This paper is dedicated to the memory of Vern Millard (1924-1999), Chairman of the former Alberta Energy Resources Conservation Board (1978-1987).

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Natural Gas Liquids from Production to Consumption in Alberta – An Overview of Process Engineering

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1. Introduction

Alberta energy sector in 1997 generated approximately 12 billion dollars from the production of conventional and synthetic crude oil, 9.7 billion dollars from natural gas, 4.2 billion dollars from natural gas liquids (NGLs), and slightly more than half a billion dollars from production of coal.

Alberta has the majority of conventional crude oil, crude bitumen (resource of synthetic crude oil), natural gas, and NGLs (ethane, propane, butanes, and pentanes plus) reserves and production in Canada.

In 1997, Alberta accounted for 100% of Canadian ethane production, 95% of propane, 92% of butanes, and 95% of pentanes plus production. In the same year, Canada produced 10.9x of ethane, 9.7 x 10^6 m^3 of propane, 5,2 x 10^6 m^3 of butanes and 10.5 x 10^6 m^3 m of pentanes plus.

The majority of Alberta's energy production including NGLs was shipped outside of Alberta, particularly to the US. In 1997, Alberta counted for 40% of the US imports of ethane, 51% of propane, 60% of butanes and 60% of pentanes plus.

In 1997, the US demand for ethane was 42 x 10^6 m^3, propane 70 x 10^6 m^3, butanes 32 x 10^6 m^3, and pentanes plus 20 x 10^6 m^3. In the same year the US imported 9% of its demand for ethane, 12% for propane, 7% for butanes, and 10% for pentanes plus.

The purpose of this paper is to describe Alberta supply sources of NGL and its uses with an overview of process engineering. In the next section, the sources of NGL supply from processing and reprocessing plants and refineries will be described. In the third section, the uses of NGL in Alberta market will be discussed. In the fourth section, export market and pipeline capacities will be demonstrated. Conclusions will be presented in the last section.

Appendix 1 will provide definitions of technical words and terms that will be used in this paper. The sources of data are Alberta Energy and Utilities Board (AEUB), Statistics number (ST) 13A, ST-17, and Statistics Canada, Quarterly Report on Energy Supply-Demand in Canada, 1997-IV, Catalogue number 57-003-XPB.

2. Supply of Natural Gas Liquids

Natural gas consists primarily of mixtures of hydrocarbon gases, predominantly methane, along with smaller amounts of ethane, propane, butanes and pentanes plus. In addition to the hydrocarbon gases, the mixture also contains non hydrocarbons such as nitrogen, oxygen, water, carbon dioxide, hydrogen sulphide, helium, sulphur, carbon disulphide, carbonyl sulphide, and mercaptans. Removing the following elements purifies natural gas:

- Water must be removed from natural gas to prevent hydrate formations, a form of freezing in the gas transmission pipelines.
- Hydrogen sulphide and carbon dioxide must be removed since they are toxic and corrosive. In larger quantities, hydrogen sulphide is converted through gas processing facilities to produce a pure elemental sulphur product.
- Natural gas liquids (NGL) should be removed to serve by-products markets. NGL consists of ethane, propane, butanes (a mixed product from isobutane and normal butane), and pentanes plus.

The NGLs are recovered from three sources. Gas processing plants or field plants which extracts NGLs from raw. Natural gas reprocessing plants, or straddle plants which extracts NGLs from marketable natural gas. The third source of NGL supply is refineries which recover propane and butanes. **Figure 1** shows a simplified schematic of natural gas and NGL flows in Alberta.

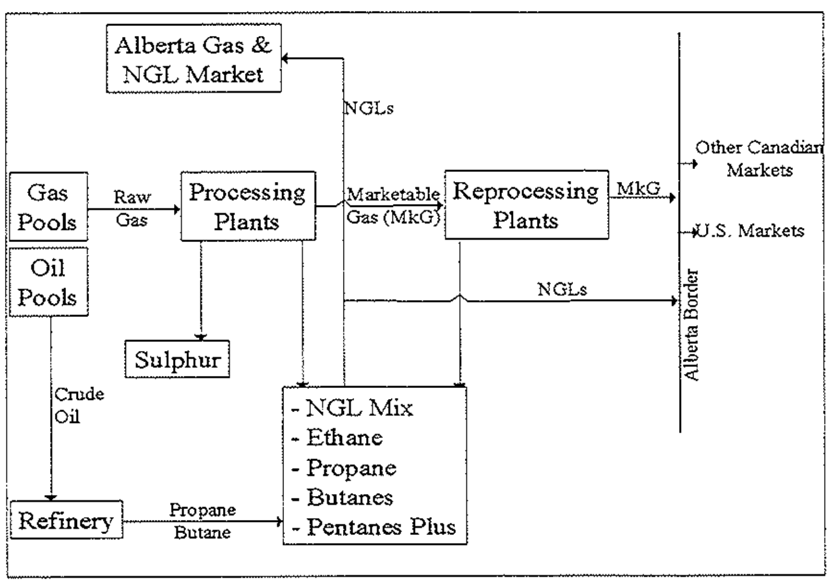


Figure 1: Simplified Schematic of Alberta Natural Gas and NGL Flows.

2.1 Gas Processing and Reprocessing Plants

The main products of gas processing plants (field plants) are propane, butanes, pentanes plus and sulphur. Deep-cut facilities adjacent to or within gas field plants (gas processing plants as used hereafter include any associated deep-cut facilities) permit the recovery of ethane as well.

The main product of gas reprocessing plants (straddle plants) is ethane. Minor products are propane, butanes and pentanes plus.

According to the Alberta Energy and Utilities Board Report ST 98-50, there are 674 operating processing plants and 8 operating reprocessing plants in Alberta.

Figure 2 shows a simplified block flow diagram of a sour gas processing plant. The first operation of the plant occurs at the inlet separator, where the raw gas is separated into water disposal (1), sour gas (2), and sour gas condensate (3).

Sour gas (2) flow from the inlet separator is metered and sent on for further treatment such as sweetening, dehydration, and removal of LPG's (propane and butanes). Sour gas condensate (3) flows to the stabilization facilities for removal of remaining gases and pentanes plus. Water is sent to disposal facilities.

In the gas sweetening section, hydrogen sulphide, carbon dioxide, and any small quantities of carbonyl sulphide, carbon disulphide, and mercaptans are removed.

After sweetening, the sweet wet gas is dehydrated to reduce the water content of the gas and to eliminate the potential of hydrate formation. Then the dry gas can be used as marketable gas, or sent to the fractionation unit. A fractionation unit is used to physically separate a gaseous mixture of hydrocarbons into individual products as propane, butanes, and pentanes plus.

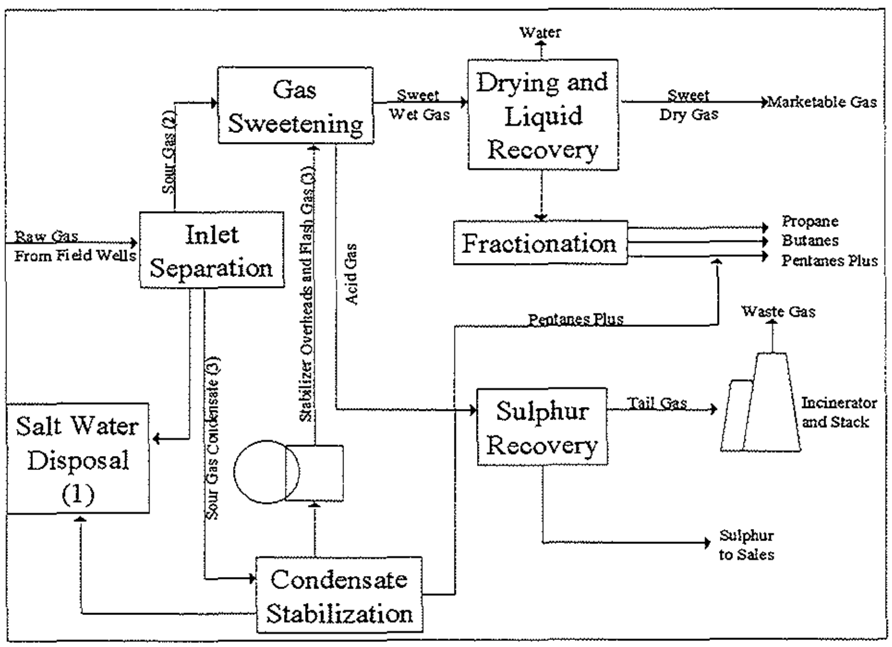
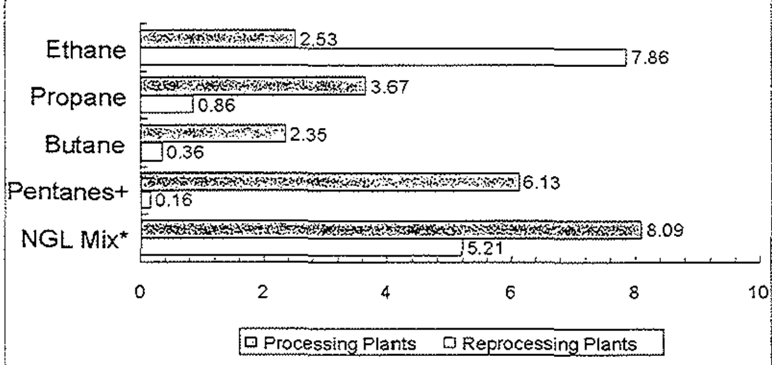


Figure 2: Simplified Flow Diagram of a Gas Processing Plant

Acid gas (H_2S and CO_2) from the gas sweetening unit is directed to the sulphur recovery plant where elemental sulphur is recovered from the H_2S. In this stage the range of the sulphur recovery efficiency level is from 95 to 97 per cent. To achieve sulphur recoveries in excess of 97 per cent, the tail gas should move to the "cleanup processes" such as sulpfreen. Otherwise, it moves to incinerator and stack for burning.



* A portion of this NGL mix is fractionated outside the Alberta market into spec products. The fractionated mix is composed of roughly 50% propane, 30% butane and 20% pentanes plus.

Figure 3: Average Extraction of NGL to Inlet Gas Ratio at Processing and Reprocessing Plants in Alberta

Ratios of NLGs to inlet gas at processing and reprocessing plants are illustrated in **Figure 3.**

It should be noted that gas processing plants are the major sources of propane, butane, and pentanes plus (C3+), while reprocessing plants are the major sources of ethane (C2).

The amount of NGL extraction varies with the amount of inlet gas, the liquids content of the gas, and developments in NGL extraction technology. The liquids content of natural gas may drop over time due to decline in production of solution gas and recycling dry gas to the existing oil reservoirs for enhanced oil recovery. However, in Alberta the decline of liquids content of natural gas has been offset to some extent by Caroline gas pool (rich in C2+) which was discovered in 1986.

Recent developments in NGL extraction technology (the turbo-expander process) have resulted in plants that can economically recover essentially 100% propane and over 85% ethane (the early plants were designed for 85% propane and 50-60% ethane). This means that the cost of maximum NGL recovery is dropping and that the minimum economic plant size is declining.

2.2 Refineries

Crude oil itself has limited usefulness as an end product. It has found some direct burning applications as a fuel in industry and electricity generation but generally it must be transformed into finished products for end use.

One of the main refinery processes is distillation. A simplified typical distillation scheme is shown in **Figure 4**. Distillation is the start of the refining process where crude is split into a number of parts or fractions by condensing the vapours produced when the liquid is boiled.

The separation between fractions is made on the basis of boiling points and groups of hydrocarbons. Over all, this split may vary, depending on the refinery configuration systems, type of crude oil, and the desired products.

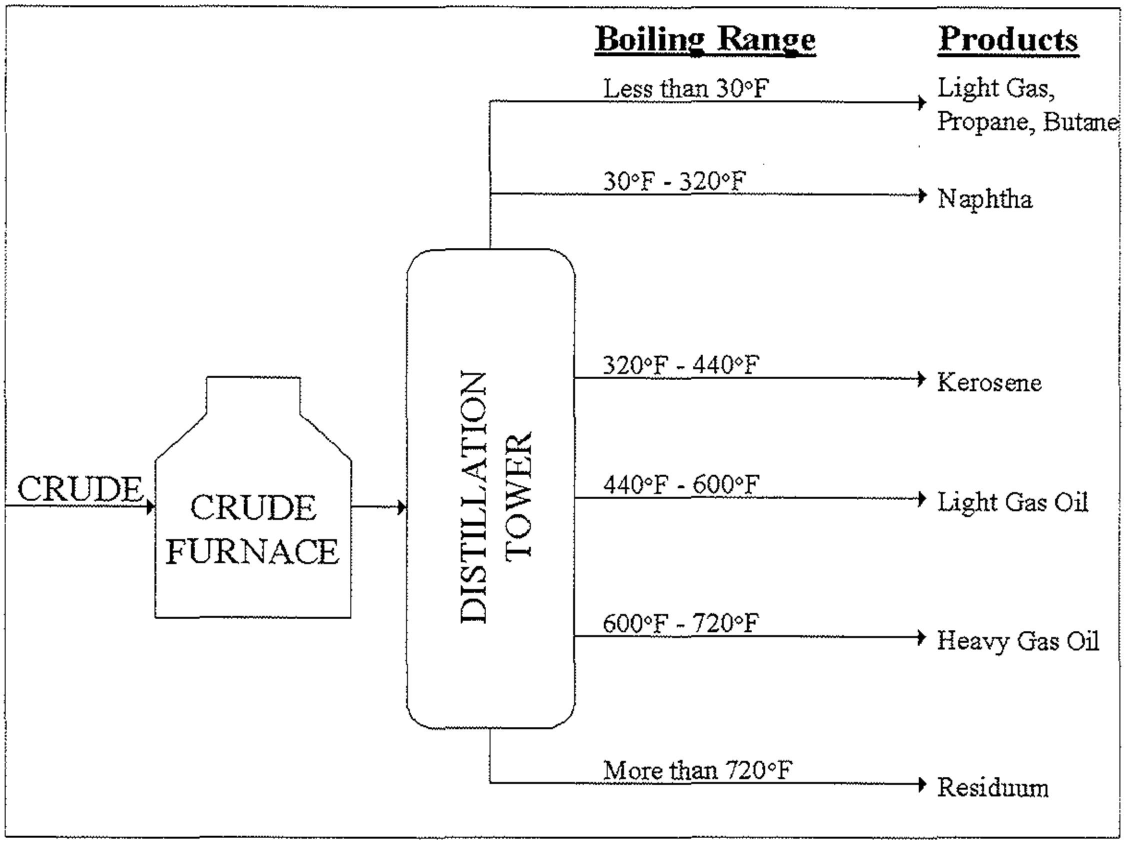


Figure 4: Crude Oil Distillation

Butanes and propane collectively are known as Liquefied Petroleum Gases (LPG), are extracted at the boiling range of less than 30 F.

Natural gas liquids extraction from Alberta processing and reprocessing plants and recovery of LPG from refining crude oil for the period of 1994 to 1997 are shown in **Figure 5.**

It should be noted that in this figure since statistics do not distinguish between processing and reprocessing volume of non-fractionated NGL mix, the total volume of NGL mix is shown in a separate category.

Although, the share of refineries is not significant, however, the amount of butanes production is increasing as it is used to boost octane levels, and improve anti-knock qualities of motor gasoline.

Figure 5 shows the share of specification productrs in 1997. In this graph, recovered products contain NGL mix fractionated at the destination point. The share of ethane has become larger than other specification products because of the associated deep-cut facilities.

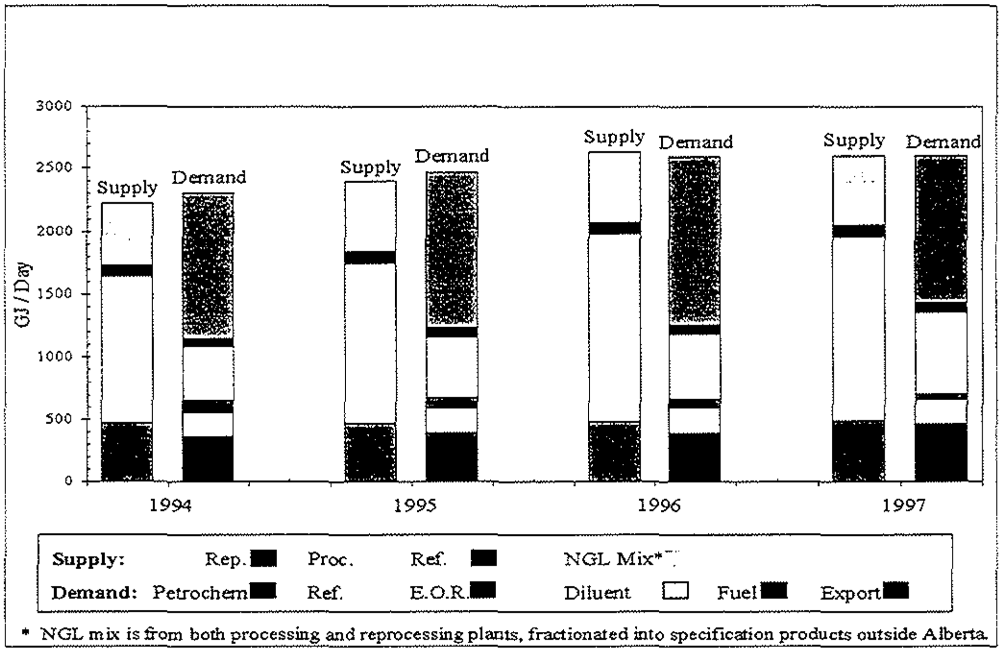


Figure 5: Alberta NGL Supply and Disposition

Figure 6, shows the share of specification products in 1997. In this graph, recovered products contain NGL mix fractionated at the destination point. The share of ethane is more than other specification products due to associated deep-cut facilities.

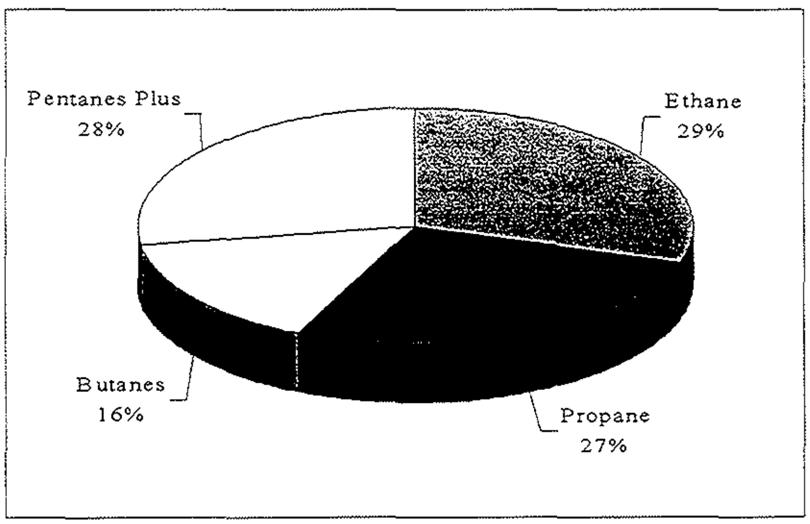


Figure 6: Share of Natural Gas Liquids Supply - 1997

3. Demand for Natural Gas Liquids

NGLs can be used as feedstock, fuel, solvent flood, and diluent. The disposition of NGL from 1994 to 1997 depicted in **Figure 5**, and will be discussed in this section.

3.1 Petrochemical Industry

The type of feedstock requirements for the petrochemical industry can be determined through their process plants which are categorized into steam cracker, catalytic reformer or steam reformer. A summary of the feedstock requirements, primary products and end use products of each type of process plant are shown in **Figure 7** and are described as follows:

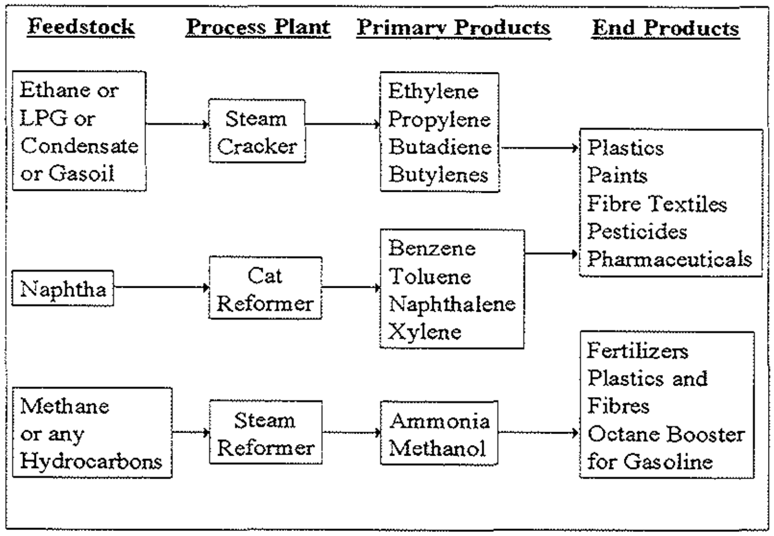


Figure 7: A Simplified Flowchart of the Petrochemical Industry

- Steam Cracker: The feedstock requirements for the steam cracker can be ethane, LPG, condensate or gas oil. The primary product is olefins, which includes ethylene, propylene, butadiene and butylenes. The major end products of the olefins are plastics, paints, fibres, textiles, pesticides or pharmaceutical.
- Catalytic Reformer: The only feedstock suitable for a catalytic reformer is naphtha. The primary product is aromatics, which includes benzene, toluene naphthalene or xylene. The major end use products of aromatics are similar to olefins.
- Steam Reformer: The feedstock requirements for the steam reformer are methane or any hydrocarbon. The main primary product is synthesis gas from which ammonia and methanol are derived. The major end use products of synthesis gas are fertilizers, plastics and fibres and octane booster for gasoline.

There are seventy-nine petrochemical plants in Canada, where thirty-five plants are located in the west and the remainder in the east. The provinces with the largest number of petrochemical plants in each region are Ontario (thirty-two) and Alberta (twenty-four).

The major feedstock requirements for Alberta petrochemical plants are natural gas, ethane, and butanes. The primary products of Alberta petrochemical plants are ethylene, ammonia, and methanol. **Figure 8** shows current and future production and planned expansion of Alberta primary petrochemical products.

The primary petrochemical products use as feedstock as well for the secondary petrochemical products such as polyethylene, urea, acetic acid, and methyl tertiary butyl ether (MTBE). The use of MTBE as octane enhancer will be discussed in section 3.2.

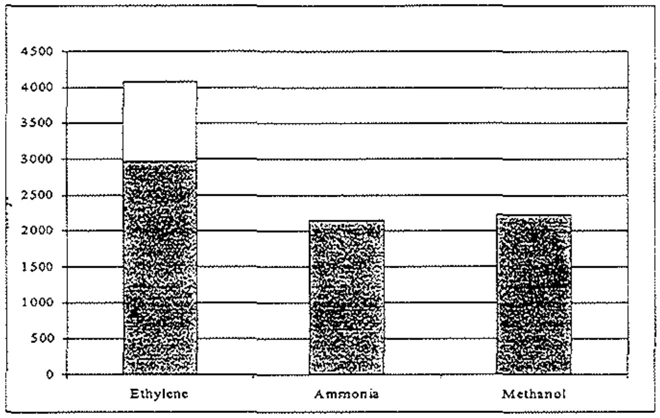


Figure 8: Alberta Primary Petrochemical Products in 1997 and Planned Expansions

In the near future, the expansions of the current MTBE Plant and two new additional plants of ethylene and MTBE will increase the amount of ethane and butane requirements in Alberta.

Figure 9 shows a simple block diagram for MTBE production. Field butane is fed to the Deisobutanizer (DIB) Tower. The resulting normal butane (n-butane) is sent to the ismerization unit, where the isomerization product returns to the DIB Tower. The product isobutane heated and sent to Dehydrogeneration reactor where isobutane is converted to isobutylene at a 40% to 50% conversion rate. In MTBE synthesis, isobutylene reacts with methanol to produce MTBE.

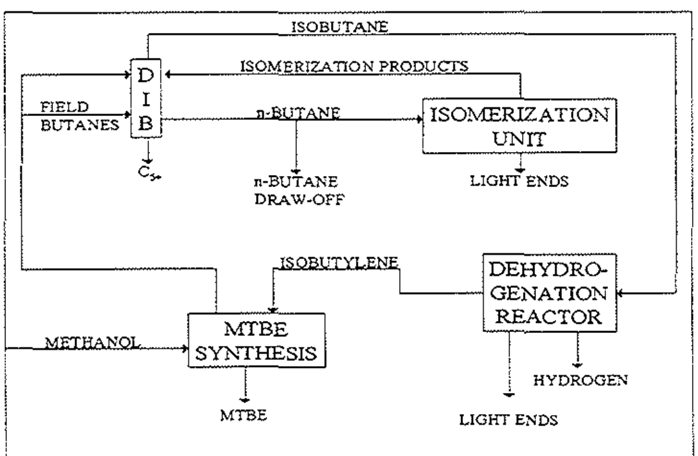


Figure 9: A Simplified Flowchart of MTBE Project

3.2 Refining Industry

Butane is one of the refinery requirements which is used in gasoline blending as an octane enhancer. Among the variety of octane enhancers (lead, alcohols, MTBE, butane, etc.), lead is the cheapest one. However, the lead in gasoline has been a prime target of the environmental lobby because of poisonous characteristics. Lead in gasoline has been prohibited in the US, and currently curtailed to 5 mg/L in Canada.

The second cheapest octane enhancer is normal butane blended into gasoline. This octane enhancer has a high vapour pressure in summer months. A high vapour pressure is acceptable in winter months while it should be reduced in summer months. The direct use of normal butane in gasoline blending has been curtailed, particularly in the summer months because of higher vapour pressures results in diminished air quality.

In general, the trend of normal butane requirements for blending is expected to decline, but the opportunity exists to increase summer season use of butane as alkylate. In this process octane enhancer (iso-octane) could be made from isomerized normal butane (iso-butane) displaced from motor gasoline and olefins from catalytic cracking (iso-butylene). Alkylation is highly capital intensive and requires isomerization of n-butane driven out of gasoline markets.

In future, refineries should either rely on external octane enhancing sources (MTBE, alcohols, aromatics) or on boosting volumes of their octane blending components, through isomerization units, catalytic reformers, and alkylation units.

There are twenty-five refineries in Canada with a crude oil capacity of 1,915,500 barrels per calendar day (BPCD). Fourteen refineries are located in the east with a capacity of 1,329,700 BPCD and eleven in the west with capacity of 835,700 BPCD.

In the west, Alberta, with 5 refineries, has the highest capacity of production at 381,200 BPCD. The detailed capacity of Alberta refineries is depicted in **Figure 10.** Alberta refineries require normal butane in gasoline blending and isobutane in alkylation, where both uses serve the market for motor gasoline.

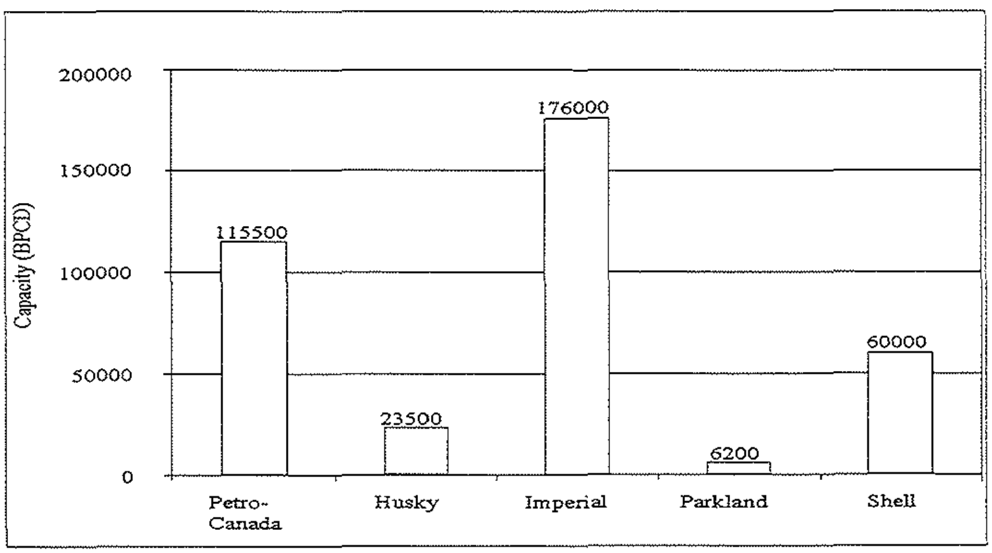


Figure 10: Alberta Refineries Capacity

3.3 Solvent Flood

The development of a hydrocarbon reservoir can be divided into three depletion phases: primary, secondary and enhanced or tertiary recovery. The enhanced oil recovery (EOR) phase uses the addition of artificial energy consisting of three generic types of processes. *Thermal process* uses heat to reduce the viscosity of the crude oil. This is mainly applicable in heavy oil reservoirs. *Chemical process* behaves like detergent to wash the remaining oil. *Miscible process* is used to recover oil trapped in reservoir rock after a waterflood.

A hydrocarbon solvent is a blend of dry gas with natural gas liquids which is designed specifically for the oil present in a given reservoir through miscibility testing in lab. A range of compositions should satisfy the miscibility requirements, where this composition depends upon flood operating pressure, gas/NGL availability and cost, reservoir oil characteristics, and facilities design.

The higher reservoir pressure requires the leaner solvent, where the lighter solvents are cheaper. However, a heavier solvent may have better resale value when reproduced in the future.

A simple block diagram of hydrocarbon miscible flood facilities is shown in **Figure 11.** As illustrated in this diagram the output of the oil well enters the battery which contains a three phase separator for oil, water and raw gas. In the gas plant a gaseous mixture of hydrocarbons is split into gas co-products (C3+) and sulphur. Then deep cut facilities will knock out more portion of gas co-products and ethane (C2+). Finally raw gas, methane (C1) and C2+ are re-injected into the oil reservoir as solvent flood.

For light oil the most common tertiary technique involves the injection of a fluid that is miscible with the oil under reservoir conditions. For heavy oil, the most common tertiary process is steam injections or in-situ combustion.

Use of natural gas liquids in EOR projects reached their peak in the early 1990's. Since then, their use in solvent flood schemes has had a precipitous descent. The fall in solvent flood injection of NGL's is due to a decrease in the number of economically attractive reservoirs for the process.

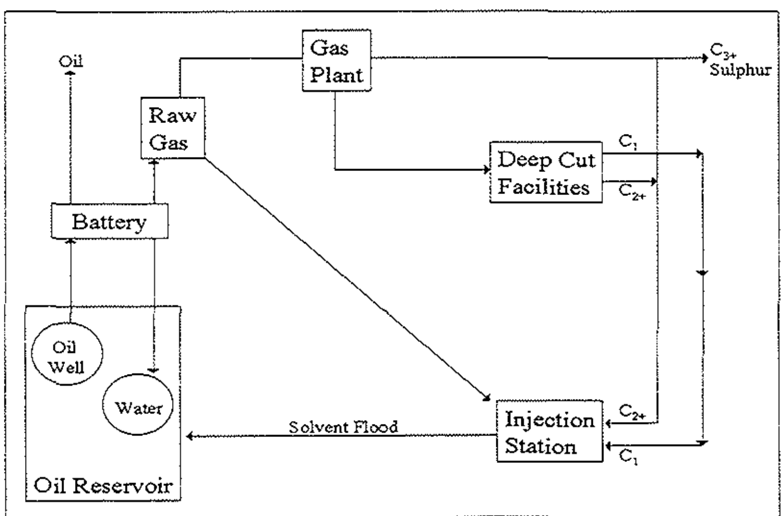


Figure 11: Typical Hydrocarbon Miscible Flood Facilities

3.4 Diluent

The largest component of the market for pentanes plus is diluent for transporting heavy crude and for in-situ bitumen in Alberta. Diluent is required to increase the API gravity and reduce viscosity of heavy crudes to allow conventional pipelining. The required diluent, depending upon the characteristics of the oil, may account for one third to one half of the total volume transported.

The availability of pentanes plus as diluent is an issue with respect to development of in-situ bitumen production. However, in the long run promising alternatives include oil-in-water emulsions, importing pentanes plus, upgraded refinery configurations, partial field upgraders and the use of re-produced diluent.

3.5 Fuel

Propane is the only natural gas liquid that is used directly as fuel for space heating, drying industrial fuel, asphalt paving and construction, water heating and cooking, and as an alternative fuel in transportation sector because it is cheaper than butanes.

Two federal programs were introduced in 1981 to promote propane fuelled vehicles thorough a taxable grant of $400 per commercial vehicle equipped to run exclusively on propane, as well as providing a federal excise tax exemption to propane vehicles.

The conversion incentive program then extended to dual-fuel and private vehicles in March 1985. The number of propane vehicles in Alberta has continued to rise, despite the end of the federal incentive program.

4 Export Markets and Pipeline Capacity

Export demand consists of NGL mix that is not fractionated in Alberta (it is fractionated at the destination point) and specification products. Out of province markets traditionally balance Alberta's NGL supply and demand. The historical data shows that the largest importing province is Ontario and the main US market is Petroleum Administration for Defense District II (PAD II) that covers Northern Mid-west areas of the U.S.

The major Alberta feeder pipelines that move NGL's from different production areas to Edmonton and Fort Saskatchewan are Empress Ethane pipeline with capacity of 85 thousand barrels per day (85 mb/d). The Federated Pipeline, owned by Imperial and Anderson to serve miscible flood markets: consists of sections of South (64.8 mb/d), and North (35.2 mb/d).

The Cochrane - Edmonton (Coed) Pipeline developed by Dome and Amoco as a result of the straddle plant operation at Cochrane: consists of two sections of North (100 mb/d), and South (80 mb/d). The remaining capacity belongs to Cochrane Ethane (57.5 mb/d), and Peace Mainline (170 mb/d), which are shown in **Figure 12.**

Two major pipelines move NGL's from Alberta. Interprovincial Pipeline, primarily a carrier of crude oil, moves NGL batches from Alberta to Superior (Wisconsin) and finally to Sarnia. The mixed NGL capacity of this pipeline is 146 mb/d. The Cochin Pipeline, which is essentially a specification product pipeline, moves propane, ethane and ethylene (which has the same physical properties as ethane) to Sarnia. Its capacity is 112 mb/d. Rangeland is a small pipeline (5 mb/d) which carries crude oil and some butanes from Alberta into Montana.

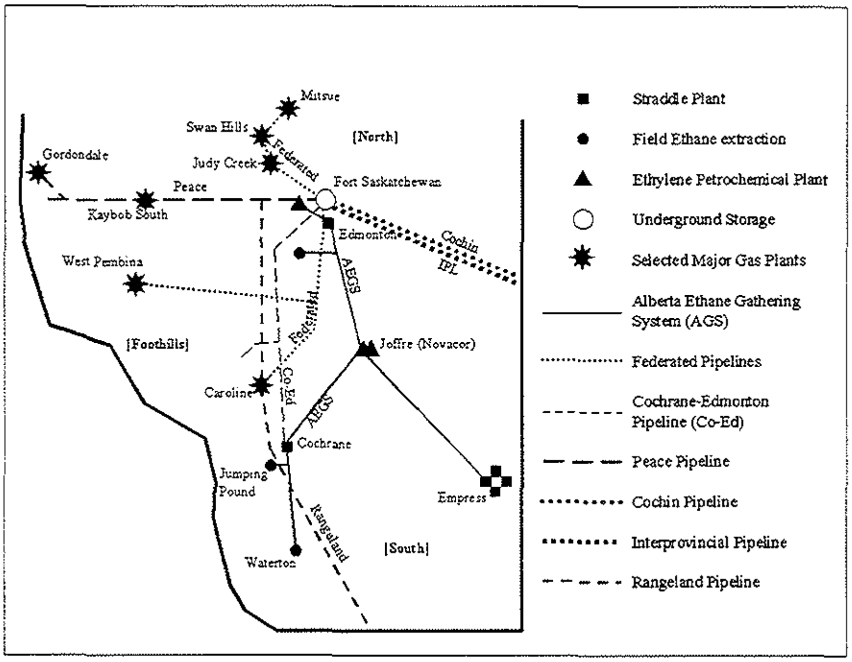


Figure 12: Alberta NGL Feeder Pipelines

5 Conclusions - Projections of NGLs

Alberta, like other parts of the world, obtains NGLs from the processing of natural gas and refining of oil. Its demand for NGLs, however, is determined more by local circumstances, particularly the mix of chemical processes. For example acetic acid in Alverta is produced from butanes, whereas elsewhere the feedstock is usually methanol; propane is the heating fuel of choice in Alberta remote areas whenever natural gas is not available, whereas elsewhere "fuel oil" is more common.

In general, supply of NGL varies with the amount of natural gas production, the liquids contents ofinlet gas, and advances in NGL extraction technology.

In addition to gas processing and reprocessing plants, refinery production is another source of NGL supply. Types and volumes of crude oil used in refining, and refinery configurations determine the amount of butane and propane production.

The last potential source of supply is solvent flood reproduction, which is not usually taken into ccount because measurement can not identify it separately.

The disposition of NGL can be categorized into petrochemical plants, refineries, solvent flood, dileuent, fuel and export.

The future increase in ethane and butane petrochemical feedstock demand depends on the capacity utilization rate of ethylene, and MTBE plants. Similarly, the butane requirements in the refineries depend on the production of motor gasoline, and type of octane enhancer and octane blending needs.

The NGL mix used for solvent floods varies with crude oil prices, remaining reserves in exiting light and medium oil reservoirs under tertiary recovery, flood operating pressure, and facility design. The pentanes plus requirements (diluent) are determined based on heavy crude oil and non-upgraded in-situ bitumen production to serve Alberta refineries or markets outside of Alberta.

The propane use as fuel depends upon the conversion of vehicles from motor gasoline to propane, as well as cooking, crop drying, heating, etc. in remote areas. A summary of NGL supply and demand sources is shown in **Figure 13.**

Finally the potential shipment of NGL from Alberta depends on the supply of NGLs, Alberta's requirements, and pipeline capacity.

Processing Plants (Incl. Deep-cut facilities)	S	S	S	S
Reprocessing Plants	S	S	S	S
Refinery		S	S	
Solvent Flood Reproduction	S	S	S	S
SUPPLY ↑↓ DEMAND	**ETHANE**	**PROPANE**	**BUTANE**	**PENTANES+**
Petrochemical	D		D	
Refinery			D	
Solvent Flood	D	D	D	D
Diluent				D
Fuel		D		
Export (other than diluent)	D	D	D	D

Figure 13: Sources of NGL Supply and Demand

Appendix 1: Definition of Technical Words and Terms

Acid Gas
The hydrogen sulfide and/or carbon dioxide contained in or extracted from gas or other streams.

Alkylate
Alkylate is the product of alkylation process, where in this process combining isobutane and isobutylene form iso-octane. Alkylation is simply the reverse of cracking and has largely replaces polymerization.

Catalytic Reforming
Catalytic reforming is a process in which napthenes are converted to aromatics by removal of hydrogen in the presence of a catalyst.

Carbon dioxide
A heavy, colourless gas having the formula CO_2. When in its solid state, it is commonly called "dry ice".

Condensate
The liquid formed by the condensation of a vapour or gas: specifically, the hydrocarbon liquid separated from natural gas because of changes in temperature and pressure when the gas from the reservoir is delivered to the surface separators. Such condensate remains liquid at atmospheric temperature and pressure. It may also be water condensed and returned to boilers in a steam system.

Deep-Cut Facilities
A gas plant adjacent to or within gas field plants for extraction of ethane and further extraction of propane, butanes and pentanes plus.

Dehydration
The act or process of removing water from gases or liquids.

Distillation
The process of separating a multiple component feed of differing boiling points into two or more products. In absorption plants, the term is used to describe the separation of product components from absorption oil.

Dry Gas
Gas whose water contents has been reduced by a dehydration process.

Extraction
The process of separating one material from another by means of a solvent. This tem can be applied to absorption of liquid, liquid extraction, or any other process using a solvent.

Inlet Separator
A vessel in the oil or gas field for separating the gas, hydrocarbon liquid, and water from each other.

Flare Gas
Gas that is burned in a flare or pit.

Gas Injection
The injection of natural gas into a reservoir to maintain or increase the reservoir pressures or reduced the rate of decline of reservoir pressure.

Gas processing Plant
A plant which processes raw natural gas for recovery of natural gas liquids and sometimes other substances such as sulphur. Such facilities are also referred to as field plants.

Gathering System
The network of pipelines which carry gas from the wells to the processing plant or other separation equipment.

Hydrocarbon Solvent
Two methods exist in flooding a hydrocarbon reservoir with solvent. The first method is vertical miscible flood where solvent displaces the oiil downward to the producing zone. Te second method is a horizontal flood, which represents the remaining share of NGL demand and floodable original oil in-place. Vertical and horizontal floods have an average recovery of 25% and 12 % respectively.

Incinerator
Apparatus or equipment, which converts undesirable material to ashes and less objectionable flue gasses.

Inlet Gas
Gas entering a gas processing plant or unit.

Isomerization
Isomerization is a process for rearraing the atoms in a molecule so that the product has the same formula but a different structure, e.g. converting normal butane to isobutane.

Liquefied Petroleum Gases (LPG)
Predominantly propane or butane separately or in mixtures which are maintained in a liquid state under the pressure within the confining vessel.

Marketable Natural Gas
Gas which meets specifications for direct use as a residential or commercial fuel. It is made up of the volume of gas available for marketing after the extraction of natural gas liquids and sulphur at field processing plants, plus the volumes of gas available from fields for which processing is not required. Marketable gas is measured at the field or processing plant gate.

Miscible Flood
A method of secondary recovery of fluids from a reservoir by injection of fluids that are miscible with the reservoir fluids.

Natural Gas Liquids (NGLs)
Propane, butanes, and/or pentanes plus, obtained from the processing of raw gas or condensate.

Pentanes Plus
A mixture mainly of pentanes and heavier hydrocarbons which ordinarily may contain some butanes and which is obtained from the processing of raw gas, condensate, or crude oil.

Primary recovery
Primary recovery uses the natural gas energy of reservoir such as gas cap expansion and solution fas drive.

Raw Gas
Unprocessed gas or inlet gas to a plant.

Reprocessing Plant
A gas plant used to extract ethane and natural gas liquids from marketable natural gas. Such facilities, also referred to as straddle plants, are located on major gas transmission lines.

Secondary Recovery
Secondary recovery adopts mechanical energy as a supplement to primary recovery, The two typical methods are water floods and gas floods.

Shrinkage
The reduction in volume and/or heating value of a gas stream due to removal of some of its constituents.

Solvent Flood
The process by which a suitable mixture of hydrocarbons ranging from methane to pentanes plus but consisting largely of methane, ethane, propane, and butanes is used for enhanced-recovery operations in oil reservoirs.

Solution Gas
Gas which originates from the liquid phase in an oil reservoir.

Sour Gas
Gas containing an appreciable quantity of hydrogen sulfide and/or mercaptans.

Stabilization Facilities
A fractional system that stabilizes any liquid, i.e. reduces the vapour pressure so that the resulting liquid is less volatile.

Sulphur Plant
A plant that makes sulphur from the hydrogen sulfide extracted from natural gas. One-third of the hydrogen sulfide is burned to sulphur dioxide, which is reacted with the remaining hydrogen sulfide in the presence of a catalyst to make sulphur and water.

Sulfreen
The Modified-Clause process is based on the chemical reaction of H_2S and SO_2 to form elemental sulphur. The Sulfreen process is tail gas clean-up extension of the Clause reaction that promotes the reaction of H_2S and SO_2 (125 to 150 degrees Celsius temperature) to form sulphur to the extent that the overall design sulphur recovery level can exceed 99 % .

Sweet Gas
Gas, which has no more than the maximum sulphur content defined by the specifications for the sales gas from a plant.

Synthetic Gas
The preferred term to describe the saleable gas product resulting from the gasification of coal and/or gas liquids or heavier hydrocarbons.

Tail Gas
The exit gas from sulphur recovery unit.

Wet Gas
Raw gas which is rich in hydrocarbon liquids.

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