatically. MarkWest, a major pipeline and processing company operating in PADD I, has 1.5 bcf/d of processing capacity under construction and 136,000 b/d of fractionation capacity in the Marcellus region.⁷⁶

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In the meantime, additional ethane will be exposed to infrastructure constraints, while additional propane can be absorbed by the local market replacing imports from Canada.

PADD II is the second largest NGL producing region of the US, generating 18 percent of total US supply from natural gas plants. There is significant and growing supply of NGLs from the Bakken, which is matched by demand in the Conway area that serves as a regional hub for NGL pipelines and fractionation in the region.
While supply and demand of NGLs in PADD II were almost in balance in 2012, supply is growing much faster than demand, leading to an NGL surplus. Consequently, much of the raw mix NGLs as well as finished products are shipped out of the region primarily into PADD III (but also PADD I). While current infrastructure from PADD II to PADD III is sufficient for transportation of NGLs, with more production coming out of the Anadarko and Williston basins, additional infrastructure will be required in the future.

PADD II is also a significant receiver of NGLs from both PADDs III and IV. Inflows from PADDs III and IV are balanced by the outflow of NGLs to PADDs III and I. In 2012, total inflow was 370 kb/d, while total outflow was slightly higher at 395 kb/d. Imports and exports to and from PADD II were largely dominated by trade with Canada, swapping LPGs for pentanes plus.

PADD III dominates the US NGLs market, in terms of production, processing, fractionation and demand. In 2012, PADD III accounted for 62 percent of total US NGL production. With rich deposits of gas in plays such as the Eagle Ford, Permian and Anadarko, along with significant inflows of NGLs and raw-mix from other PADDs (II, IV, and increasingly I) supply in PADD III is more than three times larger than PADD II, the next largest PADD.

Matching this strong supply is strong demand in PADD III, which stems from the hub of refineries and petrochemical facilities. With PADD III fractionating the majority of total US NGLs, it therefore experienced the highest inflow of NGLs from other PADDs, receiving NGLs from both PADD II and IV, totaling 546 kb/d in 2012.

**Figure 2.11: PADD III Supply and Demand Balance, 2012**

PADD III also exports the largest volume of NGLs of all the PADDs. In 2012, PADD III exported 169 kb/d, more than half of the total exports from the US, headed for Mexico, South America and Europe.
PADD IV is the third largest producing region in the US, accounting for 13 percent of total US production of NGLs in 2012. PADD IV has ample gas processing capacity in place to service an increase in gas from the Niobrara shale and other emerging plays in the region.

While supply is strong in PADD IV, demand for finished products is quite low as there is no market for ethane and the markets for propane, butanes, and pentanes plus are limited. Consequently, any supply above this limited demand level must move out of the PADD to other markets. Most of the supply goes to PADDs II and III where there is greater demand for products and higher prices. Along with the significant inter-regional transfers, PADD IV also exports a small amount of LPG as well as pentanes plus to Canada (for use as diluent in the oil sands industry).

**Figure 2.12: PADD IV Supply and Demand Balance, 2012**

Source: EIA data. Figures by CERI

The market for NGLs in PADD V is almost completely separate from the rest of the US, as it lacks the infrastructure needed to transport raw mix NGLs or finished products to other regions. Consequently, PADD V’s supply-demand balance is almost equal for 2012.

Although limited, imports and exports to and from Canada play a part in balancing the PADD V market.

Figure 2.13 summarizes the inter-PADD flow of NGLs that occurred in 2012.

In summary, PADDs I and III receive a net inflow of NGLs from the other PADDs. PADD III had the greatest inflow from other regions (PADDs II (366 kb/d) and IV (179 kb/d)) at 545 kb/d mainly due to the hub of processing and fractionation facilities. PADD I requires an inflow of NGLs to meet their heating demands. PADDs II and IV are net outflow regions, as they lack enough processing and fractionation capacity to service all their production. PADD II had the greatest outflow at 394 kb/d, with the majority going to PADD III for processing.
In addition to inter-regional transfers, the US is also importing and exporting NGLs from and to other countries to balance its NGL markets.

Traditionally, the US has been a net importer of NGLs. But with the proliferation of shale-gas production and the associated NGL production, imports have switched to exports. The US has for the past few years been exporting pentanes-plus (largely to Canada as diluent for bitumen), and over the last few years began exporting increasing propane volumes, mostly to Latin American countries.

Source: EIA data. Figures by CERI

Source: EIA map and data

Butanes are primarily used in the oil refining process as an additive to gasoline. Consequently, most butane has remained in the US for use in domestic refineries, yet export volumes are increasing.

Net imports of each component have decreased substantially, and the trend is likely to continue given the projected development of shale gas resources in the US. Figure 2.15 illustrates historical US net imports of NGL products.

**Figure 2.15: Net Imports/Exports by NGL Product**

Source: EIA data. Figure by CERI

Figure 2.16 shows imports and exports of NGLs for each PADD.

**Figure 2.16: Total Imports and Exports of NGLs by PADD**

Source: EIA map and data
The majority of imports of NGLs into the US come from Canada, these accounted for 78 percent of all imports in 2012. Imports from Canada were primarily made up of imports of LPGs, with about one-half being imported into the Midwest (PADD II) and about one-third being imported into PADD I.

South America is the next largest importer of NGLs into the US. These primarily come in the form of pentanes plus and account for 9 percent of imports in 2012. They enter the US in PADD III for use in the petrochemical industry. The remainder of imported NGLs comes from Europe, Mexico and OPEC nations.

Exports of NGLs from the US are dominated by exports of pentanes plus to Canada through PADD II for use as diluent in the oil sands industry. These exports accounted for 37 percent of all NGL exports in 2012. The next largest export is of LPGs to South America and Mexico through PADD III, these accounted for 26 and 16 percent of total NGL exports in 2012, respectively. LPGs in these markets are primarily used for heating, cooking and motor fuel.

The future evolution of NGL supply and demand balances will rest on the ability of the industry to build enough infrastructure in a timely fashion to deliver increasing supply from existing and emerging areas to both expanding domestic industries (such as petrochemicals) and also increasingly to Canada (most NGLs) and the global LPG market.
NGL Pricing and Economics

This section will briefly discuss NGL prices in North America and NGL extraction economics in the Western Canadian Sedimentary Basin (WCSB) context.

As previously discussed, the spread between weak local gas prices and high global crude oil prices in North America has created favoring conditions for NGL extraction in the WCSB. Since overall NGL price levels have already been discussed, this section will focus on the pricing dynamics of each liquid.

Starting with ethane, prices generally trade in a range between natural gas prices (heating value, or floor price) and the price of the next best alternative feedstock for petrochemical producers with flexible feedstock capacity, for which propane is generally the next best feedstock. This is the case primarily in a liquid and transparent market such as the USGC as seen on the top portion of Figure 3.1.

In Alberta, there is generally no spot market for ethane and given the structure of the market (two main buyers) contracts and prices are negotiated with sellers on a one by one basis. CERI estimates that two types of prices exist in the AB market including a “gas plus” ethane price – which includes the shrinkage costs, fractionation and transportation costs, and a return on capital, and a “Belvieu minus” price which is determined on a netback basis to the Mt. Belvieu (USGC) market, the world’s largest ethane market. These are illustrated in the bottom portion of Figure 3.1.

CERI believes most contracts are currently priced on a “gas plus” basis as this has historically been the case.

From the buyers’ perspective a “gas plus” price insulates them from price fluctuations in the larger USGC market and it ties ethane prices to local natural gas markets and economic conditions. From the sellers’ point of view a “gas plus” ethane price means they are guaranteed to cover their extraction and marketing costs while earning a return on their operations. This means the netback price received for ethane at the wellhead will normally be above shrinking costs (or the floor price), thus dissipating ethane rejection economics, which are currently common south of the border in various US areas (particularly those further away from PADD III).

78 Depending also on the dynamics between ethylene and by-product prices and credits as heavier feeds have lower ethylene yields and higher by-product yields
79 CERI estimates the average ethane price in AB for 2012-13 on a “gas plus” basis to be about $13/bbl or a $1.9/GJ premium over AECO ($2.6/GJ)
80 Buyers are petrochemical producers, while sellers are WCSB gas/NGL producers and NGL marketers
Figure 3.1: Ethane Prices in USGC (Top) ($/GJ) and Alberta Estimates (Bottom) ($/bbl) (2002 - 2013)

Source: Data from ADOE, Bank of Canada, CERI estimates, EIA, and Industry data. Figures by CERI

Under a “Belvieu minus” ethane price estimate it appears that sellers would have more upside price potential (historically), but it also indicates that this type of pricing can persistently be below a “gas plus” alternative (even below heating value in some cases). From the buyers’ point of view, because of the netback nature of the “Belvieu minus” pricing structure, ethane prices in AB maintain the ethylene feedstock advantage over USGC prices, yet there are instances in which ethane price estimates can be well above their “gas plus” alternative.

It is important to note that while persistently low ethane prices are good for the buyer, it discourages sellers from bringing in additional supplies to market.

81 “Gas plus” estimates are AECO-C GJ equivalents for shrinkage values, fractionation allowances as per ADOE monthly gas reference price bulletins, CERI transportation estimates, and return base on Bank of Canada’s Long-Term Bond Rates (LTBR) plus a risk premium
Under a “gas plus” ethane price estimate it appears that AB petrochemical producers generally hold a price advantage in relation to their USGC peers. However, the “Alberta Advantage” seems to have been eroded over the last part of 2013 and into 2014 as USGC ethane prices are trading at floor prices (or heating value).

CERI believes that this situation cannot continue indefinitely as ethane values trading at heating costs indicate that ethane producers in the US are getting negative netbacks at the wellhead (ethane price – transportation – fractionation – processing and extraction costs = netback at wellhead) and thus will reject ethane up to the technically feasible level until prices recover. On the other hand, a persistent oversupply of ethane in the US could keep prices from improving much until new demand, via the expansion of the petrochemical industry, is created.

One more price is provided in the bottom portion of Figure 3.1, a “Conway Plus” ethane price which CERI estimates as Conway prices plus transportation to US Upper Midwest ethylene crackers (Equistar’s Clinton, Iowa and Morris, Illinois plants). This price is important in the WCSB context because while producers do not sell directly into that market, they do have optionality through Aux Sable which extracts NGLs from Alliance’s gas and provides producers in the WCSB with rich-gas premiums that should reflect NGL market prices in the US Upper Midwest.

While the Alberta ethane market is somewhat separate from the USGC, under a “gas plus” price there is a direct connection through Henry Hub natural gas prices which generally determine AECO prices but also have an influence on USGC ethane prices.

Interestingly enough, the Alberta ethane market has created an outlet for Bakken ethane producers in the US, which would otherwise have stranded ethane supplies as USGC ethane rejection economics affect ethane producers that are the furthest away from the market (as more costs need to be incurred).

While there are only a handful of buyers in the Sarnia market (as Marcellus/Utica ethane starts to flow), producers will have optionality for marketing routes, either via raw mix pipelines or spec product (C₂) pipelines to other regions (most importantly the USGC). In that case, CERI expects the price for ethane at Sarnia to be determined on a netback basis from the USGC to the Marcellus/Utica region and on a net forward basis from there to Sarnia.

Propane prices in North America are determined at the USGC in Mt. Belvieu, TX as this location is the single largest market for this commodity in the continent. Given propane’s versatility as a petrochemical feedstock or a fuel, there are various factors that affect propane pricing.

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83 This will however depend on long-term contractual obligations and other similar factors
85 Bluegrass pipeline or Utica Marcellus Texas pipeline
86 ATEX and Mariner East pipelines
87 USGC ethane prices – transport costs from Marcellus/Utica = Ethane price at Marcellus/Utica
Ethane price at Marcellus/Utica + transport costs to Sarnia = Marcellus/Utica ethane delivered at Sarnia
While most propane in North America is produced from gas plants rather than refineries, crude oil prices have a direct influence on propane prices as alternative liquid fuel prices such as heating oil are determined by crude oil prices. Propane prices are also affected by other NGL prices due to their use as a petrochemical feedstock and can be dictated by their relative value to ethane and butanes (as seen in Figure 3.2).

Figure 3.2: Propane Prices in North America (Top) and Price Differentials (Bottom) ($/bbl) (2002 - 2013)

Supply and demand balances, which can vary considerably by season due to weather conditions, also play a major role in determining propane prices.

There are four major propane trading hubs in North America located in the USGC (Mt. Belvieu, TX), the US Midwest (Conway, Kansas), Eastern Canada (Sarnia, ON) and the WCSB (Edmonton/Fort Saskatchewan, AB). Most prices at these locations trade on a netback basis (discount) to Mt. Belvieu, with the exception of Sarnia, which generally trades on a net forward basis (premium) to the Edmonton market.
Differentials between the market hubs have widened over the last few years (since 2008) as a propane (LPG) oversupply position has developed in most of the continent while demand has been soft. Furthermore, more propane moves out of the WCSB via rail than via pipeline and wider differentials partly account for higher transportation costs from Edmonton.

Gulf Coast prices have been supported by overseas exports of LPG. Meanwhile, North American propane prices have continuously traded at a lower percentage value to WTI crude over the last few years, partly due to a displacement of overseas LPG imports into North America.

LPG in the international market follows a close relationship to crude oil prices and RPPs (Figure 3.3) and as Gulf Coast prices decouple from oil prices, there is an arbitrage opportunity which supports the case for increased North American LPG exports (primarily propane).

**Figure 3.3: Saudi LPG Prices Correlation with North Sea Brent Crude Oil and Singapore Naphtha (2002 - 2013)**

Mixed butane prices are shown in Figure 3.4. Butanes in North America have traded in price ranging between the price of propane (alternative petrochemical feedstock and heating fuel) and crude oil (refining market).

Within North America, trends in the price differentials for butanes can be described between two periods, prior to, and after 2008. Prior to 2008, differentials worked very much like those for propane where Conway and Edmonton prices traded at netbacks to Mt. Belvieu and Sarnia or a net forward basis. Starting in 2008, the pattern changed and Edmonton became the premium market with prices at Conway, Sarnia, and Mt. Belvieu trading at a discount to Edmonton, and Conway prices trading at a premium to Mt. Belvieu.

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89 This also coincides with rapid increases in butanes used as a diluent in AB since 2008
North American prices for pentanes are shown in Figure 3.5.

The pricing range for pentanes is given as between the price of mixed butanes (which are used both as a diluent and for gasoline blending, just like pentanes) and the price for RPPs such as heating oil. While heating oil is not suitable as a diluent replacement, RPPs such as refinery naphtha are, and thus, heating oil prices are given as a point of reference for other RPPs.

CERI estimates that in 2012, the largest demand source for pentanes plus in Canada and the United States (combined) was for use as diluent. Therefore, pentanes plus prices in North America are being driven by diluent demand, commanding a price over light crude oil benchmarks such as WTI and making Edmonton the premium market for pentanes (as well as butanes) in North America.

Source: Data from ADOE, CERI estimates, EIA, Industry data, and SGL. Figures by CERI

Mixed butanes prices for Sarnia, Conway, and Mt. Belvieu are calculated as the price of a 50/50 n-butane/i-butane mix
Going forward, ethane prices in the USGC are expected to remain depressed and affect pricing at other locations excluding AB, where CERI believes ethane prices will continue to be determined on a “gas plus” basis.

Propane prices are decoupling from crude oil prices, and USGC prices will continue to be supported by international LPG prices as exports continue to increase. Propane across other producing regions in North America is expected to continue to trade at a discount to the USGC unless a given region becomes a premium market through increased demand or export outlets.

Edmonton appears to be a premium market for butanes and pentanes and it is expected to remain this way given the expected continued activity in the oil sands.

Having an understanding of pricing trends and mechanisms in North America, we shift the focus now to extraction economics in the WCSB.
Figure 3.6 displays an estimate for the gross processing margin in the WCSB (top) as well as a netback estimate for an NGL barrel in the WCSB (bottom).

![Figure 3.6: WCSB NGL Extraction and Economics (2002 - 2013)](image)

Source: Data from ADOE. Figures by CERI

The weighted average WCSB barrel is calculated as each NGLs’ percentage of the sum of all NGLs produced at gas plants in the WCSB multiplied by the price of each liquid, and then given on a $/GJ basis.

The top portion of Figure 3.6 shows that the gross processing margin (the difference between the AECO gas price and the average NGL barrel on a $/GJ basis) has increased significantly over the last few years. This is the case because gas prices have been low compared to liquid prices, but there is, simultaneously, downward pressure on the margin as the heating content of each WCSB barrel has been declining over time as ethane and propane now make up the largest part of the NGL barrel (65 percent combined), while they have the lowest prices among NGLs.
This leads us into the bottom portion of Figure 3.6, which illustrates each liquid’s contribution to the value of the NGL barrel as well as netbacks both at the field\textsuperscript{91} and at the wellhead\textsuperscript{92} level.

In regards to netbacks, it can be observed that prior to 2005 the netbacks at the wellhead were very slim, indicating there was little incentive to extract NGLs from the gas. This was the case not because NGL prices were not high enough, but rather because natural gas prices were high and thus shrinking costs were high as well. After 2008, while the price spread has widened providing lower shrinkage costs; fractionation and transport costs have increased, thus putting downward pressure on netbacks.

Another key observation from the bottom portion of Figure 3.6 is that over the last couple of years, while ethane and propane accounted for the majority of the NGL barrel in volume terms, about 70 percent of the value of the barrel is derived from pentanes (50 percent of barrel value in 2012-13) and butanes (20 percent), while ethane (10 percent) and propane (20 percent) account for only 30 percent of the value of the NGL barrel.

The implications of this situation are that while it is true that gas producers have switched from drilling dry gas resources to wet or NGL-rich resources, producers in the WCSB will increasingly focus on condensate/heavy NGLs yielding plays that lie closer to the oil window such as the Duvernay.\textsuperscript{93} Furthermore, this means that the incentive for producers to build deep-cut extraction facilities (in order to monetize additional volumes of propane and ethane) are not very strong, as seen on Figure 3.7.

\textbf{Figure 3.7: Shallow versus Deep-cut Extraction Economics in the WCSB (2012 – 2013)\textsuperscript{94}}

\textsuperscript{91} Netback @ Field = WCSB NGL barrel price – fractionation and transport costs
\textsuperscript{92} Netback @ Wellhead = Netback at field – shrinkage and processing costs
\textsuperscript{93} See: Delving into the Duvernay: \url{http://www.oilweek.com/index.php/oil-and-gas-news/business/434-delving-into-the-duvernay}
\textsuperscript{94} Prices are WCSB prices for 2012 -13. Ethane priced is calculated on a “gas plus” basis. Extraction efficiencies = Shallow: C2: 1%, C3: 90%, C4: 99%, C5: 99%; Deep = C2: 90%, C3: 95%, C4: 99%
Simply put, if the additional capital, operating, and marketing costs of bringing the additional propane and ethane portion of the NGL barrel to market is higher than the 10 percent per barrel estimated premium of a deep-cut facility, there is no incentive to build deep-cut facilities (under the given assumptions).

Oil sands off-gas extraction economics are also worth discussing. Figure 3.8 displays the estimated composition of off-gases from a bitumen upgrader in AB as well as the value of each component in the off-gas.

**Figure 3.8: Off-gas Composition (left) and Extraction Economics (2012-13)**

Using average prices for 2012-13, the value of the off-gas components are estimated at close to $16/mcf\(^9\) which is equivalent to the extracted value assuming 100 percent extraction efficiency. The second estimate is for the off-gas components (excluding the high-value olefins) and it illustrates that olefin extraction is one of, if not the, most important components of the off-gas extraction proposition. The third column estimates the value of the off-gas if it is to be burnt at its heating value, which as previously discussed is the main case today in Alberta.

The maximum gross margin is calculated as the difference between the components of the off-gas and their heating value which is the extraction plant’s shrinkage costs.

Therefore, as long as the sum of extraction and marketing costs are lower than the gross margin, the extraction economics are favourable. The margin will in turn also be determined by the price difference between natural gas and NGLs/olefins.

As an example, in the case given above, if the natural gas price was $10/GJ as opposed to $2.6/GJ, assuming 100 percent extraction of NGLs/olefins, the gross margin will go to $0 and then extraction economics are no longer favourable.

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\(^9\) To put this into context, this is a price similar to Japanese LNG during 2012-13
This concludes the discussion of NGL prices in North America and WCSB extraction economics.

Having an understanding of North American NGL markets, supply and demand dynamics as well as pricing trends, mechanisms, and extraction economics, we can move on to discuss opportunities for NGL exports beyond North America.

Part IV of the NGL report will delve into these issues. It will give an overview of emerging global trends in NGL markets, as well as identify prospective markets for Canadian NGLs in the global context while considering the best alternatives.