

NON-CONFIDENTIAL REPORT



Study to Evaluate Value-Added Market Opportunities for Natural Gas Liquids (NGLs) Produced in North Dakota

IHS Chemical

May 02, 2014

Final Report



IHS CONFIDENTIAL INFORMATION HAS BEEN REMOVED FROM THIS VERSION OF THE REPORT

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Introduction and Objectives

Introduction

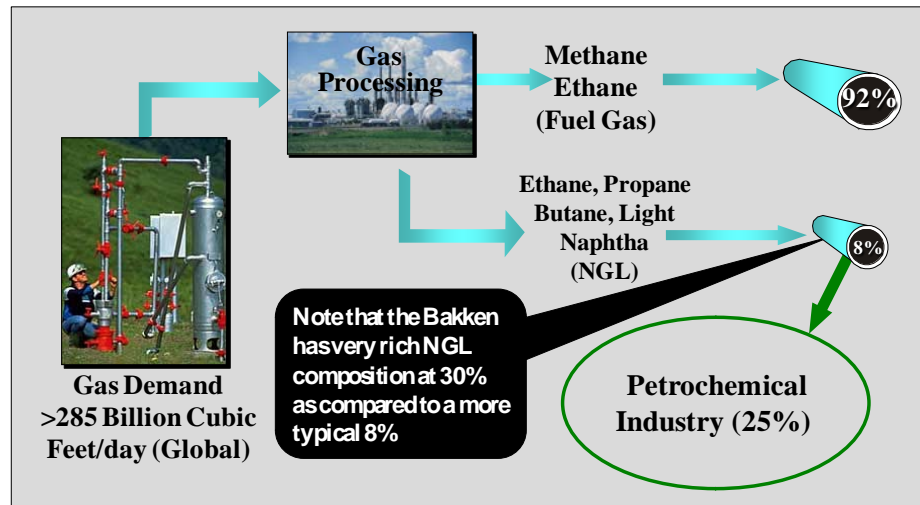
- The State of North Dakota (“North Dakota Department of Commerce”, “EmPower ND Commission”) is seeking the assistance of an independent third-party consultancy to provide an in-depth market and feasibility analysis of the NGL market in North Dakota, both on a national and global scale.
- IHS Global, Inc., with the combined expertise of IHS Chemical (including the former CMAI and SRI Consulting, IHS Downstream Energy (the former Purvin & Gertz), IHS CERA (Upstream Energy), and IHS Global Insight, is unique in our experience, expertise and databases and hence capability to be able to support the State of North Dakota entirely in this major initiative along the full value chain from NGL reserves through high-value products. Specifically, IHS has done extensive work analysing NGL resources and the implication on the U.S. Chemicals Industry. Our strong position in the petrochemicals industry and our world-class experts puts IHS in an excellent position to deliver the full scope of service requested by State of North Dakota.

The Study

- A large quantity of oil and natural gas is produced in North Dakota, primarily from the Bakken and Three Forks formations. During April 2013, 25,811,939 MCF of natural gas was produced. As of June 2013, 21 natural gas processing plants were operating in the state. Additions to gathering and processing capacity are catching up, but the percentage of gas flared remained unchanged at 29% as of June 2013. The historical high was 36% in September 2011.
- According to a report published by the North Dakota Industrial Commission, Department of Mineral Resources, dated June 17, 2013, natural gas delivered to the Northern Border pipeline at Watford City, North Dakota, was \$3.51/MCF. This resulted in an oil-to-gas price ratio of 24-to-1 (as compared to the historical ration of 6-to-1), but the high liquids content has made gathering and processing of Bakken gas challenging.
- The 2013 North Dakota Legislative Assembly authorized the Department of Commerce (Commerce), in cooperation with the EmPower North Dakota Commission (“Commission”) to issue a contract for the purpose of conducting a study to evaluate value-added market opportunities for renewable energy resources and oil and gas. The decision was made to focus the studies on ethanol and natural gas liquids.

The Study (continued)

- This proposed study will help state officials to gain an understanding of the industry and the products, with the early stage objective of determining how to add value to the NGLs by developing and commercializing the product stream.
- With respect to obtaining the downstream value, we also understand that the North Dakota shale hydrocarbons are very rich in that the natural gas liquids (GLs (ethane, propane, butane and pentanes).
- Specifically that some GLs comprise about 30% of the associated gas.
- One such approach for adding value to the NGLS beyond the y-cut value and zero value of flared gas is to use them as feedstock to high-value chemicals, which is very typical as shown in the following figure.



The Study (continued)

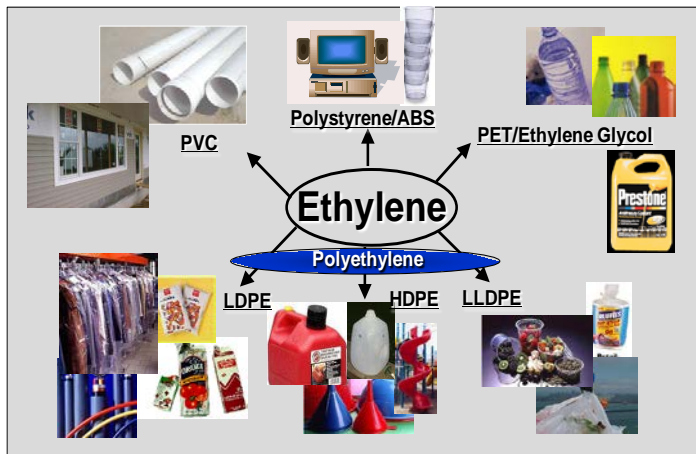
- The \$15 trillion global chemical industry is comprised of very diverse products and value chains. The opportunity for stakeholders in North Dakota could be in segments and cross-sections of these value chains in order to maximize the economic sustainability of such a localized chemical industry as illustrated in the following figure. Moreover, the first chemical derivatives of gas and NGLs initial chemical-derivatives and their derivatives are generally easily transportable, so that the customer base (expected to be outside of North Dakota) is diverse from a geography and product end-use perspective.



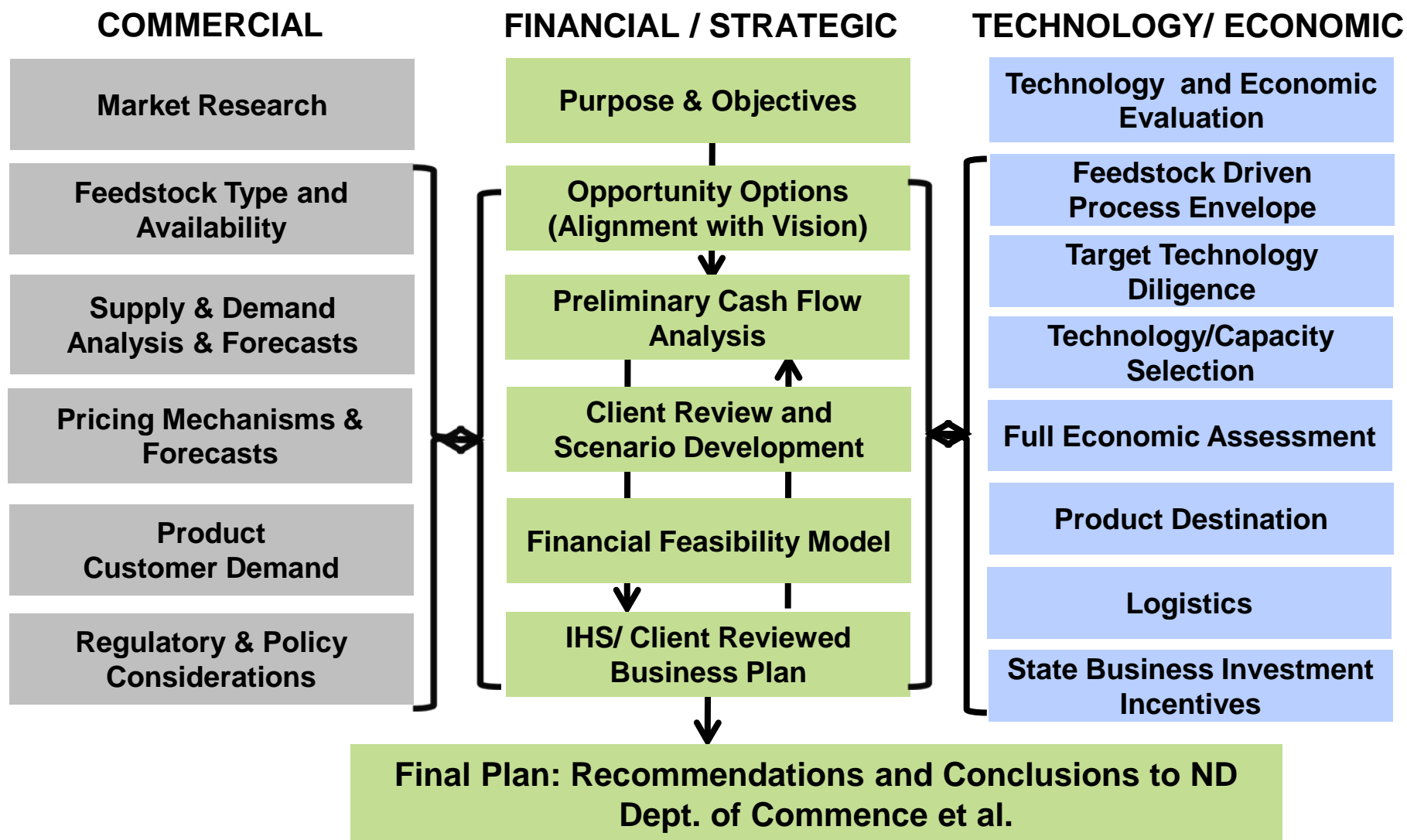
- It is also important to point out that the gas and NGLs components of: ethane, propane and butane represent the primary building chemical industry building blocks (i.e., feedstocks) of ethylene, propylene and butylenes, respectively.

The Study (continued)

- Illustrations of the diversity of end-use and familiar consumer products from these chemical feedstocks are presented in the following figures.



The Study Approach and Status



WHO IS IHS?

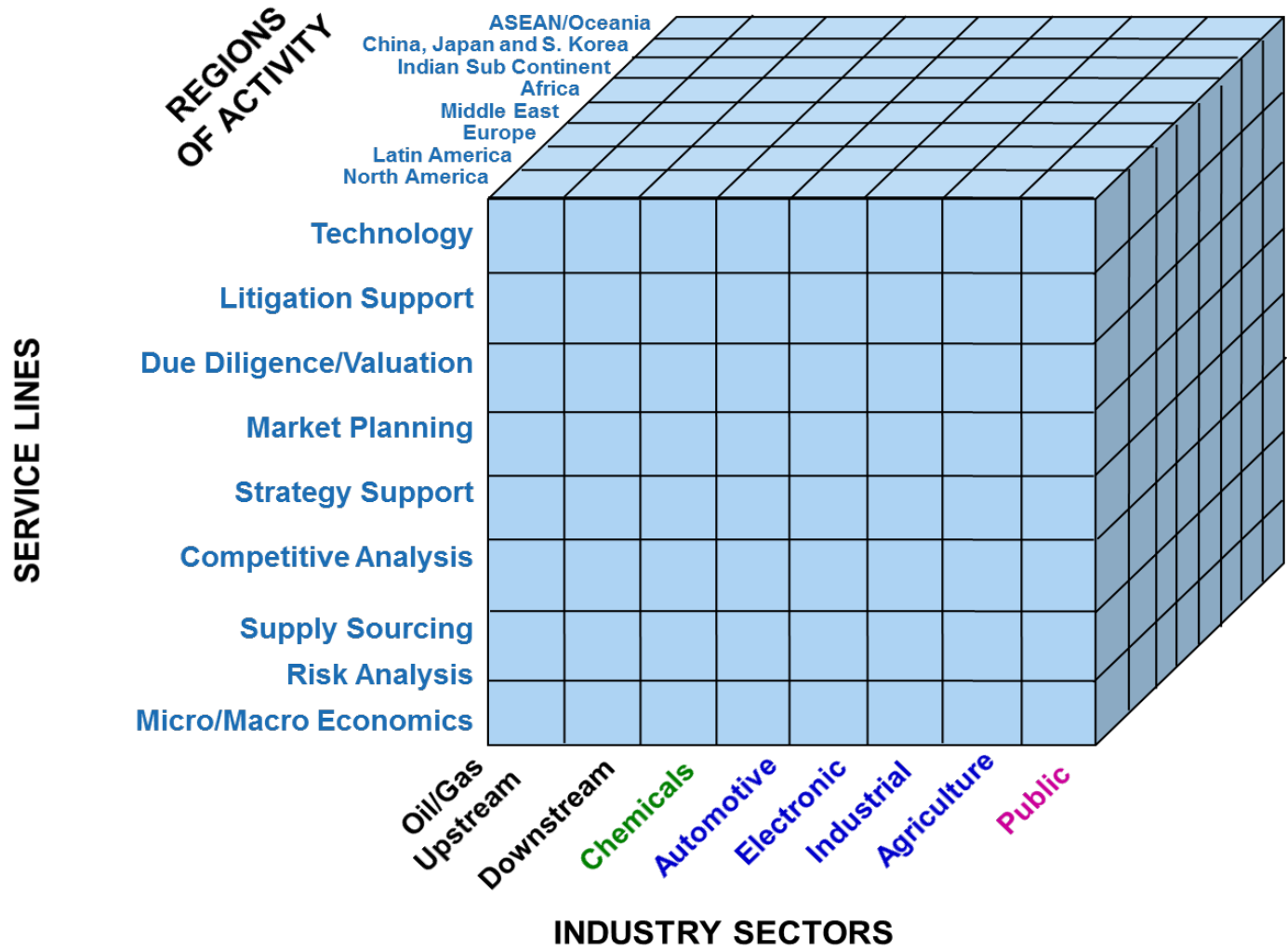
Who is IHS?

IHS' Capabilities & Expertise are Across Multiple Industries

We are a public company (founded in the 1950s)

We currently with over 8000 staff in 30 countries

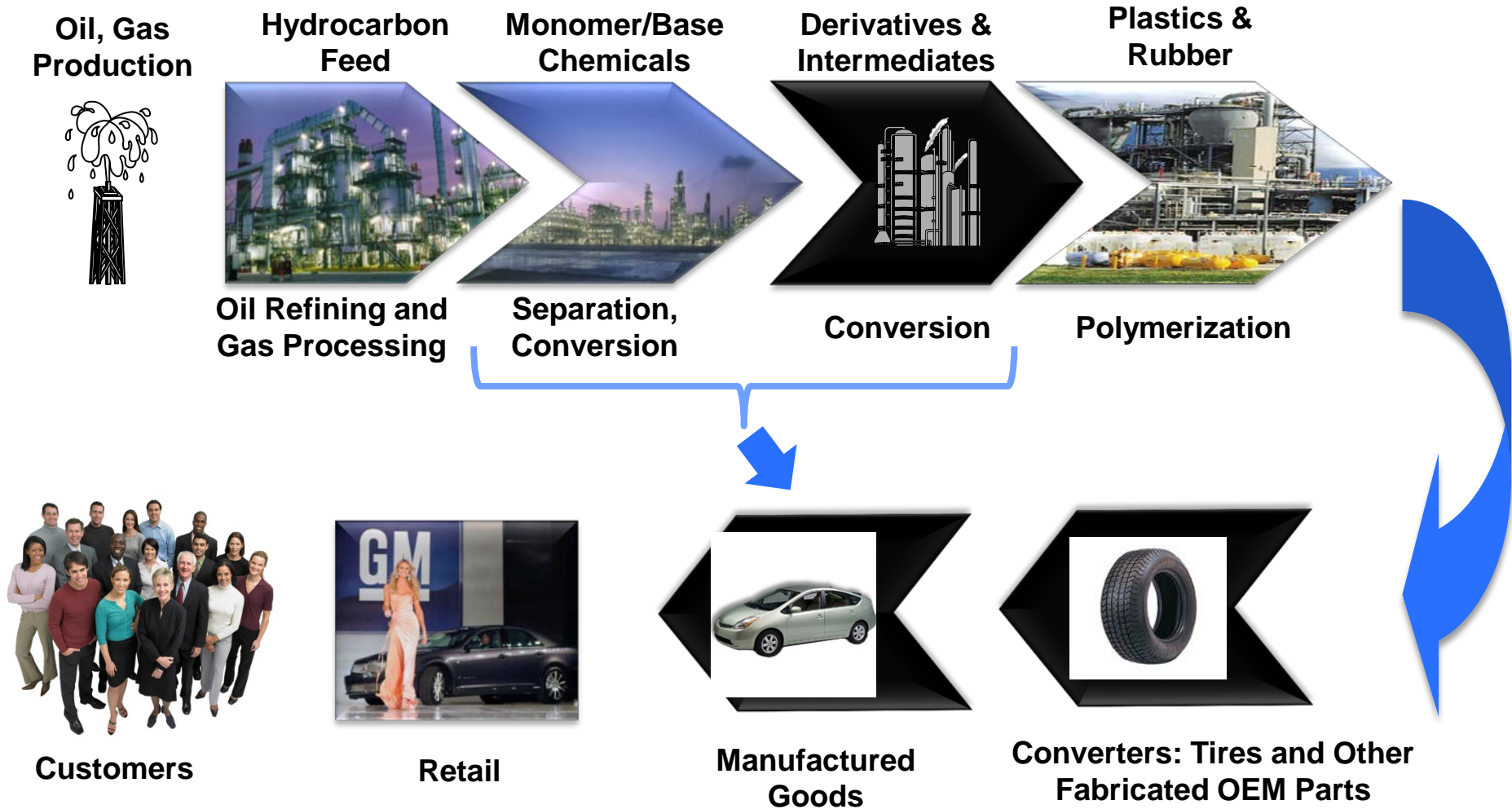
Our revenue exceeds US\$ 2 billion



Who is IHS? (continued)

- We are the industry's largest integrated source for Energy and Chemicals Research, Analysis, and Consulting Services
- During the 4 years, IHS has acquired and put under one roof...
 - CMAI
 - SRI
 - Harriman
 - Chemical Week
- IHS Chemical's group has about 350 staff in 15 offices around the globe

Who is IHS? (continued)



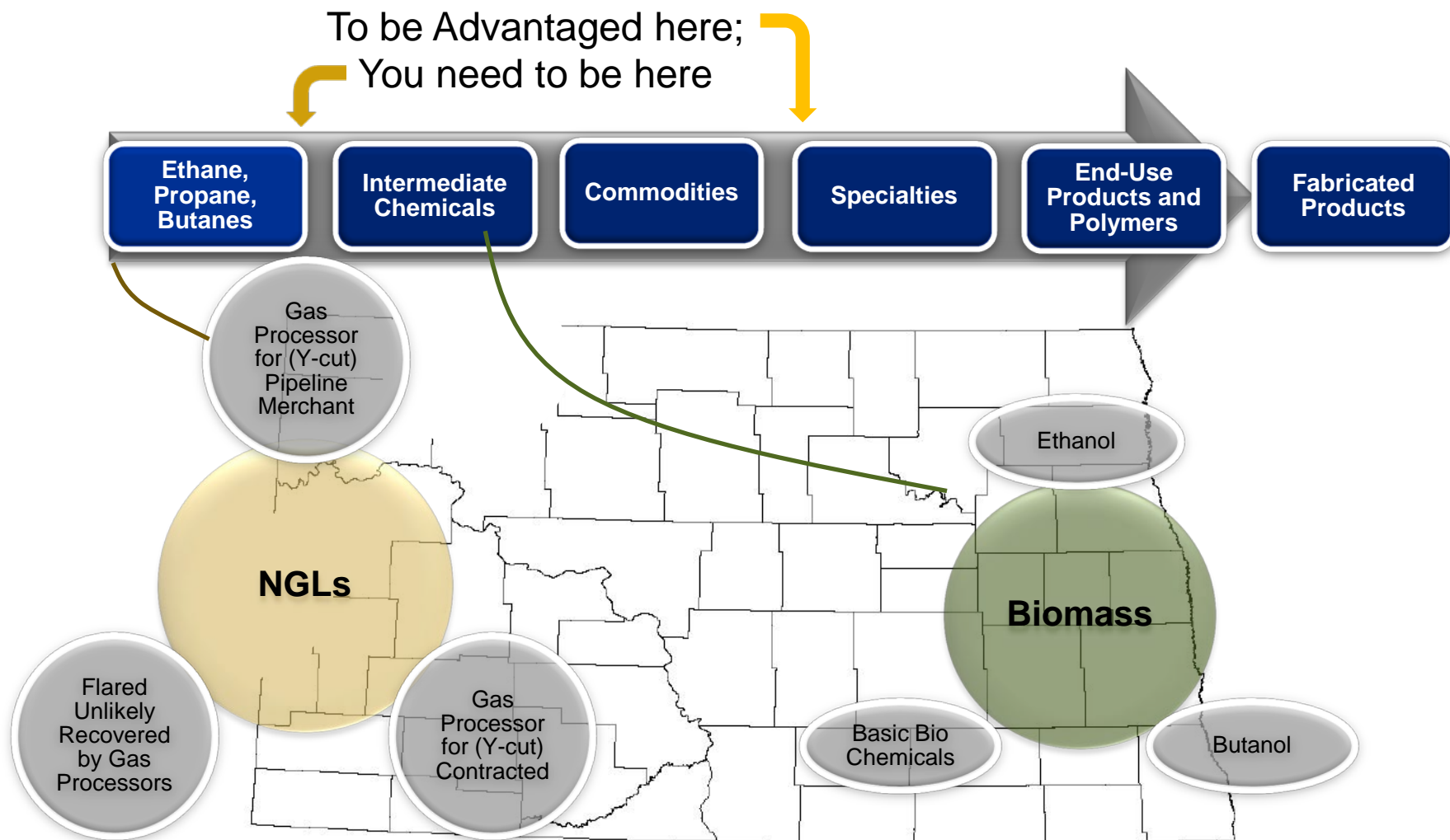


Executive Summary

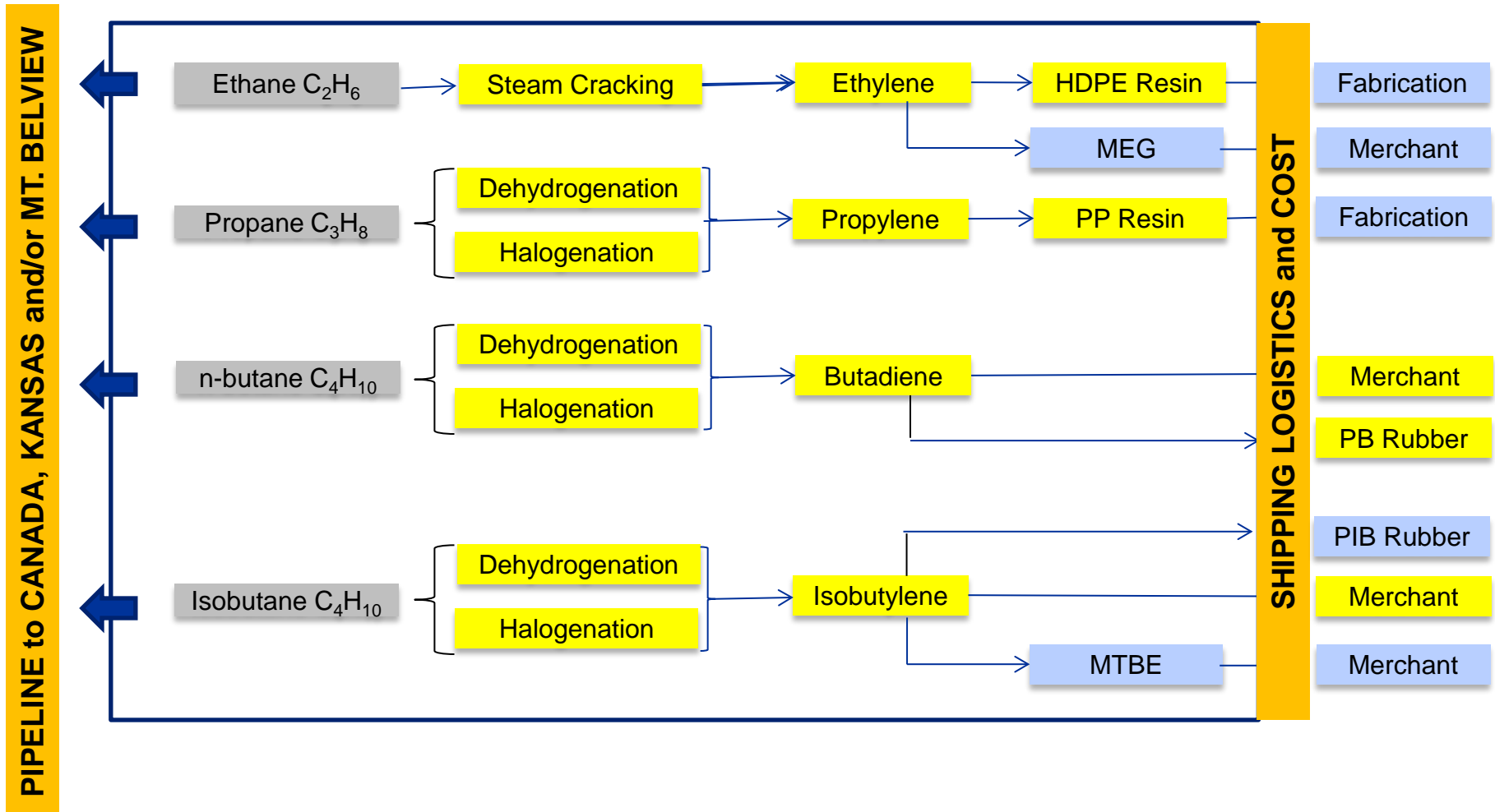
❖ *Summary, Conclusions and Recommendations*

Summary, Conclusions and Recommendations

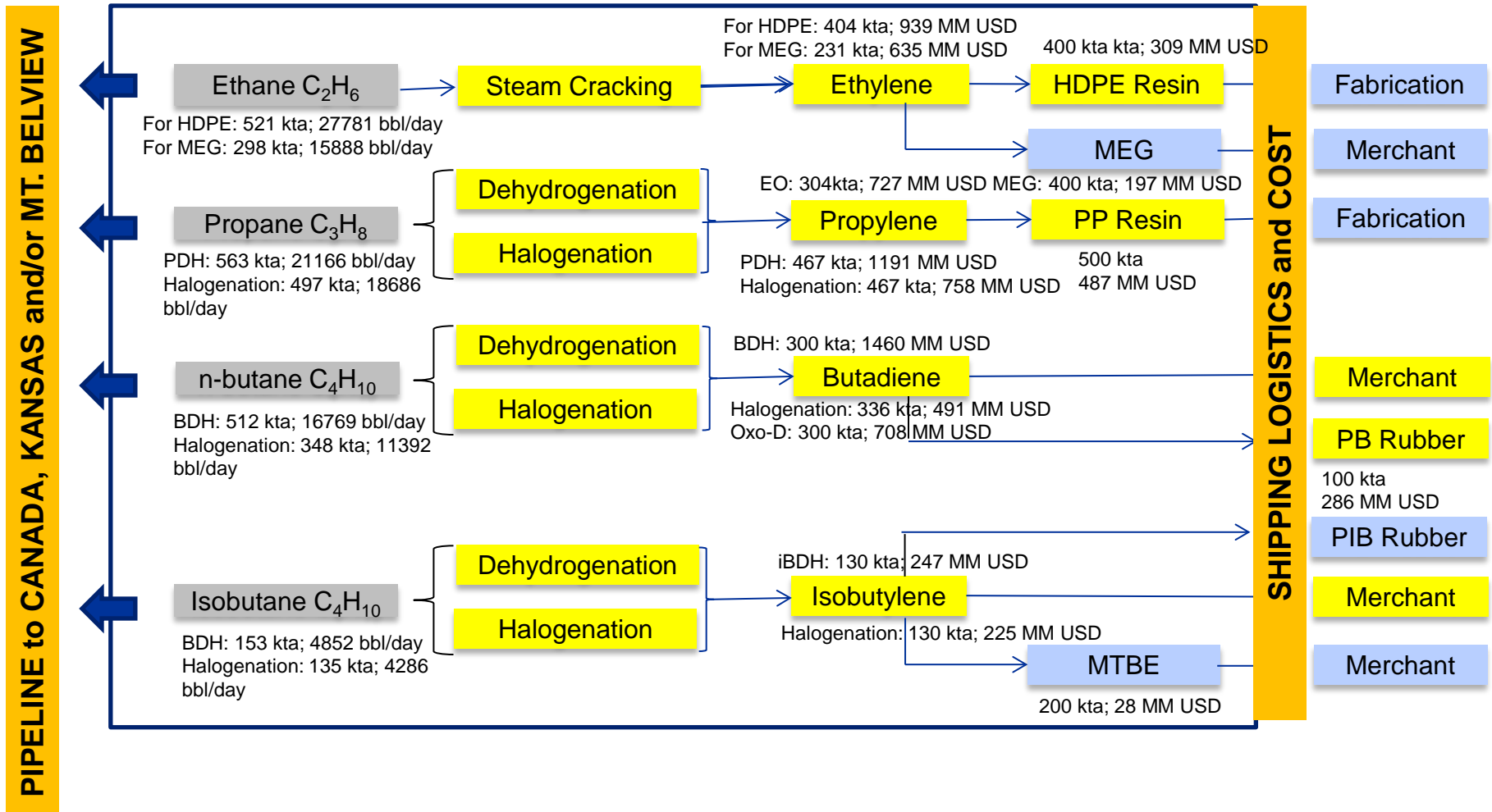
The Feedstock-Products Value Chain



NGLs to Chemicals: Economic Screening: indicates opportunity



NGLs to Chemicals: Economic Screening: indicates opportunity

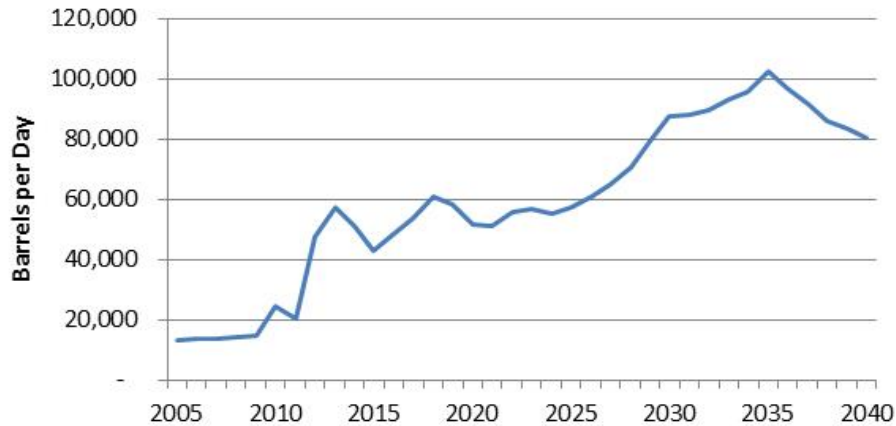


NGLs to Chemicals: Capacity and Capital Costs – North Dakota - 2020 Basis

NGL - Feed Requirements		
	KMT	Bbl/day
Ethane Feed - HDPE	520.90	27781
Ethane Feed - MEG	297.90	15888
Propane Feed - PDH	563.30	21166
Propane Feed - Halogenation	497.30	18686
n-Butane Feed - BDH	512.40	16769
n-Butane Feed - Halogenation	348.10	11392
i-butane - BDH	152.50	4852
i-butane - Halogenation	134.70	4286
NGL		
	Capacity, kMT	Capital, USMM\$
Ethane Cracker - HDPE	404.00	939.00
Ethane Cracker - MEG	231.00	635.00
HDPE	400.00	309.00
EO	304.00	727.00
MEG	400.00	197.00
Propane Dehydrogenation (PDH)	467.00	1191.00
Propane Halogenation	467.00	758.00
Polypropylene ICP	500.00	487.00
n-Butane Dehydrogenation (BDH)	300.00	1460.00
n-Butane Halogenation	336.00	491.00
Oxo-D	300.00	708.00
Polybutadiene (PBR)	100.00	286.00
Isobutane Dehydrogenation	130.00	247.00
Isobutane Halogenation	130.00	225.00
MTBE via Isobutylene	200.00	28.00

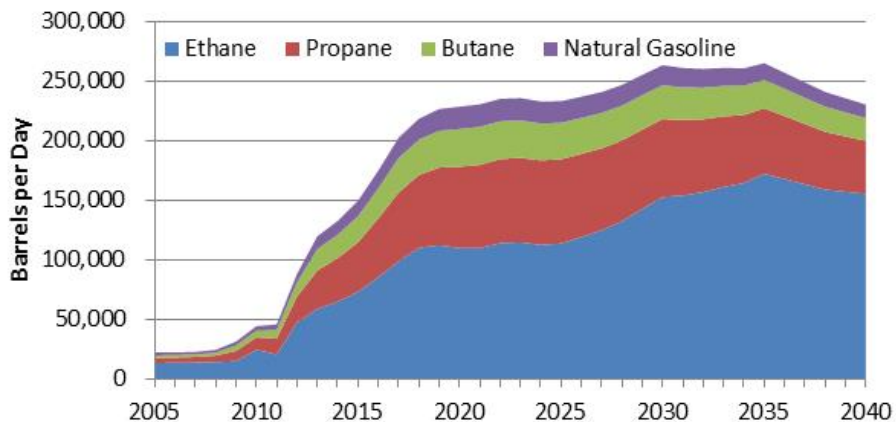
The NGL Gas Forecast Includes a Large Amount of “Rejected” Ethane

Ethane Rejection in ND



- If there is no local market for ethane part of the ethane is recovered and part is left in the gas
- If needed for local consumption it can be recovered
- The transportation costs to the USGC market is high so as much of the ethane as possible is left in the gas up to the BTU spec on the gas pipelines

North Dakota NGL Production by Type

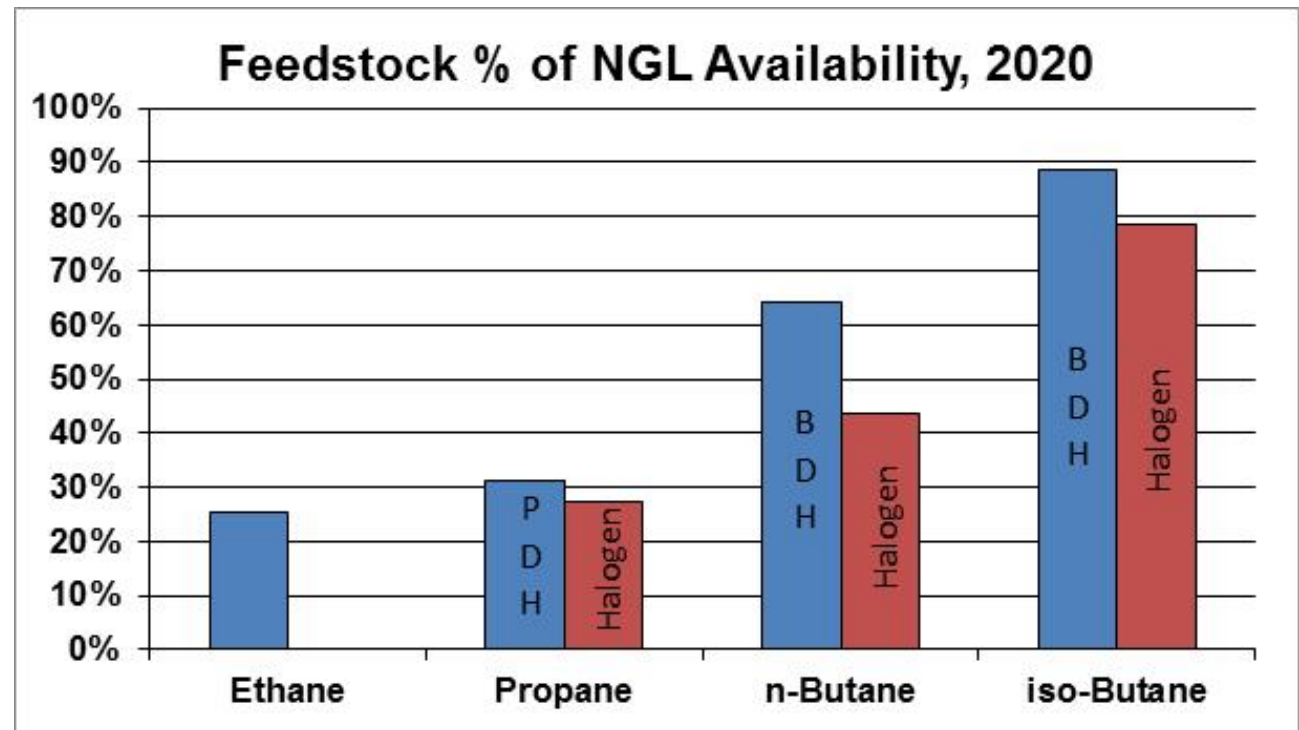


- The volume of NGLs from associated wells (including the “rejected ethane”) is forecast to increase to 2035

IHS' forecast is for sufficient NGL component gas for each proposed plants

- The recovery of “Rejected Ethane: from the pipeline gas will make ethane an especially attractive source of chemical products
- NGL component demand for the target chemical products

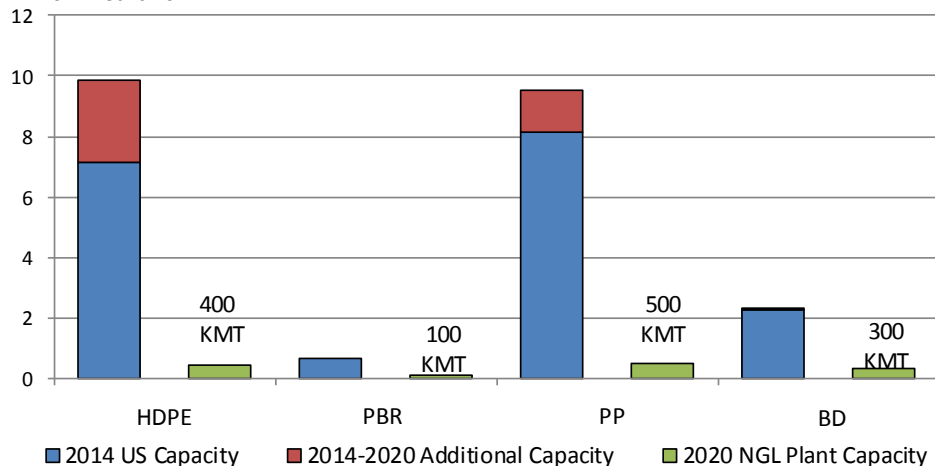
- Ethane: 521 KTA (27781 BPD)
- Propane: 563 KTA (21166 BPD); for PDH technology
- n-Butane: 512 KTA (16769 BPD); for BDH technology
- iso-Butane: 153 KTA (4852 BPD); for BDH technology



All of the Proposed Plants Would be a Small Percentage of US Capacity

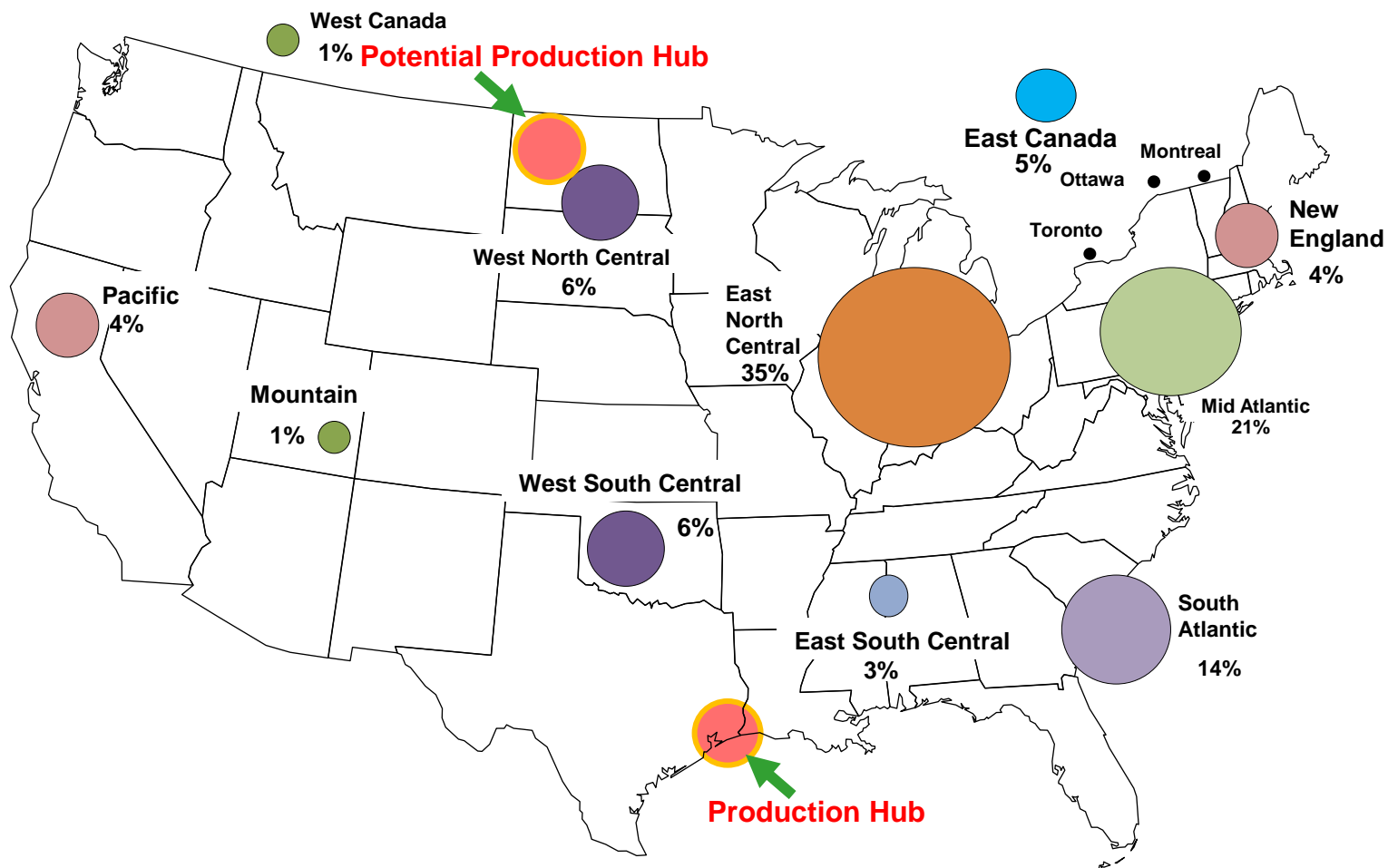
US Capacity vs. NGL Plant Capacity - 2020

Million Metric Ton



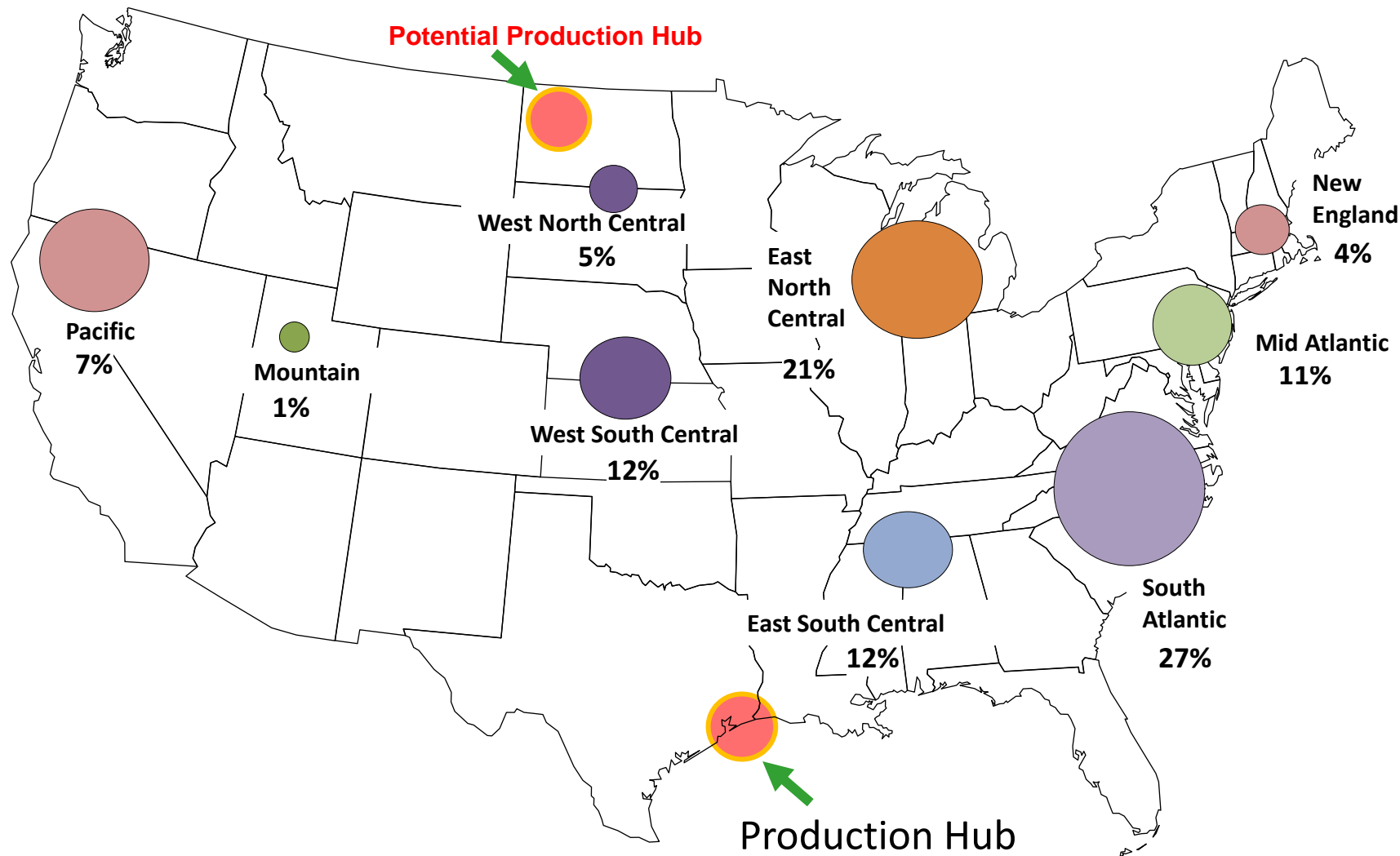
- For HDPE, the proposed plant represents a reasonably small percent of total capacity in the US in 2020 and of the required capacity addition (announced and anticipated) required to satisfy US supply/demand dynamics
- IHS forecasts no new PBR plants and, hence, the proposed plant is not viewed as necessary to satisfy production need by 2020; however, the proposed PBR plant represents 15.3% of the 2020 anticipated total US capacity, such that a competitive plant could displace current capacity
- For 1,3-butadiene (BD) IHS forecasts little or no capacity addition
- For BD, this is largely due to the fact that the BD capacity is conventionally provided by steam cracker coproduct production from heavier liquid feedstocks, which are in decline in the US as ethane and other light feeds displace the heavier feedstocks and the cost of on-purpose BD production has been uncompetitive
- The proposed BD plants represent a very small percentage (3.0%) of the total US capacity in 2020

Polyethylene Domestic Demand by U.S. Region

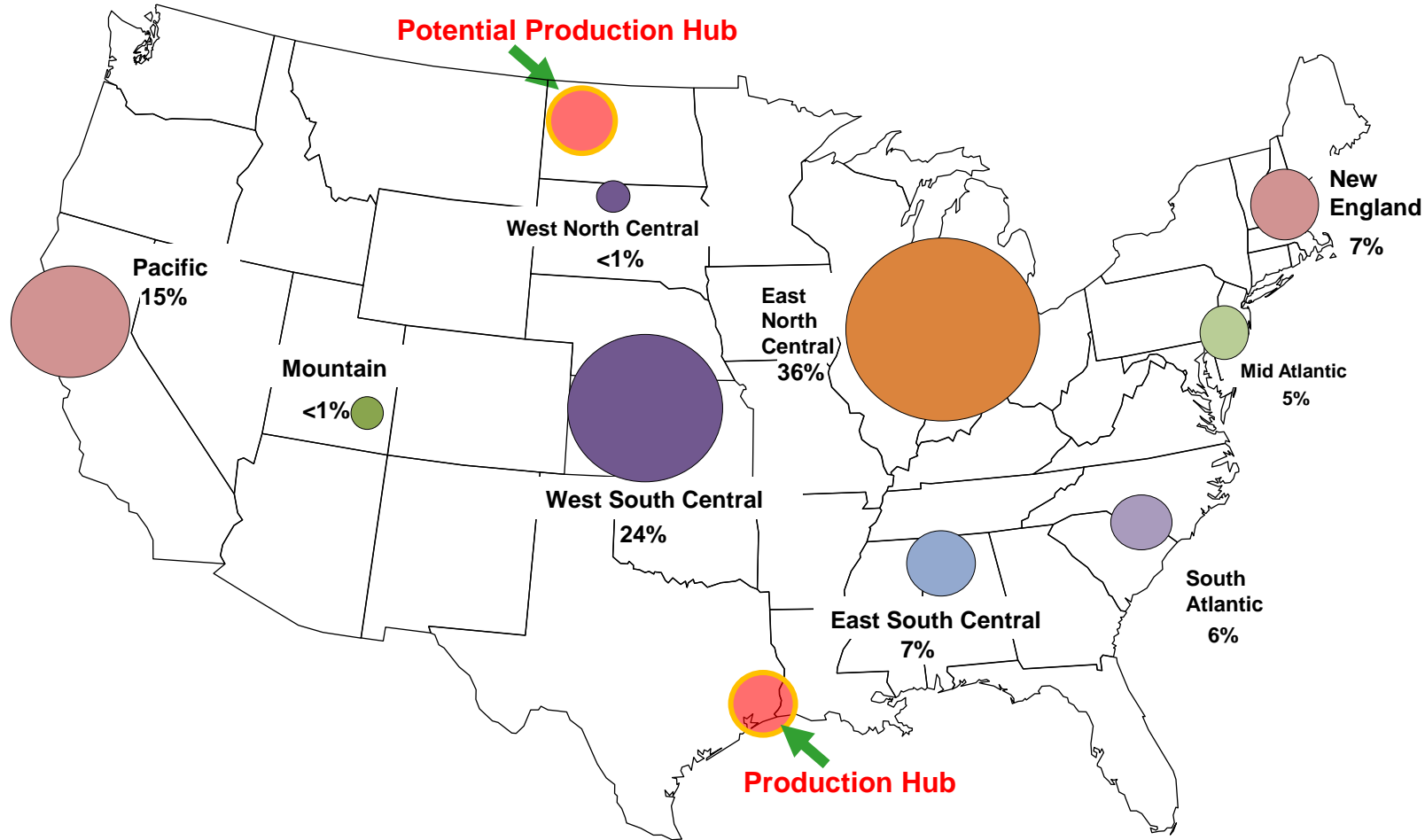


More than half of the consumption in US is within reach of a North Dakota Plant, while most production is centered in the U.S. Gulf Coast

Polypropylene Domestic Demand by U.S. Region

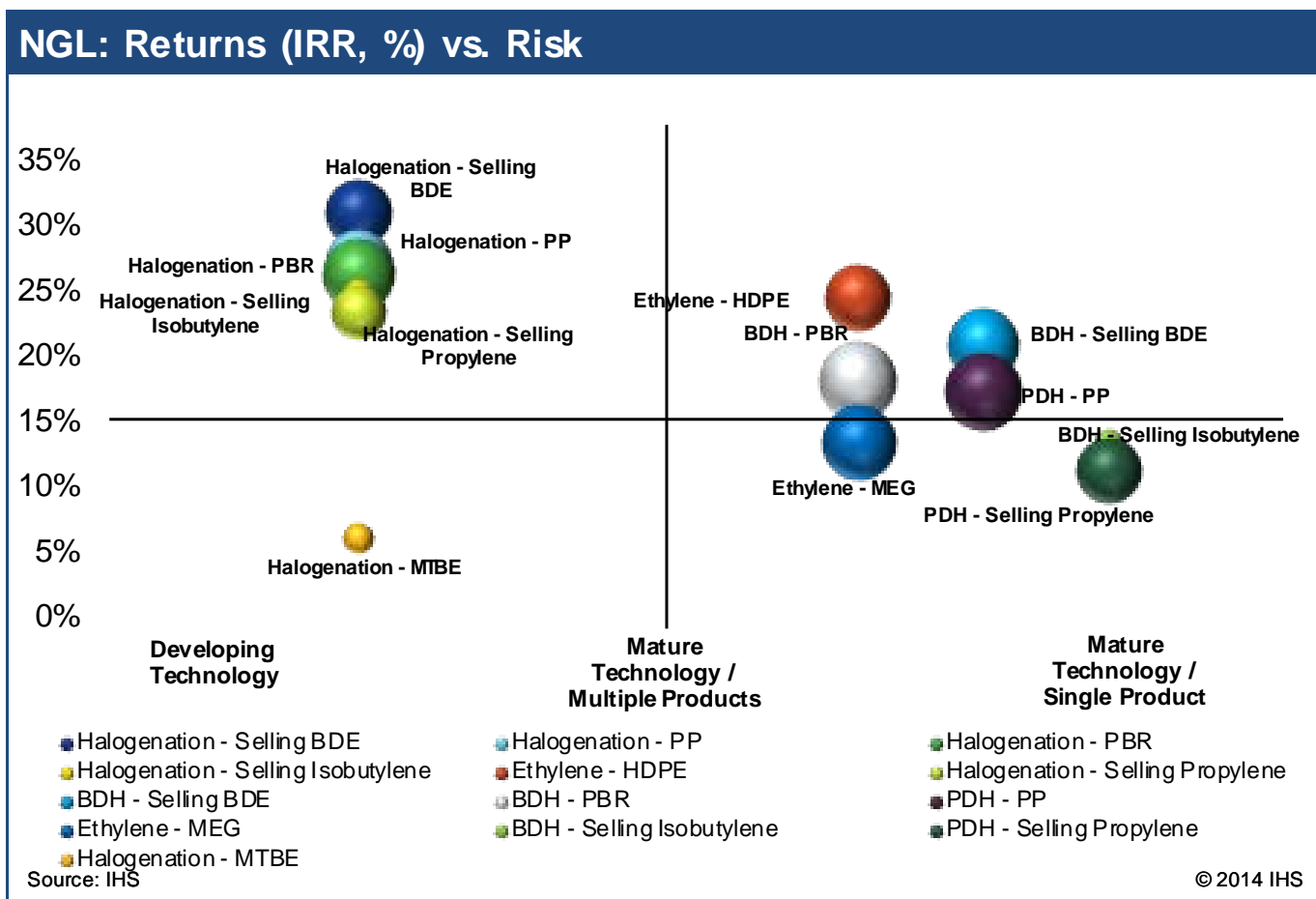


PBR Domestic Demand by U.S. Region

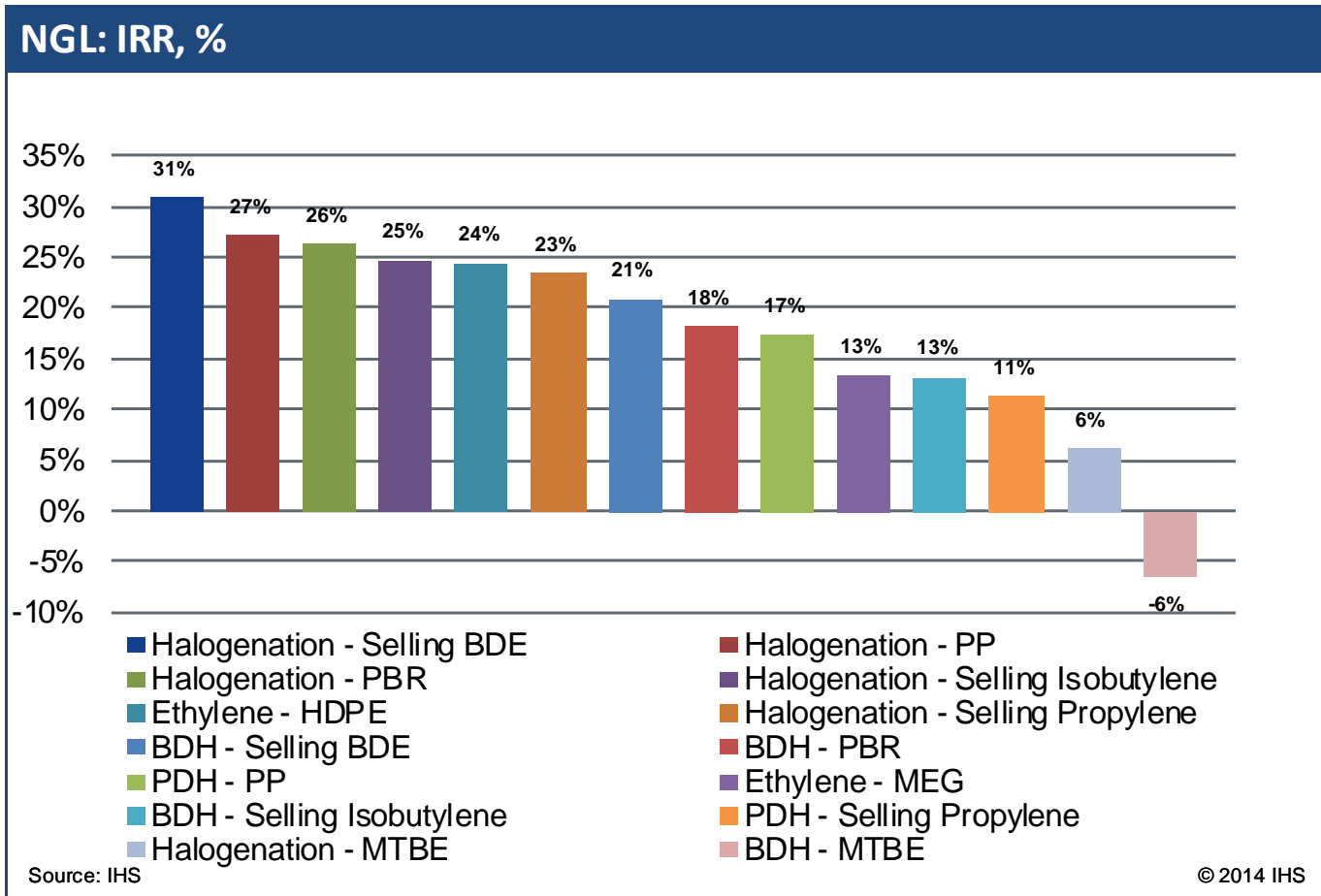


More than half of the consumption in US is within reach of a North Dakota Plant, while most production is centered in the U.S. Gulf Coast

Financial Model Results



Financial Model Results



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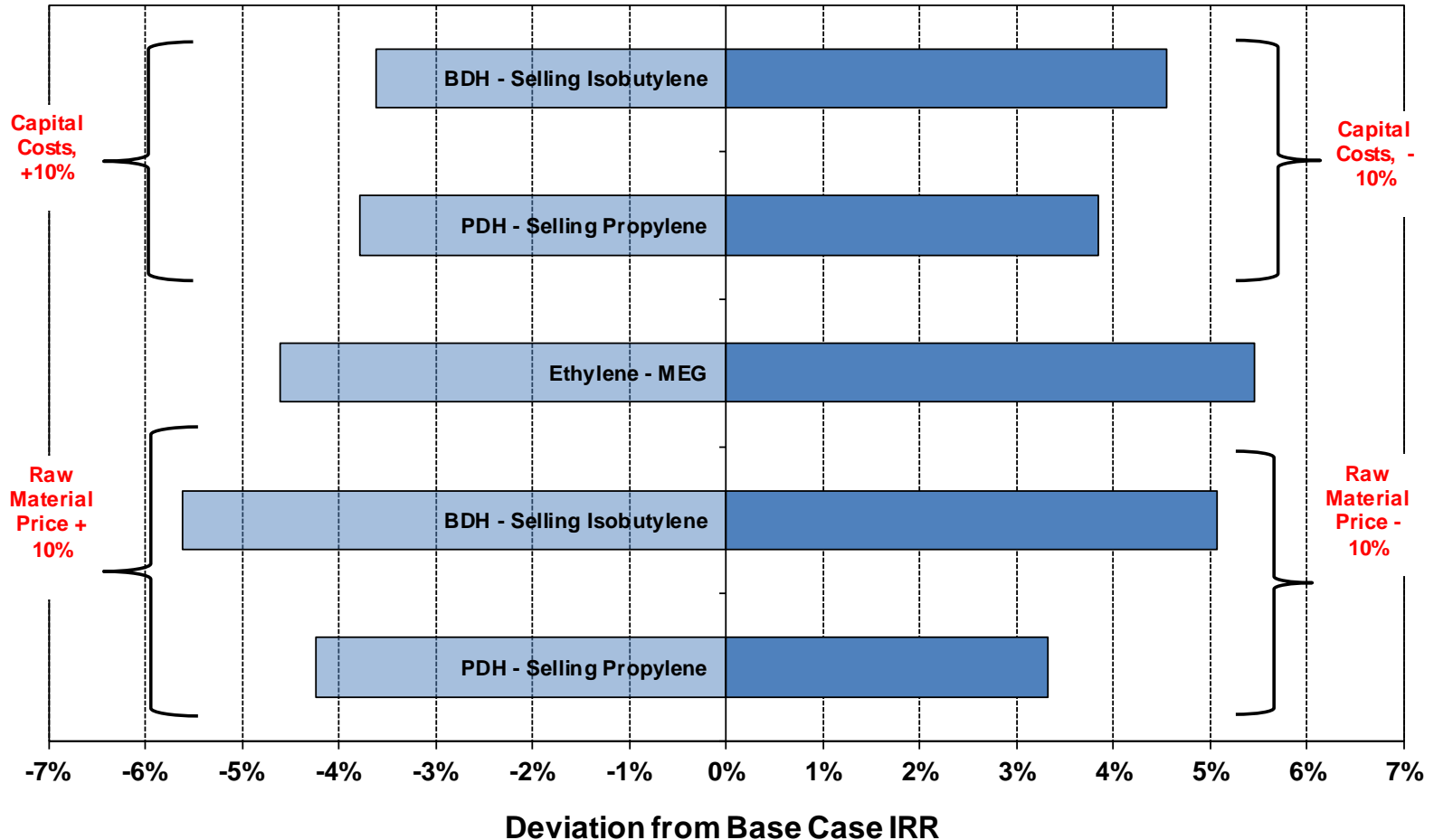
	IRR	NPV @ 0%	NPV @ 10%
Ethane - North Dakota Feed - Midwest Netback - Ethylene - HDPE	24%	3693	1409
Ethane - North Dakota Feed - Midwest Netback - Ethylene - MEG	13%	2365	756
Propane - North Dakota Feed - PDH - PP	17%	3527	1209
Propane - North Dakota Feed - PDH - Selling Propylene	11%	1499	457
Propane - North Dakota Feed - Halogenation - PP	27%	4430	1708
Propane - North Dakota Feed - Halogenation - Selling Propylene	23%	2145	809
n-Butane - North Dakota Feed - BDH - PBR	18%	3016	1175
n-Butane - North Dakota Feed - BDH - Selling Butadiene	21%	2859	1159
n-Butane - North Dakota Feed - Halogenation - PBR	26%	4051	1664
n-Butane - North Dakota Feed - Halogenation - Selling Butadiene	31%	3912	1660
i-Butane - North Dakota Feed - BDH - MTBE	-6%	-60	-99
i-Butane - North Dakota Feed - BDH - Selling Isobutylene	13%	360	117
i-Butane - North Dakota Feed - Halogenation - MTBE	6%	214	35
i-Butane - North Dakota Feed - Halogenation - Selling Isobutylene	25%	629	246

Financial Model Results

Product Line	IRR, %
Halogenation - Selling BDE	31%
Halogenation - PP	27%
Halogenation - PBR	26%
Halogenation - Selling Isobutylene	25%
Ethylene - HDPE	24%
Halogenation - Selling Propylene	23%
BDH - Selling BDE	21%
BDH - PBR	18%
PDH - PP	17%
Ethylene - MEG	13%
BDH - Selling Isobutylene	13%
PDH - Selling Propylene	11%
Halogenation - MTBE	6%
BDH - MTBE	-6%

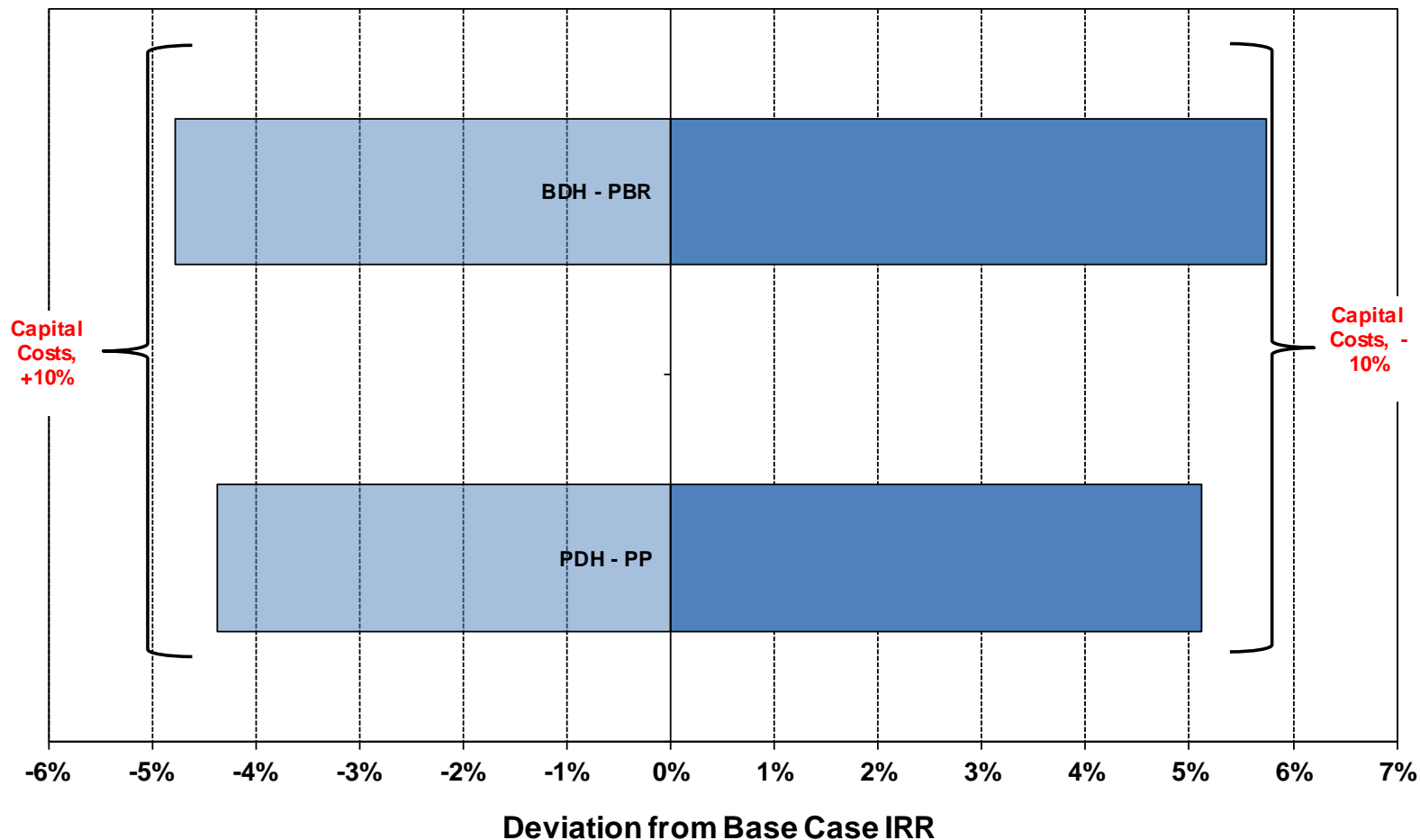
NGL – Sensitivity Analysis - Higher

NGL Project Sensitivity Analysis - Higher



NGL – Sensitivity Analysis - Lower

NGL Project Sensitivity Analysis - Lower



NGL – Sensitivity Analysis – Higher/Lower Returns on Investment

Higher

	Base	Raw Material +10%	Raw Material -10%
PDH - Selling Propylene	11%	7%	15%
BDH - Selling Isobutylene	13%	8%	18%

	Base	Capital Cost +10%	Capital Cost - 10%
Ethylene - MEG	13%	9%	19%
PDH - Selling Propylene	11%	7%	15%
BDH - Selling Isobutylene	13%	10%	18%

Lower

	Base	Capital Cost +10%	Capital Cost - 10%
PDH - PP	17%	13%	22%
BDH - PBR	18%	13%	24%

Sensitivity Analysis – Products Not recommended

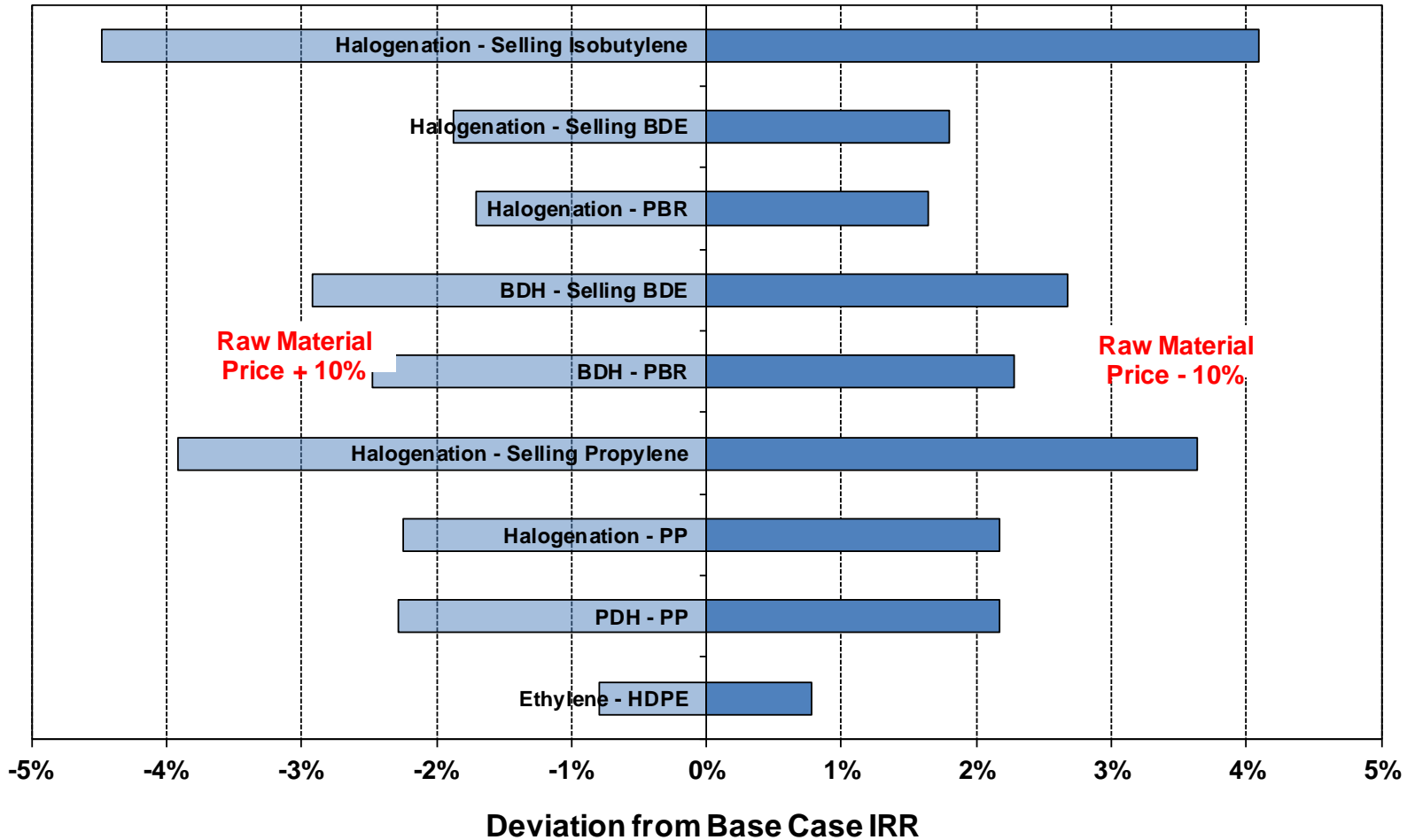
- Monoethylene glycol (MEG) becomes profitable when considering a 10% lower capital cost; the MEG IRR increases to 19%.
- This is due to the high capital cost associated with ethylene oxide production (the intermediate to MEG) and the effect that capital cost has on the economics for both EO and MEG. It should be noted that EO/MEG technology is mature and the capex is well understood in the industry such that lower capital cost would likely be a result of construction industry dynamics rather than process uncertainty
- Propylene via conventional PDH technology becomes marginally acceptable at lower raw material cost and lower capital cost. Propylene production is already a product recommended for further consideration when produced by halogenation technology (though recognizing the risks associated with a developing technology).

Sensitivity Analysis – Products Not recommended

- Butadiene via BDH has similar results to that of propylene. The lower raw material costs and lower capital cost cases result in acceptable returns on investment (18% for both sensitivity cases), though butadiene was already a product recommended for further analysis when produced by the developing halogenation technology
- Both polypropylene via PDH and butadiene rubber via BDH become unprofitable at 10% higher capex. Both products show an IRR of 13% for this scenario.
- Again, as in the case of EO/MEG production, the technologies are well known and commercialized and capital costs are believed to be reliable when disregarding the effects of the chemical industry activity

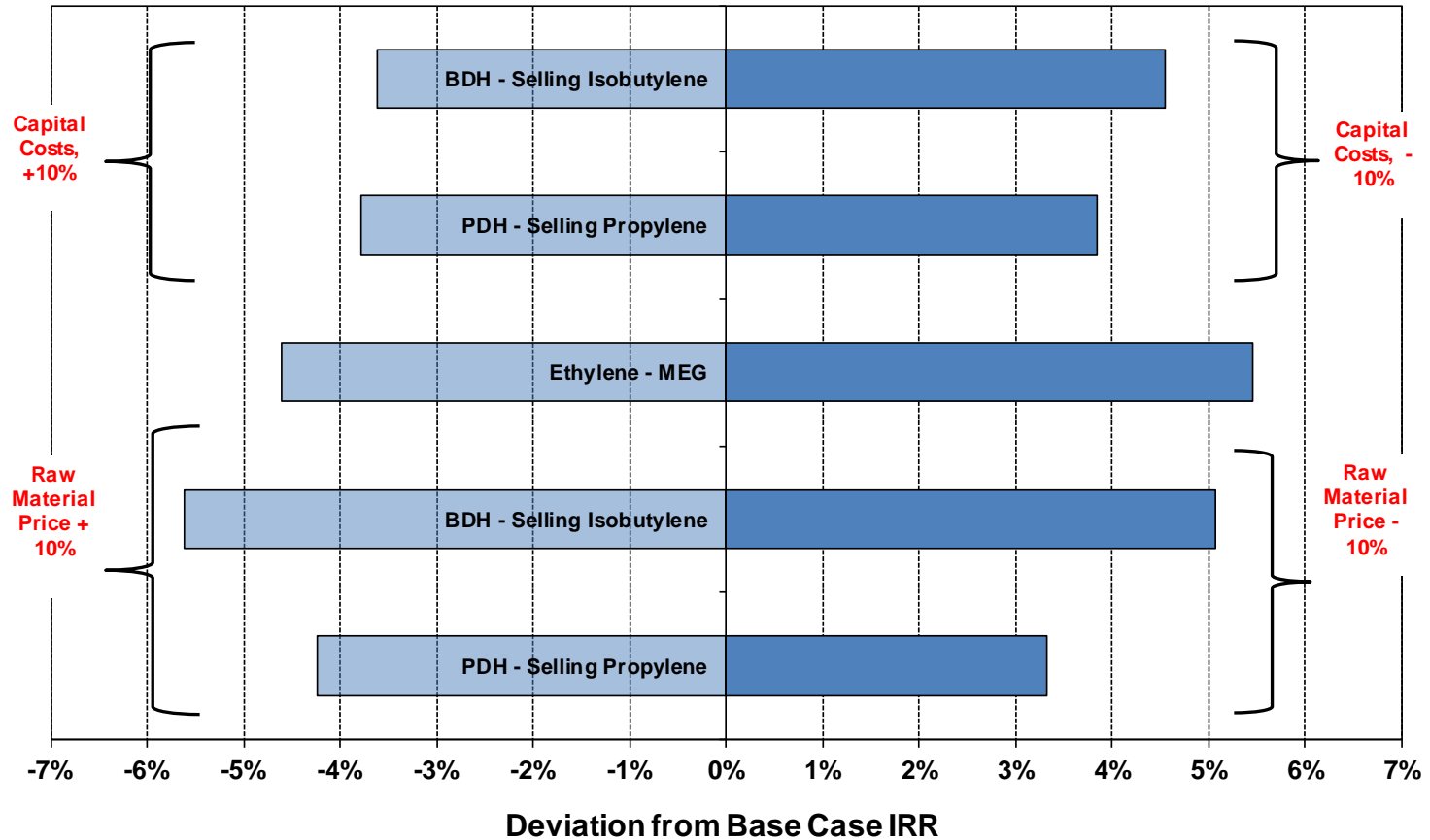
NGL – Raw Material Price Sensitivity

NGL Project Sensitivity Analysis - Raw Material Costs



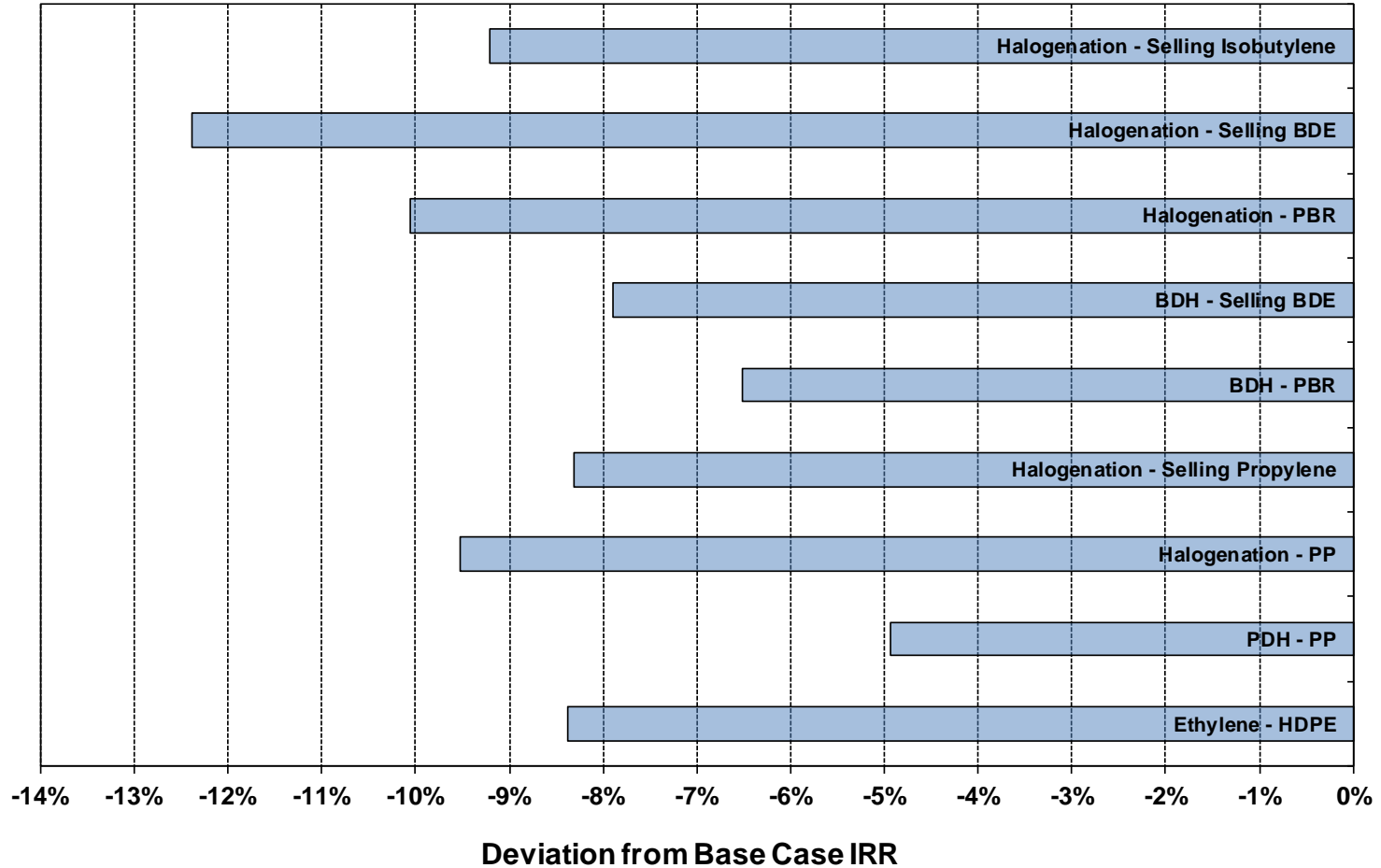
NGL – Capital Cost Price Sensitivity

NGL Project Sensitivity Analysis - Higher



NGL – Debt Equity Sensitivity

NGL Project Sensitivity Analysis - 100% Equity



NGL – Raw Material and Capital Cost Price Sensitivity

	Raw Material		Raw Material
	Base	+10%	-10%
Ethylene - HDPE	24%	24%	25%
PDH - PP	17%	15%	20%
Halogenation - PP	27%	25%	29%
Halogenation - Selling Propylene	23%	19%	27%
BDH - PBR	18%	16%	20%
BDH - Selling BDE	21%	18%	24%
Halogenation - PBR	26%	24%	28%
Halogenation - Selling BDE	31%	29%	33%
Halogenation - Selling Isobutylene	25%	20%	29%

	Capital Cost		Capital Cost
	Base	+10%	-10%
Ethylene - HDPE	24%	19%	30%
PDH - PP	17%	13%	22%
Halogenation - PP	27%	22%	33%
Halogenation - Selling Propylene	23%	19%	28%
BDH - PBR	18%	13%	24%
BDH - Selling BDE	21%	16%	27%
Halogenation - PBR	26%	21%	33%
Halogenation - Selling BDE	31%	25%	38%
Halogenation - Selling Isobutylene	25%	20%	30%

NGL – Debt Equity Sensitivity

	Base (70/30 Debt/Equity)	100% Equity
Ethylene - HDPE	24%	16%
PDH - PP	17%	12%
Halogenation - PP	27%	18%
Halogenation - Selling Propylene	23%	15%
BDH - PBR	18%	12%
BDH - Selling BDE	21%	13%
Halogenation - PBR	26%	16%
Halogenation - Selling BDE	31%	18%
Halogenation - Selling Isobutylene	25%	15%

Sensitivity Analysis – Recommended Products

- The sensitivity analysis for those products (and product routes) recommended for further analysis all retain acceptable IRR (based on 15% as the acceptable floor value) for both high and low scenarios except the following:
 - Polypropylene from propylene via PDH
- The propylene (via PDH)/PP economics at 10% higher capex results in an IRR of 13%. Though the capital costs of both PDH and PP technologies are well known, a 10% higher capital cost is certainly possible given industry conditions that might be in place at the time of investment, design and construction.
- The analysis of IRR at 100% equity shows that propylene via PDH, butadiene via BDH, and the downstream PBR all have IRRs less than 15%

Conclusions

- ✓ Feasible opportunities for the development of NGL-based chemical derivatives exist
- ✓ There should not be any particular environmental or permitting issues for the process technologies selected if good engineering design and HAZOP principles are followed. Note that the Halogenation technology will need to be designed with specific attention to bromine handling and processing.
- ✓ Growth in the United States demand and competitive cost exports will drive significant production capacity (supply) additions of commodity chemicals and polymers
- ✓ Ethane in the U.S. will remain in an oversupply situation due to the associated supply from shale-based oil and gas that will drive North Dakota post-2020 net back prices to historic low values

Conclusions (continued)

- ✓ North Dakota is expected to have an ample supply of NGLs (ethane, propane and butane); especially for ethane as it can be sourced for the “rejected ethane” content in the methane/ethane pipeline (sales) gas
- ✓ North Dakota will have a long-term “Advantaged feedstock” position of NGLs the U.S. Gulf Coast and Asia/Europe
- ✓ North Dakota has an “Advantaged geographic” location relative the U.S. Gulf Coast for supplying commodity polymers and end-users e.g., for the fabrication of automotive and consumer-related parts and components
- ✓ Commodity chemical intermediates (propylene, butadiene, n-butanol and isobutylene) can be easily transported (railed) to the U.S. Gulf Coast at a price to give North Dakota a good level of profitability

Conclusions (continued)

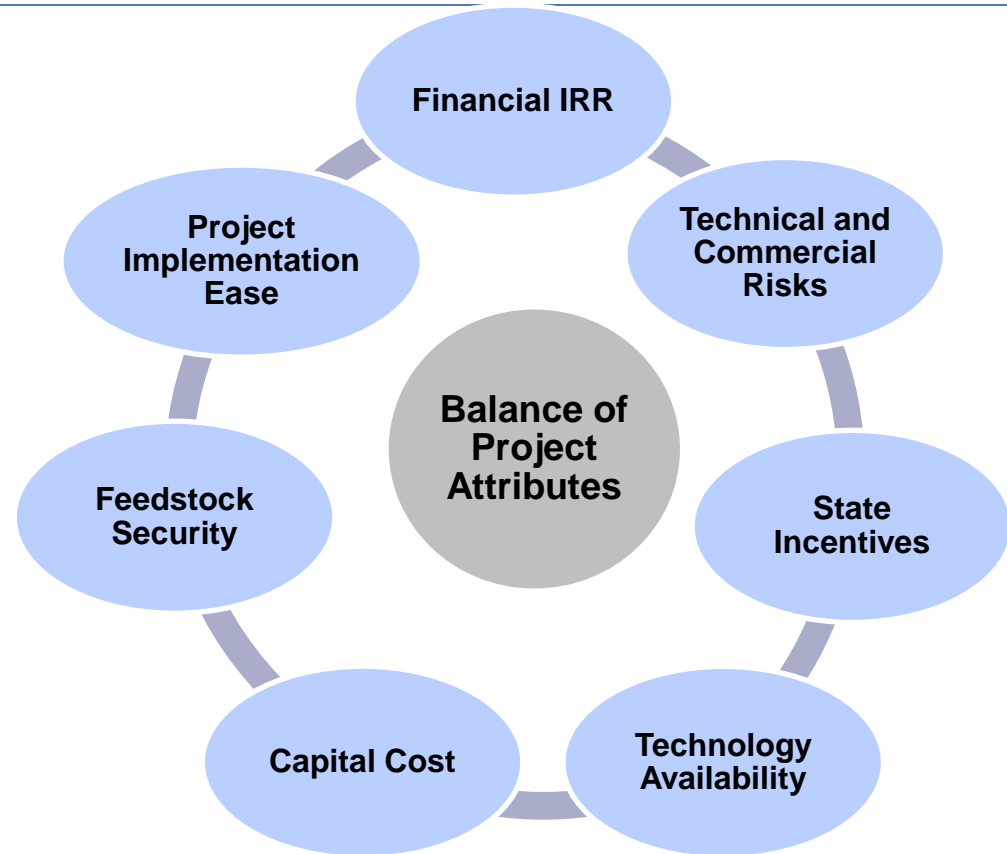
- ? Project development and implementation will have challenges that must be defined and managed carefully
- ? Investment (cost and resources) to construct the world-scale downstream chemical production plants and build their associated business, are very significant
- ? North Dakota has essentially no commodity chemical business and technical infrastructure (except ammonia and fertilizers); thus market entry into “new” commodity chemicals and polymers will have challenges on many levels, including availability of skilled and professional labor
- ? Project and business development “success” can yield a variety of sustainable benefits to North Dakota State (residents) and 3rd party sponsors and developers
- ∞ The various technologies are not an unusually high water resource requirement. For example, the Ethylene/HDPE plant operation will require around 6 million gallons per day total; which can be reduced by prudent plant design, e.g., use airfin heat exchangers.

Conclusions (continued)

- ∞ Project and business development “success” can yield a variety of sustainable benefits to North Dakota State (residents) and 3rd party sponsors and developers
- ✓ To be successful, North Dakota must aggressively solicit world-class private (chemical) industry participants/sponsors on a global basis who can bring proven project development expertise, financial strength, chemical process technology and access to customer marketing channels and customers
- ✓ Participants can be along the value chain e.g., from NGL processors considering value-add downstream investment to end-user part fabricators interested back integration to low cost secure feedstock supply
- ✓ Monitoring competitor actions in the U.S. and Western Canada is necessary as the rapid pace of shale-based project (global) interest and development continues
- ❖ **This Project will be forging new ground in North Dakota, thus project development and implementation must be done according to a well-defined and very robust roadmap, with an iterative loop for lessons learned along the way.**

Recommendations – Align balanced value proposition(s) with stakeholder/investor(s) strategic goals

- Start “small” by developing a full business case for a medium return, low risk (mature) technology and single product line to test the market (and financial) interest
- Identify/define the “appetite envelope” and concerns “road bumps” of the various North Dakota stakeholders and sponsors
- In parallel but slightly sequential to a first (conservative) option, develop a range of investor solicitation packages along feedstock lines (ethane, propane and butane) with technology and value chain complexity scenarios



Immediately solicit a broad candidate list for participation across all the scenarios

Study Next Steps

- Deliverables

- Report to Legislative Management – Energy Development and Transmission Committee - due July 2014; IHS will present its May 2014 Final Report in a face-to-face meeting or teleconference
- Report to appropriate committees at the beginning of the 2015 Legislative Assembly – due January 2015

Post-Study Next Steps

- Recommended Follow-up Work
 - Discussion and recommendation for state initiatives that might impact investment and effect on cash flow returns
 - Investigation of potential investors
 - Effect of investment on the state
 - number of jobs created
 - Businesses created to support the plant(s); downstream value chain
 - Supporting, not directly related, social infrastructure business creation (e.g., housing construction, restaurants, entertainment, etc.)



NGL Industry Overview

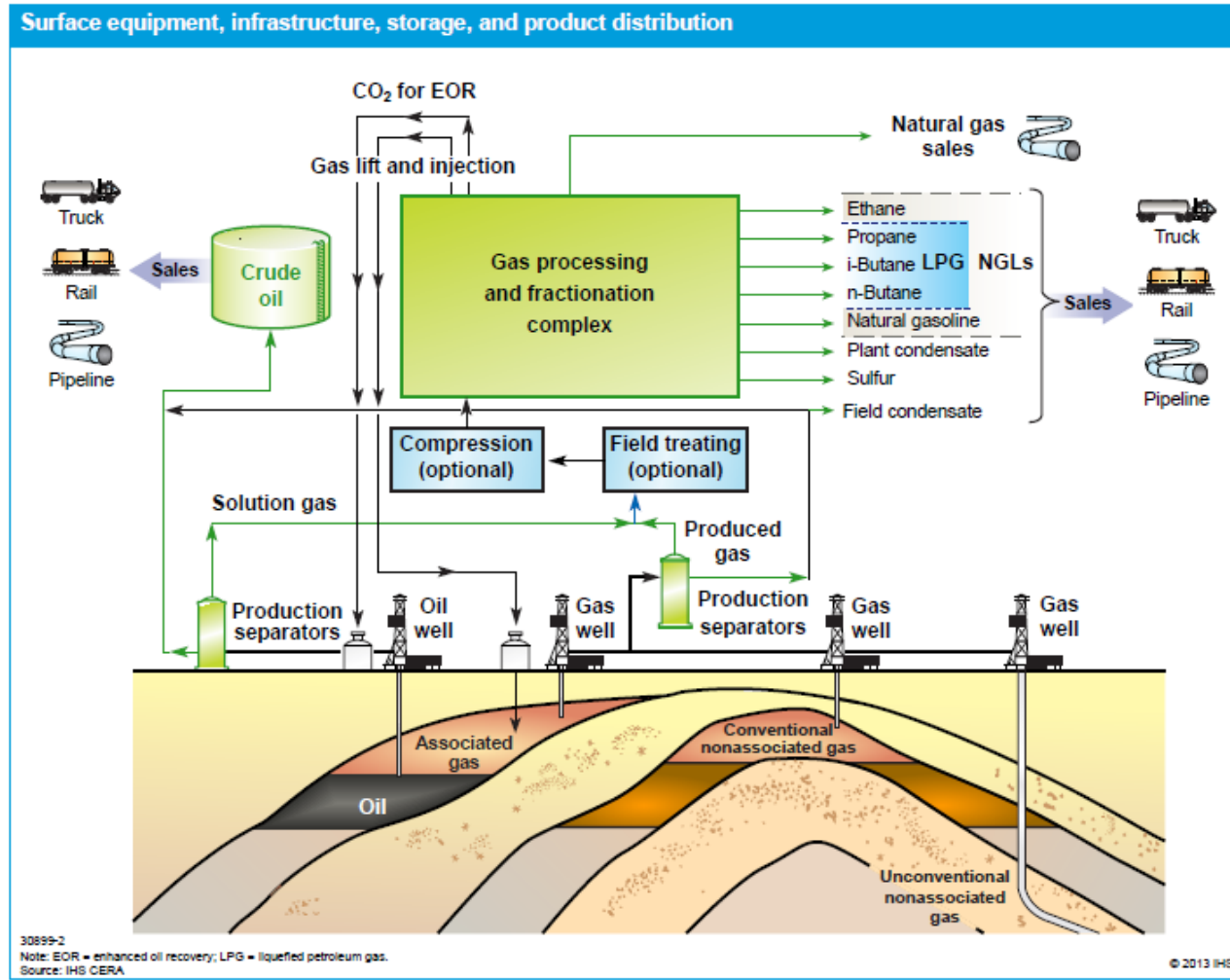
- ❖ *US NGL Industry*
- ❖ *North Dakota NGL Industry*

US NGL Industry

Hydrocarbon Fracking has Led to Significant Opportunities

- Hydraulic fracturing or “fracking,” is the gas production process for extracting natural gas from shale rock layers more than a mile deep in the earth. Fracking makes it possible to extract natural gas from shale formations (“plays”) that were once extremely difficult to reach with conventional technologies.
- Advances in drilling technology have led to new man-made hydraulic fractures in shale plays that were once not available for exploration. In fact, three-dimensional imaging helps scientists determine the precise locations for drilling.
- Horizontal drilling (along with traditional vertical drilling) allows for the injection of highly pressurized fracking fluids into the shale area. This creates new channels within the rock from which natural gas is extracted at higher than traditional rates. This process can take up to a month, as drilling delves more than a mile into the Earth’s surface, after which, the well is cased with cement to ensure groundwater protection, and the shale is hydraulically fractured with water and other fracking fluids.
- Groundwater protection remains the critical goal necessary to the success of well operation. The well design, casing, and the inherent risk associated with the hydraulic fracturing process itself all factor into new shale gas well development.
- As the technology has been used successfully in over one million wells, state regulators working with operators have reduced many environmental risks.

Shale Gas Requires Processing Before it is Distributed in Pipelines



Shale Gas Requires Processing Before it is Distributed in Pipelines

- Natural gas liquids (NGLs) are light hydrocarbons that are gaseous at reservoir temperature and pressure but are recovered as liquids from natural gas in later processing. NGL components are ethane, propane, normal butane, isobutane and natural gasoline (C5+)
- Raw natural gas is treated and the NGL extracted in order to produce a saleable gas that meets pipeline dew point specifications as well as to recover valuable NGLs for use in downstream chemical processing
- The natural gas industry has several major (and very mature) steps: production and gathering; treating also known as conditioning; processing (gas/liquid separation e.g., extraction of the liquids) and fractionation); long distance transportation, and storage and/or distribution.
- Treating and processing plants are generally located near the gas production area (field plants).
- The fractionation plant may be at the same site as the processing plant or it may be remote. Fractionators may process liquids gathered from several gas processing plants.

Three Major Steps are Involved: Gas Conditioning, Processing and Liquid Fractionation

- Gas conditioning or relates to treating and drying of natural gas to reduce the water and acid that are present in gases. The removal of acidic gases, also called sweetening, becomes essential if the hydrogen sulfide content exceeds values specified in pipeline contracts. Removal of carbon dioxide, however, is essential only if it is present in massive concentrations, as it reduces the calorific value of the gas below sales specifications.
- Removal of both hydrogen sulfide and carbon dioxide must be completed if the natural gas is to be liquefied, since solidified carbon dioxide and hydrogen sulfide, with higher freezing points than those of the other gas components, would create problems during processing
- There are three types of commercial gas conditioning:
 - Chemical reaction with a solvent such as an aqueous solution of ethanolamine or potassium carbonate solutions
 - Physical absorption
 - Fixed-bed absorption.
- After conditioning, the gas is ready for processing to isolate the condensable natural gas liquids. Gas processing extracts heavier hydrocarbon components of the gas for economic and safety reasons, as a portion of NGLs must be extracted to avoid unsafe formation of liquids in gas at the burner tip of local gas distribution systems and in transmission pipelines
- The gas processing occurs prior to the gas stream entering the pipeline

Three Major Steps are Involved: Gas Conditioning, Processing and Liquid Fractionation (continued)

- Industry commonly uses one of several process techniques:
 - Cryogenic Systems. The most commonly used method of processing natural gas; cryogenic systems use various techniques to bring operating temperatures down to the -73°C to -101°C range. These systems/processes can recover more than 90% of the contained ethane, but actual long-term recovery rates may be lower. Cryogenic processing has become the preferred technology to obtain increasing amounts of ethane from a decreasing potential supply.
 - Refrigeration. Conventional refrigeration units chill feed gas to -18°C to -40°C . The liquids are separated from residue gas and then are fractionated into separate NGL components: ethane, propane and so forth. Recovery levels vary with the feed gas composition, feed rate and process temperature. Sometimes such units are skid-mounted for movement from one field to the next as gas supplies change.
 - Absorption. The “wet” natural gas is run countercurrent to light oil (kerosene range) in an absorption column. A portion of the natural gas is absorbed in the oil, while the residue gas leaves the column overhead. The NGL components are removed from the absorber oil in a series of fractionation steps.
 - Refrigerated Absorption. By refrigerating the feed gas and absorber oil streams, recovery of natural gas liquids—especially ethane—is greatly increased. This was the most frequently used method for processing natural gas before cryogenic systems became available.
 - Adsorption. Activated carbon, alumina gel or silica gel beds adsorb the natural gas liquids. Heated gas is used to strip the liquids from the adsorption beds. The liquids are then separated by distillation. This process is used primarily when recovery of natural gasoline is emphasized over recovery of lighter liquids; however, current usage is rare in the United States.

Three Major Steps are Involved: Gas Conditioning, Processing and Liquid Fractionation (continued)

- Compression. By increasing the pressure or reducing the temperature of wet natural gas, a liquid phase of the heavier hydrocarbons is formed. The gas phase is separated, recompressed and recycled to the gas-producing formation. The natural gas liquids may be fractionated on-site or shipped as raw NGLs to a central fractionation plant
- Historically lean oil absorption is the oldest but least efficient of the processing techniques
- Today, cryogenic systems are the most technologically advanced and provide the highest level of NGL recovery with an estimate that more than half of the plants in the United States are cryogenic. One-third of these use refrigeration technology to recover NGLs.
- Liquid recovery in lean oil plants is nearly 99% of the butane and natural gas, 65-75% of propane, and 15-25% of ethane. Recovery in refrigeration is 100% of butane and natural gas, 98% of propane, and 50% of ethane. For the new cryogenic systems, full recovery of propane and heavier NGLs is achieved and greater than 90% or more of ethane is recovered.

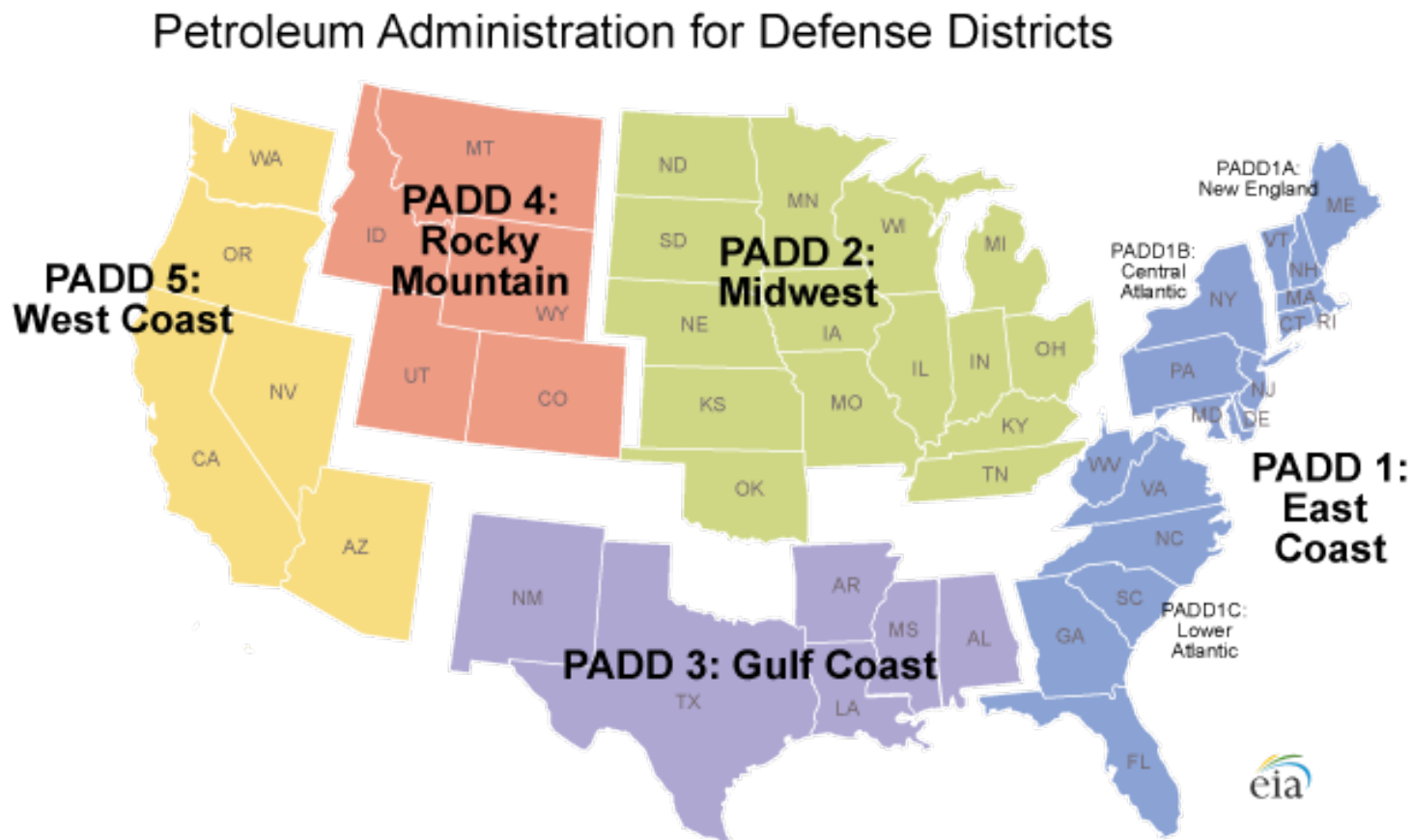
Three Major Steps are Involved: Gas Conditioning, Processing and Liquid Fractionation (continued)

- Liquid fractionation involves the separation of components of the separated NGLs by the relative volatility of the individual gases/liquids
- Fractionation trains used to separate propane, butane and natural gasoline have operating pressures ranging from 100 psia to 425 psia and temperatures from 35C to 121C. The feed composition along with the degree of separation determine the number and type of the fractionators and optimum operating conditions.
- Fractionation of NGLs to produce purity products like ethane and propane most often occurs at a location other than the gas processing facility. This is because NGL production from a number of gas processing operations is aggregated into a raw NGL mix.
- In the US, raw mix is then transported to large NGL storage and fractionation facilities at Conway, Kansas and Mont Belvieu, Texas. In Canada, there are major trading hubs in Edmonton/Fort Saskatchewan, Alberta and Sarnia, Ontario.
- These aggregation points are large underground storage facilities connected to pipeline transmission and distribution systems. The Edmonton market interacts directly with Conway
- because of connecting pipelines, which combine to serve the U.S. Midwest. Sarnia interacts with Mont Belvieu (even without connecting pipelines) to serve the U.S. Northeast.

Typical Gas Processing Contracts

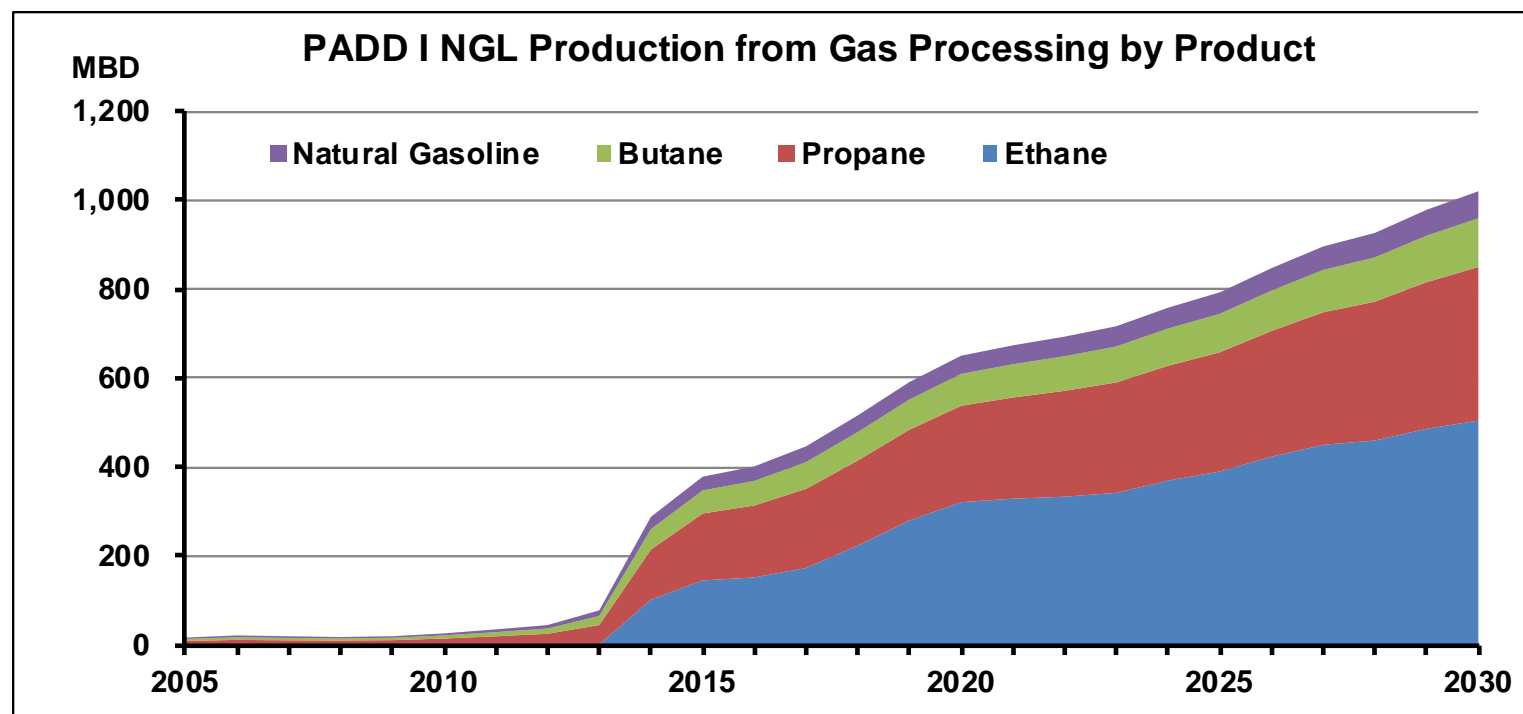
- FEE-BASED: Fees based upon volumes transported from the field to the processing facility; unaffected by gas and NGL prices
- PERCENT-OF-PROCEEDS: processor takes a percentage of composite NGL mix extracted from producer's raw natural gas stream; producer either retains title to, or receives value (Btu content) associated with the remaining percentage of NGL mix.
- KEEPWHOLE: processor processes raw gas and retains recovered NGLs as payment. The other party is *kept whole* by the processor, which returns natural gas of equivalent Btu content purchased in the open market to replace the NGLs extracted during processing. Keepwhole contracts expose the processor to NGL and natural gas price fluctuations.
- *NOTE:* regardless of which type of contract is utilized, somebody (either the gas producer or the processor) is concerned about the margin.

US NGL Production by Gas Processing by PADD



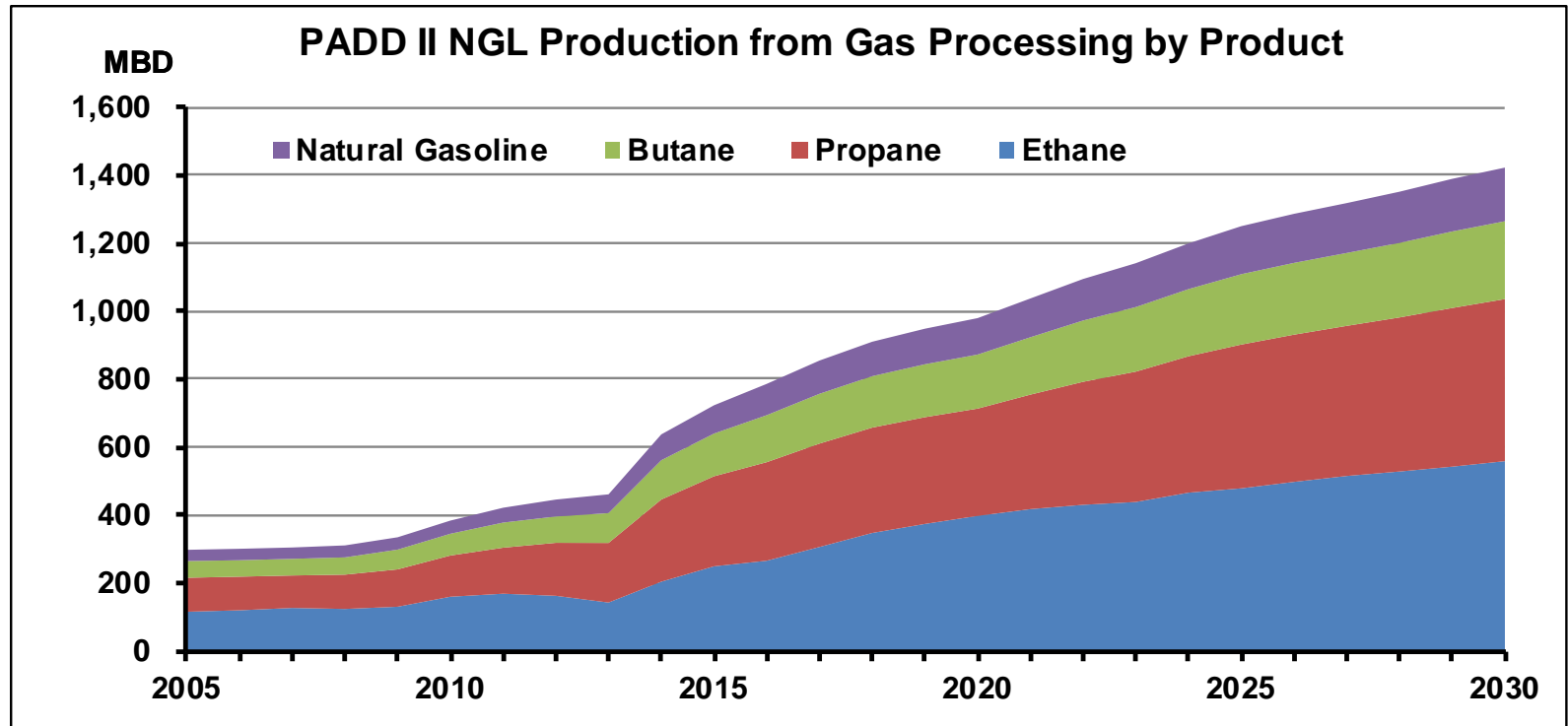
Source: EIA

PADD I: NGL Production by Gas Processing



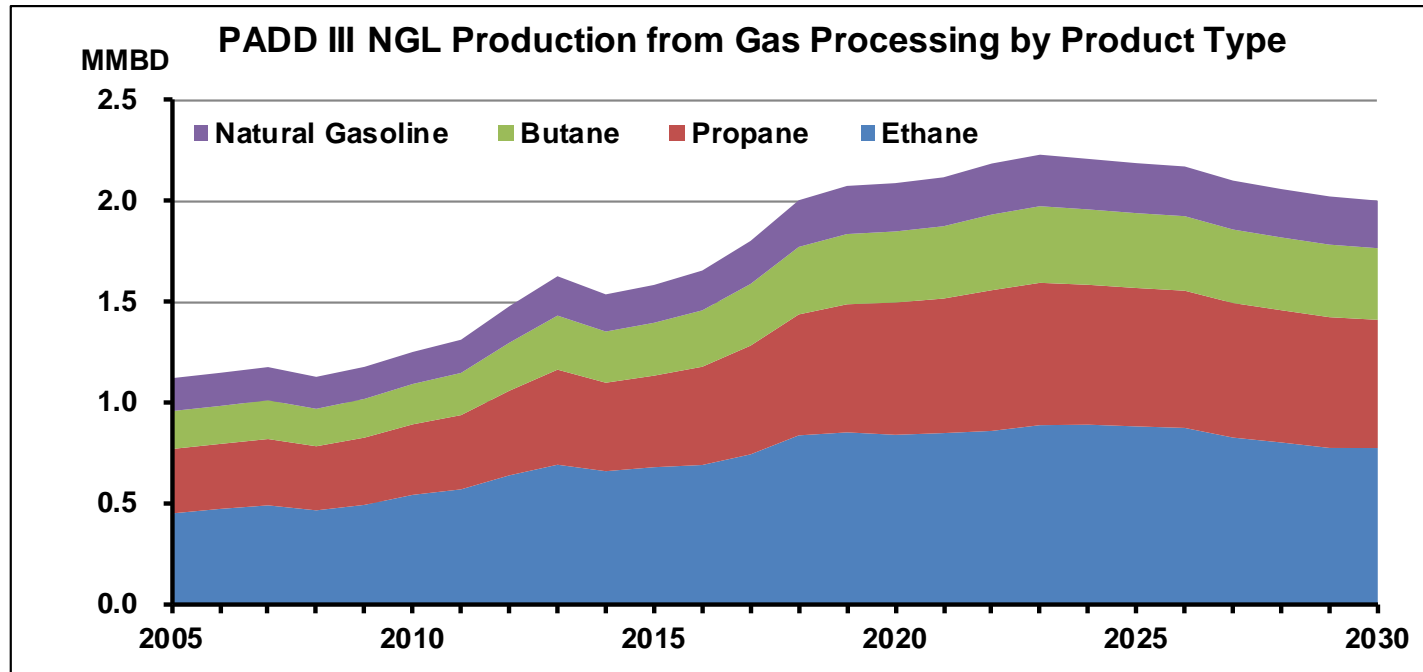
- No new gas processing facilities were added prior to 2013 but capacity more than doubled between 2013 and 2014.
- Expansions have been announced that will bring capacity to nearly 7 bcfd by 2015.
- Nearly all of the new plants are cryogenic units designed to process 200 mmscfd and are modular in design.
- To date enough fractionation capacity is being added to separate the liquids but by 2017 new Y-grade pipelines will be required to move NGL to PADD III.

PADD II: NGL Production by Gas Processing



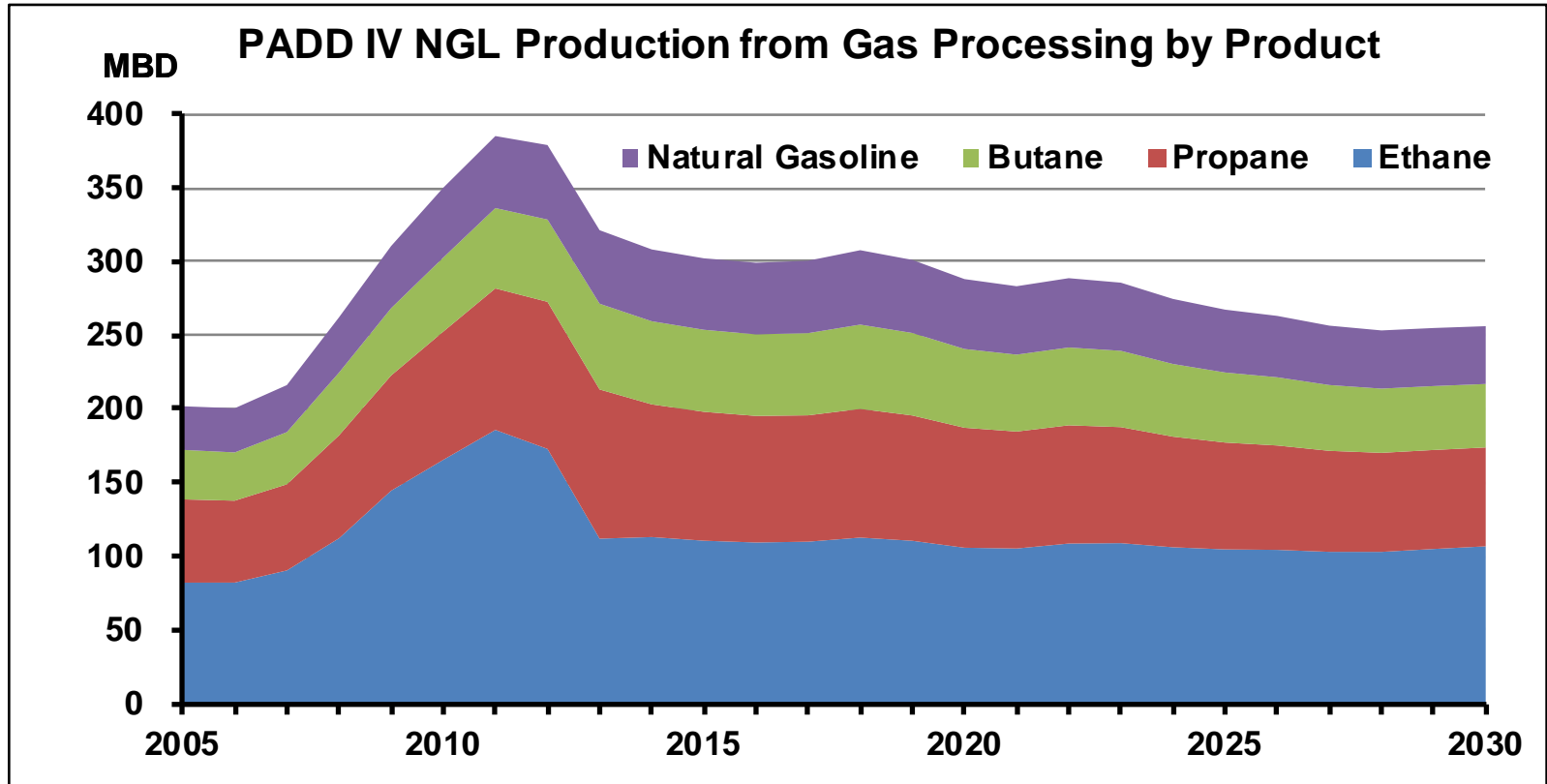
- PADD II growth in NGL production from gas processing is set to accelerate from the rate of growth exhibited between 2009 and 2013.

PADD III: NGL Production from Gas Processing by Product



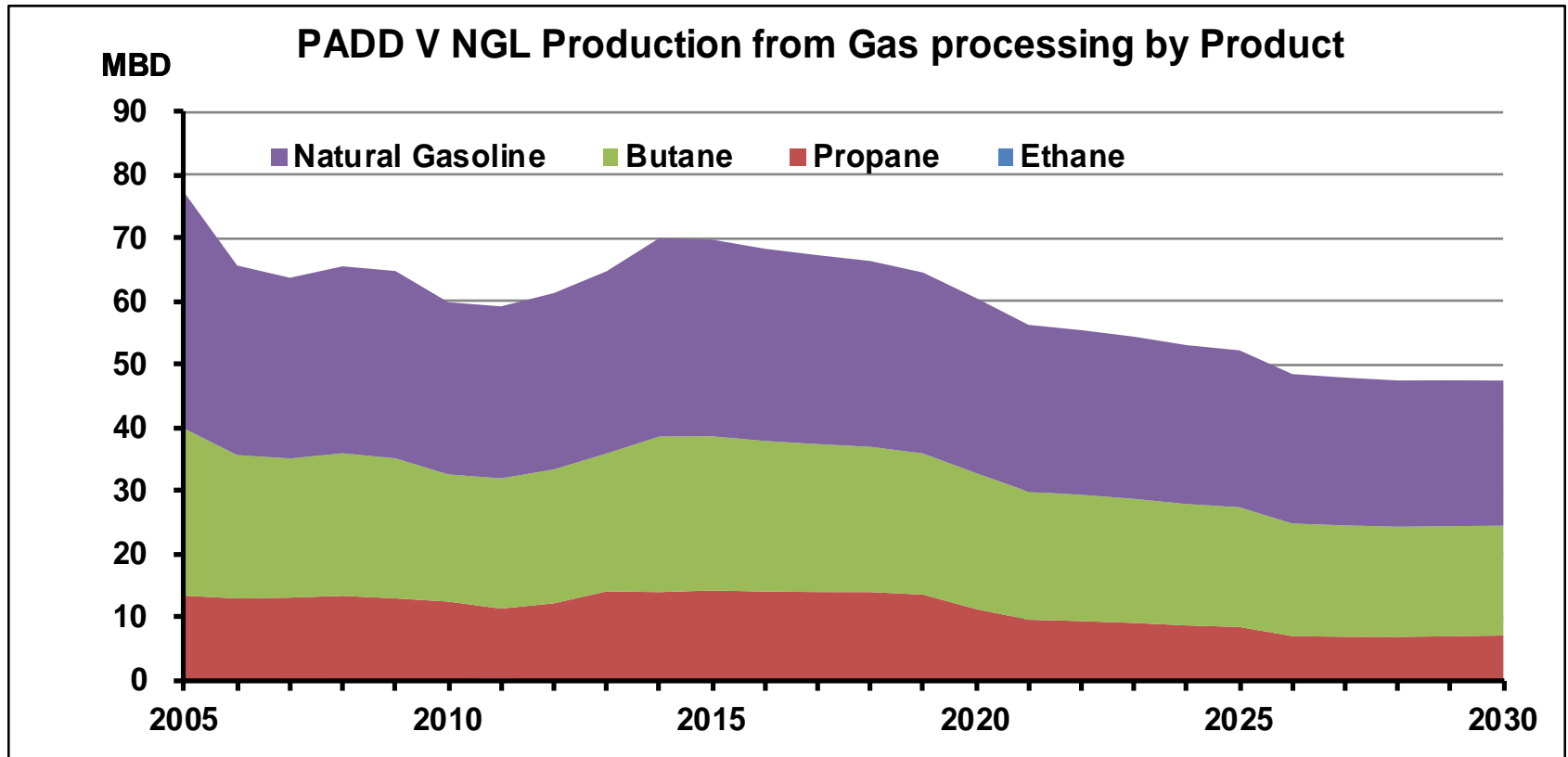
- New gas processing capacity was added in 2013 and more is scheduled for 2014, with only minor expansions announced for 2015.
- Essentially all of the gas processing capacity is planned for Texas with only one plant scheduled for Louisiana.
- New fractionation capacity is being added and more will be needed to handle the expected Y-grade volumes from Ohio, North Dakota, Pennsylvania and West Virginia.

PADD IV: NGL Production from Gas Processing by Product



- The recent drop in ethane production was the result of ethane rejection due to the drop in ethane price, making it uneconomic to ship to Texas.

PADD V: NGL Production from Gas Processing by Product



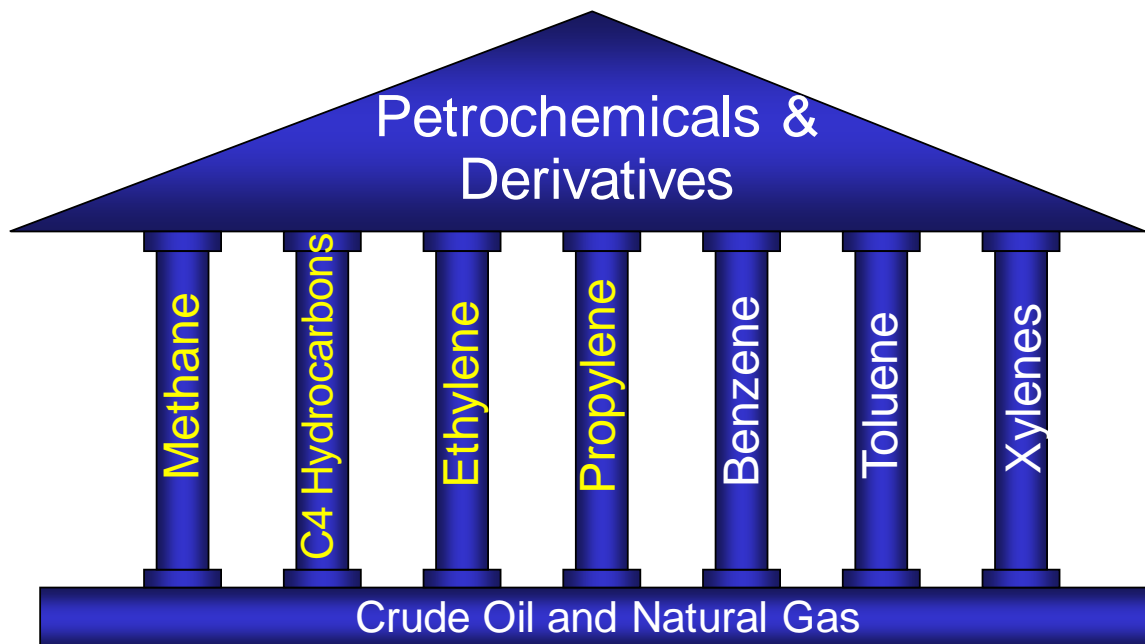
- NGL production will continue to decline along with gas production.
- No new gas processing capacity additions are expected.
- No ethane is recovered in California.

North Dakota NGL Industry

North Dakota is well positioned to be a Advantaged Supplier of Petrochemical Building Block Chemicals

- Ethylene, propylene, butylenes, represent three of the seven basic “building blocks” in the global petrochemical industry.
- NGLs (ethane, propane and butanes) are the raw material precursors to these building block chemicals

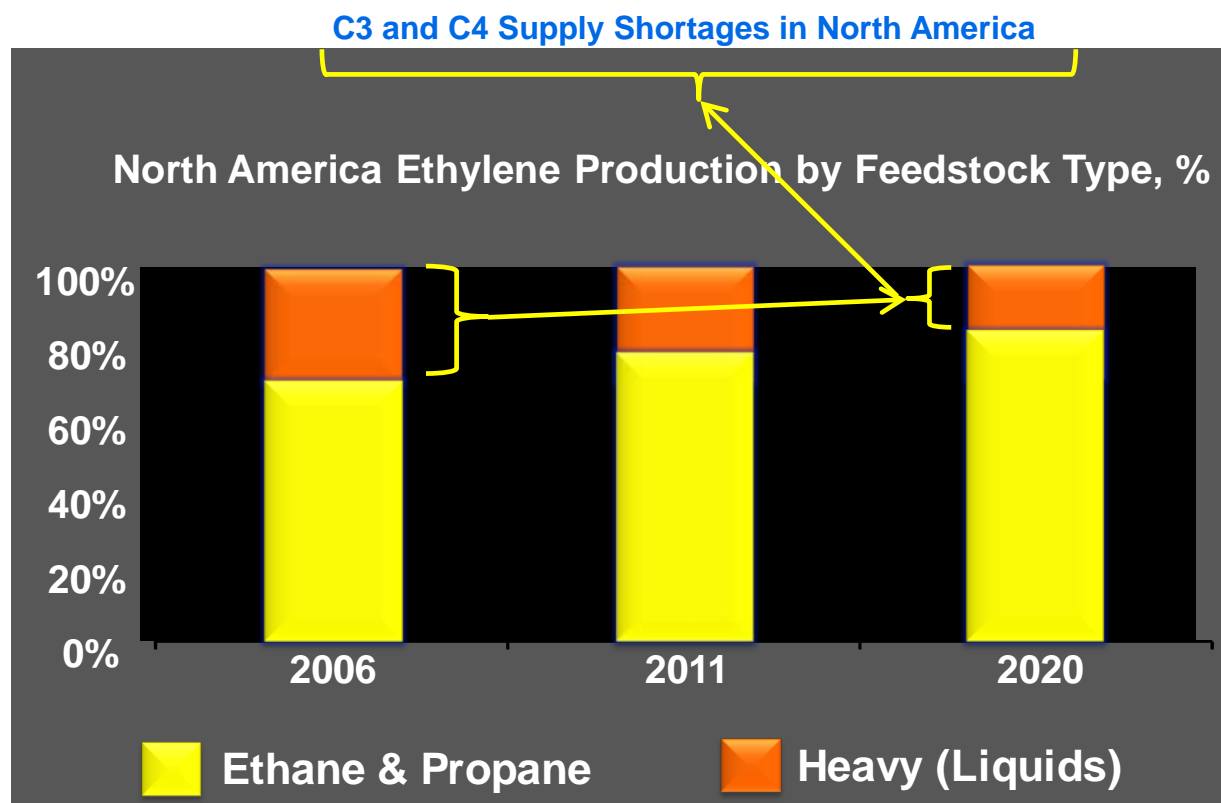
C3 and C4 Supply Shortages in North America



Most petrochemical derivatives can be traced back to one or more of these building blocks

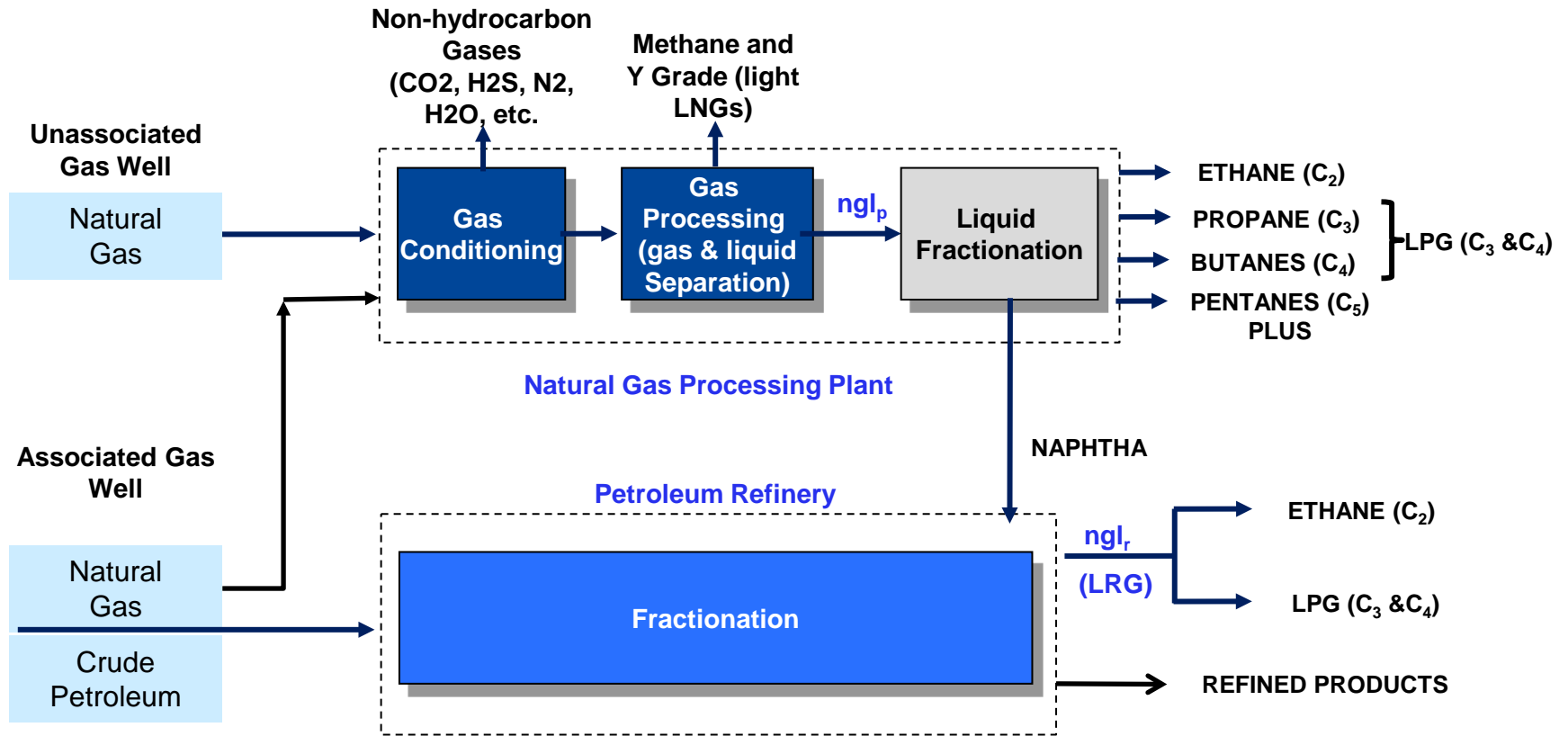
U.S. Chemical Supply Chain Shifts Further Represent an Advantage to North Dakota

- The natural gas oil dynamic shift in North America has set the stage for subsequent investment and development of non-traditional C3 and C4 alkane conversion technologies



All Gas Requires Processing and Separation. Fractionation is Dependent on the LNG Component's Downstream Use

NGL Production from Gas Processors and Petroleum Refineries



LNG = Liquefied Natural Gas

LPG = Liquefied Petroleum Gas

ngr_p = Natural Gas Liquid from Gas Processing Plants

ngr_r = Natural Gas Liquid from Petroleum Refineries (also called Liquefied Refinery Gas

(LRG)

Extraction and Fractionation Capacity and Configuration will be Based on the Chemical Complex Demand

- For this study, IHS has assumed that the fractionation plant and intermediate product storage will be at the chemical plant complex which contains all the chemical derivative plants
- IHS also assumes that the gas treatment and sulfur recovery, processing (gas/liquid separation) to some degree has been performed prior to the gas entering the pipeline from which it will undergo further ethane extraction and subsequent fractionation into separate products
- IHS set the capacity of the NGL processing (extraction) and fractionation at the relative downstream capacities:
 - Ethane 521 KTA (27781 BPD)
 - Propane: 563 KTA (21166 BPD); for PDH technology
 - n-Butane: 512 KTA (16769 BPD); for BDH technology
 - iso-Butane: 153 KTA (4852 BPD); for BDH technology
- IHS has estimated the capital costs for two cases:
 - Case 1: a single train extraction unit followed by a matched capacity single train fractionation unit
 - Case 2: two, parallel, equal sized (50% capacity) extraction and fractionation unit

Extraction and Fractionation Capacity and Configuration will be Based on the Chemical Complex Demand (continued)

- IHS has also included NGL product (ethane, propane, n-butane and iso-butane) storage for two days each to account for NGL extraction and fractionation plant disruption, stoppage or maintenance down time so as not to effect the chemical plant production

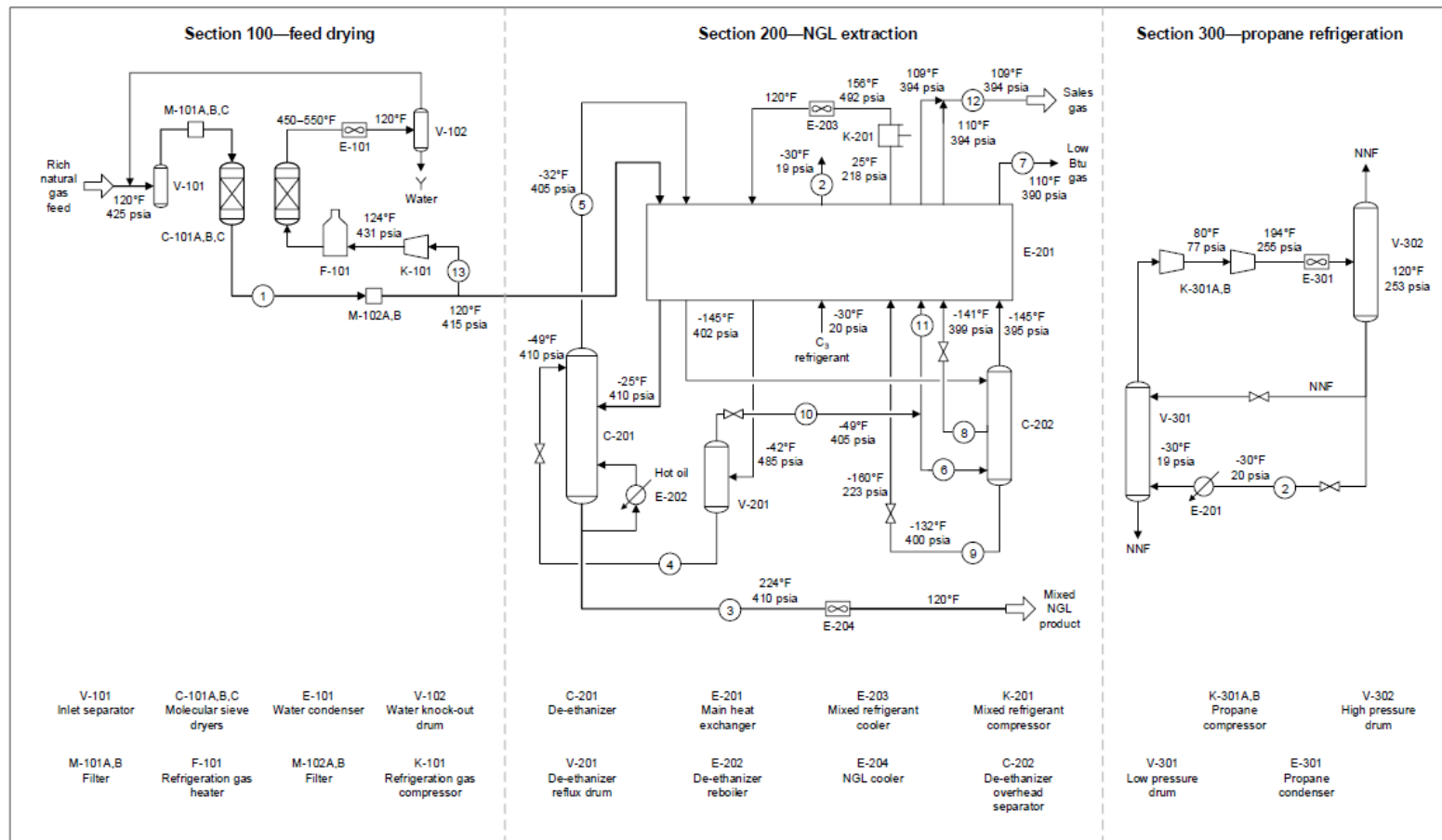
	Case 1 (single train), MM\$	Case 2 (2 trains), MM\$
Gas Processing (Extraction)	195	210
Fractionation	95	115
Storage	50	50
Total	240	375

Note: Capital costs include a North Dakota location factor relative to USGC

- The capital costs estimated above assume gas processing for both ethane separation and NGL separation into components (the installation of ethane (ethylene/HDPE), propane (propylene/PP), and butane (butadiene, isobutylene) plants)
- The cost to separate the various gas components is included in the transfer prices (“market prices”) of the components

Extraction and Fractionation Capacity and Configuration will be Based on the Chemical Complex Demand (continued)

- A typical process diagram for NGL extraction is shown below:



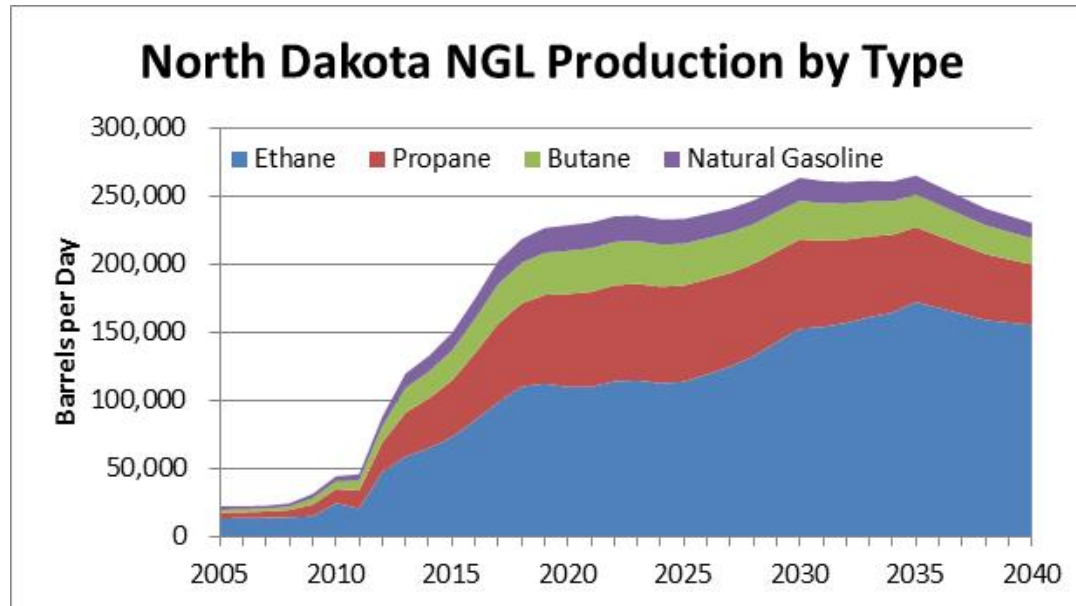
Extraction and Fractionation Capacity and Configuration will be Based on the Chemical Complex Demand (continued)

- The dried feed gas (stream 1) is cooled and partially condensed in the main heat exchanger. The cooled feed gas is then distilled in the de-ethanizer. The NGL product (3) is the portion of the de-ethanizer bottoms stream that is not reboiled.
- The cooled C2- overhead gas (5) flows to the de-ethanizer separator column. Nitrogen is stripped in the separator column by a portion of the reflux drum overhead stream.
- The liquid from the reflux drum is the reflux for the de-ethanizer column (C-201). The vapor from the reflux drum (10) is split to provide the stripping gas (6) for the de-ethanizer overhead separator (C-202).
- The balance of the gas is combined with the de-ethanizer side product (8) to form the sales gas product (12).
- The ethane component is contained in the Sales Gas stream (stream 12) with the methane content

Extraction and Fractionation Capacity and Configuration will be Based on the Chemical Complex Demand (continued)

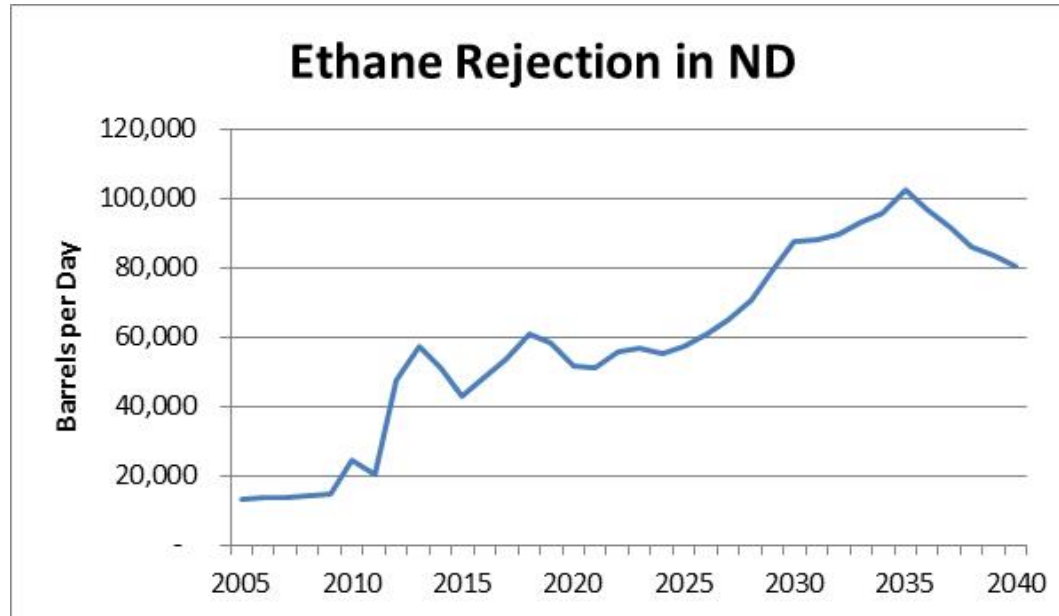
- For an ethane only scenario (only an ethane derivative plant is built), IHS believes that the “rejected ethane” can be sources from the methane/ethane gas stream with the addition of a de-ethanizer at an existing gas process plant(s). With consumption of about 28 thousand barrels per day, a single gas processing facility source may be achievable
- The ethane would subsequently stored for 5- 7 days as an inventory to the ethylene plant
- While the cost of recovery of the “rejected” ethane varies depends on the specific commercial situation, IHS has allowed for a typical processing cost in the market price of ethane to the ethylene plant e.g., \$45 per metric ton (6.2 cents per gallon) of ethane

North Dakota NGL Production from Gas Processing will be Ample to Supply the Proposed Chemical Chains



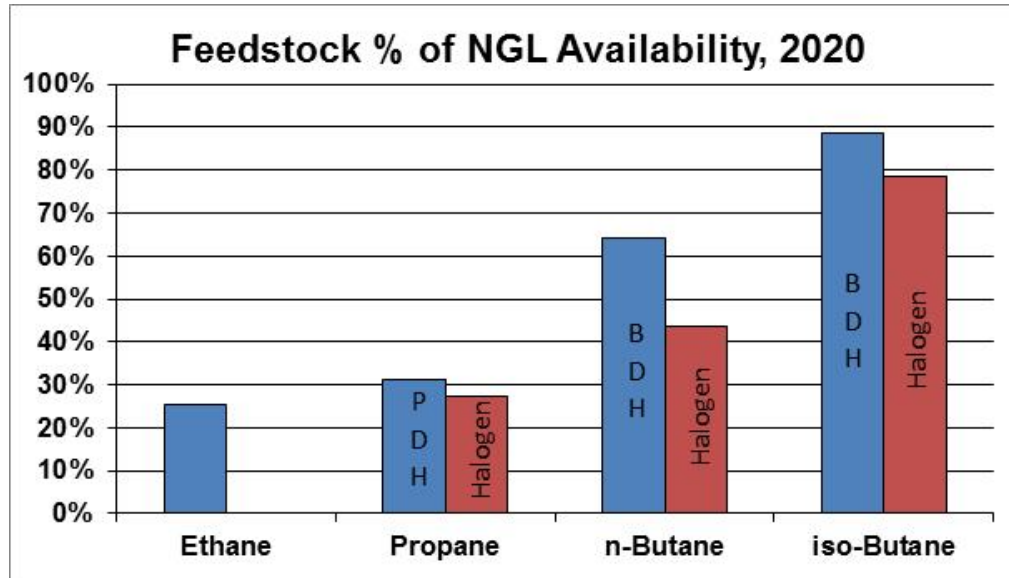
- Gas processing capacity will essentially double over the 2012 to 2016 period raising gas processing capacity to 1.6 bcf/d.
- Only modest increases in gas production are forecast as the rate of expansion of crude oil production slows.
- Nearly 30% of the gas produced in North Dakota is flared so if regulations are changed to reduce gas flaring, the potential for gas processing could be higher.
- Currently, much of the produced Y-grade will move to PADDs II and III to be fractionated.

The NGL Gas Forecast Includes a Large Amount of “Rejected” Ethane



- If there is no local market for ethane part of the ethane is recovered and part is left in the gas
- If needed for local consumption it can be recovered
- The transportation costs to the USGC market is high so as much of the ethane as possible is left in the gas up to the BTU spec on the gas pipelines

North Dakota NGL Production from Gas Processing will be Ample to Supply the Proposed Chemical Chains



- There is sufficient NGL component gas for each proposed plant

North Dakota: Gas Processing Requirements

North Dakota Gas Processing Capacity	Existing	Announced		Forecast						
	2013	2014	2015	2016	2017	2018	2019	2020	2021-25	2026-30
Gas Processed (BCFD)	0.75	0.82	0.91	1.05	1.20	1.24	1.29	1.32	1.27	1.18
NGL Production (MBD)	62	81	106	126	149	157	168	176	175	175
Incremental NGL Production (MBD)	19	25	20	22	9	11	8	(1)	(0)	-
Gas Processing Capacity at Start of Year (BCFD) *	1.00	1.21	1.41	1.61	1.61	1.61	1.61	1.61	1.61	1.61
Gas Processing Capacity Added (MMSCFD) **	205	200	200	-	-	-	-	-	-	-
Number of New Plants Added	1	1	1	-	-	-	-	-	-	-
Plant Capacity Utilization %	75%	68%	65%	65%	75%	77%	80%	82%	79%	73%
Plant Size (MMSCFD) ***	200	200	200	200	200	200	200	200	200	200

Notes: * For 2021-25 = start of 2025; for 2026-30 = start of 2030

** Capacity added during the year available at the start of the next year

*** 2013-2030 = Average size of new capacity

North Dakota Gas Processing Capacity

Plant Name	Owner Company	Status	County	Estimated Plant Capacity (MMcfd)
Tioga	Hess Corporation	Expansion	Williams	250
Badlands	Hiland Partners, LP	Operational	Bowman	40
Norse/McGregor	Hiland Partners, LP	Operational	Divide	25
Watford City	Hiland Partners, LP	Operational	McKenzie	100
South Heart	New Frontier Midstream	New Build	Stark	40
Garden Creek	ONEOK Partners	Operational	McKenzie	100
Garden Creek II	ONEOK Partners	New Build	McKenzie	100
Garden Creek III	ONEOK Partners	New Build	McKenzie	200
Lignite	ONEOK Partners	Operational	Burke	12
Marmrath	ONEOK Partners	Operational	Slope	9
Mckenzie Grasslands	ONEOK Partners	Operational	McKenzie	95
Stateline I	ONEOK Partners	Operational	Williams	100
Stateline II	ONEOK Partners	Operational	Williams	100
Little Knife	Petro-Hunt Corporation	Operational	Billings	22
Ross	Plains Gas Solutions	New Build	Mountrail	75
Ambrose	Sterling Energy Company	Operational	Divide	1
Little Missouri	Targa Badlands	Operational	McKenzie	30
Red Wing Creek	True Oil Co.	Operational	McKenzie	5
Belfield	Whiting Oil & Gas Corporation	Operational	Stark	35
Ray	Whiting Oil & Gas Corporation	Operational	Williams	10
Robinson Lake	Whiting Oil & Gas Corporation	Operational	Mountrail	60
Nesson	XTO Energy Inc.	Operational	Williams	9
			Total	1,418

North Dakota Fractionator Capacity

Plant Name	Owner Company	Status	County	Estimated Plant Capacity (MMcfd)
McKenzie/Grasslands Plant	Bear Paw Energy (ONEOK-owned)	Current	Natrona	15
Badlands	Hiland Partners, LP	Current	Washakie	4
Robinson Lake	Whiting Oil & Gas Corporation	Current	Richland	6
			Total	25

- Fractionator capacity in North Dakota is limited and not much additional fractionator capacity is anticipated unless a petrochemical industry develops in North Dakota to use NGL as feedstock.
- A 60,000 bpd de-ethanizer was added at Hess' Tioga gas processing plant to recover ethane to be shipped by the Vantage Pipeline to Alberta.

NGL Pipelines Out of North Dakota

- The Bakken NGL pipeline (owned by Oneok) can ship 60,000 bpd of unfractionated NGL out of state.
- The Bakken NGL pipeline connects to the Overland Pass NGL pipeline and is being expanded by 60,000 bpd to 255,000 bpd to accommodate the Bakken raw NGL.
- The only pipeline out of North Dakota which ships specification LPG product is the Vantage Pipeline which ships ethane. The initial rate will be 40,000 bpd but will increase to 60,000 bpd by year-end 2014.
- The Prairie Rose pipeline ships dense phase gas to the Alliance pipeline after the heavy fractions are stripped out at the Stanley gas processing plant.
- The Tioga Lateral also ships dense phase gas to Alberta after the stream has been de-ethanized at Tioga.

Gas Processing in Kansas

Plant Name	Owner Company	Status	County	Estimated Plant Capacity (MMcfd)
National Helium	DCP Midstream	Current	Seward	800
National Helium	DCP Midstream, LP	Expansion	Seward	600
Jayhawk	Linn Energy	Current	Grant	450
Kingman	Lumen Midstream	Current	Kingman	26
[Not Yet Named]	Next Generation Processing	New Build	Reno	0
Bushton	ONEOK Partners	Current	Ellsworth	0
Cheney	ONEOK Partners	Current	Kingman	100
Scott City	ONEOK Partners	Operational	Scott	200
Spivey	Pioneer Exploration LLC	Current	Harper	22
Satanta	Pioneer Natural Res. USA, Inc.	Current	Grant	220
			Total	2,418

- Some of the liquids from the Oneok pipeline system are fractionated at Bushton Kansas and specification products serve markets in the upper Midwest.
- The upper Midwest (including North Dakota) also receive LPG, primarily propane, from Canada via Cochin pipeline or by rail.
- The Cochin pipeline is scheduled to be taken out of service in March 2014 to convert to a condensate/diluent line to Canada.

Kansas Fractionators

Plant Name	Owner Company	Status	County	Estimated Plant Capacity (MMcfd)
Bushton(Exp-2008)	ONEOK Inc.	Current	Kern	210
Hutchinson Fractionator	ONEOK Inc.	Current	Reno	49
Conway Fractionation Facility	Williams Partners	Current	McPherson	107
			Total	366

These fractionators are used to process NGL originating in the Rocky Mountains and in North Dakota as well as locally produced NGL.

North Dakota Natural Gas and Natural Gas Liquids Availability

- The production of natural gas and gas liquids (NGLs) associated with oil production will continue to grow over the next tens years and then remain a significant part of North Dakota's hydrocarbon economy.
- Flared gas and NGLs, while currently significant, will likely decrease dramatically based on economic, state policy and environmental drivers. As such, gas processing capacity is growing significantly and is expected to exceed gas production volumes over the next ten years; 87% of North Dakota's gas processing capacity is owned and controlled by 4 companies – ONEOK Partners, Hess Corporation, Whiting Oil & Gas Corporation, and Hiland Partners L.P.
- Current and forecast production volumes for ethane, propane, n- and iso-butane are at world scale levels. However, the availability for a downstream chemical industry will be solely dependent on competitive market forces and current contracts commitments... pipeline values and long-term contracts in place e.g., the Vantage Pipeline with have a 10-year contract of ethane to Alberta.

North Dakota Natural Gas and Natural Gas Liquids Availability

- Nevertheless, demonstrating a value proposition to the gas processors should allow for the availability of ethane, propane, n- and iso- butane for North Dakota chemical production. Polyethylene and polypropylene, will continue to have strong growth and offer North Dakota a logistical advantage to regional markets. Butadiene will be a high value chemical due to short supply dynamics.
- These findings support the objectives of this Study. To identify and profile the “on-purpose” C2, C3, C4 markets and technologies



Products Analysis

- ❖ *Butadiene*
- ❖ *Monoethylene Glycol*
- ❖ *MTBE*
- ❖ *Polyethylene by Resin Type*
- ❖ *Polypropylene*

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Due to IHS Confidential Content













Domestic Customer Analysis











- ❖ *Target Industries*
- ❖ *Rust Belt/East North Central US Product Destination*
- ❖ *Derivatives*
- ❖ *2014 State Product Revenue*

Target Industries

Product Landscape End-Use Applications

END USE										
	Automotive	Computers/Electronics	Construction	Textiles	Packaging/Consumables	Industrial/Intermediate	Housing	Agricultural	Coatings	Appliances
ABS Resin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>			<input type="checkbox"/>	<input type="checkbox"/>
Adipic Acid				<input type="checkbox"/>		<input type="checkbox"/>			<input type="checkbox"/>	
Acetate Esters					<input type="checkbox"/>				<input type="checkbox"/>	
Alpha Olefins					<input type="checkbox"/>					
Ammonium Nitrate			<input type="checkbox"/>					<input type="checkbox"/>		
Ammonium Sulfate								<input type="checkbox"/>		
Benzene						<input type="checkbox"/>				
Butadiene						<input checked="" type="checkbox"/>				
Butanediol	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>				
Calcium Chloride			<input type="checkbox"/>			<input type="checkbox"/>				
Caprolactam				<input type="checkbox"/>		<input type="checkbox"/>				
DME	<input type="checkbox"/>									
Epoxy Resins		<input type="checkbox"/>	<input type="checkbox"/>						<input type="checkbox"/>	<input type="checkbox"/>
Ethanolamines						<input type="checkbox"/>				
Ethoxylates/Surfactants						<input type="checkbox"/>				
Ethylene						<input checked="" type="checkbox"/>				
Ethylene Glycol	<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>					
EVA Resins				<input type="checkbox"/>	<input type="checkbox"/>					
Glycol Ethers						<input type="checkbox"/>			<input type="checkbox"/>	
Isobutylene						<input checked="" type="checkbox"/>				
Linear Alkylbenzene					<input type="checkbox"/>					
Maleic Anhydride						<input type="checkbox"/>	<input type="checkbox"/>			
Melamine						<input type="checkbox"/>	<input type="checkbox"/>			
Melamine Formaldehyde						<input type="checkbox"/>	<input type="checkbox"/>			
Methanol	<input type="checkbox"/>					<input type="checkbox"/>				
Methyl Methacrylate						<input type="checkbox"/>			<input type="checkbox"/>	
Methylamines						<input type="checkbox"/>		<input type="checkbox"/>		
Napthalene Sulfonated Poly			<input type="checkbox"/>							
N-Methyl-2-Pyrrolidone		<input type="checkbox"/>				<input type="checkbox"/>				
Nylon 6	<input type="checkbox"/>			<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>			
Nylon 6.6	<input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>

Product Landscape End-Use Applications

END USE	 Automotive	 Computers/Electronics	 Construction	 Textiles	 Packaging/Consumables	 Industrial/Intermediate	 Housing	 Agricultural	 Coatings	 Appliances
Oxo-Alcohols					<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>	
Phenol						<input type="checkbox"/>				
Phenol Formaldehyde			<input type="checkbox"/>							
Phthalates						<input type="checkbox"/>			<input type="checkbox"/>	
Phthalic Anhydride						<input type="checkbox"/>				
Polybutadiene Rubber	<input type="checkbox"/>									
Polybutylene Succinate					<input type="checkbox"/>					
Polybutylene Terephthalate	<input type="checkbox"/>	<input type="checkbox"/>								<input type="checkbox"/>
Polycarbonate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>			
Polyethylene			<input type="checkbox"/>		<input type="checkbox"/>			<input type="checkbox"/>		
Polyethylene Glycol										
Polyisobutylene Rubber	<input type="checkbox"/>									
Polymethyl Methacrylate	<input type="checkbox"/>		<input type="checkbox"/>						<input type="checkbox"/>	
Polyols	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>		<input type="checkbox"/>	
Polyoxymethylene	<input type="checkbox"/>	<input type="checkbox"/>								
Polypropylene	<input type="checkbox"/>			<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>			<input type="checkbox"/>
Polytetramethylene Ether Glycol				<input type="checkbox"/>						
Polyvinylpyrrolidone										
Propargyl Alcohol									<input type="checkbox"/>	
Propylene						<input type="checkbox"/>				
Propylene Oxide						<input type="checkbox"/>				
Super Absorbant Polymer					<input type="checkbox"/>					
Soda Ash			<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>				
Sodium Hydroxide					<input type="checkbox"/>	<input type="checkbox"/>				
Sodium Hypochlorite					<input type="checkbox"/>	<input type="checkbox"/>				
Thermoplastic Polyurethanes	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			
Toluene Di-isocyanate	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			
Unsaturated Polyester Resins	<input type="checkbox"/>		<input type="checkbox"/>				<input type="checkbox"/>		<input type="checkbox"/>	
Urea						<input type="checkbox"/>		<input type="checkbox"/>		
Urea Formaldehyde			<input type="checkbox"/>				<input type="checkbox"/>			
Vinyl Acetate Monomer				<input type="checkbox"/>					<input type="checkbox"/>	
Vinyls			<input type="checkbox"/>	<input type="checkbox"/>			<input type="checkbox"/>			

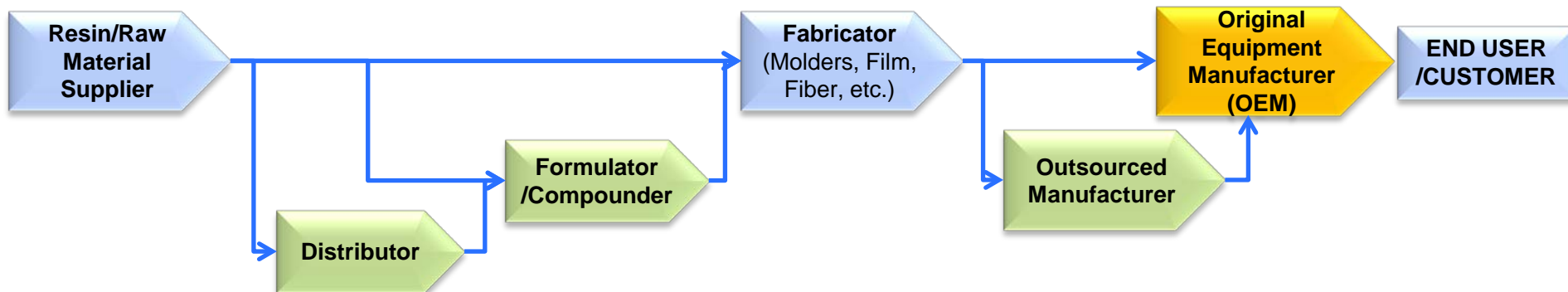
Plastics Value Chain Can Be Complex

Resin Suppliers:

- Work directly with fabricators, OEMs and distributors when OEMs and/or volumes are large. Will also work with large compounders.
- Diligent Marketing/R&D/Application development to understand product roadmaps of OEMs; specifications and new product developments
- Wide selection of materials – custom materials to meet OEM specifications
- Some customer resin tailoring for large buyers

Molders

- Typically independent players; yet often partnered with OEM or contract manufacturers (CM). Deliver product to OEM specifications.
- Develop manufacturing IP
- Try to be close to OEMs and/or end-user seeding
- Very competitive, price sensitive



Distributors:

Typically low volume material flows. Handles small/medium sized resin buyers. Big distributors also export large volumes

- Provide resin packaging requirements
- Aggregate material from multiple resin suppliers
- Add value through JIT delivery, smaller order quantities, multiple resins available

Compounders work to tailor material properties.

Create custom-formulated engineered plastic compounds, plastic concentrates and additives for Flame Retardant Resin, Toughened Resin, Reinforced Resin and Elastomeric Compounds.

- Try to focus on select markets and applications, offer broad range of capabilities
- Add value through service, customized products, and some also have distribution arms

OEMs design products and specify component needs, including writing the material specifications.. Typically have sourcing departments for plastics - understand dynamics of markets

- Often negotiate directly with resin supplier or compounders
- Treat plastics as a commodity - drive costs out of the system
- Might do in-house molding

For Resin Customers, Supplier Consistency and Reliability Are of Highest Importance, Along With Resin Properties

RESIN CUSTOMER NEEDS (COMMODITY POLYMER RESINS) CRITICAL BENEFIT ATTRIBUTE SUMMARY			
Top Box Rank	Need Attribute	Respondent “TOP BOX” Count	Percentage of “TOP BOX” Responses
1	Lot to lot consistency	289	71.7%
2	Supplier is honest and trustworthy	288	71.1%
3	Resin processability	266	68.2%
4	Proactive communication in the event of a potential supply problem	260	66.7%
5	Competitive pricing	240	66.5%
6	Resin quality issues are resolved adequately	241	66.4%
7	Resin quality issues are addressed in a timely manner	242	65.6%
8	Consistent and accurate on-time delivery	265	65.4%
9	Supplier is committed to my business long term	258	65.0%
10	Supplier always meets commitments	254	62.7%
11	Sufficient inventory is maintained to accommodate operational incidents	226	58.9%
12	Accurate invoices	201	58.8%
13	Original order acceptance is error free and quickly processed	216	58.1%
14	Expertise of technical representatives	179	56.8%
15	Value received for the money paid	217	56.1%
16	Flexible in accommodating my needs	210	52.1%
17	Customer service reps respond to my needs in a timely manner	183	51.8%
18	Sales representatives respond in a timely manner	196	50.4%
19	Quality of online ordering and tracking system	111	50.2%
20	Technical representative communicates knowledge of product, properties, and applications	155	50.0%

A New Supplier From ND Will Need to be Perceived as a Reliable Long-term Supplier

U.S. Market Characteristics

- The North American commodity polymer resin market is a very competitive market with numerous large buyers with huge purchasing power leverage. Buyers are very informed about market prices and market developments.
- Given the relative large number of resin suppliers in the Americas, they are very protective of their domestic markets.

What Do Customer Want and Key Requirements To Serve US/North America Markets

- US customers, converters and distributors, need a reliable long-term supplier that makes high quality grades required for their end use applications. Leading producers dedicate individual reactors to specific product families to maintain high quality demanded of major US buyers.
- A resin supplier needs to maintain a 30-day equivalent in inventory at all times. Customer may change its timetable for product delivery at any time.
- Customer can shift orders to a competitive supplier if market prices have come down and supplier is not willing to meet new price (Meet or Release Clause is standard in almost all contracts)

An Off-take Agreement With a Strong Financial Distributor Would Help Maintain High Production

- Off-take agreements are complex & have multiple components – all of which are negotiable. Both parties must be protected, and it must be a win/win for both:
 - Reference pricing (Platts, ICIS)
 - Pricing formula (discount from Platts/ICIS or cost-based or intermediate). This could be a complex equation or something simple
 - Commission (3-8 percent negotiated)
 - Volume (does not have to be an ironclad fixed volume over the time period)
 - Product portfolio (export grade slate)
 - Monthly export forecasts (volumes, grades)
 - Time period
 - Geographic boundaries and limitations(example – must sell outside Andean region)
 - Non-performance/force majeure components
 - Escape clause/termination
 - Arbitration rules
 - Exclusivity (mutual and competitive)
 - Causes for changes in the agreement
 - Periodic review
 - Other issues that arise during negotiation

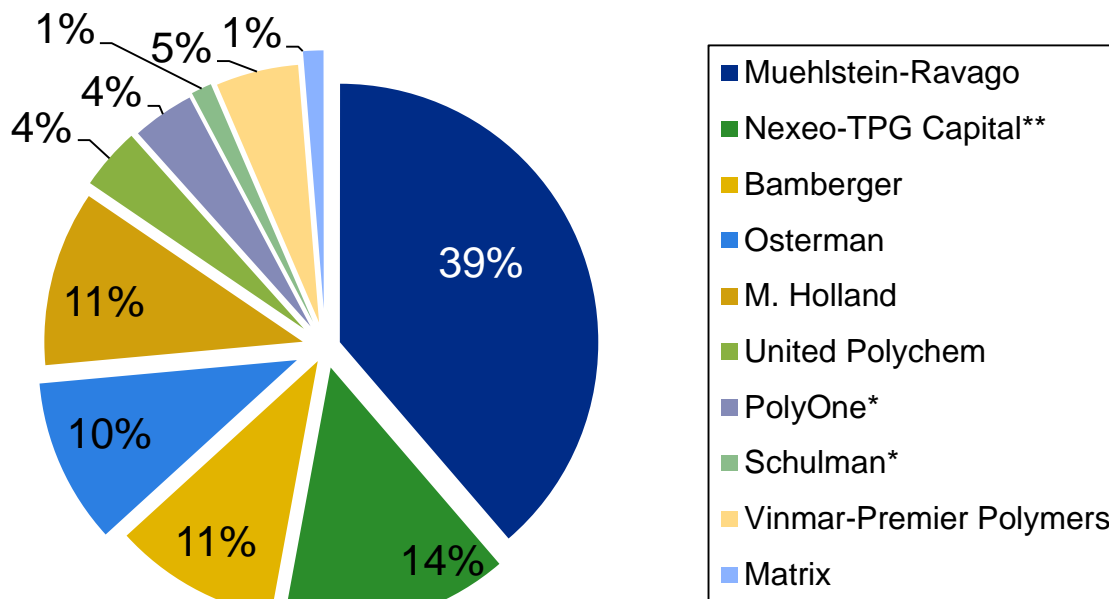
An Off-take Agreement With a Strong Financial Distributor Would Help Maintain High Production (continued)

- These can be an ironclad take-or-pay contract, for 25 to 100% of production.
- The term of the off-take agreement is typically equal to or longer than the term of the loan , providing comfort to project lenders with regard to debt service and supports the financing process

These First Tier Reseller/Distributors Alone Account for Over 60 Percent of Third Party Sales; Most Are Privately Owned

- Third party sales of PP in North America have been increasing consistently over the past decade
 - PP resin producers have relegated small/medium sized customers to their distributor-partners
 - Major US distributors have dominated the Latin American market supplying US-based PP repackaged in 25 kilo bags (name brand and generic)
 - New companies have entered as this outlet has grown (Vinmar's Premier Polymer Div, Spartan Polymers,)

Leading NAM Polyolefin Distributors & Resellers



* Publicly held companies
 ** acquired Ashland Distribution in 2011

Resellers/Distributors – Business Overview

- Prime resin break-bulk distributors like Nexeo and M. Holland typically buy in bulk rail from their suppliers and warehouse/transload to supply smaller/medium sized customers that resin producers are relinquishing to cut sales costs
 - Emphasis on one-stop shopping, often supplying many different resins in one truck load
 - Approximately 5 to 6% of NAM polyolefin domestic sales move through prime-resin distributors
 - Small/medium converters serviced are typically injection molders or rotomolders
 - Tier One distributors buy large volumes of prime resin at large customer bulk rail resin prices
 - They do have relatively high overhead and inventory costs, but high price upcharges for break bulk packaging
- Resellers/Brokers like Ravago and Bamberger move most (75% or more) of their resin by bulk, directly from a resin producer's plant. Some also have warehousing and break bulk facilities.
 - Inventory low compared to break bulk prime distributors. Typically 2 weeks, or as long as it takes to deliver a rail car to a customer
 - About 11% of NAM polyolefin domestic sales move through resellers
 - They move almost all of polyolefin wide-spec, taking responsibility from the producer, priced at 5 cpp discount off prime (for good wide-spec)
 - Typically resellers will get a 2 to 3 cpp discount from their resin suppliers to move excess prime inventory (downgraded inventory), and depending on how the reseller can sell it, can make ½ to 2 cpp profit

Resellers/Distributors – Business Overview (Continued)

- Major NAM resellers like Ravago and Bamberger also export a large volume of resin, mainly to Latin America. These are mostly packaged in 25 kilo bags or supersacks, or in some cases, moved by rail into Mexico
- Both have strong long term relationships with NAM resin suppliers, although these relationships can be disrupted with consolidation at resin producer or distributor/reseller level
- Key to success for Distributor/Resellers in NAM PE/PP markets is strong industry knowledge, which take years of experience
- Strong field sales and tech service experience – usually from years in the polyolefin industry. Average 25 to 30 years experience for most Tier 1 employees.
- These companies do not own their own rail cars, just move those owned or leased by the resin producers, typically taking possession of the resin when it leave the producer's facility

These Tier 1 Third-party Companies are Considered Core Customers/Partners of Resin Producers

- The volume of resin moved through resellers & distributors will continued to increase in the future.
 - Move to cut inventory and sales costs by resin producers. Small/medium converters (5 to 10 million pounds/year) are shifted to distributors
 - Shifting credit risk to distributors/resellers, which generally have more flexible credit terms
 - Continued grade differentiation by NAM producers as imported commodity fabricated products continue to increase. This lends itself to more small/medium sized converters
 - Converters/fabricators who buy from these distributors also can better-manage (spread out) working capital by purchasing 4 bulk trucks a month vs. one rail car of resin a month
- Distributors and resellers have taken on larger resin volumes, but have also reduced margins and carry more inventory than in past years, and have also added more products services (logistics, recycling, engineering resins, direct or toll compounding, etc.)
- Consolidation continues with resellers & distributors, with Ravago alone buying up numerous smaller resellers/distributors/compounders globally
- Their margins come under severe pressure in poor demand environments and when there is a sharp resin price drop catching them by surprise with high priced inventory
 - They can usually capture more margins during periods of upward price movement, but savvy converters often wait it out and maintain low resin inventory levels until prices fall again
 - Some major converters hold as little as 3 days of resin inventory

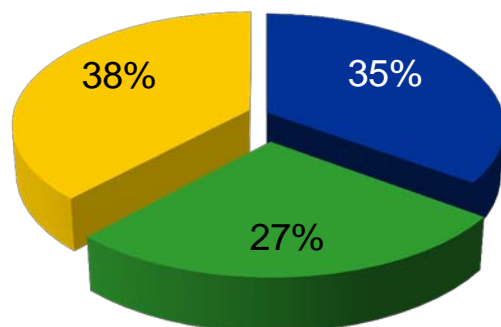
Wide Spec and Third Party Resin Pricing

- Wide Spec/Off Grade:
 - Typically 4 to 10% of a polyolefin producer's production, depending on reactor transitions (time, frequency, etc)
 - Pricing currently 5 cpp less than comparable prime resin for each application for slightly off-spec resin
- Prime Break-Bulk Distributors (Nexeo, M. Holland):
 - Considered major bulk customers/partners of most NAM PE/PP producers, and have resin supply contracts
 - Resin is priced based on volume purchased, like any other large bulk rail resin customer
 - Profits are made on their upcharges for packages, truck load and less than truckload (LTL) sales volumes
 - High inventory costs
- Resellers/Brokers (Muehlstein, Bamberger, etc.)
 - Generally opportunistic - 75% or more bulk rail re-distribution of producer railcar inventory, taking possession of the car when it exits producing plant
 - Some transloading to bulk trucks, and some exporting (Latin America focus)
 - Pricing discount from their key resin suppliers is about 2 to 3 cpp for prime resin, allowing reseller to capture 1 to 2 cpp for each rail car

As an Example, Sales to Third Party Resellers, Distributors and Compounders Account for Over 30% of Total NAM PP Sales

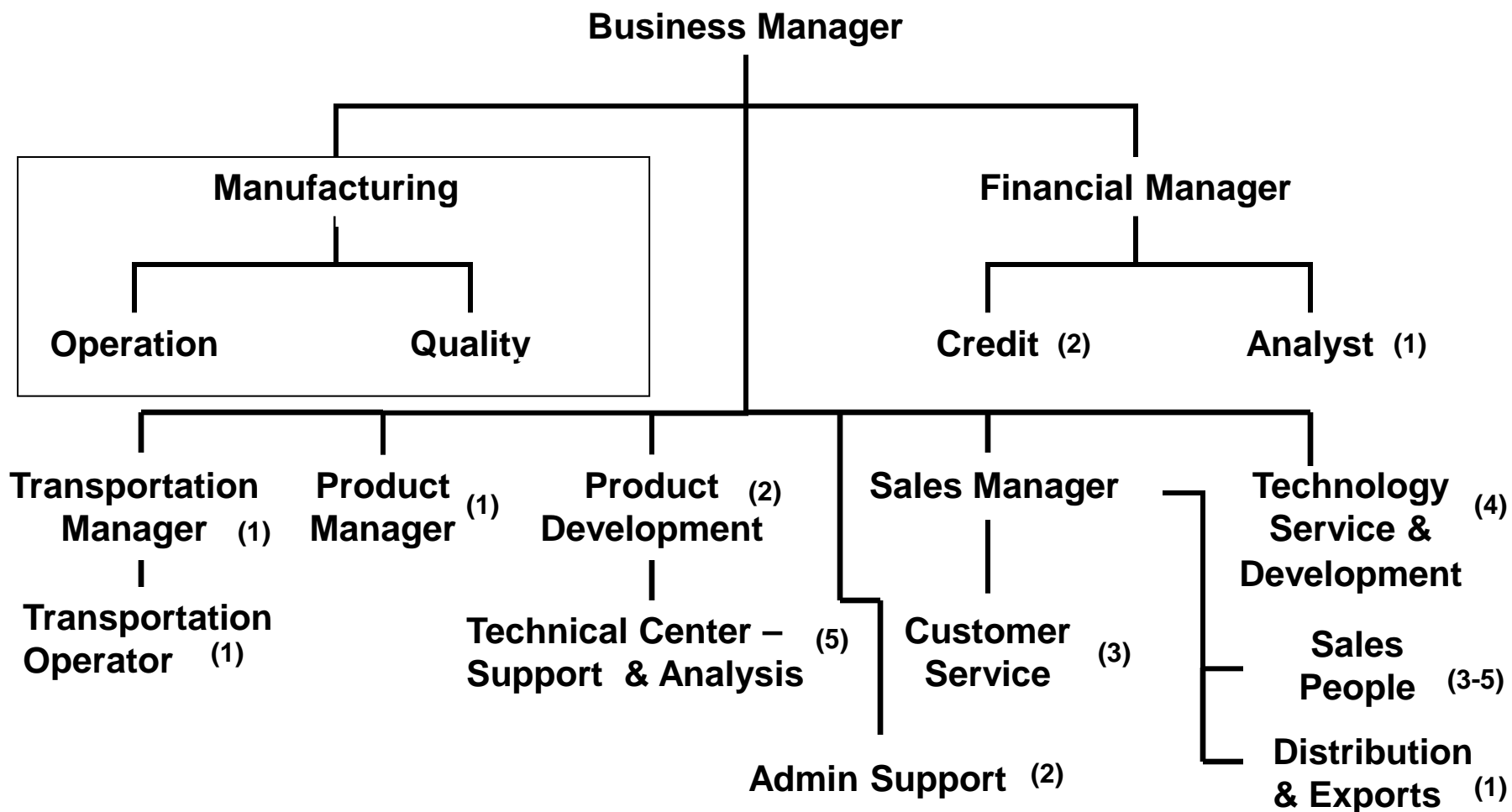
North America - Third Party PP Sales, 2012

■ Resellers ■ Distributors ■ Compounders



- **Resellers:** major resellers like Muehlstein Ravago are also major prime and generic resin distributors. Although off-grade/wide-spec production varies depending on the producer, their processes and how they may dedicate reactors, and estimated 5% of NAM PP production is wide-spec. Most wide-spec resin is sold to Resellers who move it into commodity PP markets:
 - Injection molding markets(consumer products, pails, all other). Most commodity injection molding applications are fairly tolerant of incorporating wide-spec resin
 - Fiber applications (carpet and slit film). Slit film raffia grades are often slightly wide-spec BOPP film resins that cannot be used in tight spec BOPP applications
- **Distributors:** for prime resin distribution, distributors buy resin in bulk rail from their key resin suppliers/partners and break it into smaller volumes to sell to medium and small customers that producers do not have the flexibility to service, or to small volume products consumed by large converters. Major resin producers with world scale plants that are typically dedicated to a few reactor grades, prefer to sell to the very large converters.
 - About 70% of prime resin distribution is going to the very fragmented injection molding market, into most applications except Transportation.
 - The remaining 30% of PP prime resin distribution goes into other large categories like slit tape, blown film and non-TPO compounds and masterbatches
 - Markets not typically serviced by distributors where major PP producers sell only via direct sales are BOPP, sheet for thermoformed containers, and nonwovens
- **Compounders:** the major use is in TPO compounds for automotive, and much of this is captive to producers like LyondellBasell and ExxonMobil. But there are merchant PP compounders like WashingtonPenn, PolyOne, A. Schulman, etc – that consumer large volumes of PP resins.

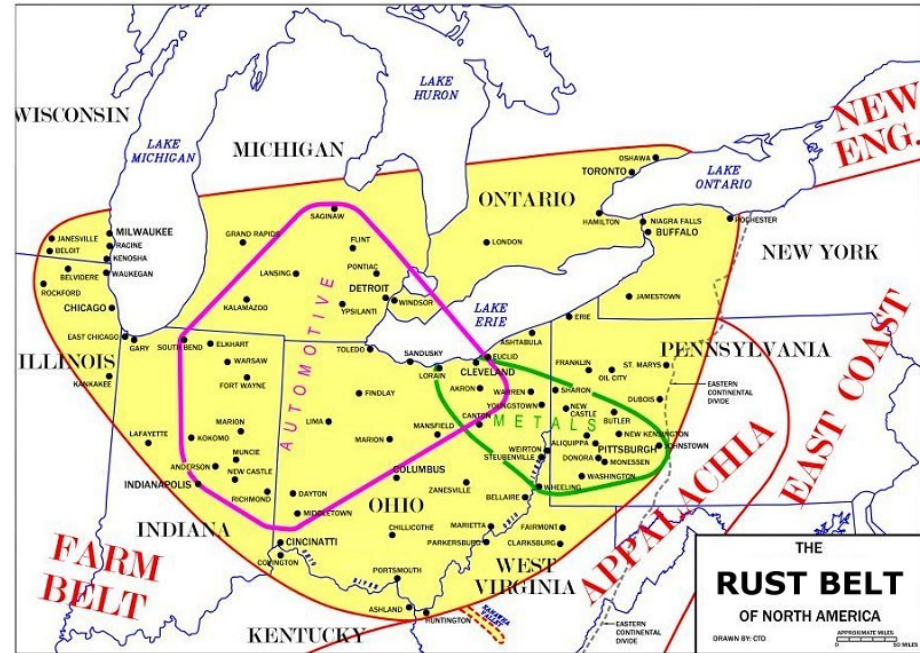
Recommended Resin Producer Organization Chart



Rust Belt/East North Central US Product Destination

The Rust Belt is a Likely Destination for Products Produced in North Dakota

- The Rust Belt is the informal description for a postindustrial region straddling the Northeastern and the East North Central States, referring to economic decline, population loss and urban decay due to the shrinking of its once powerful industrial sector.
- The Rust Belt begins in central New York and predominantly includes Pennsylvania, West Virginia, Ohio, Indiana, and the Lower Peninsula of Michigan, ending in northern Illinois and eastern Wisconsin and northern Kentucky.
- This geographical sector also includes the center of the US automotive industry, as indicated in the map:
 - Michigan
 - Ohio
 - Indiana



The Automotive Industry is a Likely Target for Some Potential Products from North Dakota Such as PP, HDPE and PBR

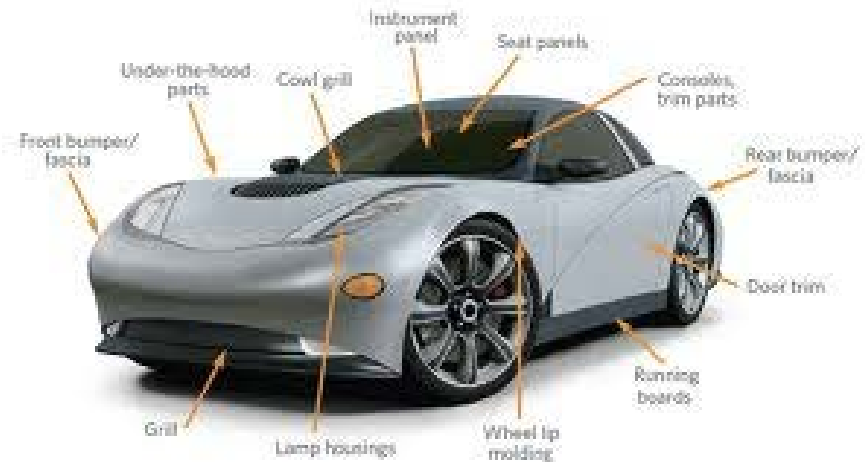
Partial List of Vehicle (Final Assembly) Plant in North America



- Plastic resin and chemicals are used in the production process but usually not at the final assembly site – most of these feeder plants are within a 4-hour window of the final assembly site.

Several of the First and Second Derivative Products in Our Evaluation Are Used in the Automotive Industry - PP

- Polypropylene is used in auto exterior, interior and under the hood applications
- Polypropylene has become the most important thermoplastic material in an automobile, with an average utilization of 50kg per vehicle
- PP is predominantly used in major auto parts:
 - Bumpers
 - Body panel
 - Trim
 - Interior trim - both above and below shoulder level
 - Functional surfaces such as seat backs and access panels/covers.
 - Supporting components including hangers and fillers
 - Under the hood
 - Batteries.
 - Foamed surfaces.
 - Tubing and conduits



Several of the First and Second Derivative Products in Our Evaluation Are Used in the Automotive Industry - PE

- High Molecular Weight HDPE is typically used in blow molded coextruded fuel tanks
- HDPE is also used for motor oil containers and portable gas cans
- Under-hood applications include reservoirs and wire insulation
- Other auto/truck applications:
 - Battery boxes
 - Air ducts
 - Splash shields
 - Air duct/channels which are part of the lower part of the dashboard.

Fuel Tank



Splash Shield



FRONT & BACK VIEW

Several of the First and Second Derivative Products in Our Evaluation Are Used in the Automotive Industry - PBT

- PBT can be found in both automotive exterior and interior parts and most particularly, in auto electrical system components
- Typical examples include windshield wiper covers, mirror housings, cowl vents, handles, fans, fuel system components, connectors, sensor housings, fuse boxes, actuator cases, power relays, switches, motor components, and ignition system components
- PBT alloys are most commonly used in body exterior and safety applications including airbag covers and containers brake and fuel line clips, cable liners, and power distribution boxes.



Window Motor Support



Sensor



Headlight Bezel



Electrical Connectors



Lamp Socket



Fuse Box

Several of the First and Second Derivative Products in Our Evaluation Are Used in the Automotive Industry – PET, polyester

- PET is used in interior and exterior auto applications such as door handle systems, multifunction switches, mirrors, door trim, window lift brackets, roof racks, wiper tubs and numerous automotive electrical/electronic components
- Filled or reinforced PET is used in automotive molded electrical connectors, switches, and relays
- Polyester nonwovens are used in automotive headliners and hood and trunk liners
- High-tenacity polyester filament yarn or staple has a particularly high tensile strength and reduced elongation. It is used for industrial applications that require high strength and low creep. End uses include tire cord, automotive seat belts, hoses, belts, rope and cordage and substrate fabrics.
- Transportation upholstery end uses for polyester staple nonwoven webs include paneling, hood linings, trunk liners and molded trim in automotive and other transport vehicles; marine fabrics; and coverings



Several of the First and Second Derivative Products in Our Evaluation Are Used in the Automotive Industry - PBR

- Polybutadiene has a high resistance to wear and is used especially in the manufacture of tires, which consumes about 70% of the production
- Styrene-Butadiene Rubber (SBR) is a copolymer of butadiene and styrene. It has a wide range of applications in the automotive industry due to its high durability, resistance to abrasion, oils and oxidation. SBR applications vary from tires to vibration isolators and gaskets.
- SBR is also used in tuned dampers which aim to reduce and control the angular vibrations of crankshafts, acting as an isolator and energy absorber between the tune damper's hub and the inertia ring

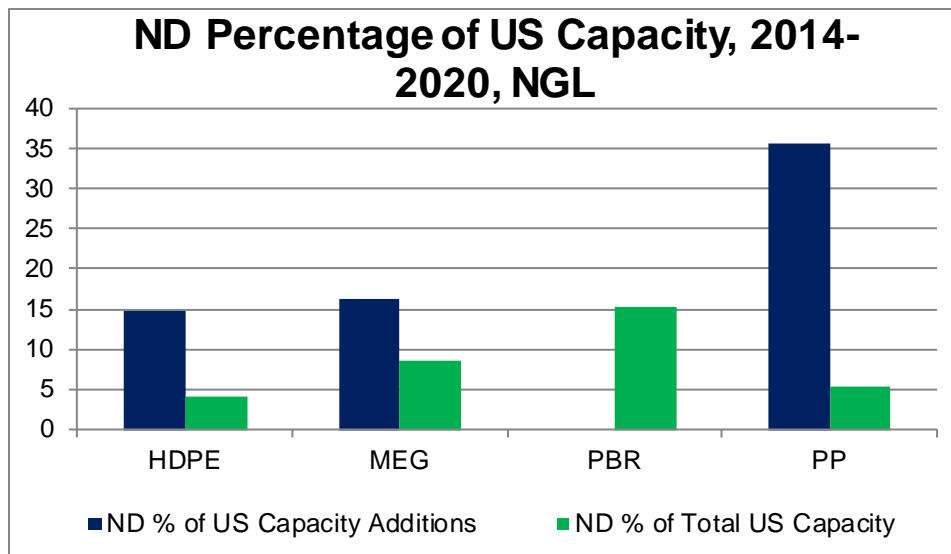


Several of the First and Second Derivative Products in Our Evaluation Are Used in the Automotive Industry - PIB

- Polyisobutylene added in small amounts to the lubricating oils used in machining results in a significant reduction in the generation of oil mist and thus reduces the operator's inhalation of oil mist
- As a fuel additive, polyisobutylene has detergent properties. When added to diesel fuel, it resists fouling of fuel injectors, leading to reduced hydrocarbon and particulate emissions
- Butyl rubber, the copolymer of isobutylene with isoprene, provides excellent inflation pressure retention for bicycle, truck, agricultural, industrial and specialty tires.
- Butyl rubber's barrier properties, high damping, resistance to ozone and heat aging makes it ideal for automotive vibration control, hoses and gaskets.

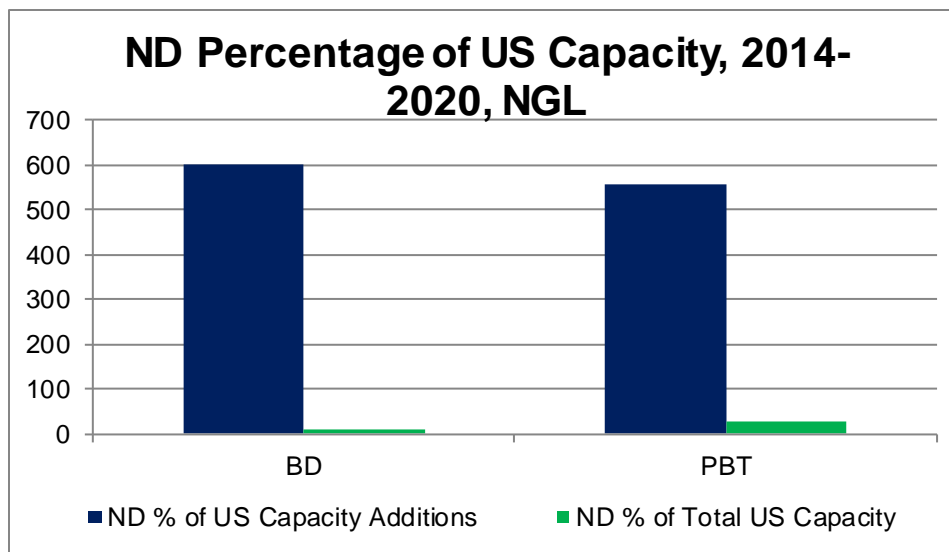


North Dakota Proposed NGL-base Petrochemical Plant Impact



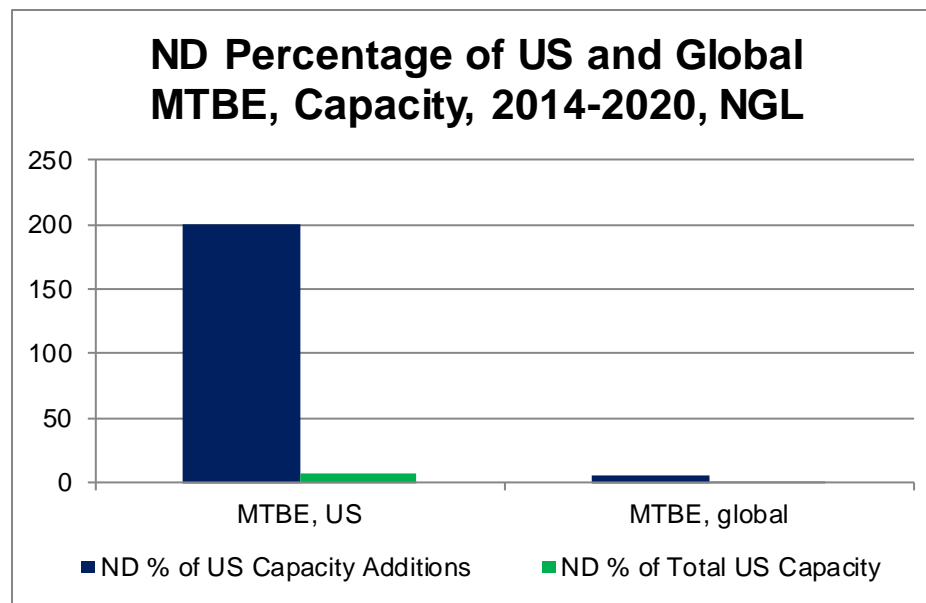
- For HDPE and MEG, the proposed plant represents a reasonably small percent of total capacity in the US in 2020 and of the required capacity addition (announced and anticipated) required to satisfy US supply/demand dynamics
- IHS forecasts no new PBR plants and, hence, the proposed plant is not viewed as necessary to satisfy production need by 2020; however, the proposed PBR plant represents only 15% of the 2020 anticipated total US capacity, such that a competitive plant could displace current capacity

Proposed NGL-base Petrochemical Plant Impact



- For both 1,3-butadiene (BD) and polybutylene terephthalate (PBT), IHS forecasts little or no capacity addition
- For BD, this is largely due to the fact that the BD capacity is conventionally provided by steam cracker coproduct production from heavier liquid feedstocks, which are in decline in the US as ethane and other light feeds displace the heavier feedstocks and the cost of on-purpose BD production has been uncompetitive
- PBT capacity is not expected to grow
- In both cases, BD (4.3%) and PBT (1.1%), the proposed plants represent a very small percentage of the total US capacity in 2020

Proposed NGL-base Petrochemical Plant Impact



- MTBE is being considered as an export product
- The majority of MTBE produced in the US is exported to South America
- Because of the US legislation phasing MTBE out as a fuel additive, US capacity has actually declined since 2005, from 9.9 million tons per year to 3.2 million tons in 2014
- If appraising at US capacity and US capacity additions, MTBE would not appear to be a promising option; however, if we consider the proposed plant as a part of the global supply, the proposed plant is a very small addition.

Derivatives

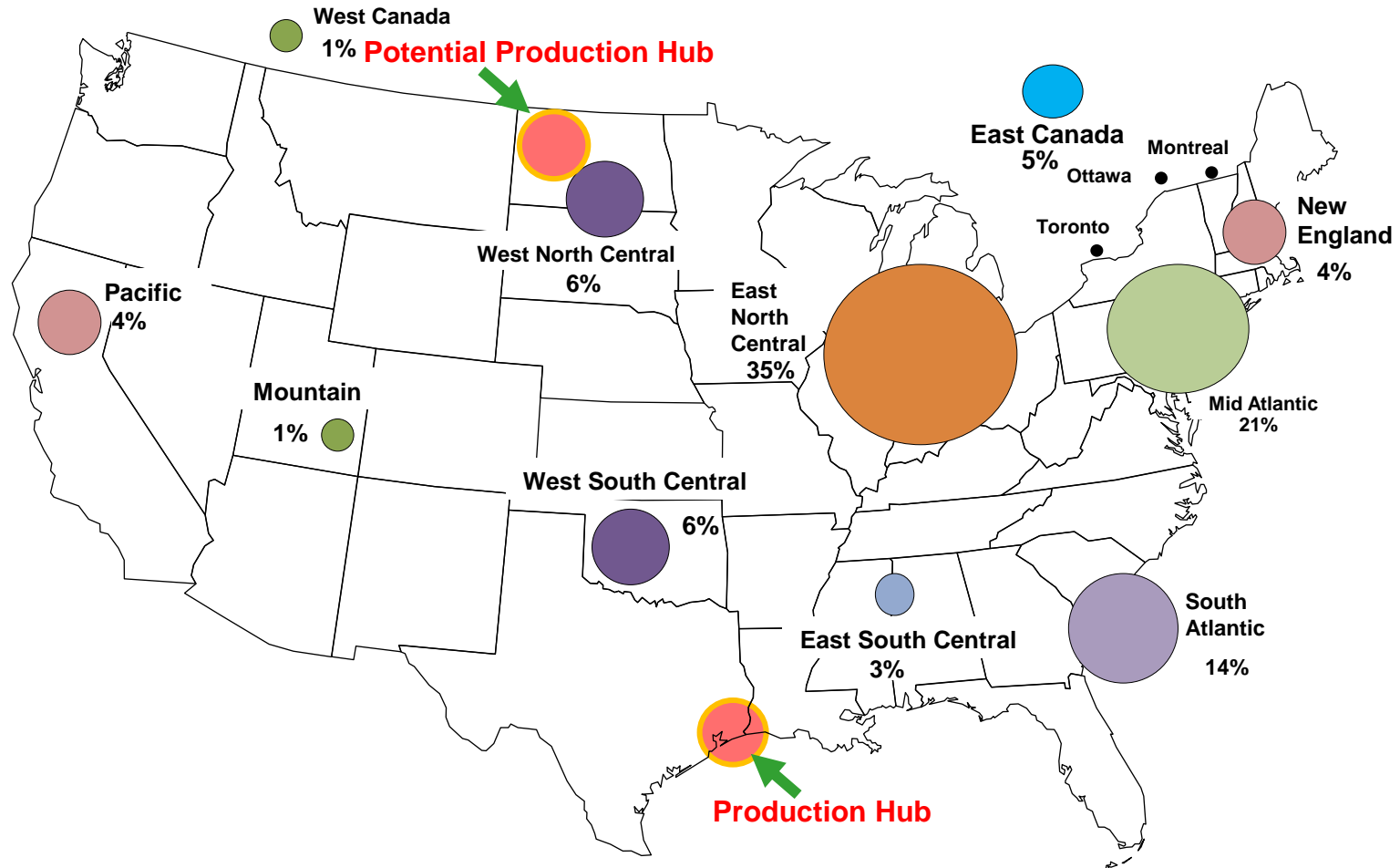
❖ *HDPE*

❖ *PP*

❖ *PBR*

High Density Polyethylene

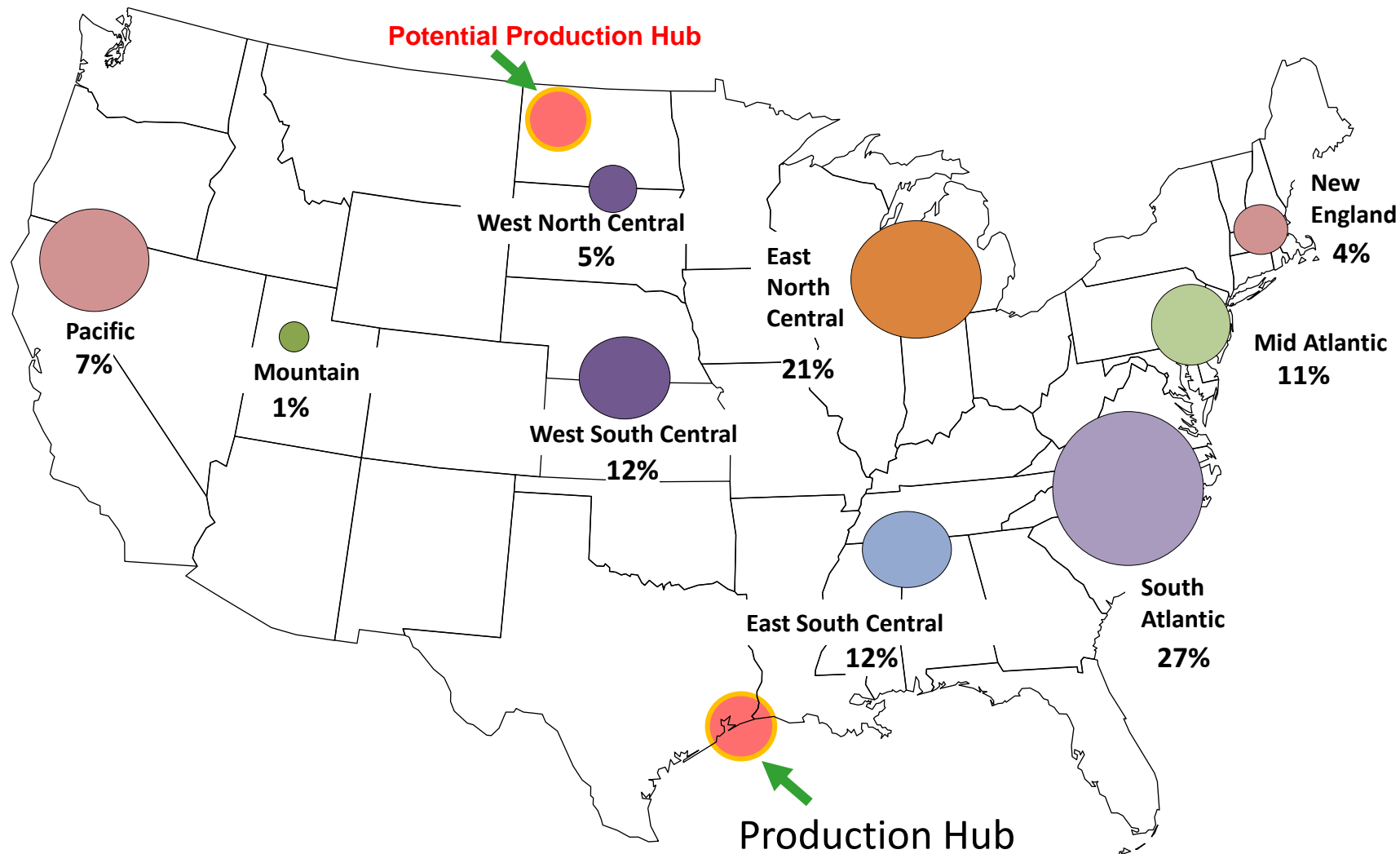
There is a Significant Market Within Easy Reach of a North Dakota-based Project



More than half of the consumption in US is within reach of a North Dakota Plant, while most production is centered in the U.S. Gulf Coast

Polypropylene

The East North Central Market for PP is Substantial

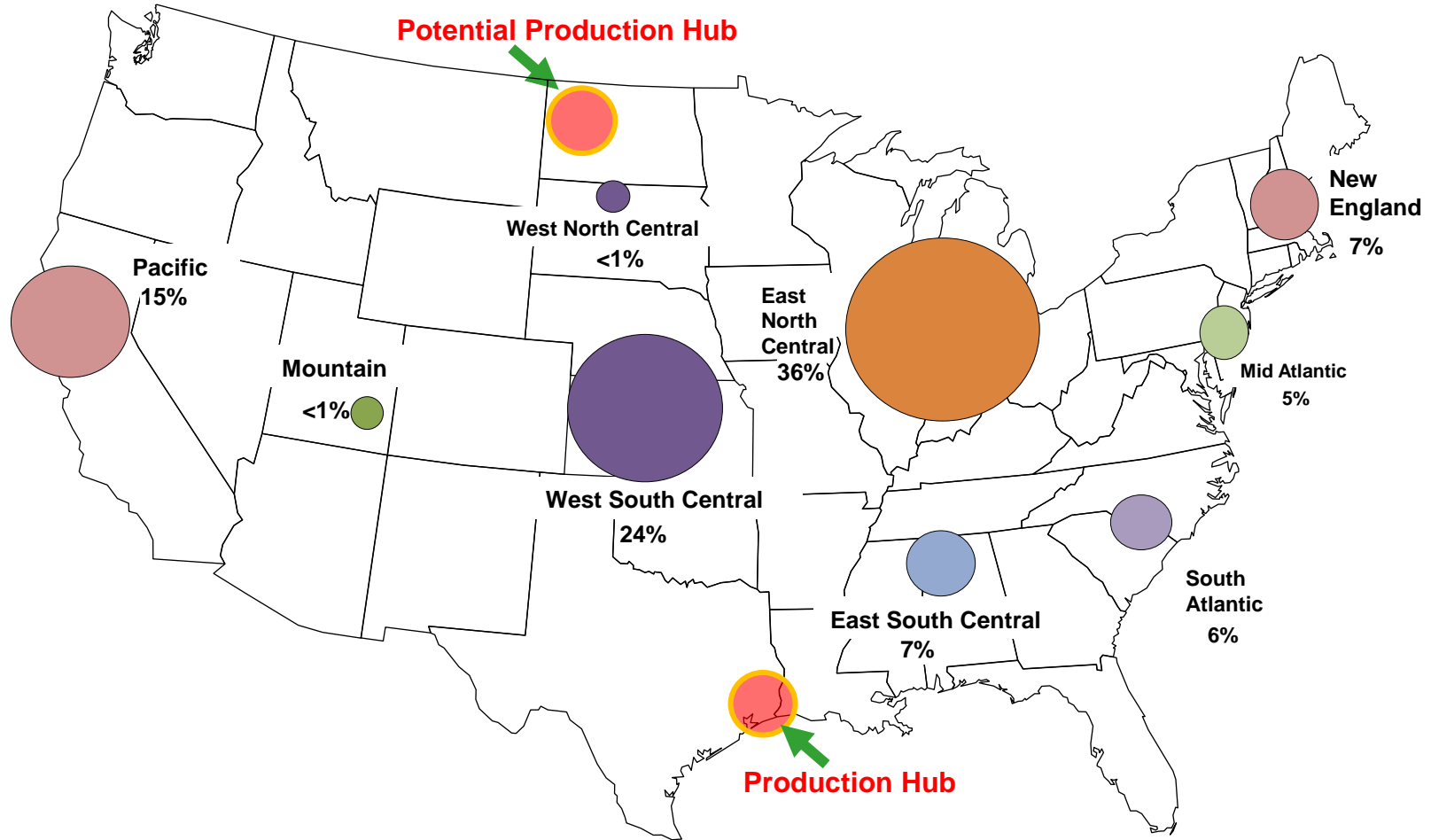


40 Percent of US/Canada PP Consumption is Copolymer Resins

PP: 2012 Market segmentation by Product Type - US & Canada								
			%			000 Tons		
DEMAND	Total – 000 Tons	Total - %	Homo	Random	Impact	Homo	Random	Impact
Film & Sheet	880	15%	79%	15%	6%	695	132	53
Injection Molding	1986	33%	52%	13%	35%	1033	258	695
Pipe & Profile	0	0%	69%	0%	31%	0	0	0
Extrusion Coating	0	0%	50%	25%	25%	0	0	0
Blow Molding	89	1%	18%	82%	0%	16	73	0
Wire & Cable	0	0%	0%	0%	100%	0	0	0
Rotomolding	0	0%	0%	0%	100%	0	0	0
Fiber	1014	17%	100%	0%	0%	1014	0	0
Raffia/Slit Tape	0	0%	100%	0%	0%	0	0	0
Other	1985	33%	40%	5%	55%	794	99	1092
Domestic Demand	5954	100%	60%	9%	31%	3552	562	1840

Polybutadiene Rubber

There is a Significant Market Within Easy Reach of a North Dakota-based Project



More than half of the consumption in US is within reach of a North Dakota Plant, while most production is centered in the U.S. Gulf Coast

US PBR Producers

PRODUCT	COMPANY	PLANT CITY	PLANT STATE	CAPACITY	CAPACITY UNITS
Polybutadiene rubber	American Synthetic Rubber Company, LLC	Louisville	Kentucky	90	thousand metric tons per year
Polybutadiene rubber	Firestone Polymers, LLC	Lake Charles	Louisiana	55	thousand metric tons per year
Polybutadiene rubber	Firestone Polymers, LLC	Orange	Texas	105	thousand metric tons per year
Polybutadiene rubber	The Goodyear Tire & Rubber Company	Beaumont	Texas	260	thousand metric tons per year
Polybutadiene rubber	LANXESS Corporation	Orange	Texas	265	thousand metric tons per year

Source: IHS Directory of Chemical Producers

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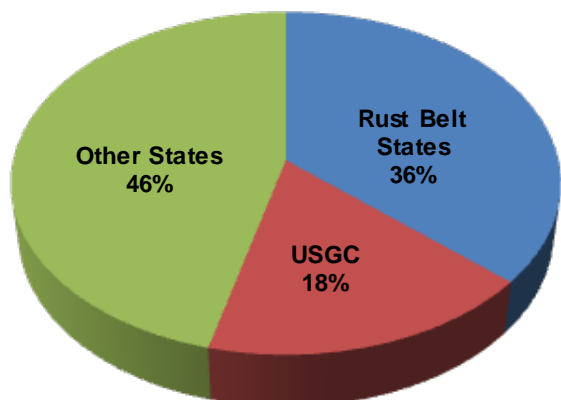
2014 State Product Revenue

State Breakdown

- **Rust Belt**
 - New York
 - Pennsylvania
 - West Virginia
 - Ohio
 - Illinois
 - Indiana
 - Michigan
 - Wisconsin
- **USGC**
 - Texas
 - Louisiana
- **Automotive States**
 - Ohio
 - Michigan
 - Indiana
- **Other States**

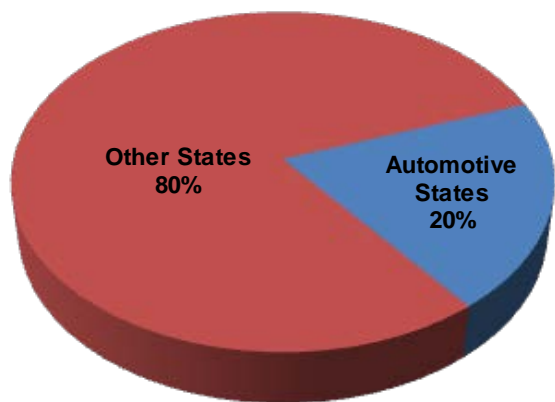
Plastics Resin Manufacturing Revenue Projection, 2014

USGC/Rust Belt States Plastics Resin* Revenue



2014 US Revenue = \$86 Billion

Major Automotive States Plastics Resin* Revenue



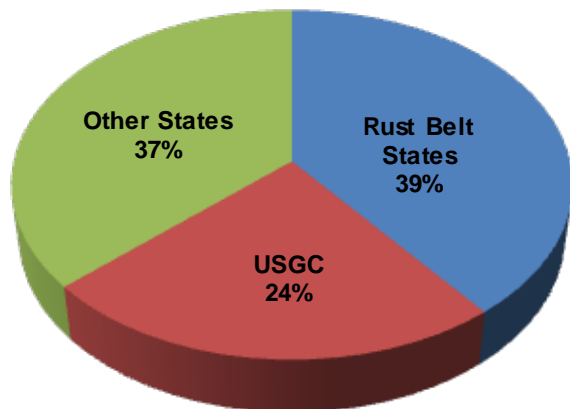
2014 US Revenue = \$86 Billion

*Plastics resin revenue consists of polyester, polyethylene, polyethylene terephthalate, polyisobutylene, and polypropylene resins manufacturing

- Products injection molded from polypropylene, include container caps and closures, appliance parts, disposable syringe and a wide variety of household and miscellaneous products.
- As fiber, PP is used in carpet backing and has a strong growth market in carpet face yarn, particularly in the United States, Turkey, Egypt and Iran. Polypropylene fiber also plays an important part in the nonwovens market, an end use that continues to experience rapid growth in virtually all regions of the world.
- PET resin was introduced commercially in 1953 for use as a textile fiber and, shortly thereafter, as a film. It was not until 1966 that the first injection-molding PET resins were introduced, followed by development of injection (stretch) blow-molded bottles in 1973.
- One of the largest global uses of PET resin is the stretch blow-molded soda bottle. These bottles are lightweight, shatterproof and (potentially) reusable.
- Polyester fibers are noted for their high resistance to initial stretching, fair resilience and good heat-set capability.

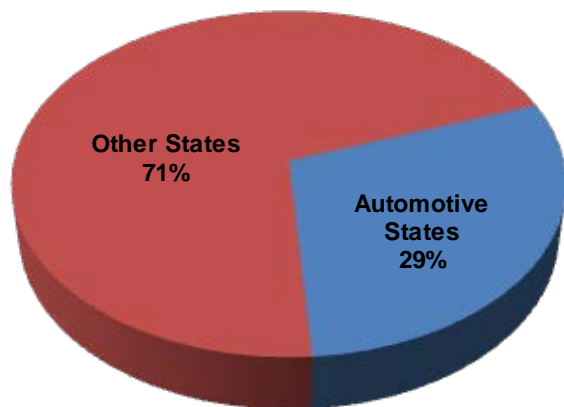
PBR Revenue Projection, 2014

USGC/Rust Belt States PBR Revenue



2014 US Revenue = \$16 Billion

Major Automotive States PBR Revenue

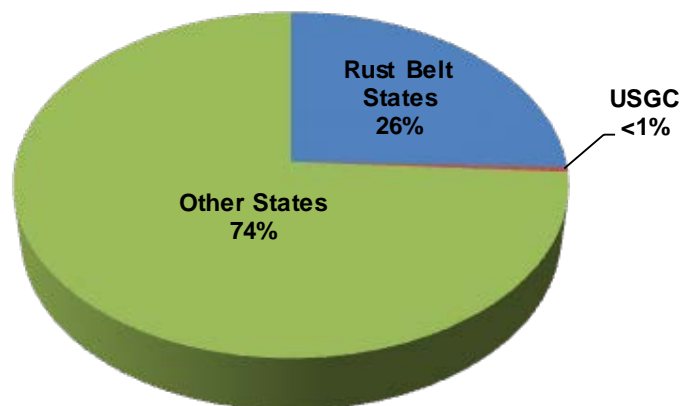


2014 US Revenue = \$16 Billion

- Global butadiene demand is dominated by the production of synthetic rubber. Production of the two major commodity types of synthetic rubber, namely polybutadiene rubber (PBR) and styrene butadiene rubber (eSBR and sSBR), presently accounts for more than 50% of global butadiene demand.
- The major end use of polybutadiene rubber is for production of tires and tire products.
- Tires and tire products accounts for 71% of total global consumption. Polybutadiene is highly resistant to heat buildup, abrasion resistance, and wear resistance, but has poor processing, oil resistance, and wet traction.
- In the sidewall of truck tires, the use of PBR helps to improve fatigue-to-failure life improving blowout failures under extreme service conditions. Usually, polybutadiene is combined with SBR, natural rubber, or chloroprene in the final product. PBR is usually combined with SBR in the manufacture of tire treads.

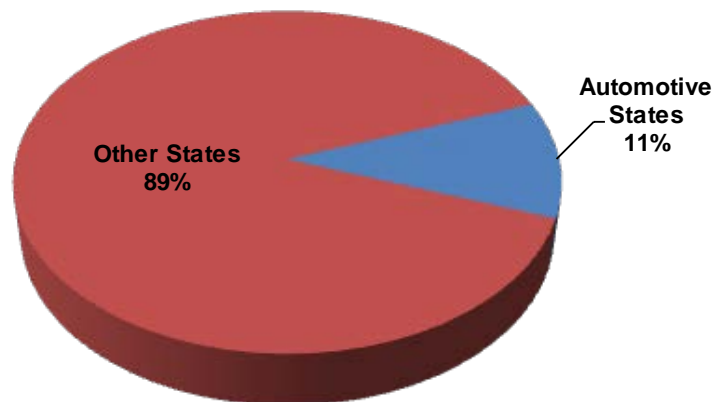
Tire Manufacturing Revenue Projection, 2014

USGC/Rust Belt States Tire Manufacturing Revenue



2014 US Revenue = \$14 Billion

Major Automotive States Tire Manufacturing Revenue

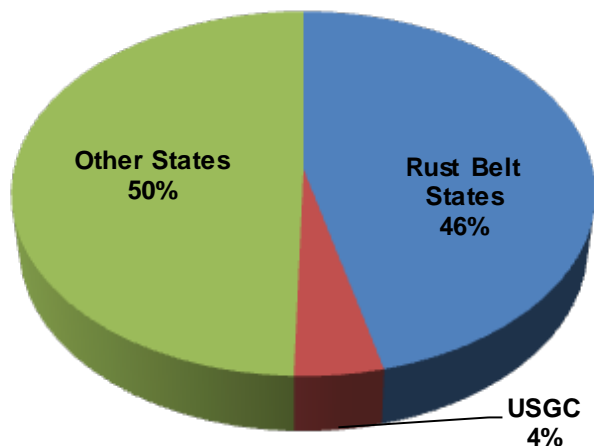


2014 US Revenue = \$14 Billion

- Tires and tire products have always been the largest end-use category for natural rubber in the United States. In 2010, tires and tire products accounted for about 741 thousand metric tons of natural rubber, or 80% of total U.S. natural rubber consumption.
- Until the advent of World War II, all of the rubber used in tires was natural rubber. Since that time, most tires have used blends of natural and synthetic rubber, depending on the type of tire and the cost performance balance that is desired.
- There are three routes to which a U.S. company can obtain natural rubber—purchasing the rubber directly from a dealer, purchasing the material from producers in the Far East (or other producing regions) through its own buying offices, or importing natural rubber produced by the company's own plantations (tire companies).
- Some natural rubber dealers have their own plantations, purchasing offices in the Far East (or other producing regions) and/or special arrangements with producers in producing regions. In addition to selling natural rubber to consumers, dealers also buy and sell natural rubber among themselves.

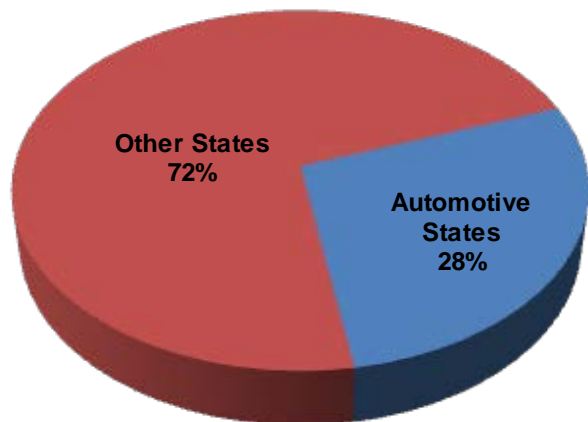
Automotive PP Revenue Projection, 2014

USGC/Rust Belt States Automotive PP Revenue



2014 US Revenue = \$86 Billion

Major Automotive States Automotive PP Revenue

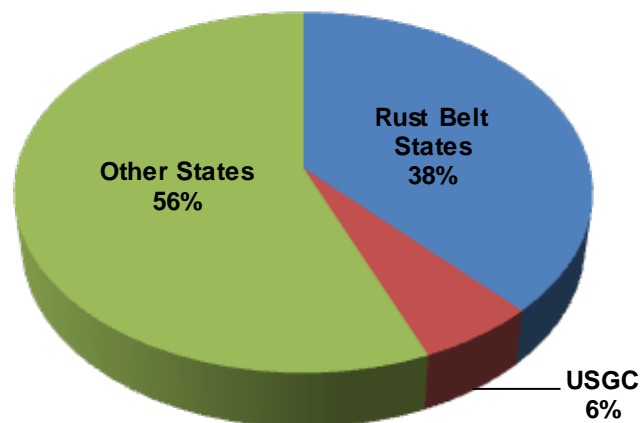


2014 US Revenue = \$86 Billion

- Transportation constitutes one of the major end-use markets for injection-molded polypropylene. Polypropylene's very low density (0.89-0.91 gram per cubic centimeter) combined with its good mechanical properties (especially when filled or compounded) and injection-molding characteristics make it especially suitable for the large-volume cost- and weight-conscious automotive market.
- Depending on the intended use, PP resins may be injection-molded, extruded, compression-molded or blow-molded into automotive components. Because of the prevalence of a low inventory, just-in-time supply chain, injection-molding processes produce 80-85% of all PP resins consumed in automotive uses.
- The PP transportation market may be divided into two major sectors: automotive original equipment manufacture (OEM) and automotive replacement parts. In addition, smaller markets exist for battery cases (both OEM and replacement), automotive accessories and other transportation parts.
- The largest OEM market for PP is in interior trim parts where it competes with ABS and other materials. ABS costs considerably more than PP. Consequently, PP usage in interior trim has increased wherever its performance has been deemed adequate. PP is used in pillars and trim, door panels and instrument panels.

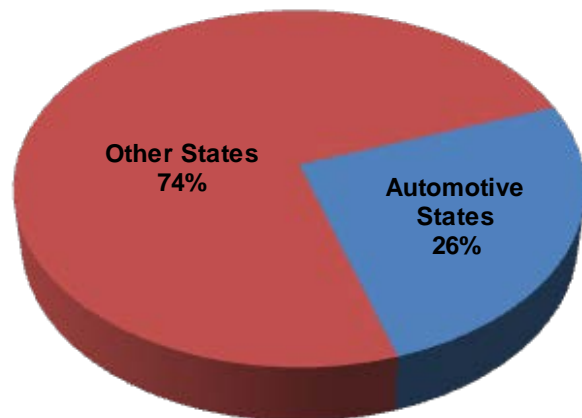
Automotive PBR Revenue Projection, 2014

USGC/Rust Belt States Automotive PBR Revenue



2014 US Revenue = \$10 Billion

Major Automotive States Automotive PBR Revenue



2014 US Revenue = \$10 Billion

- In the United States, polybutadiene rubber is consumed mainly in tires and tire products at about 70-75% of total consumption in recent years. BR has another important outlet for impact modification of plastics/resins, particularly high-impact polystyrene and ABS.
- U.S. consumption of BR is projected to increase at an average annual rate of 3% through 2018. If and when mandated tire-labeling in the United States comes into existence, the BR consumption growth rate is expected to rise by 1-2%.
- Tire components containing BR include sidewalls, body plies, tread, chafer and bead compounds. These components make use of the high resilience, abrasion resistance and good flex fatigue characteristics of polybutadiene.
- BR in tires helps reduce rolling resistance (especially high-cis content BR, for example, Nd-BR), which thus brings on fuel efficiency, an important aspect in today's society.
- Polybutadiene contributes to low-temperature flexibility in tires and increases their resistance to aging, resulting in longer service life.

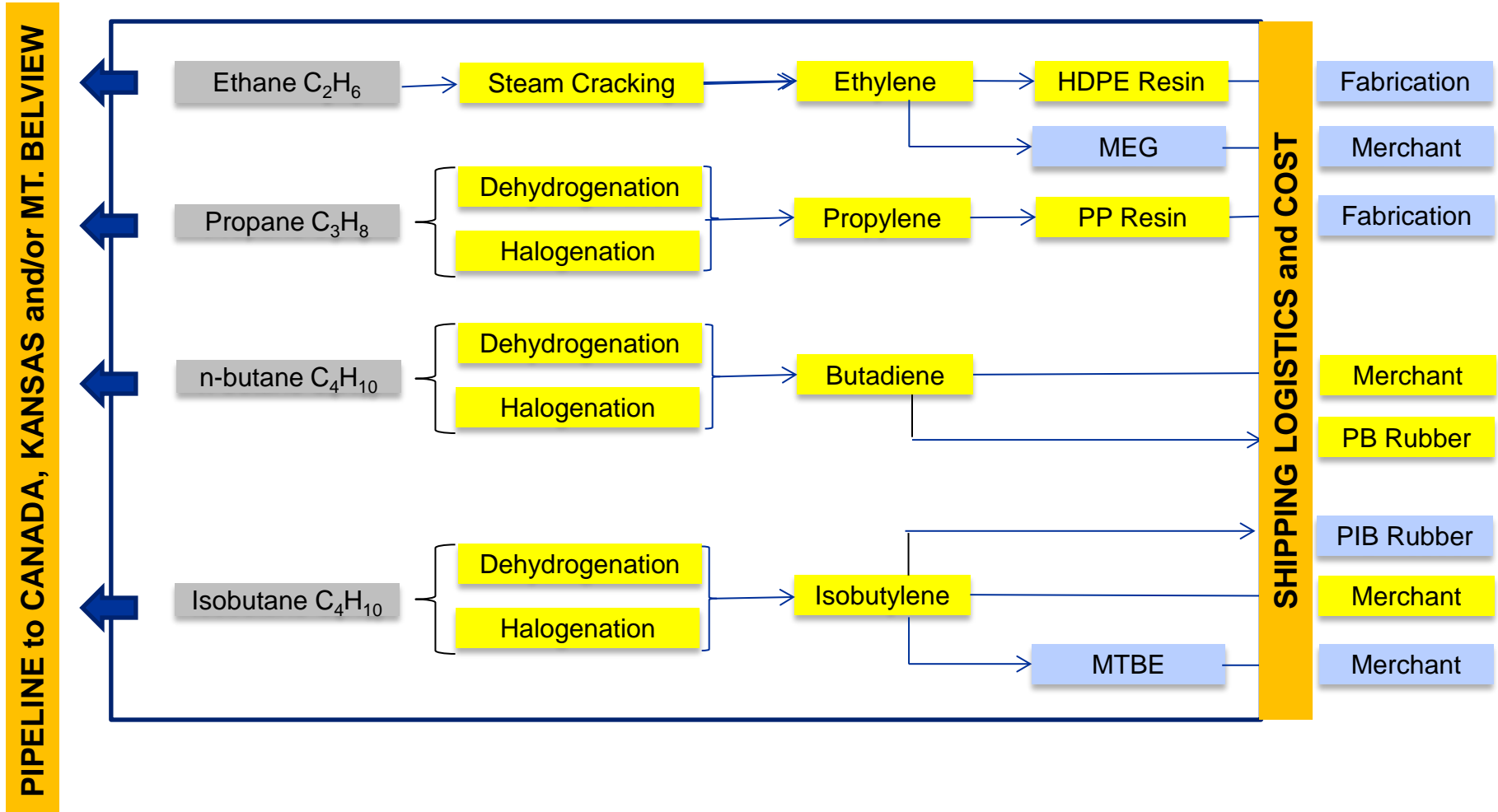


Process Technology Assessment

- ❖ *Proposed Product Configurations for North Dakota*
- ❖ *Ethane Chain – Ethylene*
- ❖ *High Density Polyethylene*
- ❖ *Ethylene Oxide & Monoethylene Glycol*
- ❖ *Propane Chain – Propylene*
- ❖ *Polypropylene*
- ❖ *n-Butane Chain – Butadiene*
- ❖ *Polybutadiene Rubber*
- ❖ *n-Butane Chain – Butylenes*
- ❖ *iso-Butane Chain – MTBE*

Proposed Product Configurations for North Dakota

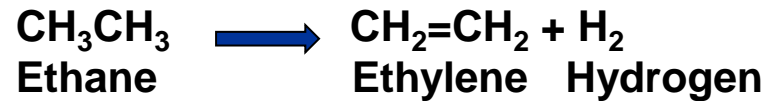
NGLs to Chemicals: Economic Screening: indicates opportunity



Ethane Chain – Ethylene

Ethane Steam Cracking – Technology Overview

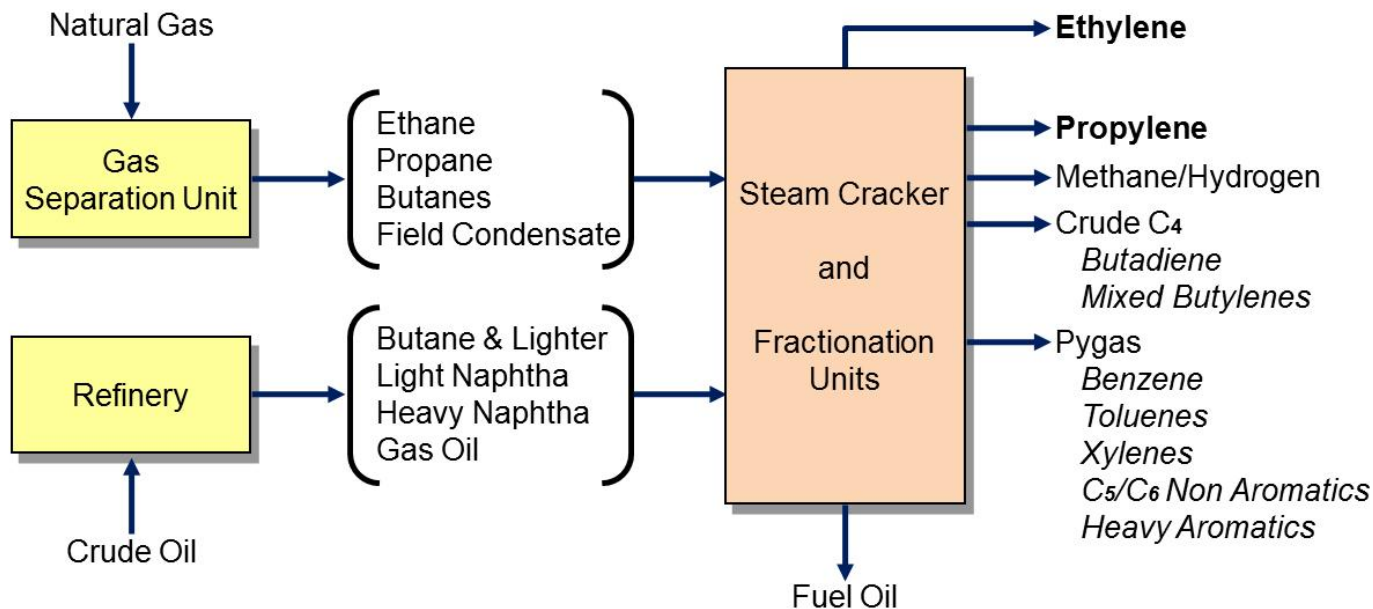
- Steam cracking is a non-catalytic thermal free radical cracking of hydrocarbons, including ethane to ethylene:



- Steam cracking, developed in the 1920's is the predominant commercial technology for ethylene (and propylene) production.
- Among the cracker feedstocks, ethane gives the highest ethylene yields and the smallest amounts of by-products, and affords lower capital cost.
- Hydrocarbon cracking is carried out in tubular reactors in direct-fired heaters (furnaces) operating in parallel.
- Capital cost for the technology is high; however, because it is based on multiple reactor trains, there is an opportunity for more linear reduction in capital cost.
- Steam cracking can be designed for ethane, ethane and propane, or ethane, propane and butane feed combinations.

Ethane Steam Cracking – Technology Overview

Generalized Steam Cracker Process Flow



Ethane Steam Cracking – Technology Overview

- Hydrocarbon cracking or pyrolysis is carried out in tubular reactors in direct-fired heaters (furnaces) in the presence of steam.
- A number of furnaces operating in parallel are normally used. The number of furnaces required depends on the capacity of the plant and the capacity of the individual furnaces.
- After pyrolysis, the cracked gas is immediately quenched to stop the pyrolysis reactions and to recover the sensible heat in the gas by generating high pressure steam.
- Product separation normally follows one of the following three sequences: front-end demethanization; front-end depropanization; front-end deethanization.

Ethane Steam Cracking – Recommendation

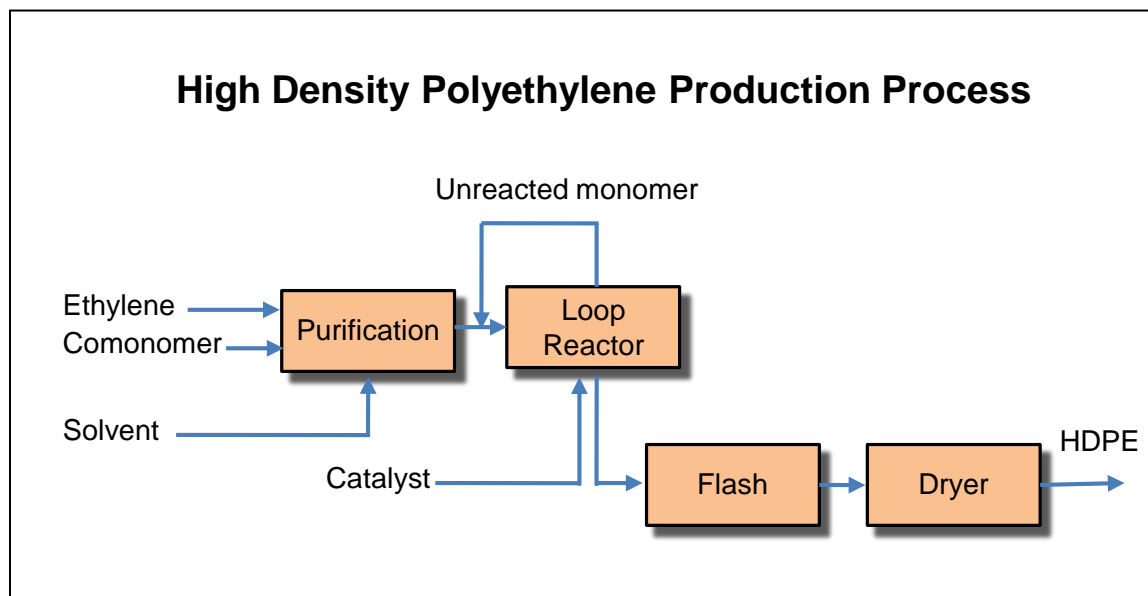
- Steam Cracking is commercially proven and can be licensed from several companies:
 - Linde
 - Lummus Technology
 - Technip
 - Shaw Group
 - KBR
 - Lurgi
 - Others
- All steam cracking technologies are relatively similar, except for the arrangement of the separation section.

High Density Polyethylene

High Density Polyethylene (HDPE) – technology overview

- HDPE homopolymer is made in the low pressure (solution, slurry and gas phase) processes by polymerizing ethylene, and HDPE copolymer is made by polymerizing an alpha olefin co-monomer (butene-1, hexene-1, or octene-1) with ethylene.
- The amount of co-monomer used determines the branching in the polymer chains, thus varying the density.
- As the density or crystallinity decreases in the homopolymer or copolymer, an improvement in impact resistance and flexibility occurs; but stiffness, chemical resistance, temperature range and resistance to water vapor permeation are diminished.
- Most HDPEs produced are copolymers.

High Density Polyethylene (HDPE) – Technology Overview



High Density Polyethylene (HDPE) – Recommendation

- HDPE technology is commercially proven and can be licensed from several companies.
- Solution-phase processes:
 - NOVA Sclairtech
 - Dow
 - DSM
 - SABIC SABTEC
- Bulk loop reactors:
 - LyondellBasell Spherilene

Ethylene Oxide & Monoethylene Glycol

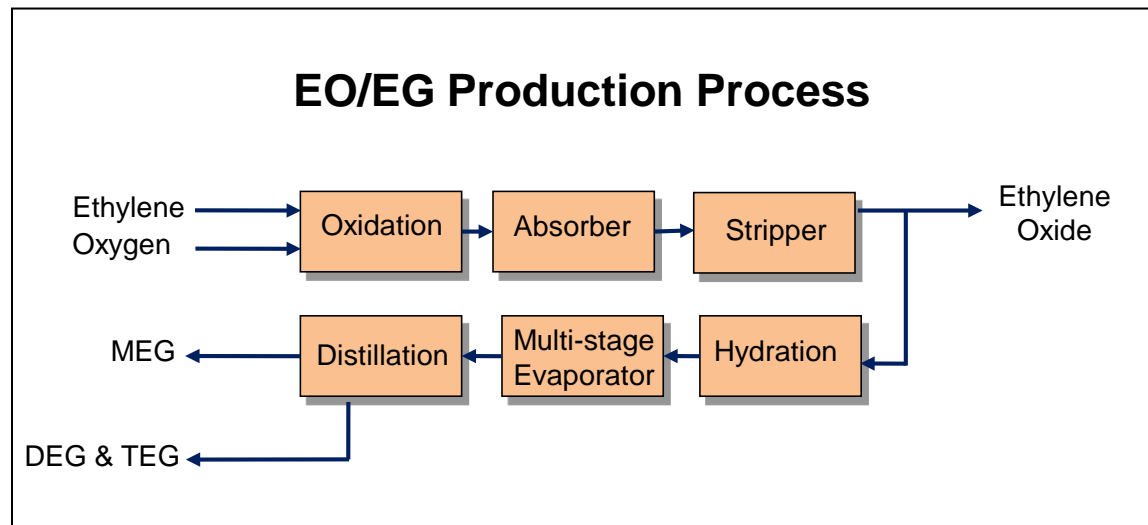
Ethylene Oxide/Monoethylene Glycol (EO/MEG) – Technology Overview

- Compressed oxygen, ethylene and recycled gas are mixed and fed to a multi-tubular catalytic reactor. Boiling water in the shell side of the reactor controls the reaction temperature.
- From the reactor, the effluent gases, which contain EO, are cooled and compressed. The cooling is accomplished by cross exchanging the reactor effluent with recycled gases.
- The cooled reactor effluent then passes to a scrubber where EO is absorbed as a dilute aqueous solution. Recycle gas is compressed and returned to the reactor, with a portion drawn off and diverted through a carbon dioxide removal system.
- Ethylene oxide is steam-stripped from the ethylene oxide-rich absorber bottoms and fed directly to an adjoining ethylene glycols unit or purified in a fractionation train for merchant sale as EO or consumption into other derivatives. Purification of EO is required before the product may be sold in the merchant market or used in the synthesis of other EO derivatives.

Ethylene Oxide/Monoethylene Glycol (EO/MEG) – Technology Overview

- In the ethylene glycol production process, ethylene oxide and make-up process water are mixed with recycled water in the feed tank and pumped through heat exchange to the hydration reactor.
- In the glycols reactor, there is typically no catalyst, but sufficient residence time is provided to react all of the ethylene oxide with excess water. A mixture of mono-, di- (DEG), tri- (TEG) and higher substituted glycols is produced and sent on to purification.
- The water-glycol mixture from the reactor is fed to the first stage of a multiple stage evaporator.
- The crude glycols solution from the final evaporation stage is then stripped of remaining water and light ends. The water-free glycols mixture is then fractionated in a series of vacuum distillation towers to produce purified monoethylene glycol and co-products, diethylene glycol (DEG) and triethylene glycol (TEG).

Ethylene Oxide/Monoethylene Glycol (EO/MEG) – Technology Overview



Ethylene Oxide/Monoethylene Glycol (EO/MEG) – Technology Overview

- EO/MEG technology is commercially proven and can be licensed from several companies:
 - Scientific Design
 - Dow
 - Shell Global Solutions

Propane Chain – Propylene

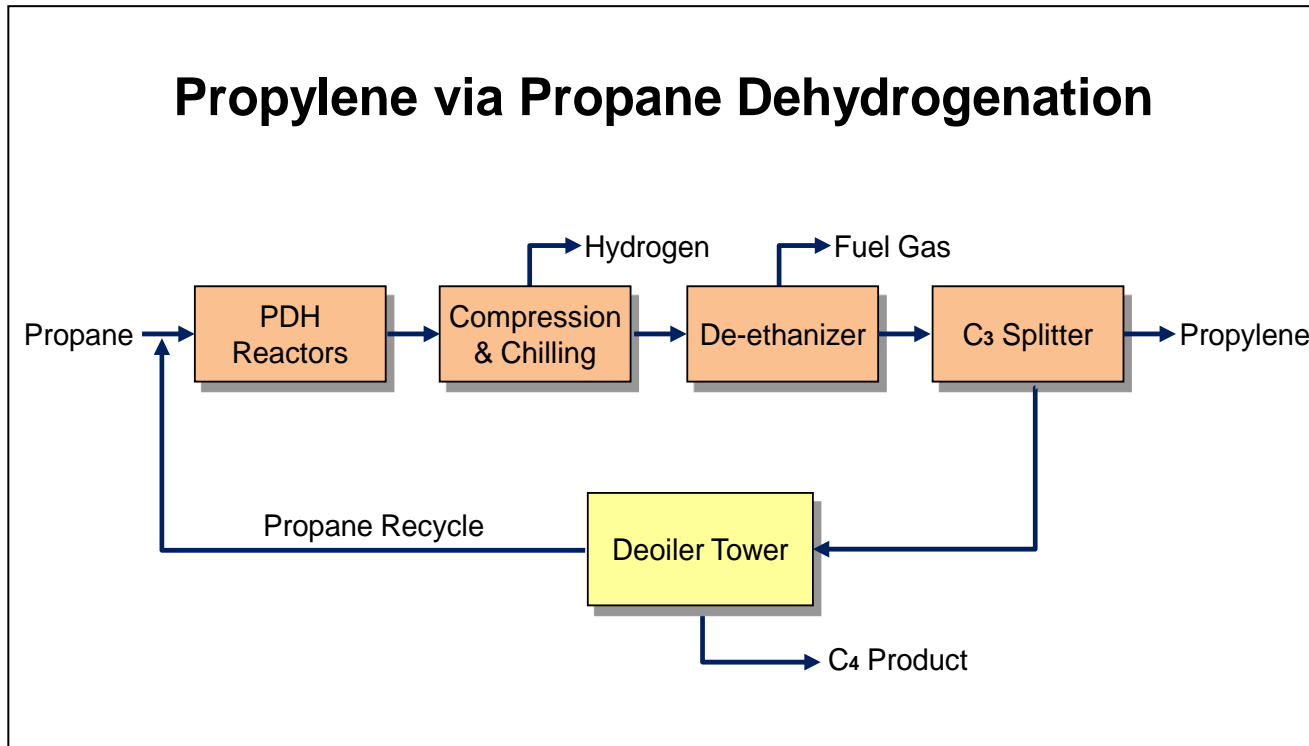
Propane Dehydrogenation – Technology Overview

- Propane dehydrogenation is an endothermic equilibrium reaction generally carried out in the presence of a noble- or heavy metal catalyst such as platinum or chromium.
- The following equation shows the propane dehydrogenation reaction:



- Alkane dehydrogenation for the production of olefins has been used since the 1930s.
- Since then commercial interest in propane dehydrogenation (PDH) has been increasing and numerous plants dedicated to the process are currently under construction outside the US (with one plant operating in the US).

Propane Dehydrogenation – Technology Overview



Propane Dehydrogenation – Technology Overview

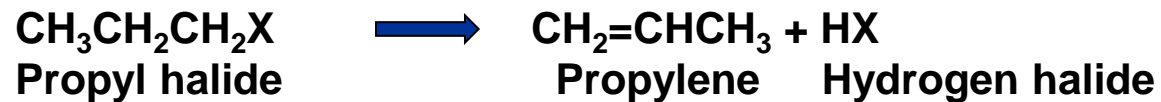
- In the reactors, fresh propane feed is combined with recycled propane and hydrocarbons reactions take place.
- In the compression section the reactor effluent gas is cooled and then compressed to a suitable level for the operation of the recovery section, which removes inert gases, hydrogen and light hydrocarbons from the compressed reactor effluent.
- The propylene, propane and heavier components are sent to the product purification section, which is designed to recover a high-purity polymer-grade propylene product from such propane and heavier material.
- Finally, propane is recycled to the reaction and the heavier material is purged.
- These technologies differ primarily in the type of catalyst and regeneration methods used; the design of the reactor; and the methods used to increase the conversion rate.
- The principal technologies are CATOFIN (Lummus) and Oleflex (UOP).

Propane Dehydrogenation – Recommendation

- PDH is commercially proven and can be licensed from five companies:
 - Oleflex™ from UOP
 - CATOFIN® from Lummus Technology
 - Fluidized Bed Dehydrogenation (FBD) from Snamprogetti/Yarsintez
 - STAR process® from Krupp Uhde
 - PDH from Linde/BASF
- All PDH technologies are similar, involving basically four sections:
 - Reaction
 - Compression
 - Recovery
 - Product purification

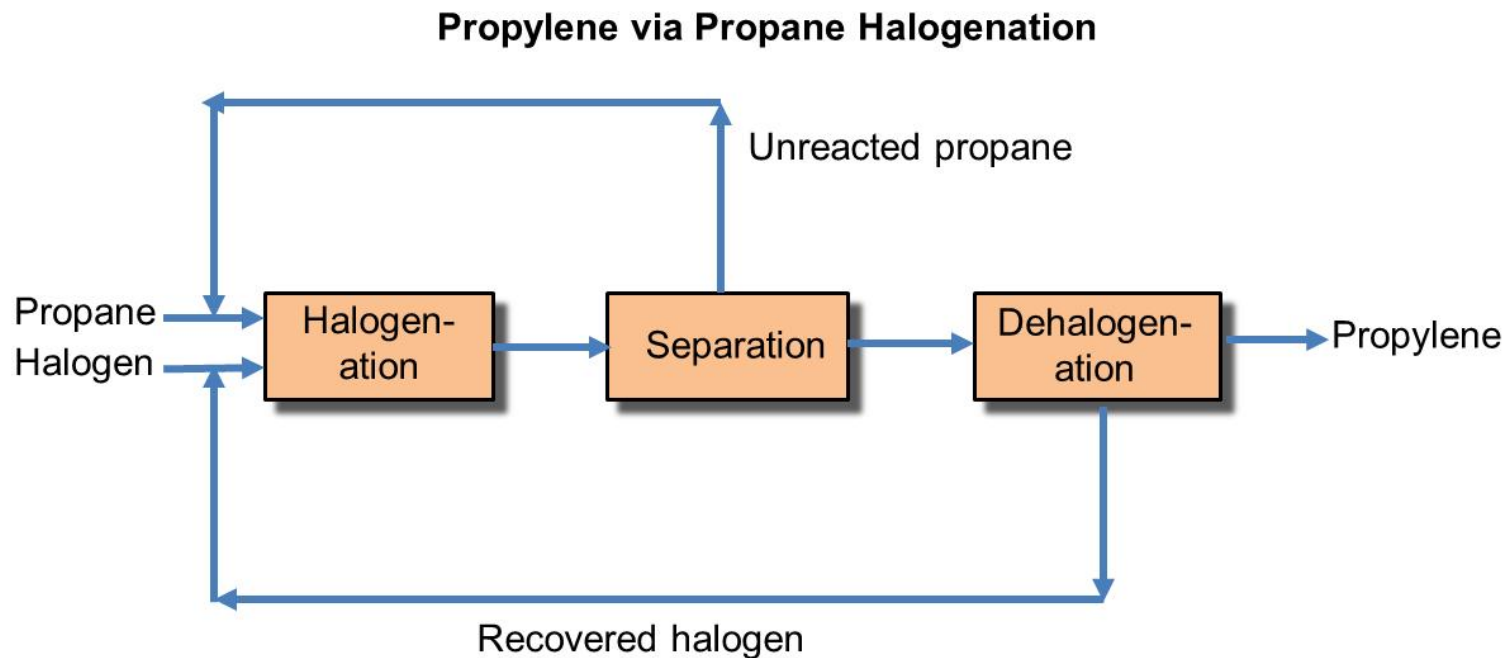
GRT Propane to Propylene via Halogenation – Technology Overview

- Propane is halogenated to a propyl halide, then de-halided to propylene:



- Regeneration and recovery of the halide is a critical step in respect to the economics of the process.
- Material handling (safety) and materials of construction (corrosion) are of critical importance.
- GRT, Inc was founded in 1999 as a privately held Delaware C corporation. GRT's main objective is to identify and develop technologies for natural gas conversion to higher value products.

GRT Propane to Propylene via Halogenation – Technology Overview



GRT Propane to Propylene via Halogenation – Technology Overview

- All non-commercial C1 operations have been piloted at scales ~ 1 liter per day.
- Integrated operation of methane-to-liquids process option in a demonstration facility with our strategic partner at scale > 200 gallons/day.
- Materials of construction suitable for commercial facilities identified and tested.
- Aromatic rich, high octane hydrocarbon product equivalent to lab-scale products produced in pilot.
- Capital cost estimates reviewed by Fluor.

GRT Propane to Propylene via Halogenation – Applicability

- The GRT route appears to offer an economical technology for the conversion of propane to a valuable commodity, propylene.
- The process route does include safety cautions from the presence of the halogen and associated acid, but there is commercial history of dealing with these issues.
- Each of the three reaction steps that comprise the GRT technology have been operated at lab, pilot and demonstration facility scales using methane as a feedstock. Both the halogenation and conversion steps have been successfully operated at the lab scale for all non-methane.
- From a commercialization perspective, GRT has been focused on the development of the propane to propylene (P2P) process, due to 1) the large spread between propane and propylene and 2) the interest GRT has received in this application from multiple potential partners.

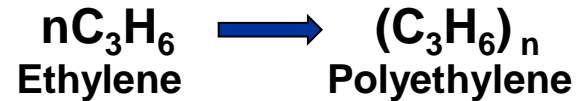
GRT Propane to Propylene via Halogenation – Recommendation

- Conclusion:
 - Though not commercialized, the technology is advanced sufficiently to warrant further consideration.

Polypropylene

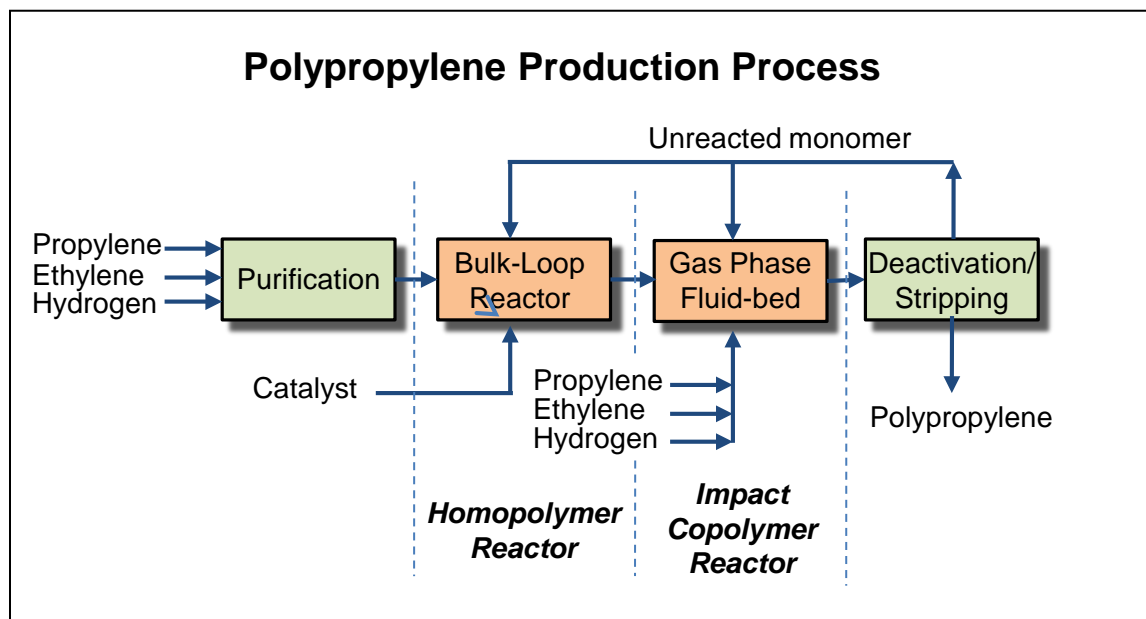
Polypropylene (PP) – Technology Overview

- The two processes primarily used to manufacture polypropylene are gas phase and bulk slurry in liquid propylene. In addition, there remain a few of older slurry process plants in operation that use a saturated liquid hydrocarbon as a reaction medium.



- Homopolymer and random copolymer are produced in the first reactor while block copolymers are formed in a second reactor; in series with the first reactor.
- The process is continuous and a single reactor is installed if only homopolymer and random copolymer products are desired.
- Ethylene is needed for making copolymers, either in the first reactor for random copolymers, or in the second reactor for impact copolymers.
- Hydrogen is used to control chain length and polymer structure. The powder gas separation and purge tower are used to remove un-reacted monomers from the resin. Recovered propylene is recycled back to the reactors.

Polypropylene (PP) – Technology Overview



Polypropylene (PP) – Technology Overview

- The bulk process combines the bulk slurry reactor for producing homo-polymers with the fluidized bed gas phase reactor for impact copolymers.
- Pre-polymerized catalyst is then injected into the polymerization loop reactors, along with fresh and recycled propylene and hydrogen.
- Two reactors in cascade configuration are typically used, as some applications of polypropylene, such as BOPP film, benefit from a bimodal molecular weight distribution. The polymer slurry is withdrawn from the second reactor and flashed into a high pressure degasser where the polypropylene homopolymer powder is separated from the liquid monomer.
- When making impact copolymers, the powder from the degasser, along with ethylene and additional propylene, are fed into the gas phase fluidized bed reactor.
- For higher impact copolymers, a second gas phase reactor may be used.

Polypropylene (PP) - Recommendation

- PP technology is commercially proven and can be licensed from several companies.
- Gas phase processes:
 - Dow Unipol
 - INEOS Innovene
 - LyondellBasell Spherizone
 - JPC Horizone
 - CBI Lummus Novolen

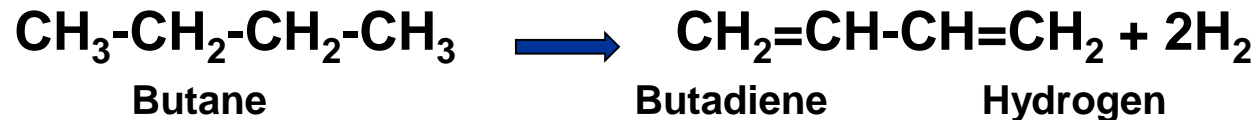
Polypropylene (PP) - Recommendation

- PP technology is commercially proven and can be licensed from several companies.
- Bulk loop processes:
 - Borealis Borstar
 - ExxonMobil PP
 - LyondellBasell Spheripol
 - Mitsui Hypol II

n-Butane Chain – Butadiene

n-Butane Dehydrogenation to Butadiene – Technology Overview

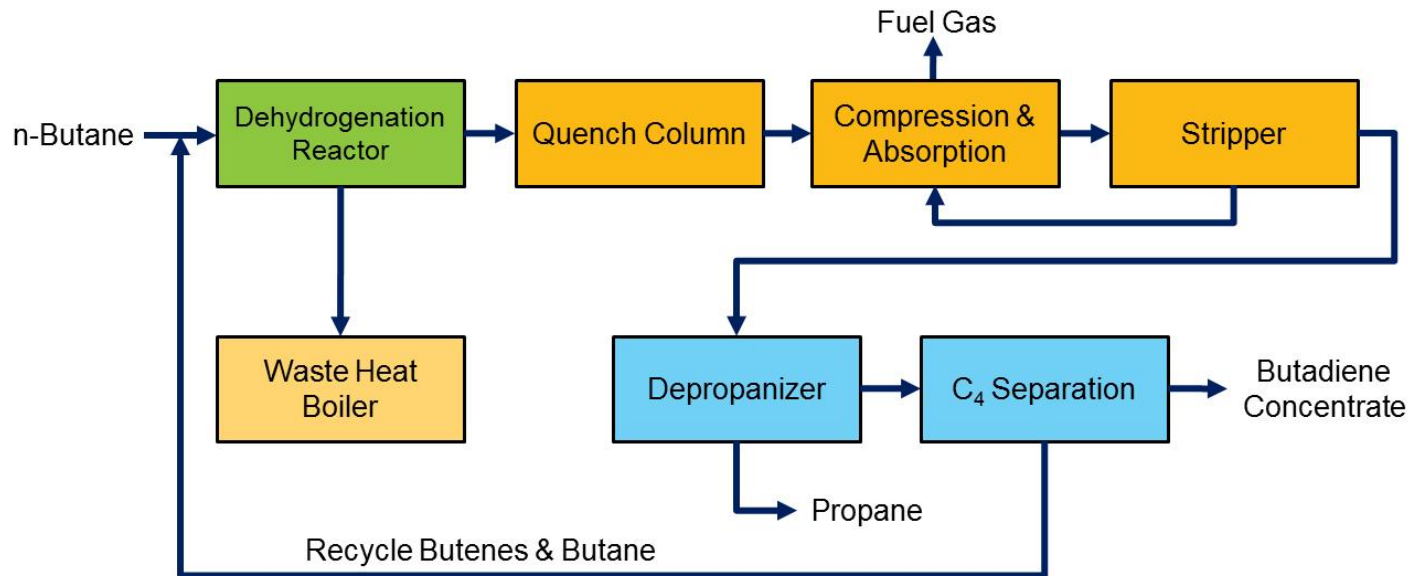
- n-Butane dehydrogenation to butadiene is a series of endothermic equilibrium reactions of n-butane to n-butenes to butadiene. Butenes are intermediates in the production of butadiene. Some butene may isomerize to isobutene and some may dimerize to octenes. In this process, some butane is cracked to propane, ethane and methane.
- The following equation shows the butane dehydrogenation reaction:



- The commercialization of butadiene production from n-butanenes began in the 1940s with the construction of dehydrogenation plants using the Houdry process.
- An improved Houdry butadiene process is now licensed by Lummus as the Catadiene® process.

n-Butane Dehydrogenation to Butadiene – Technology Overview

Butadiene via n-Butane Dehydrogenation



n-Butane Dehydrogenation to Butadiene – Technology Overview

- Feed stream with high concentration of n-butane is preheated to 600°C. A mixture of butenes, butadiene and gaseous by-products are produced in a single reaction step using chromium oxide (18–20 wt%) on activated alumina at 600 to 675°C, 15 to 70 kPa absolute.
- Once through conversion is 50 to 60%. After 5 to 10 minutes, depending upon the number of reactors, the reactor temperature drops by 15 to 20°C and the catalyst is regenerated for 5 to 10 minutes by controlled burning with preheated air. Three or more reactors are operated in parallel to achieve continuous operation.
- Reactor effluent is quenched, compressed and cooled. Cryogenic separation is used to remove the fuel gas. C3 and lighter products are distilled from the C4s. Butadiene is recovered from the mixed C4s by solvent extraction. Unconverted butenes and butanes are recycled to the feed preheat furnace.

n-Butane Dehydrogenation to Butadiene – Recommendation

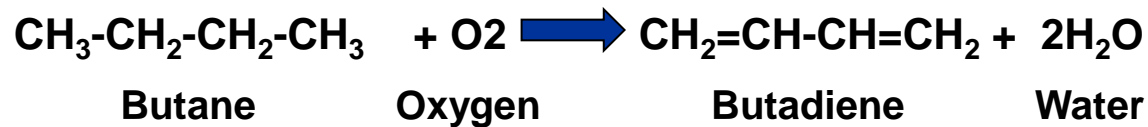
- Butane dehydrogenation to butadiene is commercially proven and can be licensed from Lummus Technology:
 - Catadiene® process
- On-purpose butadiene production currently only accounts for a small percentage of the total butadiene production in the world. About 95% of butadiene is currently produced as a by-product of ethylene steam cracking, using naphtha or gas oil feedstocks.
- However, ethylene crackers are switching to lighter feedstocks (butane and lighter) due to high oil prices and low natural gas prices which reduces the amount of butadiene available from ethylene cracking and presents a foreseeable market demand for on-purpose butadiene production.

n-Butane Oxo-Dehydrogenation to Butadiene – Technology Overview

- The Oxo-D process is by definition a oxidative catalytic dehydrogenation-based process.
- Accordingly, the conversion and the selectivity of the dehydrogenation of n-butenes to butadiene are significantly improved by removing the hydrogen from the equilibrium. The addition of oxygen causes the oxidation of hydrogen to water, thus accomplishing that.
- The advantages of the Oxo-D process include:
 - Low steam consumption
 - Low fuel consumption
 - High per pass conversion
 - High 1,3-butadiene selectivity
 - Long catalyst life (less coking)

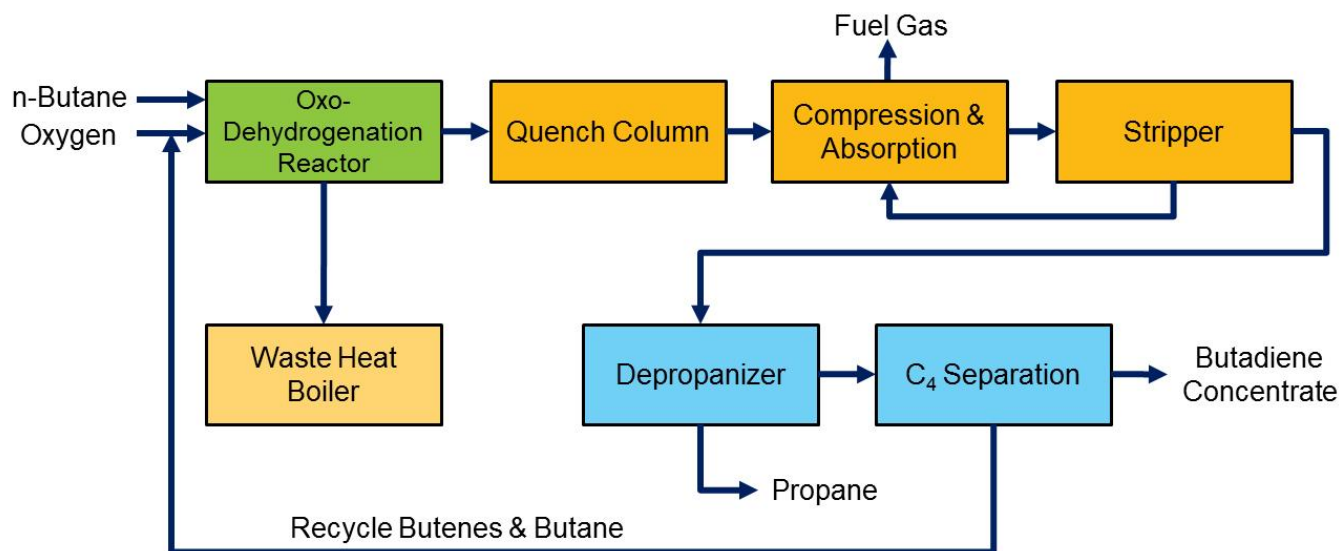
n-Butane Oxo-Dehydrogenation to Butadiene – Technology Overview

- Catalyst is auto-regenerated (no separate regeneration required)
- The key to the process' success is low energy consumption
- The following equation shows the butane oxo-dehydrogenation reaction:



n-Butane Oxo-Dehydrogenation to Butadiene – Technology Overview

Butadiene via n-Butane Oxo-Dehydrogenation



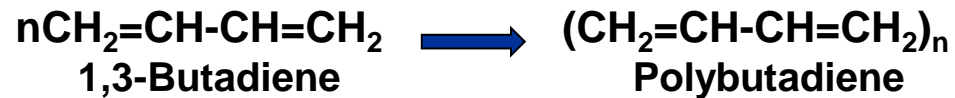
n-Butane Oxo-Dehydrogenation to Butadiene – Recommendation

- Butane dehydrogenation to butadiene is commercially proven and may be licensed from TPC; though it may have to be acquired as part of a joint venture.
- There were six BD units built in the early-mid 1980's that utilize Chinese butylene oxidative dehydrogenation technology.
- There are 2 Chinese butylene oxidative dehydrogenation technology licensors:
 - QPEC, the licensor with most updated and active on-purpose BD technology
 - Lanzhou Institute of Chemical Physics of the Chinese Academy of Sciences

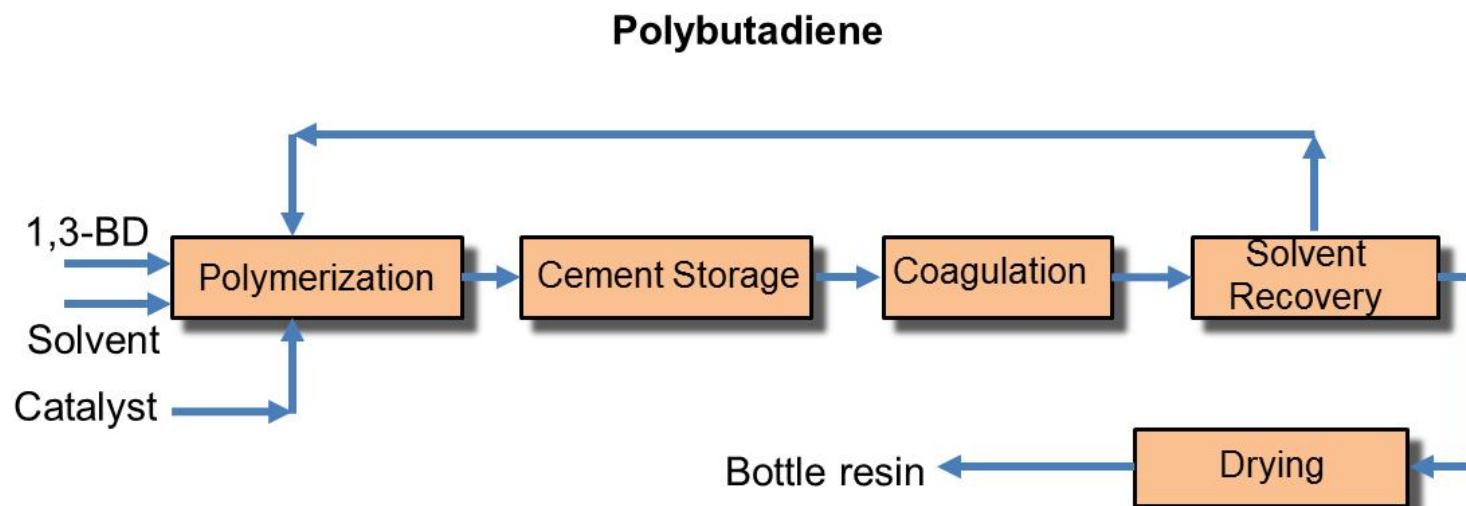
Polybutadiene Rubber

Polybutadiene Rubber – Technology Overview

- Polybutadiene is produced by the polymerization of butadiene monomer, using either solution or emulsion polymerization processes. Most commercial production employs solution polymerization.
- In the commercial production of polybutadiene elastomers, the isomer composition of the final product depends on several factors, the most important of which are the catalyst system and the reaction medium (solution or emulsion polymerization).
- Several catalyst systems are used in the production of polybutadiene elastomers and yield varying percentages of the cis-1,4; trans-1,4; and vinyl 1,2 microstructures.
- The following equation shows the butane dehydrogenation reaction:



Polybutadiene Rubber – Technology Overview



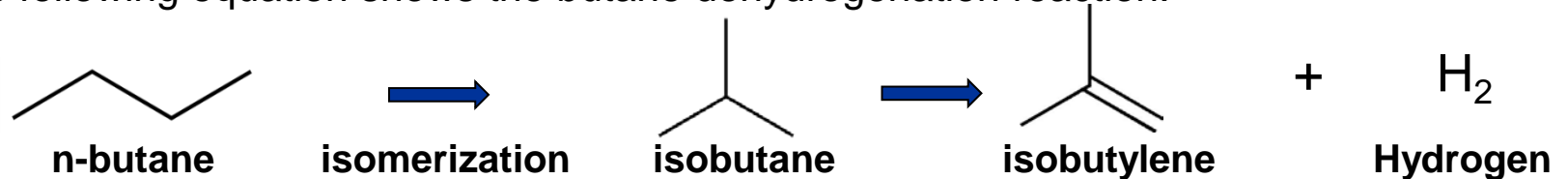
Polybutadiene Rubber – Recommendation

- PBR technology is commercially proven and can be licensed from several licensors
 - Zeon
 - ENI

n-Butane Chain – Butylenes

n-Butane Dehydrogenation to Butylenes – Technology Overview

- The dehydrogenation of butanes to isobutylenes is a highly endothermic reaction typically carried out in the gas phase over a solid catalyst.
- The following equation shows the butane dehydrogenation reaction:



- Alkane dehydrogenation for the production of olefins has been used since the 1930s.
- Butane dehydrogenation to isobutylene is very similar to the propane dehydrogenation to propylene. PDH technologies apply to butane dehydrogenation to butylene.

n-Butane Dehydrogenation to Butylenes - Recommendation

- BDH is commercially proven and can be licensed from:
 - Oleflex™ from UOP
 - CATOFIN® from Lummus Technology
 - Fluidized Bed Dehydrogenation (FBD) from Snamprogetti/Yarsintez
 - STAR process® from Krupp Uhde
- Butane Dehydro to Butylene is frequently combined with other processes to achieve a higher end product value.
- Many Butane Dehydrogenation to Butylene plants are built in combination with Isobutylene to MTBE process. Most plants are between 100-500 KTPA.

GRT Butane to Butylene via Halogenation – Applicability

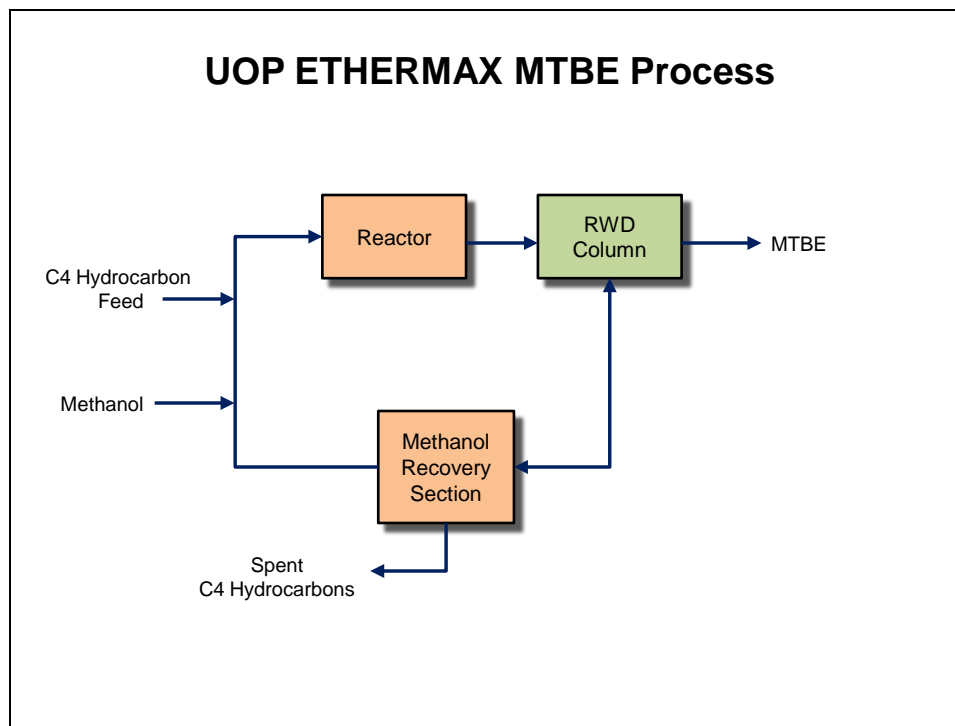
- The progress and status of the GRT technology is discussed in the propane section of this report.
- The technology conceptually shows significant potential to pursue further.
- Butylene currently does not have as much commercial interest as Propylene and the process should be considered to be 6 months behind in the paths to commercialization. Further halogenation to butadiene is of greater commercial interest but should be considered at least 2 years behind in the path to commercialization.

iso-Butane Chain – MTBE

Isobutane to MTBE – Technology Overview

- There are currently several commercial processes for MTBE production. These processes differ in detail; however, all of them produce MTBE by reacting isobutylene with methanol in the presence of a catalyst such as a styrene-divinyl benzene copolymer cationic ion exchange resin. The isobutylene used to manufacture MTBE comes largely from four sources:
 - Isolation from refinery or steam cracking streams.
 - By-product of propylene oxide (PO) production (often via intermediate coproduct tertiary-butyl alcohol).
 - Dehydrogenation of butanes (usually isobutane; n-butane also requires isomerization). Butanes can be obtained either from natural gas or from refinery operations.
 - Isomerization of normal butylenes.

Isobutane to MTBE – Technology Overview



Isobutane to MTBE – Technology Overview

- Designs vary depending on product specifications, conversion rates, MTBE purity and residual C4 stream composition.
- Isobutylene conversion can be increased by adding reactor stages with lower operating temperatures and stronger catalysts. Reactors are usually interstage-cooled and packed (most common), although water-cooled tubular or suspended-catalyst liquid-phase reactors can be used.
- The mixture exiting from the reactors is sent to a purification column where methanol-free C4 effluents are obtained by water-washing the column overhead stream.
- The bottom product has a typical MTBE concentration of 96-99% by weight. Further distillation can achieve MTBE purity levels of 99.9%.

Isobutane to MTBE - Recommendation

- MTBE technology is commercially proven and can be licensed from several companies:
 - CDTech
 - IFP
 - KBR
 - LyondellBasell
 - Snamprogetti
 - UOP



Price and Economic Forecast Methodology

- ❖ *Price Forecasting Methodology*
- ❖ *Capital Cost Estimates (CAPEX) Basis*

Price Forecasting Methodology

Price Forecast Methodology

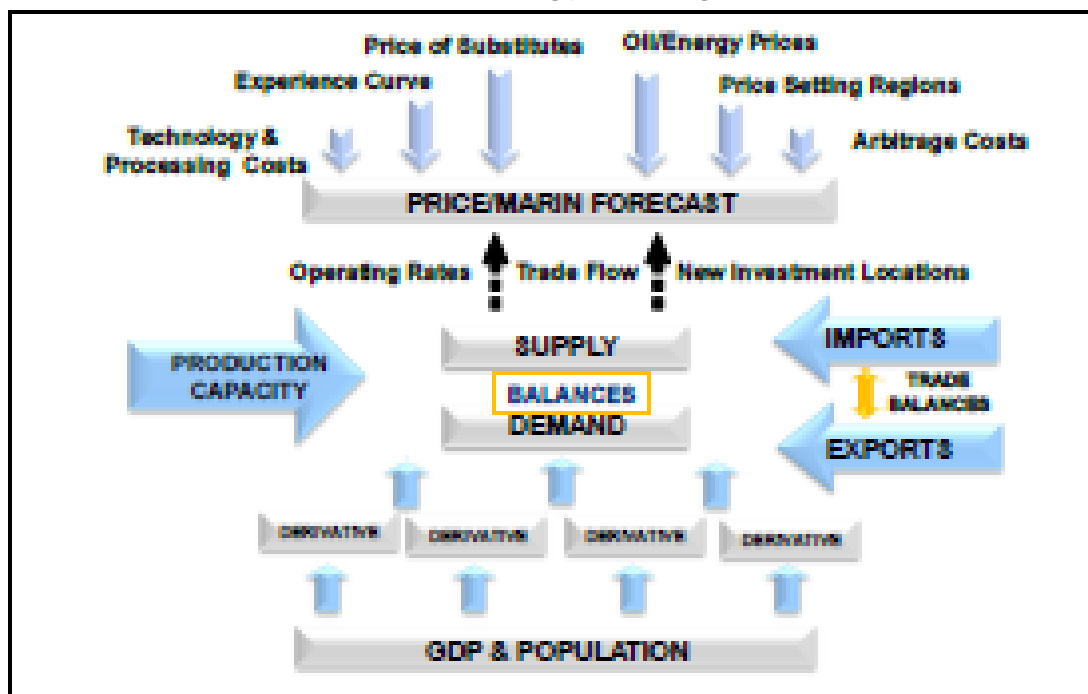
- Over the long term, international commodity petrochemical prices are ultimately a function of production costs plus some level of profitability for the high cost producer. Three elements are therefore necessary to generate a price forecast. The first is to calculate a production cost forecast, the second a margin/profitability forecast and the third, to insure price linkages between regions, a forecast of trade patterns and freight cost.
- To generate a forecast of production costs one must generate a forecast of feedstock cost and, in most cases, these feedstock are either other petrochemicals or petrochemical feedstock, such as naphtha, propane and ethane. It is therefore necessary to generate a price forecast for the feedstock first that is related to basic energy values. Yet petrochemical demand, ethylene consumption of natural gas liquids in particular, can impact the feedstock price forecast. As a result, some iteration is required.
- Supply/demand balances are used to generate the forecast of margins and profitability. High operating rates lead to good margins and low operating rates lead to poor margins. Historic trends are used to derive these forecasts. For the short-term, competitive cash cost curves set the floor prices on both a world and regional basis. In the long-term price forecast, an understanding of supply and investment economics is essential.

Price Forecast Methodology (continued)

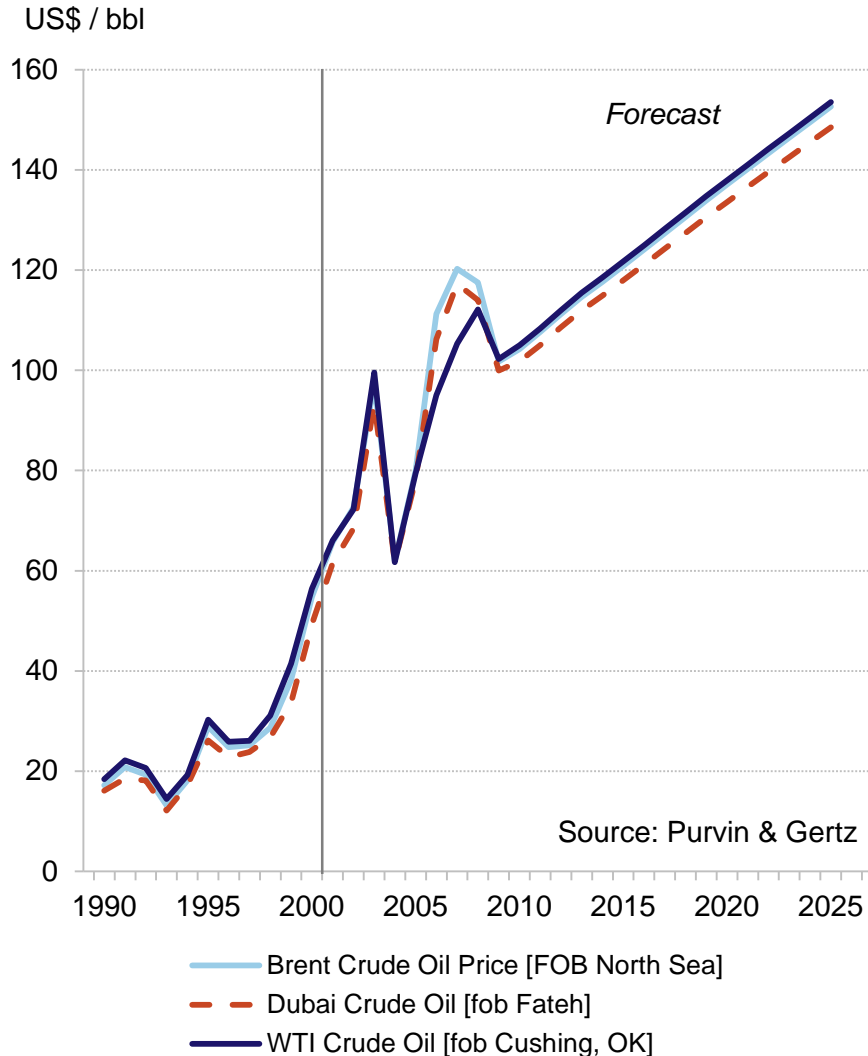
- IHS consultants employ several different price forecasting methodologies depending on the timeframe in question.
- **Short Term** - Defined as the period inside two years, the consultant is looking carefully at current pricing in the regions, inventory levels, momentum, maintenance outage schedules and other market-oriented indicators. IHS consultants will review the month-by-month energy prices and adjust their short-term petrochemical forecasts accordingly.
- **Mid Term** - IHS considers the mid-term to be the next petrochemical pricing cycle. This of course differs from product to product, thus the length of this term differs. Price forecasting within this mid-term is done by examining the factors used in the short term, but more emphasis is placed on the supply and demand fundamentals and the underlying cost structure of production. Within the mid-term consultants will also use historical data to apply the appropriate margin levels to the cost of production. These margins are a function of the supply and demand balances as well as an understanding of how these markets behave in different parts of the cycle. Changes in energy costs will flow through and affect these prices.

Price Forecast Methodology (continued)

- Long Term** - The long term is the segment of the price forecast most obviously impacted by the underlying energy price change. After a complete price cycle, the product prices are forecasted on a trend basis. The cost of production for the price setting technology is examined regionally. To this cost a margin is added to derive a market price. The margin is determined by examining the returns on investment necessary to entice new construction without making them so attractive as to encourage overbuilding. It is within this long-term segment where the true effect of a base energy change is seen on petrochemical pricing.



Crude Oil Price Forecast



- With the Middle East unrest, declining production from the North Sea and production gains in North America, the global benchmarks in oil prices began to diverge.
- West Texas Intermediate (WTI) and Brent crudes historically traded in tandem with one another, with WTI representing the Western market and Brent representing the markets in the rest of the world. The spread between the two benchmarks reached record levels in 2011, frequently trading above \$20 per barrel in favor of Brent. This resulting dynamic has enabled a decoupling of WTI from the rest of the world.
- Prices are high enough to encourage additional investment in drilling in higher cost locations, including ultra deep water. These underlying factors lead to a forecast of moderating crude oil prices through 2012, coupled with a narrowing of the Brent-WTI spread by 2014, then followed by increasing prices toward the middle of the decade once global supply begins to tighten in the face of higher demand from developing countries.

Capital Cost Estimates (CAPEX) Basis

Capital Cost Components for a Petrochemical Project

- ISBL – Inside Battery Limits. This is the cost to engineer, procure, and construct on plot plant and equipment to the extent that the ISBL unit is ready to commission. ISBL estimates typically include:
 - Equipment cost
 - Direct installation
 - Indirect costs
- OSBL – Outside Battery Limits. This is the cost to engineer, procure, and construct plant and equipment required within a complex to support the ISBL unit. This would include storage facilities, administrative building, roads, connecting piping, utility systems like steam and electricity within the complex.
- Owners Costs – These include costs outside of a complex such as pipelines, tanks, railroad track connections, etc. that would be required to service a facility. For purpose of this project, we have estimated 10 percent of ISBL and OSBL. Owners cost also includes license fees and startup and commissioning costs.

AACE⁽¹⁾ Cost Classification Matrix - Sets the Standard Definition for Capital Cost Estimates

ESTIMATE CLASS	Primary Characteristic	Secondary Characteristic			
	LEVEL OF PROJECT DEFINITION Expressed as % of complete definition	END USAGE Typical purpose of estimate	METHODOLOGY Typical estimating method	EXPECTED ACCURACY RANGE Typical variation in low and high ranges	PREPARATION EFFORT Typical degree of effort relative to least cost index of 1
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Feasibility	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid/Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	5 to 100

(1) Association for the Advancement of Cost Engineering International

ISBL Capital Costs Were Estimated From IHS Databases

- IHS has an extensive capital cost database for major commodity and specialty chemicals and polymers developed from our SRI legacy program, PEP.
- IHS also solicits capital cost information from technology licensors and developers where available.
- This capability is built on former CMAI and SRIC technology and engineering expertise and IHS' SRIC PEP (Process Economics Program) methodology; one based on process simulation, development of heat and material balances and equipment sizing and pricing for capital cost development.
- IHS Tools
 - ASPEN
 - PEPCOST: Computer Program for Estimating Plant Investment
 - PEPCOST II is a computer program to estimate chemical plant investment and production costs. It is meant primarily for preliminary studies of alternative processes on a relative basis. The input to the program requires material and energy balances and sizing of the major process equipment items. The output includes:
 - Equipment f.o.b. and direct installation costs
 - Battery limits and off-sites investment
 - Production costs Master list of equipment and utilities requirements
- The IHS CERA Capital Costs Analysis which is applied to all petrochemical plants for estimation of representative replacement capital cost and capital cost based fixed costs.

Capital Cost is Made Up of Specific Components

- Direct Installation Cost includes bulk material and bulk labor:
 - Bulk Material:
 - Building housing process units
 - Process and utility pipes and supports within the major process areas
 - Instruments, including computer control systems
 - Electrical wires and hardware
 - Foundations and pads
 - Structures and platforms
 - Insulation
 - Paint/corrosion protection
 - Bulk Labor: the Construction Labor associated with construction of the plant:
 - Structural, piping, equipment mounting, electrical, instrumentation, etc.

Capital Cost is Made Up of Specific Components

- Indirect Costs:
 - Indirect Costs are costs that are not directly accountable to the plant installation
 - Indirect Costs may be either fixed or variable
 - Indirect costs include administration, personnel and security costs
 - These are those costs which are not directly related to production. Some indirect costs may be overhead. But some overhead costs can be directly attributed to a project and are direct costs.
- Indirect Costs include:
 - Prorateable Costs
 - Fringe Benefits
 - Burdens
 - Insurance
 - Field Expenses
 - Consumables
 - Small Tools
 - Equipment Rental
 - Field Services
 - Temporary Const. Fac.
 - Field Constr. Supervision
 - Home Office Costs + Fee (EPC)
 - Engineering + Incidentals
 - Purchasing
 - Construction Management

OSBL Capital Costs Cannot be Accurately Estimated Without a Site Survey

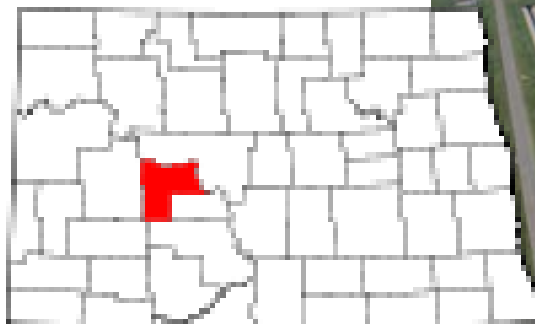
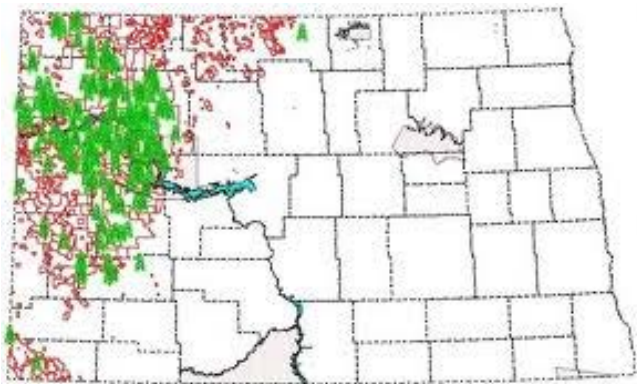
- OSBL capital cost is very dependent upon the site condition:
 - Greenfield
 - Developed
 - Shared with other chemical plants
- Typical OSBL Equipment
 - Tank farm + secondary containment berms
 - Cooling water piping systems
 - Converting raw water to process water
 - Sanitary waste treatment systems
 - Boiler feed water preparation and steam boiler system
 - Fuel gas networks for fired heaters
 - Inert gas and instrument air
 - Hot oil and refrigeration package systems
 - Back-up power generation

OSBL Capital Cost is Typically Estimated as a Greenfield (“Grassroots”) Installation as Part of a Desktop Study

- The Greenfield status is considered reasonably conservative in that existing or shared services are not assumed, which would lower the OSBL capital cost
- In actual fact, there is opportunity to take advantage of existing infrastructure and site development in North Dakota, suitable for a petrochemical plant operation
- Basin Electric, through its for-profit subsidiary, Dakota Gasification Company (Dakota Gas), owns and operates the Great Plains Synfuels Plant (Synfuels Plant).
- The Synfuels Plant is the only commercial-scale coal gasification plant in the country that manufactures natural gas.
- Located five miles northwest of Beulah, ND, the Synfuels Plant has been owned and operated by Dakota Gas since 1988. It is also the cleanest energy plant operating in the state of North Dakota, according to a comparison of emissions data available from the North Dakota Department of Health.
- Basin Electric's Antelope Valley Station, a lignite-based electric generating station, is located adjacent to the Synfuels Plant
- The two plants share resources such as fuel supply and site access along with water intake, delivery and storage facilities. Water for the facilities comes from Lake Sakakawea nine miles north of the energy site

This heavy industrial site near by Beulah is in close proximity to the Williston Basin fields

Williston Basin



Beulah, ND, the Synfuels Plant



The Beulah, ND Site Affords the Capability for Minimizing OSBL Capital

- Due to the nature of the installation at Beulah, one can assume that a petrochemical complex installed at or near the existing site would make available OSBL components that would be existing or obtainable with lower capital expenditure, such as:
 - Site preparation
 - Roads
 - Rail ties
 - Site security (fire department, fencing, etc.)
 - Medical facilities and staff
 - Warehousing
 - Power grid
 - Waste treatment
 - Utility generation
- It should be noted that the existence of usable services, such as utility generation and warehousing, will have to be investigated for applicability and usable capacity, but the existence of the site will certainly minimize costs for site development and access

The Capital Cost for a North Dakota Site is Adjusted for by a Location Factor

- A location factor is an instantaneous, total cost factor for converting a base project cost from one geographic location to another.
- IHS' TIP program developed a rigorous and reliable methodology for calculating location factors for the regions under consideration.
- IHS' location factor takes into consideration the differences in cost for labor and productivity, duties, taxes and freight over imported material, and the relative cost of domestic (ND) equipment based on the differences of steel prices and labor requirement for the manufacturing of such equipment.
- The factors also include differences in local business environments, availability of nearby sources of spare materials and local currency fluctuations (irrelevant in this analysis).
- The overall factor for ND is analyzed is a multiplier relative to the base project cost.
- The final factor is determined by four major indexes: Material (composed of both imported (USGC) and domestic (ND) materials), Labor, Spares and Business Environment. The cost distribution between the material index and the labor index in the base location is determined using technology-specific construction cost data and the distribution for the other locations are calculated based on their respective indexes. Factors for spares and business environment apply as overall multipliers.

ISBL and OSBL Capital Costs are Typically Estimated for the US Gulf Coast (USGC)

- The USGC is the center of the petrochemical and Home Office expense/EPC (engineering, procurement and construction) industries in the US.
- Capital costs can typically be expected to be higher outside the Gulf area:
 - Longer delivery distances for equipment
 - Potentially higher labor costs (definitely higher for North Dakota)
 - The added cost of winterization for equipment and bulk materials
 - Higher field expenses for the less developed sites
- Cost components that would not necessarily be expected to change relative to the USGC include:
 - Home Office costs; EPC services are global and do not vary by plant location
 - Contingency; a percentage of Direct Installed cost
 - Escalation; a national value, not dependent upon specific location

IHS Developed a North Dakota Location Factor (relative to USGC) using Two Methods

- Method 1: Developed as part of CMAI TIP Program:
 - Method 1 applies ND off-set factors (relative to the USGC) to high level in-state (domestic) and out-of-state (imported) materials and business conditions/status.
 - The methodology applies 14% higher labor rate to all applicable categories
 - The overall Location Factor is 12% relative to USGC.
- Method 2: Developed from adjustment of CAPEX components:
 - Method 2 applies ND off-set factors (relative to the USGC) to the accepted cost buildup criteria.
 - The methodology applies 14% higher labor rate to all applicable categories
 - The methodology applies 9% higher labor rate to all applicable categories.

	USGC	ND	Comments
Labor Index	1	1.14	Based on construction wages
Material Index	1	1	
domestic	1	1.03	
% domestic	100%	0%	
imported	1	1.03	
% imported	0%	100%	For the evaluation, imported into ND
Material/Labor Distribution in TFI			
labor	30%	30%	typical US distribution
material	70%	70%	
Spare Factor	1	1.005	Higher for ND to account for delay in accessing replacement equipment compared to USGC
Business Environmental Factor	1	1.05	Higher degree of site preparation
Location Factor	1.00	1.12	12% higher capital cost for ND

categories			ND adjustment	comments
equipment	18.8	19.3	+3%	higher cost then USGC for freighting
bulk materials	20.7	22.0	+6%	higher cost then USGC for freighting + winterization
bulk labor	18.1	20.6	+14%	higher labor cost
Direct Installed Cost	57.6	61.9		
proratable costs	6.3	7.2	+14%	higher labor cost
field expenses	6.0	9.1	+50%	higher labor cost + more involved setup
home office	16.4	16.4	0	
contingency	11.0	11.9	0	
escalation	2.6	2.8	0	
Total ISBL	100.0	109.3		



Financial Analysis

- ❖ *NGL Price in North Dakota*
- ❖ *Raw Material/Product Prices*
- ❖ *Mass Balance*
- ❖ *Cash Flow Model Assumptions (NGL)*
- ❖ *Cash Flow Model Results (NGL)*

The Risks to a Project's Results Can Come From Numerous Sources and Causes

Typical risks include:

- Catastrophic event risk
- Engineering risk
- Completion risk
- Technology risk
- Supply risk
- Market risk
- Infrastructure risk
- Participant risk
- Political risk
- Bankruptcy risk
- Foreign Exchange risk
- Operating risk
- Environmental risk
- Infrastructure risk
- Force Majeure risk
- Interest rate risk
- Syndication risk
- Legal risk
- Sovereign / national risk
- Documentation risk

An accounting approach is fundamental, but the most common investment decisions result in a different emphases as to the most relevant financial measures and performance indicators:

- For Project Investment and Project Finance: Project profitability measures and debt coverage ratios:
- For M&A transactions: Transaction price/EBITDA and debt coverage ratios.
- For investing in common stock (minority owners, i.e. in publicly traded stock markets): Price/earning, and Price/Free Cash Flow ratios.

The Most Common Project Financial Measures are Probably the Following:

- Net Present Value (“NPV”) of the Project Cash Flows
 - Definition: The present value of the total cash flows (both negative during the investment phase, and positive (hopefully) during the operational phase. The net present value at the “hurdle rate” should be a positive and substantial value for the investment to be truly attractive on a financial basis.
- Internal Rate of Return (“IRR”) for the project investment and operating cash flows
 - Definition: The discount rate that when applied to each year’s cash flows, result in a net present value of precisely zero. (Note: The logic of the IRR calculation implicitly assumes that positive cash flows during operations are reinvested at the IRR rate of return.)
- Debt coverage ratios
 - Interest coverage ratios
 - Total debt service coverage ratios
 - Fixed Charges coverage ratios
- Cash Flow volatility (sensitivities on key metrics e.g., feedstock and product prices, capital investment and infrastructure cost, operating rates, debt service and financial incentives, etc.)

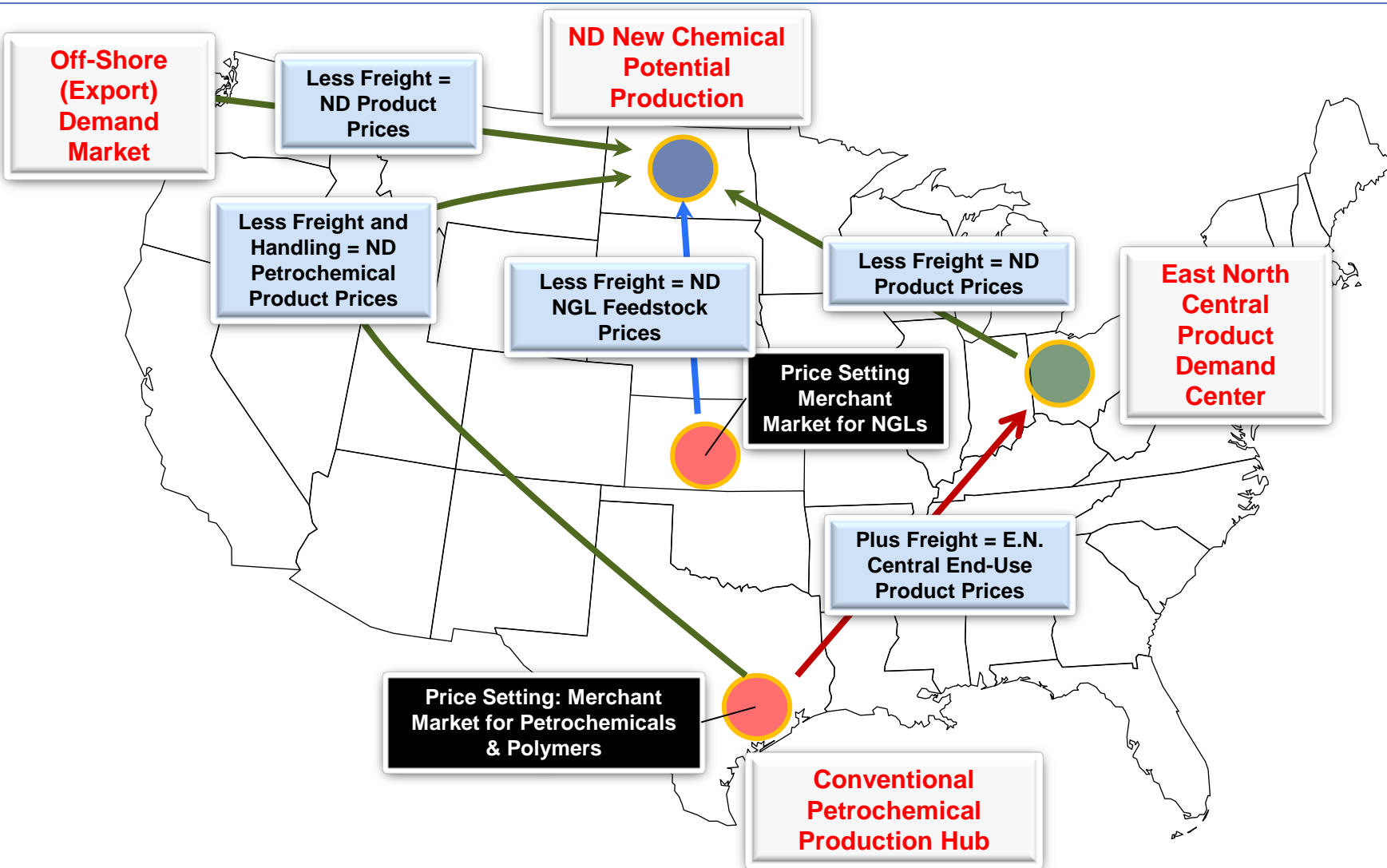
NGL Price in North Dakota

North Dakota Netback Prices

- Ethane to become more valuable post 2017 and go above break even costs once petrochemical plants come on line.
- Propane prices will continue to rise as U.S. LPG exports balance off the increased U.S. production due to shale gas development.
- Butane prices will also benefit from the ability of LPG exporters to balance the market with exports.
- Condensate will continue to be a valuable commodity to the Canadian Heavy Oil producers in Alberta as diluent.

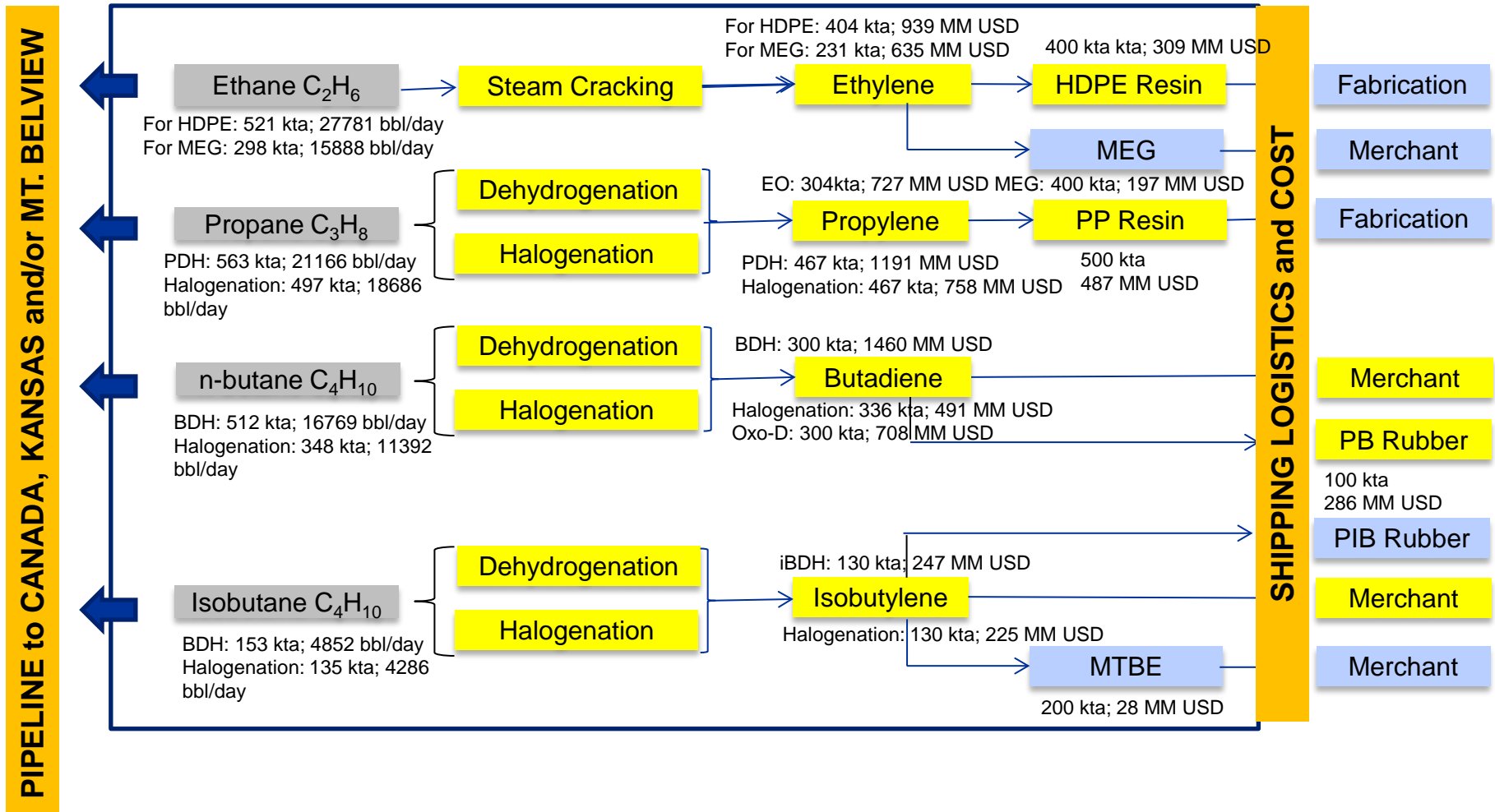
Raw Material/Product Prices

Product and Feedstock Prices Setting Mechanisms for North Dakota



Mass Balance

NGLs to Chemicals: Economic Screening: indicates opportunity



NGLs to Chemicals: Capacity and Capital Costs – North Dakota - 2020 Basis

NGL - Feed Requirements		
	KMT	Bbl/day
Ethane Feed - HDPE	520.90	27781
Ethane Feed - MEG	297.90	15888
Propane Feed - PDH	563.30	21166
Propane Feed - Halogenation	497.30	18686
n-Butane Feed - BDH	512.40	16769
n-Butane Feed - Halogenation	348.10	11392
i-butane - BDH	152.50	4852
i-butane - Halogenation	134.70	4286
NGL		
	Capacity, kMT	Capital, USMM\$
Ethane Cracker - HDPE	404.00	939.00
Ethane Cracker - MEG	231.00	635.00
HDPE	400.00	309.00
EO	304.00	727.00
MEG	400.00	197.00
Propane Dehydrogenation (PDH)	467.00	1191.00
Propane Halogenation	467.00	758.00
Polypropylene ICP	500.00	487.00
n-Butane Dehydrogenation (BDH)	300.00	1460.00
n-Butane Halogenation	336.00	491.00
Oxo-D	300.00	708.00
Polybutadiene (PBR)	100.00	286.00
Isobutane Dehydrogenation	130.00	247.00
Isobutane Halogenation	130.00	225.00
MTBE via Isobutylene	200.00	28.00

Cash Flow Model Assumptions (NGL)

Cash Flow Model Assumptions

- Project start-up year and operating period
 - Plant start up is assumed to be in 2020 with a three year construction period starting 2017
 - The first year is assumed to have an operating rate of 50%
 - The operating period for the cash flow model is assumed to be 15 years (ending in 2035)
- Capital spending schedule
 - Year 1: 2014 10%
 - Year 2: 2015 40%
 - Year 3: 2016 40%
 - Year 4: 2017 10%
- Depreciation
 - A 15 year term for depreciation is assumed
 - A straight line method is assumed
- Income Tax:
 - US: 35%

Cash Flow Model Assumptions

- Debt/Equity ratio assumed to be 70%
- Repayment period: 10 years
- Repayment scheme: Assume straight line principal repayment
- Interest rate is 6.5%
- Working capital
 - Inventory should match storage, cash at 7 days, and market at 30 days
- Build cash flow for each process unit
- Total cash flow is the sum of all process units

Model Setup

- For integrated units, prices are transferred from one unit to another either at market price or at cash cost
- Products transferred at cash costs are:
 - Ethylene
 - Ethylene Oxide
 - Propylene
 - Butadiene
 - N-butylenes
 - Isobutylene
- Model is built to allow switching between cash cost and market for each product
- The following products were modeled so that they could be either sold into the market or used to make derivatives:
 - Butadiene
 - Isobutylene

Configuration Options Modeled

- Ethane
 - Ethane to Ethylene Cracker
 - Ethylene to EO/MEG, PE
- Propane
 - Propane dehydrogenation to Propylene
 - Propylene to PP
 - Propane halogenation (Reaction 35) to Propylene
 - Propylene to PP
- n-Butane
 - n-Butane dehydrogenation to butadiene
 - Butadiene to polybutadiene rubber
 - n-Butane halogenation (Reaction 35) to butylenes
 - Butylene OxoD to butadiene
 - Butadiene to polybutadiene rubber
- iso-Butane
 - i-Butane dehydrogenation to isobutylene
 - Isobutylene to MTBE
 - i-Butane halogenation (Reaction 35) to isobutylene
 - Isobutylene to MTBE

Configuration Options Modeled

- Ethane
 - The capacity for the ethane chain is based off the amount of raw material needed for either the world scale HDPE plant or MEG plant. There is no excess ethane, ethylene, or ethylene oxide being sold into the market
- Propane
 - The capacity for the propane chain is based off the amount of propane/propylene required for a world scale polypropylene plant. There is no excess propane or propylene being sold into the market
- n-Butane
 - The capacity of the n-butane unit is sized to produce 300 thousand metric tons of butadiene to approximate on-purpose butadiene production (the majority of butadiene is produced as coproduct). There is no excess n-butane being sold into the market.
 - PBR capacity is set to 100 thousand metric tons, a world scale capacity
 - Butadiene capacity is set to 300 thousand metric tons regardless of PBR capacity size. Butadiene not consumed into PBR is sold into the target market
- iso-Butane
 - The iso-Butane unit capacity is sized to produce 200 thousand metric tons of MTBE with no excess i-butane to be sold into the market

North Dakota Assumptions

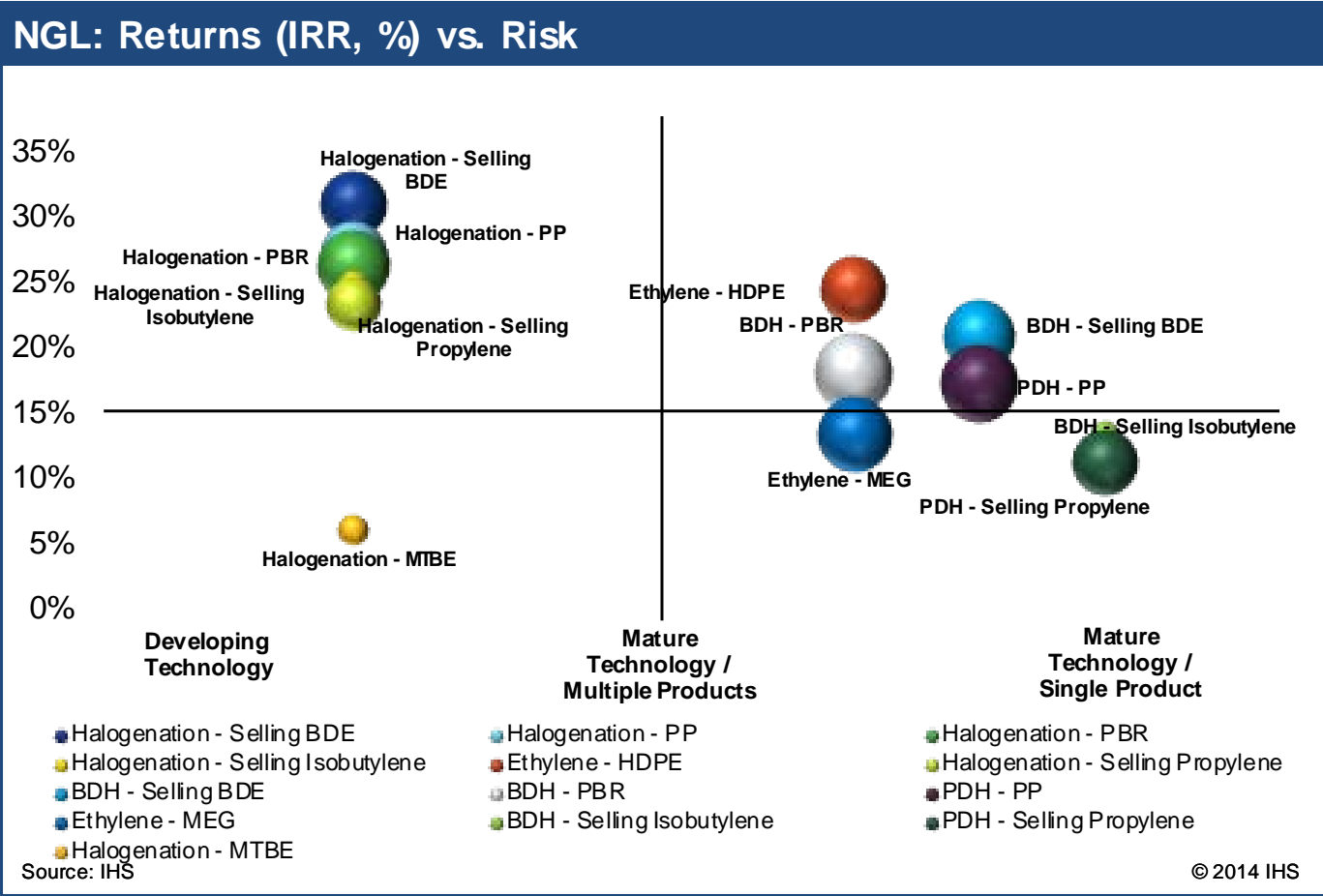
- North Dakota location
 - Capital location factor = 1.12 x USGC
 - Labor factor = 1.4 x USGC
 - Utility costs factor = 0.9 USGC (lower fuel prices)

Target Market Assumptions

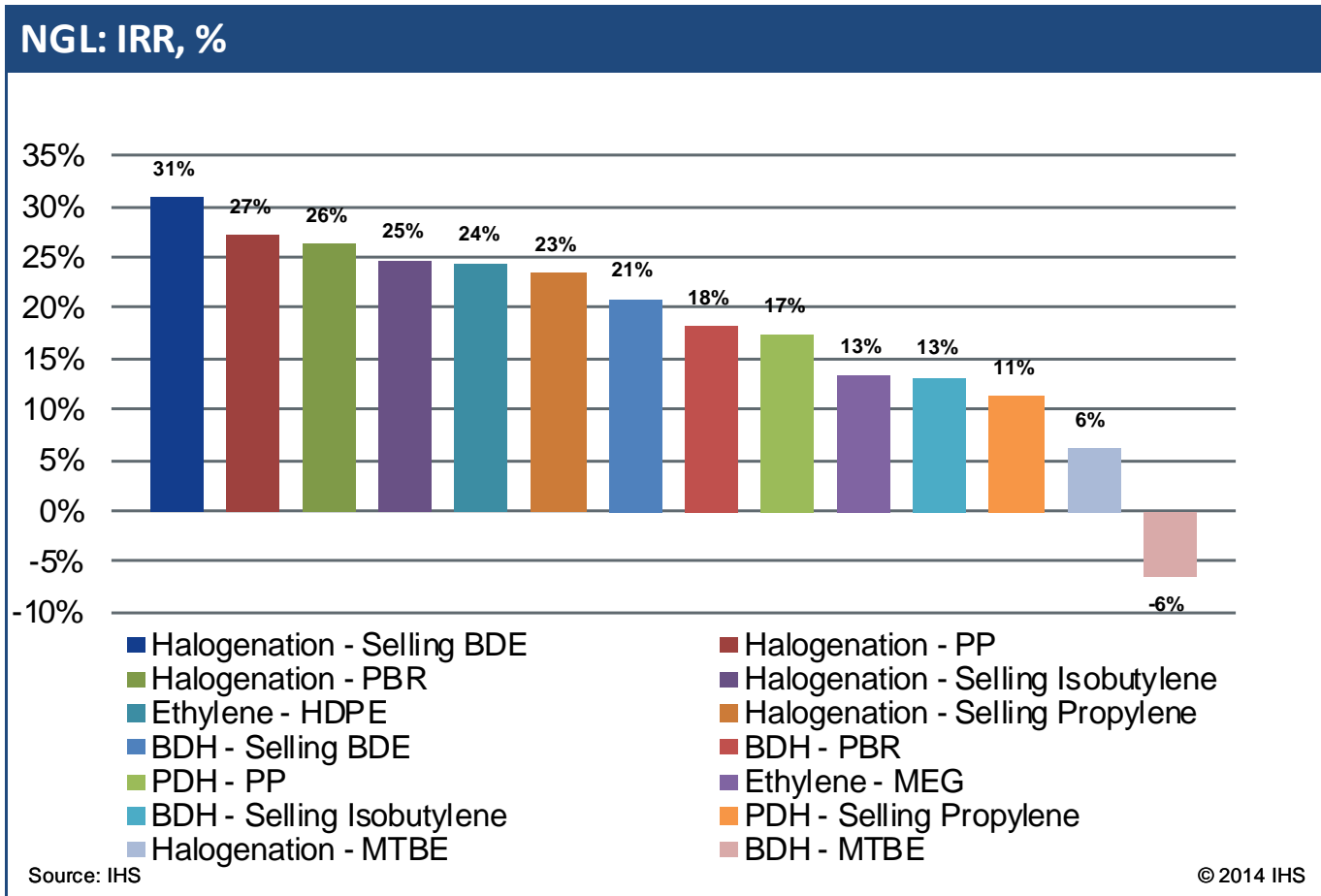
- Ethylene:
 - HDPE: The amount of HDPE produced in this complex is assumed to be sold into domestic and export markets. As such, 50% of the HDPE product in this complex is exported to China, where there is higher demand, with the remainder shipped to the East North Central.
 - MEG: The amount of MEG produced in this complex is also partially exported to China (25%) with the remainder assumed to be sold in the East North Central.
- Propylene
 - Propylene: Where applicable, all propylene is sold into the USGC market. The netback price includes a discount on the USGC and an incurred unloading fee at the USGC port
 - PP: Demand in the East North Central is assumed to consume all of the PP production from the complex
- n-Butane:
 - Butadiene: Demand in the East North Central is assumed to consume all of the butadiene production from the complex.
 - PBR: Demand in the East North Central is assumed to consume all of the PBR production from the complex
- i-Butane:
 - Isobutylene: Demand in the East North Central is assumed to consume all of the isobutylene production from the complex
 - MTBE: All of the MTBE is exported to South America and is priced at a netback price including all logistics costs (rail freight, ocean freight, tariffs/duties)

Cash Flow Model Results (NGL)

Financial Model Results



Financial Model Results



Financial Model Results

	IRR	NPV @ 0%	NPV @ 10%
Ethane - North Dakota Feed - Midwest Netback - Ethylene - HDPE	24%	3693	1409
Ethane - North Dakota Feed - Midwest Netback - Ethylene - MEG	13%	2365	756
Propane - North Dakota Feed - PDH - PP	17%	3527	1209
Propane - North Dakota Feed - PDH - Selling Propylene	11%	1499	457
Propane - North Dakota Feed - Halogenation - PP	27%	4430	1708
Propane - North Dakota Feed - Halogenation - Selling Propylene	23%	2145	809
n-Butane - North Dakota Feed - BDH - PBR	18%	3016	1175
n-Butane - North Dakota Feed - BDH - Selling Butadiene	21%	2859	1159
n-Butane - North Dakota Feed - Halogenation - PBR	26%	4051	1664
n-Butane - North Dakota Feed - Halogenation - Selling Butadiene	31%	3912	1660
i-Butane - North Dakota Feed - BDH - MTBE	-6%	-60	-99
i-Butane - North Dakota Feed - BDH - Selling Isobutylene	13%	360	117
i-Butane - North Dakota Feed - Halogenation - MTBE	6%	214	35
i-Butane - North Dakota Feed - Halogenation - Selling Isobutylene	25%	629	246

Financial Model Results

Product Line	Risk/Complexity (1-10)	Returns, %	Capital Investment, MM USD
Halogenation - Selling BDE	2	31%	1079
Halogenation - PP	2	27%	1121
Halogenation - PBR	2	26%	1337
Halogenation - Selling Isobutylene	2	25%	203
Ethylene - HDPE	6	24%	1124
Halogenation - Selling Propylene	2	23%	683
BDH - Selling BDE	7	21%	1315
BDH - PBR	6	18%	1572
PDH - PP	7	17%	1511
Ethylene - MEG	6	13%	1404
BDH - Selling Isobutylene	8	13%	222
PDH - Selling Propylene	8	11%	1072
Halogenation - MTBE	2	6%	228
BDH - MTBE	6	-6%	248

Cash Flow Model Assumptions

- IHS considers a minimum rate of return (IRR) of 15 percent is necessary for consideration of investment in a commodity chemical plant
- Commodity chemicals include chemical intermediates, commodity chemicals and large volume plastics; products that do not incur unusually high expenditures for technical service and SG&A
- IHS would expect a higher IRR threshold for specialty products
- The 15% IRR threshold assumes minimal or manageable risk related to product acceptance (mature product) and production technology (mature, well proven commercially)
- For unproven technology, IHS recommends a higher IRR, as much as 10% higher to account for the greater risk undertaken. Technology risk can be manifested in several ways:
 - The technology will not work at all; a minima risk for the technologies included in this evaluation as determined by IHS review and assessment
 - The technology will operate but at lower overall rate and throughput as a result of difficult startup and operational learning curve
 - The technology will work but at lower prime-grade material production, causing downtime and/or lower quality product that must be sold at a lower price or disposed of
 - The technology will work but not at the cost of production anticipated (higher cost) and used in the analysis
- All of these conditions, individually or collectively, will result in lower IRR than estimated

For the NGL Study, Three Product Chains Show Promise

- High density polyethylene (HDPE) has an IRR of 24%
 - HDPE is predominantly ethylene (typically more than 95% plus a comonomer)
 - ND ethylene is a low cost feedstock due to advantageous netback ethane price
 - 400 thousand tons per year capacity which can be considered world scale with attendant economy of scale advantage
 - Significant HDPE markets in the East North Central (including the rust belt) and the Pacific regions which gives ND a freight to market advantage
- Polypropylene (PP) from conventional PDH technology has an IRR of 17%.
 - PP is predominantly propylene with varying (and increasing) amounts of ethylene depending on resin type; homopolymer, random copolymer and impact copolymer
 - The propylene production cost is advantageous due to low netback propane price
 - The ND ethylene cost is a low cost feedstock due to advantageous netback ethane price
 - 500 thousand tons per year capacity which can be considered world scale for PDH with attendant economy of scale advantage
 - Significant PP markets in the East North Central (including the rust belt) and the Pacific regions which gives ND a freight to market advantage

For the NGL Study, Three Product Chains Show Promise

- Butadiene and Polybutadiene (PBR) from conventional BDH technology have IRR of 21% and 18%, respectively.
 - Butadiene is in short supply due to shift to lighter feeds to ethylene crackers, which is the conventional source of butadiene (ethylene coproduct)
 - The butadiene capacity is 300 thousand tons per year, large for a butadiene plant and benefiting from economy of scale
 - The butadiene netback price is based on shipping to the East North Central, a logistical advantage compared to the USGC supply
 - ND n-butane is a low cost feedstock due to advantageous netback price
 - PBR capacity is 100 thousand tons per year, which is considered large and gets the economy of scale advantage
 - As for butadiene, the target market in the East North Central is a freight advantage for ND
 - The PBR IRR is lower than the butadiene IRR because the butadiene plant is larger relative to conventional plants and enjoys a greater scale factor advantage. The high dollar per metric ton of capital investment for PBR also lowers the IRR for the derivative

For the NGL Study, Certain Products Do Not Show Promise

- Propylene from PDH has an IRR of 11%
 - The propylene price is netted back from the USGC, a huge disadvantage versus USGC located propylene production
 - The propylene ND netback price includes a discount (which effects propylene from the USGC as well) and an unloading fee, which is not
- Isobutylene from BDH has an IRR of 6%
 - This is a non-conventional route to isobutylene, which is traditionally non-profitable
 - The BDH capital cost and contributing capital charges have a large negative impact on profit
 - Higher value isobutylene is not produced via this route; in fact it requires producing MTBE from isobutylene and then cracking the MTBE to high purity isobutylene. This is a very capital intensive route.
- MTBE from isobutylene shows a negative IRR
 - MTBE is no longer used in the US
 - Operating US plants export MTBE, predominantly to South America
 - Most of the US plants have shut down completely

For the NGL Study, the Reaction 35 Technology Shows Higher IRR

- Propylene from propane using Reaction 35 technology has an IRR of 27%
- Butadiene from n-butane using Reaction 35 technology has an IRR of 31%
- Isobutylene from iso-butane using Reaction 35 technology has an IRR of 25%
- The downstream products, PP and PBR, have higher IRRs of 27% and 26%, respectively, when combined with Reaction 35 produced monomers
- The Reaction 35 technology features lower capital cost and higher primary yields, resulting in lower capital costs
 - It must be noted that the costs of production of the various Reaction 35 routes are based on information provide but Reaction 35. IHS believes the information is credible but cannot guarantee the commercialized results

Risk Must Be Considered for Developing Technology, The Path to Commercialization Can Take Many Years

- Preliminary economic evaluation
 - Determine if economic incentive is sufficient to proceed with investigation
- Laboratory research
 - Develop basic data including physical properties and catalyst performance
- Product evaluation
 - Evaluate product suitability, applicability and potential pricing
- Process development/preliminary engineering
 - Produce preliminary design of commercial plant concept, resolving process questions as they arise
- Pilot plant study
 - Prove basic reliability of proposed process or process design
- Semi-works plant
 - Demonstrate process feasibility on small commercial scale with all recycle streams and including all unit operations and develop data for commercial design
- Commercial plant
 - Full scale operating plant

Risk Must Be Considered for Developing Technology, The Path to Commercialization Can Take Many Years

Concept thru Lab testing

- Basic research
- Preliminary economics
- Lab research
- Product evaluation
- Catalyst development

Pilot plant Start up

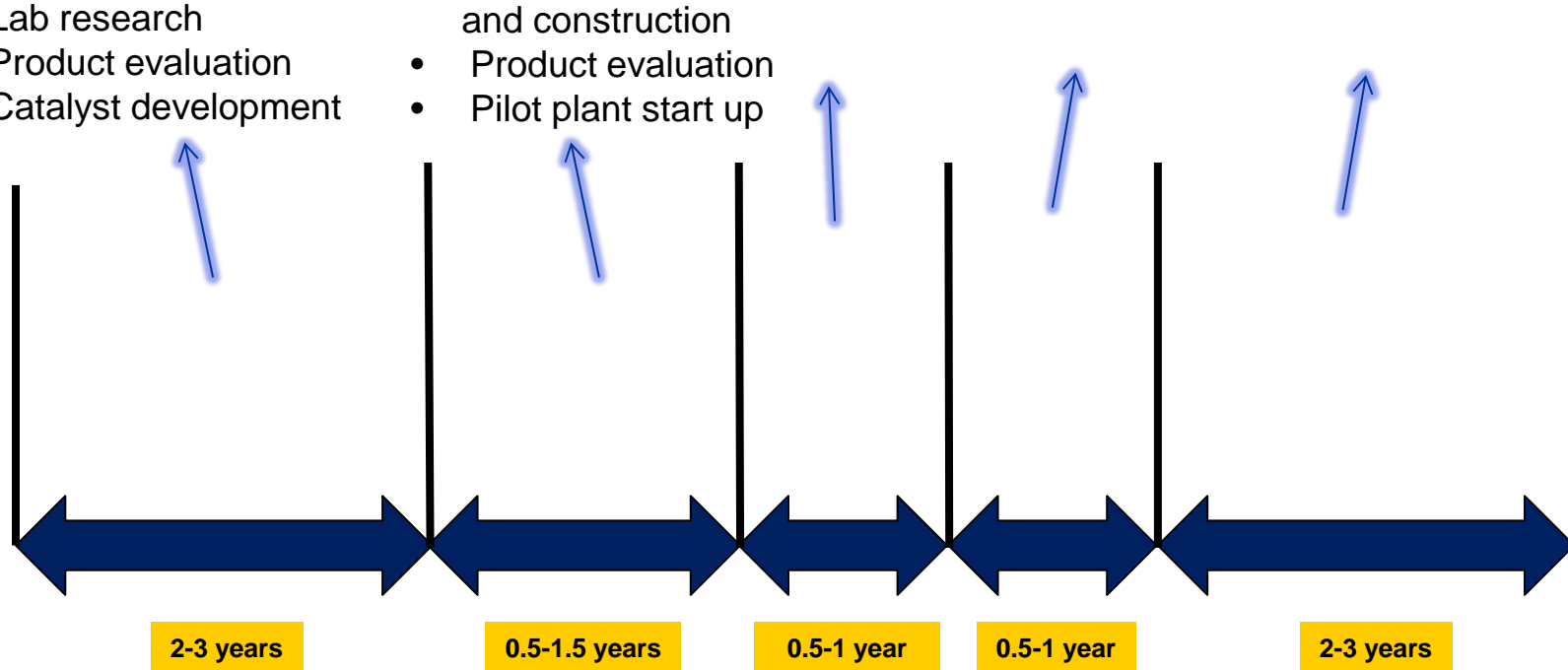
- Process develop.
- Pilot plant design and construction
- Product evaluation
- Pilot plant start up

Pilot plant operation

Demo start up

- Design and construction

Demo unit operation



Early Development Stage Evaluation is Very Risky

- Small-scale laboratory tests help minimize the uncertainty of computer modeling but present significant risk due to several factors:
 - They are small scale and manual, batch simulation of most of the process steps
 - Reactors used in lab scale are not equivalent to the types specified for the commercial plants
 - Catalyst performance is often tested in cold-flow reactors, so that reactor and catalyst performance conclusions may not be directly applicable to the actual commercial reaction conditions
- Pilot Plant Operation Adds Some Degree of Validation
 - A pilot plant is designed to operate as a miniature unit which more closely simulates the key unit operations of the planned actual process plant and is used to collect meaningful operating data for design purposes
 - If the purpose of the pilot plant is a matter of establishing operating parameters and production yields, etc. a minimum operating run time of about six months may be sufficient; this would also provide an indication of the catalyst stability and operating parameters, if not overall activity and expected useful life.
- A Demonstration Unit More Closely Approximates Commercial Scale
 - A demo unit serves the purpose of proof of concept and product; getting product into the marketplace
 - The cost of a demo unit is balanced against expectations
 - Should the complete process be built? Separations, Recycle streams, Catalyst refurbishment
 - If recycle is an important process characteristic, should a proxy recycle stream be included?

Shortcuts to Commercialization Can be Risky

- Bypassing the Demonstration Unit
 - Potential Positives
 - Shorter time to commercialization
 - Lower capital cost outlay
 - A demo unit can typically cost \$10-20MM
 - Potential Pitfalls
 - Plant doesn't work
 - Catalyst performance/separation process issues
 - Plant isn't competitive
 - Extensive rework (and CAPEX) is necessary
- Bypassing the Demonstration Unit – Exceptions to the Rule
 - Though the typical and conservative path is pilot plant followed by demo unit prior to commercial scale, some developers skip the demo unit:
 - A mature process technology; one that is similar in concept and chemistry to a proven technology
 - A homogeneous catalysis: a simpler reactor

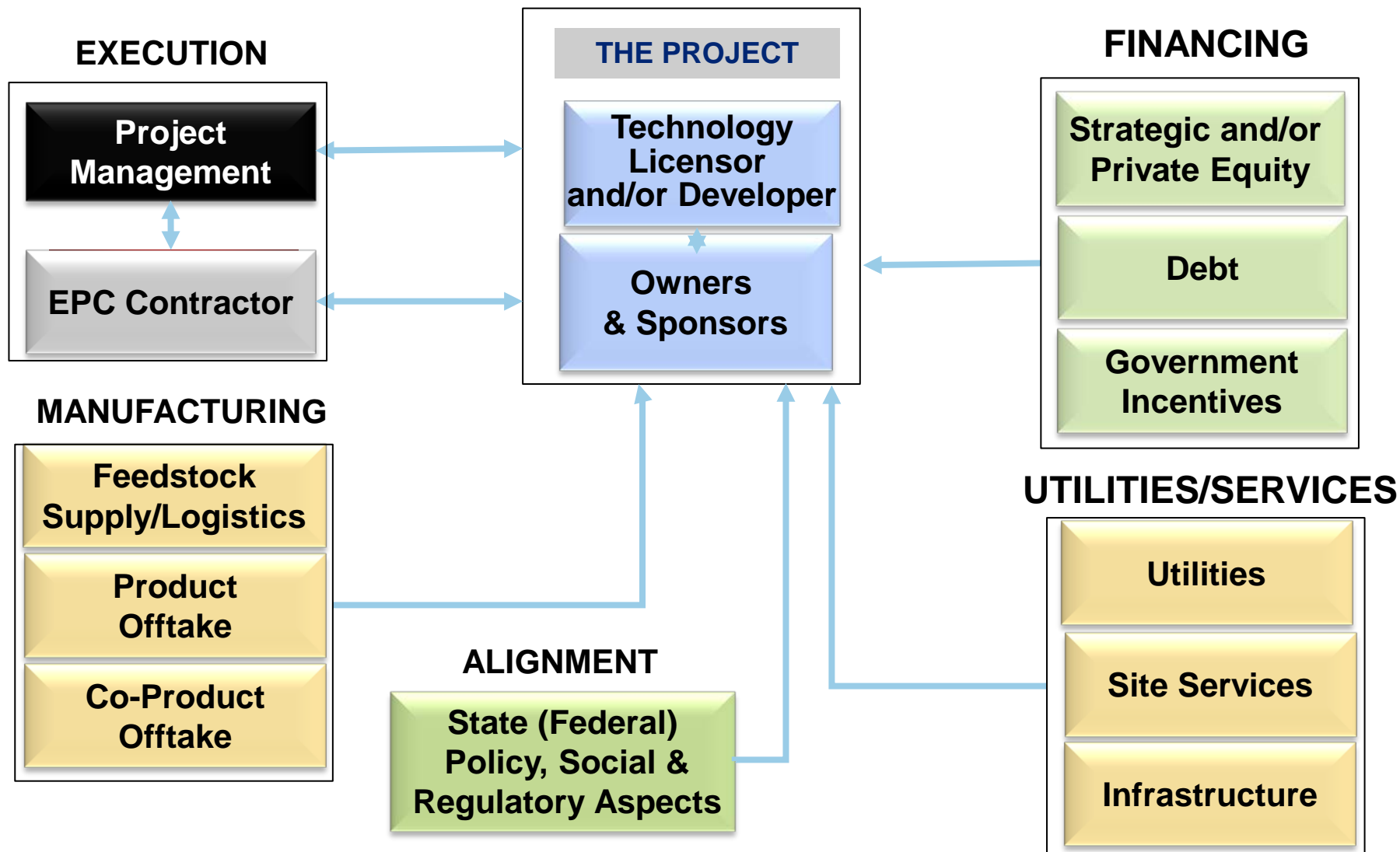
Risk Must be Considered for Developing Technology, Including Reaction 35

- Reaction 35 technology is at the pre-demonstration unit stage of development and clearly carries risk associated with a unproven technology
- IHS believes the risk will be greatly reduced once a demonstration plant is designed, erected and operated
- In addition to the risk associated with any developing technology, Reaction 35 has design and operating and safety risks associated with bromine chemistry
- The risk is also mitigated by Reaction 35's development history
 - Detailed design performed by Fluor, a major, well recognized EPC firm
 - Material of construction review by ExxonMobil, specifically regarding bromine/bromide handling and design
 - Association with major bromine supply companies, who are very experienced in bromine handling
- However, the IRR advantage estimated from the Reaction 35 technology of more than 10% for each route should be enough for the technology to be seriously considered



Project Development and Implementation

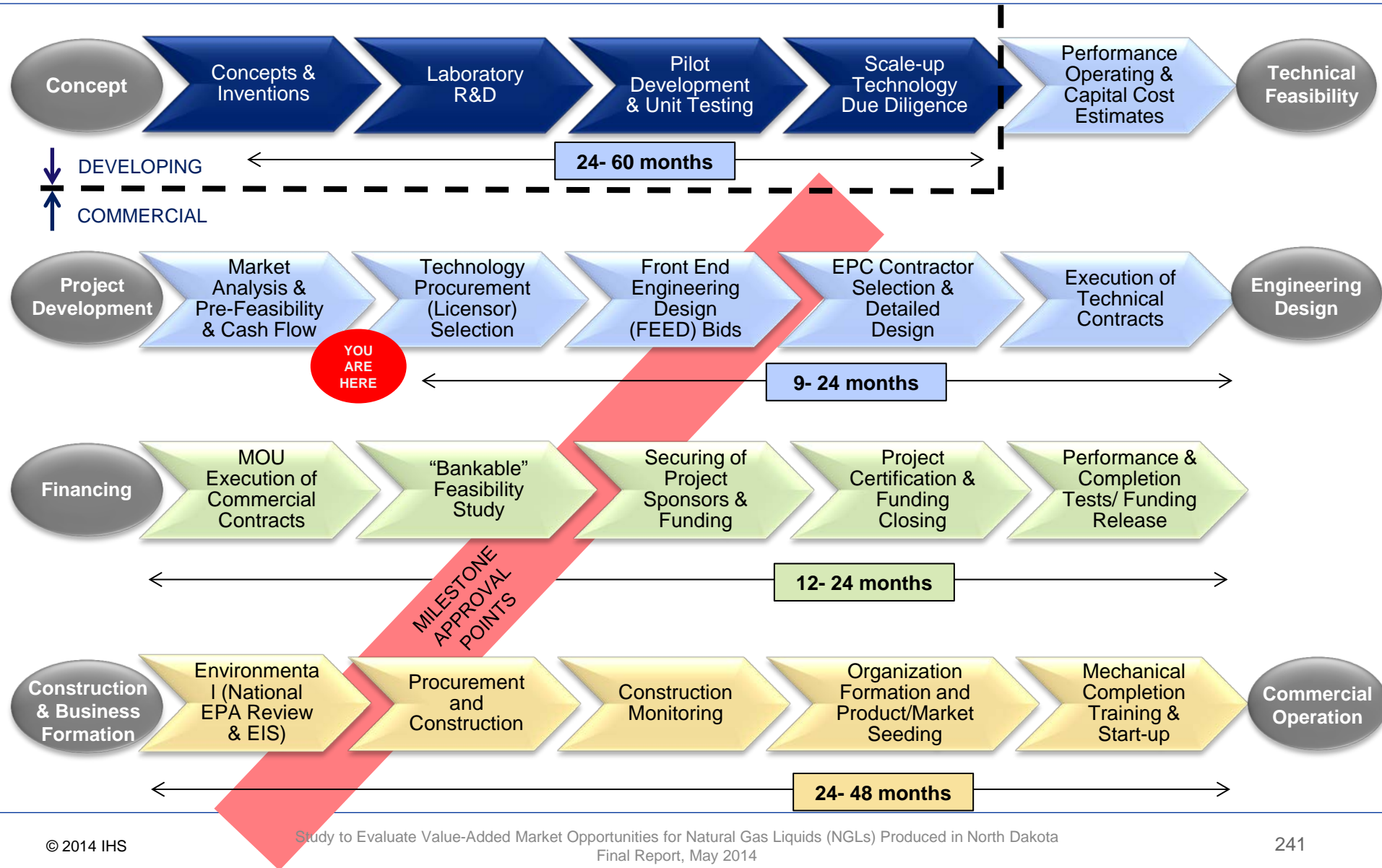
Project Development Must Successfully “Execute” All the Fundamental, Commercial and Technical Aspects



Project Development

- Project development must follow good business and chemical engineering fundamental (there are no shortcuts)
- The scope, timing, duration and ownership of specific project development implementation tasks are highly dependent on the owner's financial, technical and business position i.e., "what they bring to the project"
- The stage of development/maturity of the chemical process technology also has a significant impact on the project (can add 3 to 5 years)
- Overall project develop follows four tracks:
 - Technology availability
 - Engineering and design
 - Financing
 - Procurement, construction, business formation and startup
- The interrelation, duration and critical path milestones of the "tracks" vary as a function of project type, complexity, owner capabilities & expertise, as well as the financing and ownership structure
- With mature & available technology, project development and implementation typically spans 3 - 5 years; with simple & fully owner financed ones at 2 years

Project Development Tracks Need to be Executed in Parallel With Specific Activities Highly Dependent on Project Ownership





North Dakota Specific Analysis

- ❖ *Summary of Opportunities for North Dakota*
- ❖ *State Incentive Programs*
- ❖ *Examples of State Incentive Programs*

Summary of Opportunities for North Dakota

HDPE Value Chain

Value Chain Highlights (NA)

- ✓ High Volume (ND proposed capacity is only 4.1% of total US capacity 2020)
- ✓ Growth product (at slightly above GDP levels)
- ✓ Additional capacity needs in the post-2020 period
- ✓ Export market to China/Asia

Market (Pull) Attractiveness (NA)

- ❖ ND's 400KTPA is a state-of-the art capacity
- ❖ Stand-alone product
- ❖ Fungible commodity product

Advantages for ND Producer

- ‡ Low feedstock cost
- ‡ Competitive operating costs
- ‡ Advantaged proximity to end use markets
- ‡ Large customer base
- ‡ Large fungible market served by rail
- ‡ "Local" differentiated customer base

Market Entry Barriers for ND Producers

- ? Lack of existing infrastructure
- ? Capital intensive
- ? Need to capture market share on price
- ? Need to develop a multiproduct value chain

Propylene Value Chain

Value Chain Highlights (NA)

- ✓ High Volume (ND proposed capacity is only 2.0% of total US capacity 2020)
- ✓ Growth product (at GDP levels)
- ✓ Additional capacity needed in the post-2020 period
- ✓ On-purpose capacity setting the market price

Market (Pull) Attractiveness (NA)

- ❖ Advantaged by shale gas "effect"
- ❖ ND's 470KTPA is a state-of-the art capacity
- ❖ Stand-alone product
- ❖ Fungible commodity product

Advantages for ND Producer

- ‡ Low feedstock cost
- ‡ Competitive operating costs
- ‡ Large customer base
- ‡ Large fungible market served by rail

Market Entry Barriers for ND Producers

- ? Lack of existing infrastructure
- ? Capital intensive
- ? Need to capture market share on price
- ? Need to develop a new product "infrastructure"

Polypropylene Value Chain

Value Chain Highlights (NA)

- ✓ High Volume (ND proposed capacity is only 5.2% of total US capacity 2020)
- ✓ Growth product (at GDP levels)
- ✓ Additional capacity needed in the post-2020 period
- ✓ Export market to China/Asia

Market (Pull) Attractiveness (NA)

- ❖ ND's 500KTPA is a state-of-the art capacity
- ❖ Stand-alone product
- ❖ Fungible commodity product

Advantages for ND Producer

- ‡ Competitive operating costs
- ‡ Advantaged proximity to end use markets
- ‡ Large customer base
- ‡ Large fungible market served by rail
- ‡ "Local" differentiated customer base

Market Entry Barriers for ND Producers

- ? Lack of existing infrastructure
- ? Capital intensive
- ? Need to capture market share on price
- ? Need to develop a multiproduct value chain

Butadiene Value Chain

Value Chain Highlights (NA)

- ✓ High Volume (ND proposed capacity is only 2.2% of total US capacity 2020)
- ✓ Growth product (at GDP levels)
- ✓ Additional capacity needed in the post-2020 period
- ✓ On-purpose capacity setting the market price

Market (Pull) Attractiveness (NA)

- ❖ ND's 300 KTPA is at state-of-the-art capacity size in market
- ❖ Stand-alone product
- ❖ Fungible commodity product

Advantages for ND Producer

- ‡ Competitive operating costs
- ‡ Large fungible market served by rail
- ‡ Relatively low capital cost

Market Entry Barriers for ND Producers

- ? Lack of existing infrastructure
- ? Capital intensive
- ? Need to capture market share on price
- ? Need to develop multiple products in the value chain

Polybutadiene Rubber Value Chain

Value Chain Highlights (NA)

- ✓ Growth product (at US GDP level)
- ✓ Additional capacity needed in the post-2020 period

Advantages for ND Producer

- ‡ Advantaged proximity to end use markets
- ‡ Large fungible market served by rail
- ‡ "Local" differentiated customer base
- ‡ Relatively low capital cost

Market (Pull) Attractiveness (NA)

- ❖ ND's 100 KTPA is a state-of-the-art capacity
- ❖ Stand-alone product
- ❖ Fungible commodity product
- ❖ Differentiated product

Market Entry Barriers for ND Producers

- ? Lack of existing infrastructure
- ? Need to capture market share on price
- ? Need to develop differentiated product "infrastructure"

Isobutylene Value Chain

Value Chain Highlights (NA)

- ✓ Growth product (at below US GDP level)
- ✓ Additional capacity needed in the post-2020 period

Advantages for ND Producer

- ‡ Low feedstock cost
- ‡ Competitive operating costs
- ‡ Large customer base
- ‡ Large fungible market served by rail
- ‡ Relatively low capital cost

Market (Pull) Attractiveness (NA)

- ❖ Advantaged by shale gas "effect"
- ❖ ND's 130 KTPA is acceptable capacity level
- ❖ Stand-alone product
- ❖ Fungible commodity product

Market Entry Barriers for ND Producers

- ? Need to capture market share on price
- ? Need to develop a new product "infrastructure"

State Incentive Programs

Economic Incentives are Dependent on Project Scope and Can Take Many Forms

- Typical Economic Development Incentives by Type:
 - Financial tax incentives: credits, deductions, abatements, payment in lieu of taxes (known as PILOTs)
 - Financial capital incentives: grants, low-interest loans, interest rate subsidies
 - In-kind services: site improvements, job training, permit assistance
 - Special districts: empowerment and enterprise zones
 - Miscellaneous incentives
- Other Support
 - Ease of permitting
 - Infrastructure Development

Examples of State Incentive Programs

Financial Tax Incentives in Ohio

- Ohio Job Creation Tax Credit
 - At least 10 full time equivalents and \$660,000 in annual payroll over three years
 - Sector 325110 average annual wage in OH is \$90,100 (all occupations)
 - Credit limited to 75% state personal income tax withholdings
 - Can be taken against four OH taxes, including business franchise and corporate net income tax
 - Up to 15 years
 - Refundable
 - Sample calculation assuming 300 jobs - annual credit would be \$801,800
- Other Ohio Economic Development Incentives
 - Business incentive and economic development grants
 - Ohio Bond Fund and low interest loans (Section 166, refers to applicable regulation)
 - Workforce grants and in-kind services
 - R&D tax credit
 - Special districts, such as enterprise and empowerment zones, reinvestment areas, and brownfields.

Financial Tax Incentives in Pennsylvania

- Job Creation Tax Credits
 - Based on number of jobs created in three years
 - At least 25 new jobs or 20% increase
 - Credit per job is \$1,000 and \$2,500 if unemployed worker used
 - Sector 325110 average annual wage in PA is \$80,300 (all occupations)
 - Credit can be taken against seven PA business taxes
 - Example assuming 300 operating jobs - annual tax credit of \$345,000
- Pennsylvania Resource Manufacturing Tax Credit
 - Machinery and Equipment Loan Fund (MELF)
 - Availability of funds uncertain
 - Low Cost Capital through programs such as “PA First”, Pennsylvania Economic Development Authority taxable bond program, PA Industrial Development Authority
 - Infrastructure development (highly site specific)
 - Job Training
 - Special districts: Keystone Opportunity Zone/Keystone Opportunity Expansion Zone, Keystone Special Development Zones, Industrial Sites Reuse, Tax Increment Financing

Financial Tax Incentives in West Virginia

- Economic Opportunity Tax Credits (EOTC)
 - Five types of EOTC credits – general, corporate HQ, small business, high tech, and job creation
 - Only one EOTC credit per investment, but can apportion
 - EOTC tax credits can be used with other WV incentives
- General EOTC Tax Credit
 - Qualifying invest. based on dollar value of initial investment, equipment life, and number of jobs
 - Qualifying investment can be up to 35% of initial investment for 520 or more jobs
 - Credit pro-rated over 10-year period
 - Credit taken against corporate net income tax
 - Credit is limited to state tax obligation
 - Not refundable or transferable, but three year carry forward after 10 years
 - If initial investment was \$1.5 billion and 300 operating jobs, potential credit likely offsets virtually all of WV corporate income tax obligation

Financial Tax Incentives in West Virginia (contd.)

- EOTC Job Creation Tax Credit
 - At least twenty new full time jobs at \$32,000 with health benefits
 - Tax credit of \$3,000 per job for five year period
 - Credit against four state taxes, including corporate net income
 - Not refundable or transferable
 - If 300 new jobs – annual credit is \$900,000
- Five for Ten Program
 - Incentive: Abatement of 95% of real property taxes pro-rated for 10 years
 - Eligibility: facilities in NAICs 211112- Natural Gas Liquids Extraction, or that use products from such a facility and invest at least \$2 billion
 - Sample calculation assuming:
 - Real property of \$200 million
 - Assessment ratio of 60% (statewide figure for manufacturing real property)
 - Real property tax rate \$2.50/\$100 of assessed value
 - Annual reduction in real property taxes is \$285,000

Financial Tax Incentives in West Virginia (contd.)

- Manufacturing Investment Tax Credit
 - Incentive: avoid up to 60% of liability for the 3 state taxes, including the corporate net income tax
 - Credit is 5% of qualified investment, pro-rated over 10 years
 - Includes real property, tangible personal property (equipment), refurbishment
 - Not refundable or transferable, no carryover
 - With \$1.5 billion in investment, 60% obligation would likely be offset
- Manufacturing Property Tax Adjustment Credit
 - Credit against local personal property taxes paid on manufacturing inventory
 - Value of credit depends on local tax rate, value of inventory
 - Cannot be estimated at this time, likely small
 - Not refundable or transferable, no carryover
- Other Economic Development Incentives in WV
 - Special property tax valuation for air and water pollution control equipment
 - On the Job training services
 - Guaranteed Workforce Program
 - WV Economic Development Authority (WVEDA) loan program
 - Special districts: empowerment zones, Appalachian Regional Commission, TIFs