



**MENNTA**  
ENERGY SOLUTIONS

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NGLs Trading Fundamentals  
Session 1

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# NGLs Trading Fundamentals

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C.M. Lippert Glenn  
President & CEO

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##### **Europe, Middle East**

##### **Africa, Latin America**

John Eccles House.  
Robert Robinson Avenue,  
Oxford Science Park  
OX4 4GP United Kingdom  
Tel: (+44) 1865 250521

##### **North America**

P.O. Box 747  
Bluffton, SC  
USA 29910

Tel: +1 (609) 520-9099

##### **Asia Pacific**

#03-20 Galaxis  
1 Fusionopolis Place  
Singapore 138522

Tel: (+65) 6016 7050



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Bluffton, SC

USA 29910

**Asia Pacific**

#03-20 Galaxis

1 Fusionopolis Place

Singapore 138522

Tel: +1 (609) 520-9099

Tel: (+65) 6016 7050

## MENNTA ENERGY SOLUTIONS

Administrative Offices  
John Eccles House, Robert Robinson Avenue,  
Oxford Science Park,  
Oxford, OX4 4GP

Telephone: +44 1865 250521  
E-mail: [info@mennta.com](mailto:info@mennta.com)  
Website: [www.mennta.com](http://www.mennta.com)

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## MENNTA ENERGY SOLUTIONS

### COURSE LECTURER

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**Mary Jackson** has over twenty-five years' experience in the energy industry. After university she began her career at BP, working in the information management group, before joining the Manufacturing, Supply and Trading department. She subsequently worked at Saladin as a consultant, working closely with clients throughout the world and providing consultancy advice on energy market analysis, trading and risk management. In several senior roles at Saladin, she managed the energy consulting team, ran the energy market information service and directed strategy for new software and information product development.

Since 2000, Mary has worked as an independent energy market consultant and she formed Kingston Energy Consulting with Nigel Harris in 2002. Kingston Energy provides consultancy services to companies involved in energy markets and trading. A key area of work has been the European natural gas market - Kingston Energy has researched and authored a well-respected report on European natural gas trading which has been published annually since 2004.

Mary has lectured regularly for Mennta Energy Solutions on energy markets, trading and risk management and is also a regular speaker and panel member at public conferences. She has written articles for industry publications including Harts Energy Markets, Energy Risk, Global Energy Business and Petroleum Review.

**Nigel Harris** is a director and principal consultant at Kingston Energy Consulting, which he founded with Mary Jackson in 2002. He has been helping energy traders to analyse and understand the markets for over 25 years, initially as a developer of market analysis software systems, and more recently as a consultant.

At Kingston Energy Consulting, his main focus is on providing education and information transfer to participants in the energy trading business, through instructor-led classroom training, web-based training development, research projects, workshops, briefings and research-based report writing.

In his work with Mennta Energy Solutions, he has created a library of new instructor-led and web-based courses on European gas and power markets and trading. In 2005, he worked with Mary Jackson to develop the popular Oil Trading Orientation course, which has since been presented at venues all over the world. He has also extensively revised and updated many existing courses on derivatives, hedging and risk management. He regularly presents this material both at public venues and as in-house, often customised, courses.

He is co-author of a series of highly regarded reports on European natural gas trading and has also contributed to reports on power markets and oil trading.

In previous roles, he was a key member of the team that initially designed and developed Saladin's innovative Petroleum Analysis Workstation, a system that became an industry standard for historical price analysis during the 1990s and remained in use in the industry for two decades. During this period, he worked closely and extensively with oil and gas traders around the world to understand their information

and analytical requirements. He also spent some years as an independent consultant, working mainly with software and information providers to help them better understand the oil and gas trading sectors.



# NGLs Trading Fundamentals

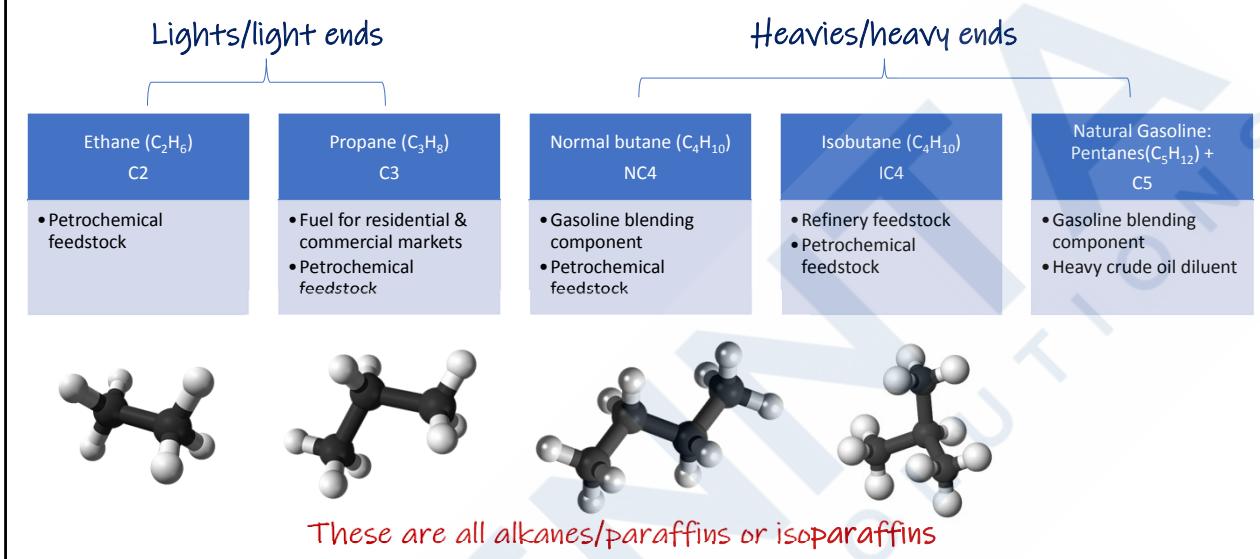




## Introduction to NGLs Trading



## What is Traded?



Natural gas liquids comprise the purity products: ethane, propane, normal butane and isobutane, as well as pentane/pentane+. NGL is a generic term for any hydrocarbons heavier than methane that are present in a raw natural gas stream. These are saturated hydrocarbons (with no double bonds), called alkanes by chemists and paraffins by petroleum engineers. Two forms of butane exist: normal butane (N-butane) with four carbons joined in a straight chain, and isobutane, with a branched chain structure. NGLs all have different physical characteristics, different end-use markets, and different price drivers.

Almost all ethane (also known as purity ethane) is used as a feedstock for the production of ethylene. Propane and butane are also used as petrochemical feedstocks, as well as being used as residential/commercial fuels.

Propane as a fuel has some unique characteristics that have found favor in many applications. It can be liquefied at reasonable temperatures and pressures for ease of transport, particularly in trucks. Yet at ambient temperatures, it will readily vaporize (making it easy to burn in home furnaces, etc.).

Normal butane is used predominantly as a motor gasoline blending component. Due to its volatility, it is good for starting cold engines yet will stay dissolved in the gasoline with minimal evaporation. Isobutane is used almost exclusively as one of the feedstocks to the alkylation process. It is also occasionally used as a motor gasoline blending component.

Heavier fractions may be used as blending components for refined products, primarily gasoline. In regions where heavy oil is produced, natural gasoline is in high demand as a diluent to reduce viscosity. This is particularly associated with Canadian oil sands production.

# Terminology

## Purity products

- Contain minimum 90% of one type of NGL

## Mixed products

- Y grade = unseparated NGLs from gas plant ('raw mix')
- EP mix = usually 80% ethane & 20% propane
- Liquefied petroleum gas (LPG)
  - In North America, almost all LPG = propane
  - Elsewhere LPG can be a mixture of propane and butane

## Hydrocarbon gas liquids

- NGLs + olefins (e.g. ethylene, propylene, butylene)

EP mix is also known as commercial ethane.

Almost all liquefied petroleum gas (LPG) distributed in the USA is propane. In Europe, the gas sold as LPG varies. In the UK, propane and butane are always sold separately (and most LPG is 100% propane). In Belgium, LPG is a 60:40 mix of propane and butane. In some countries, the mix is varied seasonally, with a higher proportion of butane in the summer. About 10% of the LPG sales are butane or butane-propane mixes.

The term isopropane is sometimes used to refer to mixtures of propane and isobutane.



## Who Trades and Why?



| Acquisition and Disposal                                                                                                                                                                                                                                                 | Supply (Asset/System) Trading with Optimization                                                                                                                                                                                                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>• Trading around physical supply chain, e.g. production, storage</li><li>• Correct volume imbalances</li><li>• Routine trading approach</li><li>• Extensive use of long-term contracts</li><li>• Aim = fair market price</li></ul> | <ul style="list-style-type: none"><li>• Still trading for physical supply chain only</li><li>• More flexible trading (timing, location...)</li><li>• Aim = better market price</li><li>• Avoid unnecessary risk &amp; price exposure...but not always a user of hedging</li></ul> |

NGL trading has different motivations.

System trading, also known as asset or supply trading, is trading to balance the surplus (long) or deficit (short) needs of the upstream, refining and marketing system (e.g., buy more supply, sell excess production). Trading is an essential part of operating a physical supply chain business.

System trading is carried out by a wide range of physical market participants, such as oil and gas producers, refiners, marketers, integrated and national oil and gas companies, and end users.





## Who Trades and Why?

### Opportunistic Trading

- Physical trading beyond own supply chain (e.g. locational arbitrage)
- Decisions driven by market opportunities, especially physical market price differences
- Requires physical assets, e.g. storage, transportation
- Aim = trading profit
- Minimize risk exposure, usually strong hedgers

### Speculative Trading

- Position taking and spread trading in financial markets
- Aim = profit
- Active seekers of price exposure

Many integrated oil companies do opportunistic trading, as well as trading houses such as Vitol, Trafigura, Glencore, Axpo and Gunvor who are among the world's largest shippers and traders of NGLs. These are physical trading companies, seeking opportunities to make profit through trading. Trading houses are usually strong users of hedging, to lock in the profits available on trades.

Other trading activities are more essentially speculative in nature. Even passive "investment" in energy commodities is essentially a large-scale bet on rising energy prices.





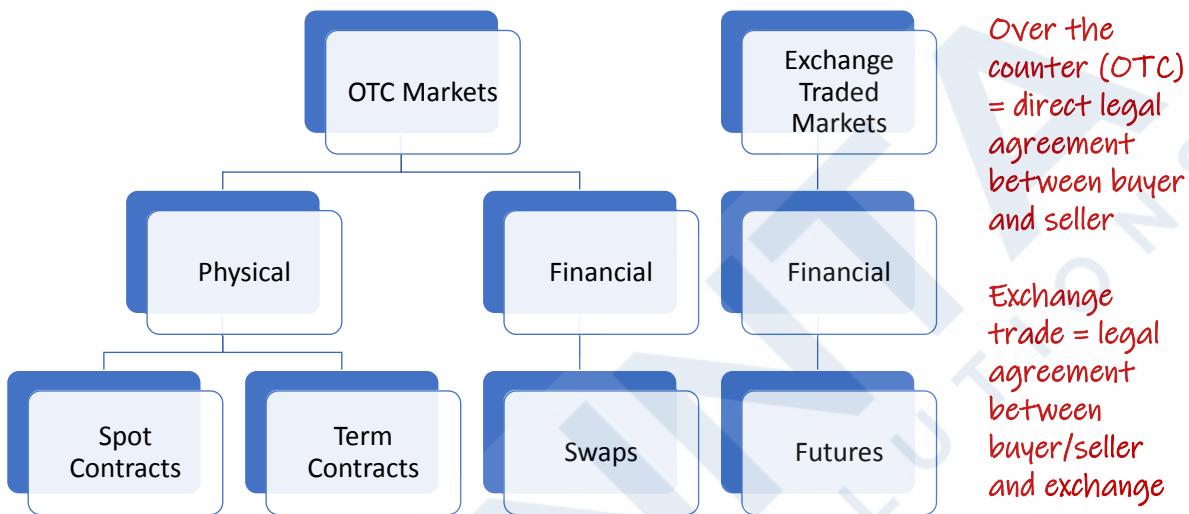
## Who Trades and Why?

### Risk Management

- Providers of risk management services, e.g. swaps
- Aim = profit from risk services
- Minimize risk and exposure
- Back to back trades or hedge

Banks and other companies that act as risk management providers are keen to avoid price risk exposure, and to hedge or offset risks so as to capture the profit available from providing the risk management service. Banks also provide trade finance.

## How are NGLs Traded?



In the physical market, the NGL commodity will transfer to the buyer at a specific physical trading location. In contrast, financial trades typically do not result in physical delivery.

OTC means “Over The Counter”, a market in which deals result in direct legal agreements between buyers and sellers, often settled by cash flows, rather than delivery.

Exchange trading involves an organized, regulated exchange operator, and buyers and sellers enter into contracts with the exchange, rather than with each other.



# Trading Markets

## Spot physical markets

- For immediate delivery
  - Within 48 hours for prompt US pipeline trades
  - 2-10 days for barge trades in north-west Europe
  - 5-25 days for railcar loadings in eastern Europe
  - 30-45 days for LPG USG export cargoes
- Delivery of a single cargo, pipeline batch etc.
- Fixed or floating price

*In a spot transaction, the "immediate" delivery period varies depending on the location & transport method*



Spot trades are once-off agreements between a buyer and a seller for a fixed quantity of the commodity, with no obligation or intention for a repeated purchase or sale.

Spot trades are often done in standard sizes, which vary by market. The European large cargo market is typically traded in 20,500 tonnes of propane or 10,000 tonnes of butane; major US products pipelines usually operate in multiples of 5,000 barrels, usually 25,000 or more at Mont Belvieu.

In spot markets, trading is for short-term delivery, which may still mean several weeks in the future, because of transport logistics and production scheduling.





## Trading Markets

### Term contracts

- Long term agreements
- Covering months or years
- Multiple loadings or deliveries
- May include volume flexibility

A term deal is for delivery of agreed volumes between the buyer and seller over an extended period of time e.g., a calendar quarter or one year. Deliveries are typically spread at intervals acceptable to both parties.

Term deals are mainly entered into for supply security. The price is usually floating, linked by a formula to spot market prices.



# How Physical Trading Works

| Cargo trading                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Pipeline trading                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>• Buyer and/or seller arrange physical delivery logistics<ul style="list-style-type: none"><li>• <i>Charter vessel, arrange storage, loading, inspections</i></li></ul></li><li>• Each trade is (potentially) unique<ul style="list-style-type: none"><li>• <i>Quality, quantity, location, timing</i></li></ul></li><li>• Exposed to full complexity of delivery<ul style="list-style-type: none"><li>• <i>Demurrage, temperature corrections, liquid &amp; vapor quantity, etc.</i></li></ul></li></ul> | <ul style="list-style-type: none"><li>• Physical delivery handled by pipeline company</li><li>• <i>Traders have contracts with pipeline companies, as registered shippers</i></li><li>• Highly standardized trades</li><li>• Pipeline specifies quality</li><li>• Some aspects of market simplified<ul style="list-style-type: none"><li>• <i>Interconnection points, storage facilities, etc.</i></li></ul></li></ul> |

Pipeline companies handle the physical flows of energy. For the most part, traders do not have to worry about how NGLs get from one place to another.



# Derivative Markets

Derivatives are mainly traded for risk management purposes (hedging) or for profit

## Futures

- Buy or sell for future delivery
- Anonymous, fixed-price transactions
- Standardized contracts
- Traded on an organized exchange, e.g. CME, ICE

## Swaps

- Financial agreements to exchange a fixed price for a floating price
- Direct bilateral contracts, but can be cleared through an exchange

Derivatives contracts are financial instruments that derive their value from the underlying physical (usually spot) markets. They may be traded on an exchange, or in the over-the-counter (OTC) market. Intercontinental Exchange (ICE) and the New York Mercantile Exchange (NYMEX, a division of CME) are the two largest exchange operators for oil and gas. Smaller exchanges operate nationally or regionally.

In the oil market, derivatives trading volumes are huge – by some estimates, over 1,000 times the size of the underlying physical markets.



# Trading Strategies

## Long position

- Have commodity to sell
  - *Producer: trader with NGLs in inventory*
  - *Speculator: "go long" by buying futures contracts*
  - *Profit if price rises*

## Short position

- Need to buy commodity
  - *End consumer: requirement to buy NGLs*
  - *Speculator: "go short" by selling futures contracts*
  - *Profit if price falls*

The terms “short” and “long” mean different things in different circumstances, but they always have common characteristics:

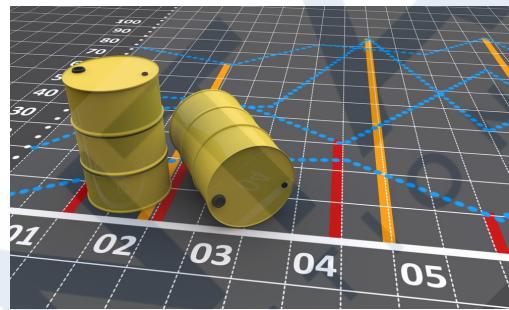
- A trader with a LONG position has something to sell, and will benefit if market prices rise so that they can sell at a high price. They are at risk of prices falling.
- A trader with a SHORT position has a need to buy something, and will benefit if market prices fall so that they can buy at a low price. They are at risk of prices rising.

In a traded market such as futures or forward contracts, traders can deliberately take a long position (“go long”) by buying for forward delivery, or take a short position (“go short”) by selling for forward delivery.

# Trading Strategies

## Spread Trading

- Simultaneous purchase of one item and sale of another (as a linked strategy), with intention of closing the trade at a later date
- Most commonly traded in futures markets, but can also be traded through swaps
- Can be executed as a single trade in some derivative markets

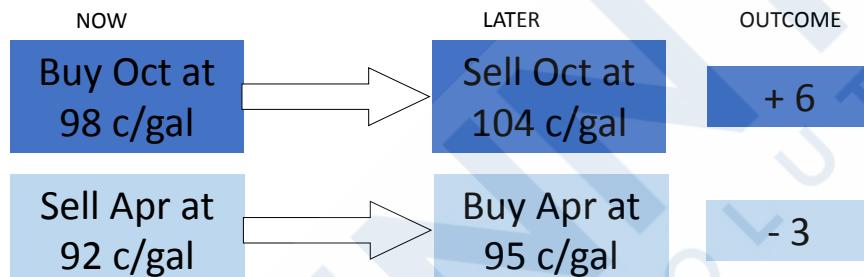


## Trading Strategies

Often used to trade  
impact of weather or  
season

### Calendar (time/intermonth) spreads

- Bull spread
  - Buy nearby, sell further out contract
- Bear spread
  - Sell nearby, sell further out contract



*Inter-month or calendar spread:* buy one month, sell another; usually in the same commodity.

A Bull Spread returns a profit if the price of the commodity for nearby (short-term) delivery rises relative to the price for delivery at a later date. It is a bullish trading strategy (that is, one designed to profit from an increase in the commodity price) but with limited risk if the market goes against the trader's expectation.

A Bear Spread returns a profit if the price of the commodity for nearby (short-term) delivery falls relative to the price for delivery at a later date. It is a bearish trading strategy (that is, one designed to profit from a fall in the commodity price) but with limited risk if the market goes against the trader's expectation.

## Trading Strategies

### Quality (intercommodity/intermarket) spreads

- Location: Mont Belvieu vs Conway, Targa vs LST, AFEI vs CP
- Quality: EP mix vs purity ethane, normal butane vs isobutane
- Crack spread: products vs crude
  - *LPG crack spread (LPGs vs crude)*
  - *Fractionation spreads: natural gas vs NGLs*

LST = Lone Star (Energy Transfer) NGL storage at Mont Belvieu

AFEI = Argus Far East Index price

CP = Saudi Arabia / Kuwait NGL export contract price

# Sources of Trading Profit

Being right about the direction of future price movements

- Physical: unhedged speculative storage or movements
- Financial: speculative positions in futures, swaps

Finding ways to benefit from existing price differences

- Physical: locational arbitrage, storage plays
- Financial: (little or no opportunity)

Providing services to other traders

- Physical: dealing with logistics, service contracts
- Financial: trade finance, risk management, dealing

Enabling the rest of the company to make profits

- Physical: supply trading
- Financial: risk management

Trading is not all about speculation. In fact, for most physical trading companies, it is not at all about speculation. In many companies, the trading activity is not itself a source of profit, but enables the company to run a profitable business, for example by supplying a petrochemical company with the feedstocks it needs, or by managing the price risk associated with an end user's fuel buying, allowing the company to better plan and invest in its business.

# Measurement Units

## Volume (barrels, gallons)

- Cents per gallon used in US for trading
- Priced per gallon but traded in barrel volumes

## Weight (tonnes)

- \$ per tonne used in Europe and Asia for trading

## Volume

- Used for production & storage
- Cubic meter or cubic foot at defined pressure and temperature

Weight to volume conversions depend on the product density  
e.g. 521 gallons of propane = 1 tonne

Trading units in the oil industry vary by region. US dollars is the usual currency.

Petroleum products are usually priced in US dollars but they can also be priced in local currencies, such as Japanese Yen. Refined products are measured in various units including gallons and barrels (volume measurements) and tonnes (weight measurements).

The SI unit of volume is the cubic meter ( $m^3$ ). The liter (US spelling) or litre (European spelling), a synonym for a cubic decimeter, is also commonly used for liquid volumes. Cubic meters are commonly abbreviated as cbm when referring to tank storage capacity. Kcm, mcm and bcm indicate thousands, millions and billions of cubic meters, respectively. The abbreviations scm and ncm indicate standard and normal cubic meters. Normal is measured at zero degrees Celsius and standard at 15°C or 60°F.

In the USA, cubic feet are commonly used when describing gas volumes at standard conditions; the abbreviation scf is explicitly used to indicate measurement at 60°F. Abbreviations Mscf and MMscf indicate one thousand standard cubic feet and one million standard cubic feet, respectively. Liquid volumes or tank capacities are more commonly stated in barrels or gallons.

## Key Physical Properties

Hydrocarbons with up to four carbon atoms are gases at standard temperature and atmospheric pressure

C2-C4 can be liquefied using pressure or by cooling them to their boiling temperatures

|               | Pressure needed to liquefy at<br>21°C / 70°F | Boiling temperature |
|---------------|----------------------------------------------|---------------------|
| Ethane        | 38.5 bar / 560 psi                           | -89°C / -128°F      |
| Propane       | 8.6 bar / 125 psi                            | -42°C / -44°F       |
| Isobutane     | 2.1 bar / 31 psi                             | -12°C / 10°F        |
| Normal butane | 1.2 bar / 17 psi                             | -1°C / 30°F         |

Hydrocarbons with four or fewer carbon atoms are gases at standard temperature and atmospheric pressure. They are liquefied using pressure or cooling for storage and transportation, and are then regasified by returning them to atmospheric temperature and pressure for use. The pressures and temperatures at which gases liquefy vary depending on the specific hydrocarbon.

Butane and propane can be liquefied by the application of quite modest pressures. Ethane can be liquefied by pressure, but requires a very high pressure. Its critical temperature is 32.2°C (90°F), so above that temperature (easily reached in an above-ground tank in many parts of the world), it can exist only as a gas. And at that temperature, the tank pressure will have risen to over 700 psig. So above-ground storage of ethane as a pressurized liquid is not practically possible.

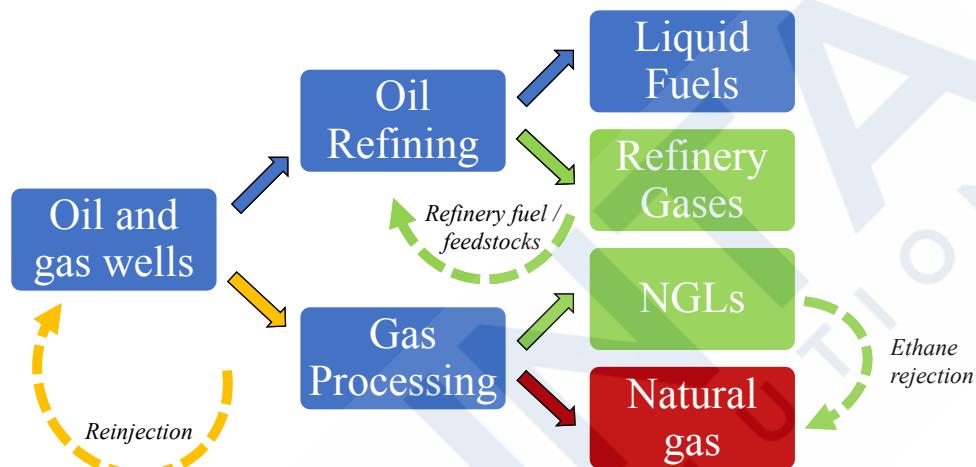
Gases can be liquefied by cooling them to their boiling temperature. At this temperature, they can be held as liquids without the application of pressure. Cooling materials to temperatures below -80°C is very expensive.

NGLs do not have odor, so typically for safety reasons they are odorized through the addition of ethyl mercaptan.

NGL Supply  
Chain &  
Infrastructure



## Sources of NGLs



Gas produced at a wellhead which contains less than 15% liquids is known as dry gas (also known as lean gas). Gas containing more than 15% liquids is known as wet or rich gas. Oil wells produce associated gas that is rich in NGLs. Gas processing plants separate heavier hydrocarbons from methane. Pipeline quality natural gas is mostly methane, but typically also contains some ethane (3-5%) and smaller quantities of propane and heavier hydrocarbon gases (0.5-1.0%). Pipeline specifications limit the amount of NGLs in natural gas to prevent the formation of liquids in a pipeline.

- Reinjection: of gas to maintain reservoir pressure and increase oil production
- Refinery fuel / feedstocks: consumption of refinery gases (mainly methane and ethane) as fuel gases for the refinery; also blending of butane and isobutane into gasoline. Refinery gases may include both paraffins and olefins, and may be purified petrochemicals grade materials, or mixed gases for fuel use.
- Ethane rejection: depending on demand and prices, ethane may be “rejected” (and left in the natural gas stream) or separated out for sale as a petrochemical feedstock. Propane and butane are always separated out, as their presence in more than small amounts in natural gas is undesirable because of their tendency to condense out in pipelines, and because of their effect on calorific value.

# Natural Gas Processing & Fractionation

## Gas processing plant

- Separate (strip) NGLs from raw gas stream using cryogenic process or lean oil absorption
- Ethane recovered or rejected depending on its fuel value compared to natural gas
- Processing plants also remove water, acid gases & other contaminants
- Plants located:
  - *Between gathering pipeline networks & interstate pipeline systems*
  - *On transmission pipeline systems (straddle plants)*
  - *At beach terminals*

## NGL fractionation

- Mixed NGLs (Y-grade or “raw make”) fractionated to create purity products
- Field grade NGLs are high quality, with no olefins
- Fractionation facilities can be sited with processing plants, or at market hubs

NGLs are separated from methane in a gas processing plant. As well as NGLs, water and other contaminants (primarily hydrogen sulfide and carbon dioxide) are removed, enabling the gas to meet pipeline quality standards. There are two main processes for extracting NGLs from natural gas:

1. Lean oil absorption method: lean oil is used to absorb heavier hydrocarbons from the gas stream.
2. Cryogenic process: chill gas to temperatures where ethane and other hydrocarbons condense, but the methane is still in its gaseous form.

The process for removing NGLs is commonly known as stripping.

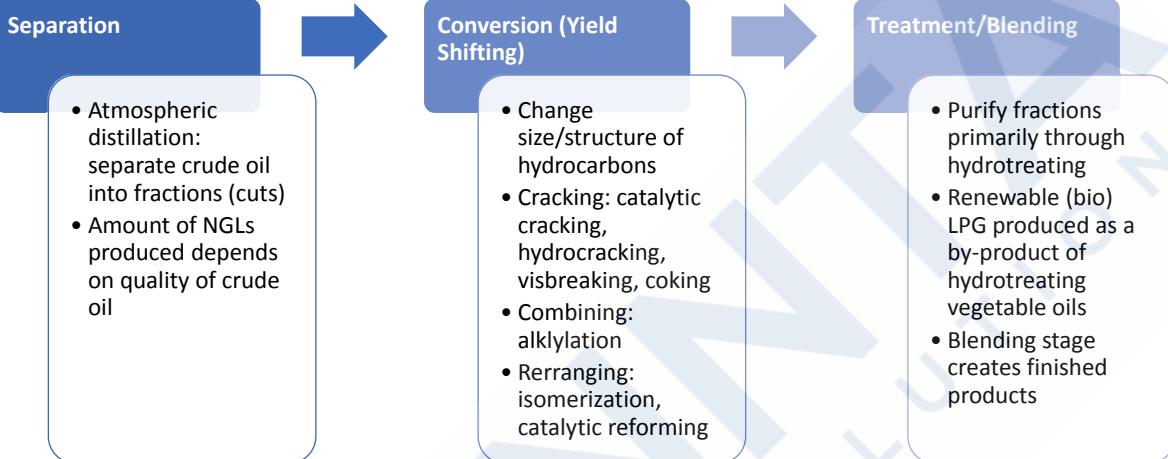
Ethane rejection: if ethane prices are low, then ethane may be left in the gas stream.

In North America, processing plants are typically located between gathering pipeline networks and major interstate pipeline systems. Some plants are on the transmission pipeline systems, and are known as straddle plants. In regions with offshore gas production, processing plants are usually located at the “beach” terminals where gas comes onshore.

After processing, the NGLs are usually fractionated to create separate streams of ethane, propane, butane and light liquids. Fractionation plants can be sited in the same location as gas processing plants, or in hubs such as Mont Belvieu which receive mixed NGL streams from many processing plants.

# Crude Oil Refining

Some of the NGLs produced in a refinery will be burned as fuel



NGLs are produced at various stage of refining. LPGs comprise around 1-4% of crude oil, depending on the crude quality, the refinery complexity, and the LPG crack spread compared to other products.

The three main refining processes are:

1. Separation: crude oil is fractionated (distilled) into groups of hydrocarbons called fractions or cuts.
2. Conversion: fractions from the distillation process are transformed into higher value intermediate components that eventually become finished products. Conversion processes change the size and/or structure of hydrocarbon molecules. These processes include the following:
  - Cracking (dividing or decomposition): various cracking units
  - Combining (unification): alkylation
  - Rearranging (alteration): isomerization and catalytic reforming
3. Finishing: a range of processes to purify the fractions into usable oil products such as fuels and petrochemicals to be made into other products such as plastics.

Renewable LPG (bioLPG) is chemically identical to conventional LPG and is produced as a byproduct of HVO production from a wide range of vegetable/animal oils and fats. Production is currently very low (around 200,000 t/yr).

# NGL Production from Refineries

## Cracking

- Breaks long chain, heavy hydrocarbon molecules to form lighter fuels
- Thermal or catalytic processes
- Catalytic cracker can produce ~8-25% C4 or lighter
- Gases produced from cracking without hydrogenation include olefins
- *Refinery grade often lower quality*

## Butane isomerization

- Rearranges structure of normal butane
- Creates isobutane, primarily for use as a feedstock for alkylation units (which create high value gasoline blendstocks)



Catalytic cracking (cat cracking) is a process of breaking larger, heavier, and complex hydrocarbons into lighter and simpler molecules. By doing so, this process increases the quality and quantity of lighter (and more desirable) products like gasolines and decreases the amount of residuals that would otherwise be produced. The typical feed for a cat cracker is vacuum gasoil. Cat cracking is a very flexible process, and production can be changed seasonally depending on product demand patterns. A cat cracker can also be run to maximize light olefin production.

Isomerization units rearrange the molecules of straight chain hydrocarbons to form branched chain hydrocarbons known as isomers. There are two distinct isomerization processes: butane (C4) isomerization (known as BI) and pentane/hexane (C5/C6) isomerization. C4 isomerization is important for the conversion of normal butanes into isobutane to provide additional feedstock for alkylation units or for MTBE manufacture.

# Purposes of Storage

## Balancing & security of supply

- Managing discrepancies between production & demand, e.g. seasonal demand changes
- Protecting against supply interruptions

## Transport logistics

- Loading different modes of transport
- Making and breaking bulk

## Taking advantage of forward price structure

- Storage play: price contango can provide “risk-free” trading opportunity if contango exceeds cost of storage



Contango = when prices for immediate delivery are lower than those for future delivery

The amount of storage required at different parts of the supply chain depends on the size and frequency of deliveries to a particular terminal but oil companies need to hold stocks (or inventory) to guard against unexpected supply interruptions or demand increases. Stocks can, therefore, help balance the discrepancies between production and consumption. Companies use storage to improve transport economics by collecting larger parcel sizes, and storage also enables them to be flexible about the timing of deliveries.

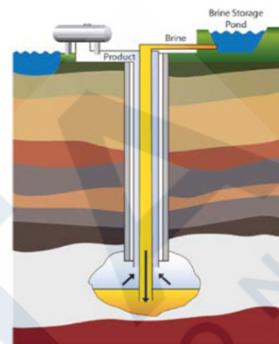
Companies also keep stocks occasionally for speculative reasons - for example, during a period of upward price movements they can buy products at a low price, store them and sell them later when prices are higher.



# Underground Storage

## Salt caverns

- Pressurized storage
- Brine compensation
  - Cavern is always full
  - As NGLs injected, brine is forced out and stored in brine ponds
  - Brine reinjected to force NGLs out



## Rock caverns

- Fully refrigerated or ambient storage



NGLs are typically stored in liquid form at high pressure. The type of storage used will depend on factors including the operational requirements (e.g. turnover), the location and availability of storage, and the amount to be stored. The first LPG bulk pressure spheres were built in the USA in 1923. 1942 saw the first storage of LPG in a salt cavern.

Underground storage is used to store large volumes. Most underground storage facilities are located in purpose-built salt caverns. The process for converting a natural underground salt formation into a storage facility involves removing the salt through leaching. Water is pumped into the salt formation, dissolving the salt, and the resulting brine is then pumped out of the formation. Salt caverns are typically located at depths of 500 to 2,000 meters. Each cavern can store between 100,000 m<sup>3</sup> and 500,000 m<sup>3</sup>, and there will be multiple caverns at each site. Storage of NGLs as a liquid works through brine compensation – the cavern is always full. To receive and store NGLs, the cavern is completely filled with salty brine. As NGLs are injected, brine is forced out and stored in adjacent brine ponds or sent to the plant for salt production. To remove NGLs, the facility operator re-injects brine to force the NGLs out.

Rock caverns are also usually purpose-made, in shale, granite or limestone formations. They are usually unlined, and can be used for fully refrigerated or ambient storage. The containment relies on hydrostatic pressure at 100-200m depth.

## Above Ground Storage



### Pressurized storage

- Spheres (Hortonspheres)
- Cylindrical horizontal (bullet) tanks
- Gas cylinders/canisters

### Refrigerated storage

- Insulated to minimize heat transfer

### Floating storage

Above ground vessels are used where geology is not suitable for underground storage, or where short-term storage is required.

Above ground vessels can be spheres, speroids or cylindrical horizontal pressure tanks (known as bullets). Pressure vessels are often located in a remote area of the tank farm. A pressure vessel is defined as a container built to operate at pressures exceeding 15 psig.

- **Storage spheres** are used to store high pressure fluids. A sphere is a very strong structure, with no weak points, but it is costly to manufacture. Spheres have a capacity up to 12,000 m<sup>3</sup>, and can typically store 2,000-5,000 m<sup>3</sup>. Pressure storage spheres for gases were introduced by the Chicago Bridge and Iron company in the 1920s, who named them Horton Spheres (or Hortonspheres) after the company's original founder.
- **Cylinders** are less expensive to produce than spheres but are not as strong as they have a weak point at each end. This weakness is reduced by using hemispherical or rounded ends. Bullet tanks can be built on any scale from individual small tanks at end-user facilities to arrays of large tanks at storage terminals. Large bullet tanks are often covered with earth (mounded or semi-mounded) for added safety. Each bullet tank has a capacity up to 1,000 m<sup>3</sup>.

Pressurized gas containers are filled to around 85% with liquid, to allow space for thermal expansion. The working pressure depends on the temperature but is maximum of 18 bar for propane and 7 bar for butane. As the LPG is drawn off the liquid will boil, cooling the tank and leading to sweating on the outside.

## NGL Storage



Major energy companies own and operate extensive storage facilities, known as captive storage. A number of independent (commercial or third party) storage operators also own and operate storage capacity. These operators generally do not take title to the material stored in their terminals.

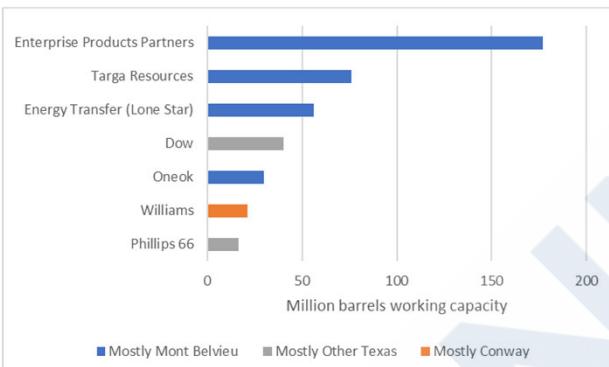
Terminals are used to receive, store and discharge material to/from tankers, barges, pipelines, road and/or rail.

Mont Belvieu, 30 miles east of Houston, has the world's largest concentration of NGL fractionation plants and underground storage facilities for NGL and LPG. Gases are brought here from many producing areas for processing and storage.

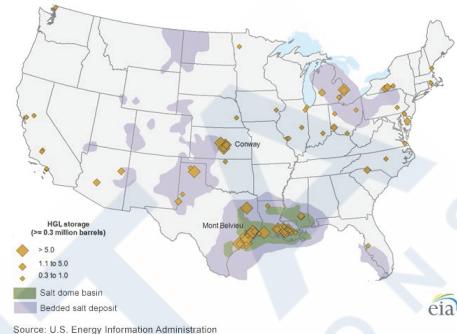
Conway, 50 miles north of Wichita, Kansas is North America's second largest NGL processing and storage hub, and the center of the Midwest LPG market.

# Storage

## NGL Storage Operators



Operating U.S. underground and aboveground wholesale HGL storage facilities, 2014



eia

The chart shows the total working NGL salt cavern storage capacity, in millions of barrels, operated by the main providers of storage at Mont Belvieu and elsewhere in Texas, or in the Conway market region.

# LPG Shipping

| VESSEL TYPE                   | CAPACITY          |
|-------------------------------|-------------------|
| Barge                         | Up to 5,500 cm    |
| Coaster                       | Up to 15,000 cm   |
| Handy gas carrier             | 15,000-25,000 cm  |
| Mid size gas carrier (MGC)    | 25,000-50,000 cm  |
| Large gas carrier (LGC)       | 50,000-70,000 cm  |
| Very large gas carrier (VLGC) | 70,000-200,000 cm |



Can carry LPG, chemical gases or ammonia

| TECHNOLOGY                           | NO OF VESSELS (2020) | PRESSURE                | TEMPERATURE |
|--------------------------------------|----------------------|-------------------------|-------------|
| Fully pressurized (PR)               | 718                  | 17.5 kg/cm <sup>2</sup> | Ambient     |
| Semi-pressurized, fully refrigerated | 363                  | 5-8 kg/cm <sup>2</sup>  | -48 deg C   |
| Fully refrigerated (FR)              | 448                  | 0.28 kg/cm <sup>2</sup> | -50 deg C   |

'LPG carrier' is a term used to describe a vessel which, depending upon design, may carry LPG, chemical gases (butadiene, propylene, vinyl chloride monomer), or ammonia. All of these products are gaseous at atmospheric pressure and at temperatures above -1°C, the boiling point of butane. All gases are transported in liquefied form either under pressure, or as refrigerated cargoes, or with a combination of pressure and refrigeration, depending upon the properties of the gas and the design of the vessel.

**Fully pressurized LPG vessels** carry their cargo in spherical or cylindrical steel tanks, designed for a working pressure of 17.5 kg/cm<sup>2</sup>. This corresponds to the vapor pressure of propane at 45°C, which is the maximum ambient temperature in which the ship is likely to operate. The tanks are generally known as 'Type C' spheres and do not require any insulation or secondary containment barrier. Their high design pressure requires considerable tank wall thickness which increases weight and cost. The decreasing ratio of cargo carried to tank weight makes fully pressurized gas carriers uneconomical over long haul routes.

**Semi-pressurized, fully refrigerated LPG vessels** can carry a full range of cargoes in cylindrical or spherical tanks and are designed for a minimum service temperature of -48°C and a working pressure of approximately 5 to 8 kg/cm<sup>2</sup>.

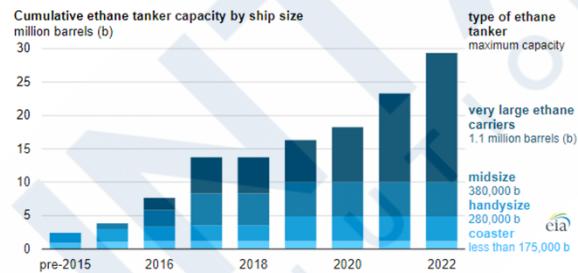
**Fully refrigerated LPG vessels** - the tanks in this type of vessel need to be free standing and fully insulated within the ship's hull to prevent cold escaping and damaging the hull. These tanks are constructed with special low-temperature nickel steels. The tanks are moulded to fit the contours of the vessel. Fully-refrigerated ships require a chiller to cool down the LPG at the load port and a re-heater to warm LPG discharging into pressure storage. The tanks are usually designed for a maximum working pressure of about 0.28 kg/cm<sup>2</sup> and a minimum working temperature of -50°C. Refrigeration means the thickness and weight of cargo tanks is reduced.

The trend for longer LPG voyages has created a need for larger ships. FR vessels are used for longer hauls and larger cargoes.

## Ethane Shipping

Growing fleet of ethane vessels, especially Very Large Ethane Carriers (VLECs)

Ethane transported at -89°C (-128°F) or colder



Large-scale international shipping of ethane is a relatively recent phenomenon. The USA exported its first ethane cargo in 2016. Two export terminals, Marcus Hook (US East Coast) and Morgan's Point in Texas, can load ethane vessels.





## Pipelines

NGLs are transported as liquids, normally using high pressure pipelines

Can carry Y-grade or purity products

- Dedicated NGLs pipelines
- Some multi-product pipelines carry propane and butane, and some crude oil pipelines transport natural gasoline

Trading market based on pipeline movement (cycles)

- Prompt = delivery within 48 hours
- Any current month ("anys") = delivery before end of current calendar month
- Anys in the following month ("out month")
- Ratable delivery

Some pipelines carry mixed NGL, called raw make or Y-grade. Other pipelines carry individual products such as propane.

NGL pipelines carry their contents as liquids, in a similar way to oil pipelines.

Y-grade is typically transported to fractionation plants. Purity products are moved from fractionation plants to end-users, such as petrochemical facilities. A lot of NGLs move only a relatively short distance. Petrochemical plants that consume NGLs, and storage and distribution terminals for propane tend to be built close to producing regions. For long distance movements, several of the refined products pipelines carry batches of propane and butane. Some of the major crude oil pipelines also carry natural gasoline.

The LPG pipeline system contains delivery terminals as well as above ground storage.

## US Pipeline Infrastructure

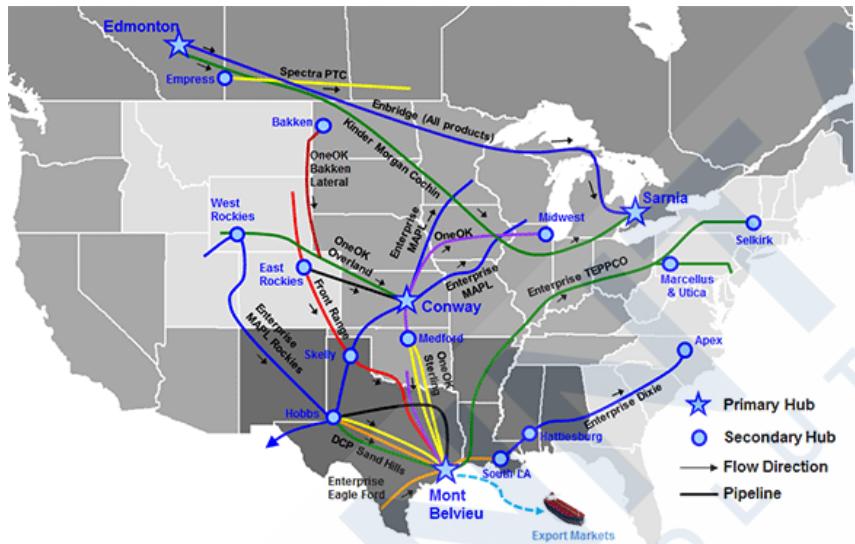


Image source: Encana, EV Maps, NEB.

# Road and Rail

## Rail

- Pressurized rail tank car
- Typical capacity of 33,600 gals



## Road

- LPG pressurized truck (tanker): semi trailers and bobtails
  - Wide variety of sizes: 3,000-20,000 gals
- Truck delivering LPG cylinders



## Intermodal ISO tank

- Can be transported by river, sea, rail or road

Rail and road transportation is used in areas without NGL pipelines, such as Florida and New England in the USA.

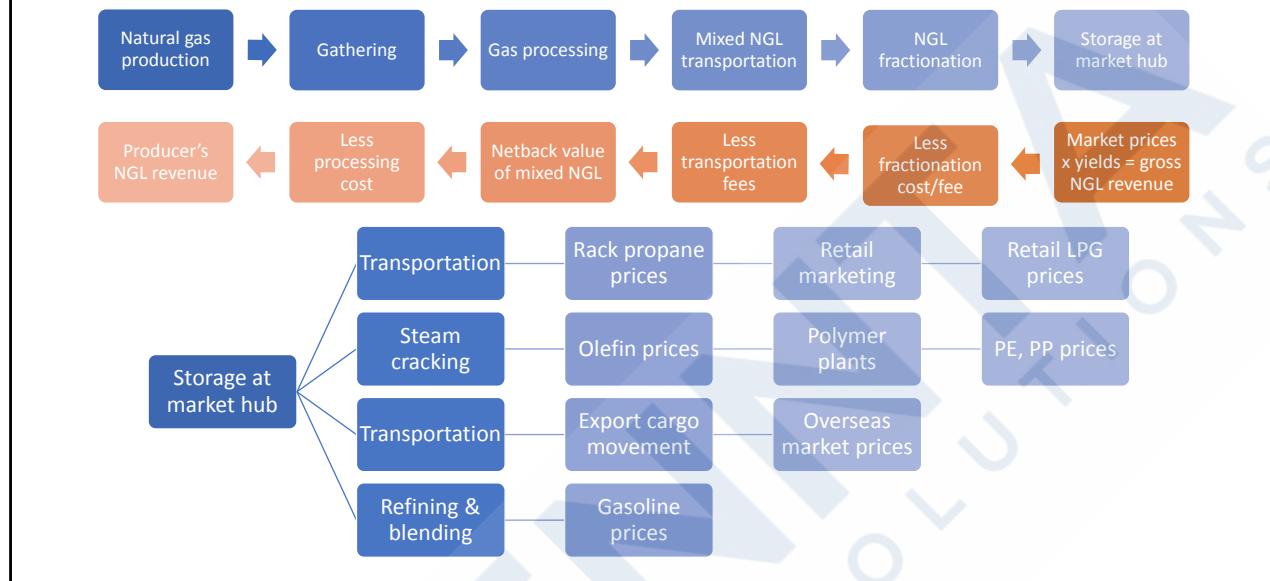
Rail tank cars are steel pressure vessels which are designed to carry around 30,000 gallons of LPGs or chemicals. They transport NGLs to consumers or to wholesalers.

Local delivery trucks (also known as tankers) are used to fill up tanks installed on an end user's property. Bobtails typically have a capacity of around 3,000 gallons.

Cylinders are used to distribute LPGs to remote locations, especially in developing countries. LPG is put into cylinders at an LPG bottling plant. There are various sizes of cylinders ranging from 5 gallons (20lb) to 25 gallons (100lb).



## NGL Value Chain Economics



The NGL value chain starts out in a straightforward linear manner, as shown in blue at the top. Natural gas is processed (at a cost) to separate a mixed NGL stream from the natural gas. The mixed NGLs may then be transported to somewhere like Mont Belvieu for fractionation. The resulting purity products each has a market value that can easily be realized by trading at a hub like Mont Belvieu.

The orange boxes show the resulting netback economics. The gross NGL revenue is the total value of all the purity products in storage at a market hub. Subtracting the cost of transportation and fractionation (T&F) from this gives a netback value for the mixed NGL at the gas processing plant. Subtracting gathering and processing fees gives a netback value for the NGL portion of the natural gas producer's production stream.

After fractionation and storage, things get more complex, as the value chain branches off in multiple directions. Some products will almost certainly follow one branch. For example, ethane will be cracked to ethylene, which will probably then be used for polyethylene (PE) production. Ultimately, the value of the ethane is determined by the final market price of PE, less the cost of transport, storage, cracking and polymerisation.

Other products may follow different branches, depending on which final product gives the best netback value in current market conditions.

Other downstream chains, such as use of C5+ as a diluent for heavy crude or denaturant for ethanol, are not shown.



Market  
Fundamentals

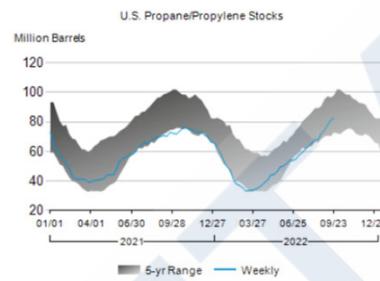


# Fundamental Analysis

Information must be timely  
to be of most value to  
traders

## Definition

- Analysis of the factors that cause price changes, in order to predict what the market may do in the future
- Market has inelastic supply & variable demand
- Perceptions of fundamentals is key – what might change supply & demand balance?



| Petroleum Supply<br>(Thousand Barrels per Day) | Current<br>Week | Week Ago | Difference |
|------------------------------------------------|-----------------|----------|------------|
|                                                | 9/23/22         | 9/16/22  |            |
| (1) Domestic Production <sup>6</sup>           | 12,000          | 12,100   | -100       |
| (2) Alaska                                     | 434             | 430      | 3          |
| (3) Lower 48                                   | 11,565          | 11,670   | -105       |
| (4) Net Imports (Including SPR)                | 3,403           | 3,407    | -4         |
| (5) Imports                                    | 8,449           | 8,947    | -498       |
| (6) Commercial Crude Oil                       | 8,449           | 8,947    | -498       |
| (7) Imports by SPR                             | 0               | 0        | 0          |
| (8) Imports into SPR by Others                 | 0               | 0        | 0          |
| (9) Exports                                    | 4,801           | 3,540    | 1,261      |
| (10) Stock Change (+build; -draw)              | -684            | -822     | 138        |
| (11) Commercial Stock Change                   | -31             | 183      | -114       |
| (12) SPR Stock Change                          | -654            | -988     | 332        |
| (13) Adjustment <sup>7</sup>                   | 1,264           | 26       | 1,237      |
| (14) Crude Oil Input to Refineries             | 15,751          | 16,355   | -604       |
| (15) Production                                | 8,041           | 8,126    | -84        |
| (16) Natural Gas Plant Liquids <sup>8</sup>    | 5,982           | 5,982    | 0          |

Commercial inventories are reported by industry participants to the U.S. government and the American Petroleum Institute, who publish weekly and monthly reports that are closely watched by oil traders around the world. The American Petroleum Institute publishes their weekly reports on Tuesday afternoons and the Department of Energy on Wednesday mornings.

Sources of information include international organizations (e.g. IEA), national organizations (e.g. DOE), as well as consultancies and publishers (e.g. Argus Media, Platts, Wood Mackenzie).



# Market Fundamentals

## Supply

- Natural gas production
  - Actual & forecast production rates; volumes of each purity product
  - Scheduled & unscheduled field maintenance
  - Ethane recovery / rejection
- Refining
  - Capacity, complexity & throughputs
  - Scheduled & unscheduled turnarounds
- Imports/exports
- Inventory levels
- Transportation
  - Freight availability & cost, e.g. pipeline space
  - Infrastructure capacity & flexibility; transit delays
- Risks to supply, e.g. weather-related disruption



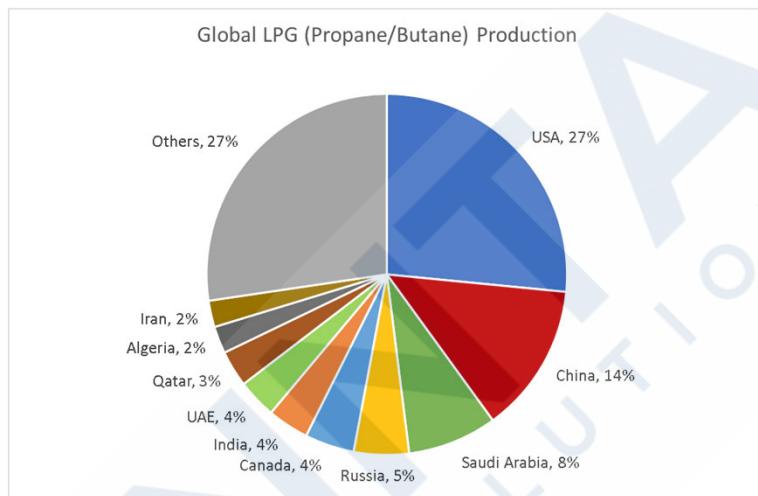
Any cuts to field production and refinery utilization rates will curtail NGL supply. Inventory levels (particularly in comparison to historical levels) are also important for helping to keep a lid on prices. Transportation delays, such as waiting times at Panama, can influence regional prices.

## Global Production

USA is the largest producer of LPG, and has even higher share of NGL production

Other leading producing countries are China, Canada, Saudi Arabia and Russia

Over 60% of LPG comes from gas processing, and the rest from oil refining



Source: World LPG Association, 2020 data

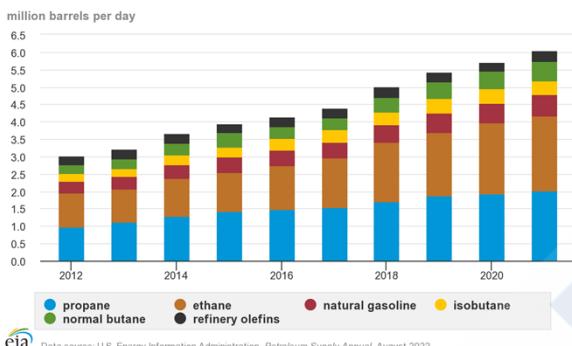
The source of LPG production varies considerably by region. In Europe and Asia, refining accounts for most production, particularly in European countries such as Germany, Italy, the Netherlands, Spain, Turkey, and the UK, and in China, India, Japan, South Korea, Thailand and Vietnam in Asia. Around two-thirds of European supply comes from refinery production. In North America and the Middle East, most propane and butane is from natural gas or oil production.

The chart shows LPG (propane and butane) production. Consistent international data on overall NGL production are hard to come by, but there is no doubt that the USA is the world's largest producer of all forms of natural gas liquids. US shale gas resources are particularly rich in liquids, as are some western Canadian resources that have been exploited in recent years (Montney / Duvernay).

In the Middle East, particularly Saudi Arabia, NGL production is linked to crude production rates, and OPEC decisions can be influential on NGL prices.

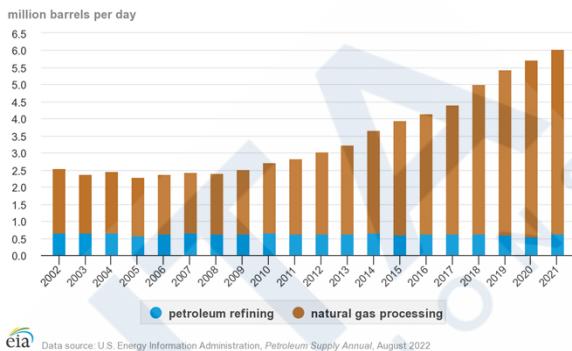
# USA Production

U.S. hydrocarbon gas liquids production by type, 2012-2021



Source: U.S. Energy Information Administration, Petroleum Supply Annual, August 2022

U.S. hydrocarbon gas liquids production by source, 2002-2021



Source: U.S. Energy Information Administration, Petroleum Supply Annual, August 2022

Refinery NGL production is mostly propane. Any ethane produced by refineries is usually consumed as fuel gas; any C4 or heavier material can be used for blending or as a feed to refinery units. Refineries export butanes during the summer (when its use for gasoline blending is restricted by vapor pressure limits) and re-import butanes for winter gasoline blending.

NGLs and condensates between them make up over 15% of global petroleum liquids supply. Global natural gas production is growing faster than oil production, so the contribution of condensate and NGL to the overall petroleum liquids total is increasing. The gas produced from U.S. shale plays is particularly rich in liquids, and the U.S.A. is the largest producer of condensate and NGLs in the world.

Oil, gas and NGL production continues to rise in regions such as the Permian basin, requiring ongoing development and expansion of pipeline networks. These shales also produce prodigious quantities of NGL, and new pipelines have been developed to handle this material, including Enterprise's ATEX pipeline taking 190,000 bpd of ethane to Mont Belvieu in Texas. Increasing LNG exports have also contributed to rising supplies.

# Market Trends

## Supply

- Growth in US & Middle East supply
- Even before Ukraine invasion, Russian NGLs were being used for domestic petrochemical markets
- European supply declining due to refining capacity contraction & mature North Sea sector
- New refinery capacity growth in Asia & Middle East

The US and Middle East have dominated the growth in NGLs supply in the last decade. Globally refining capacity has fallen by 3 mn bpd since 2020, with new refinery capacity coming on stream in the Middle East and Asia.

# Market Fundamentals

## Demand

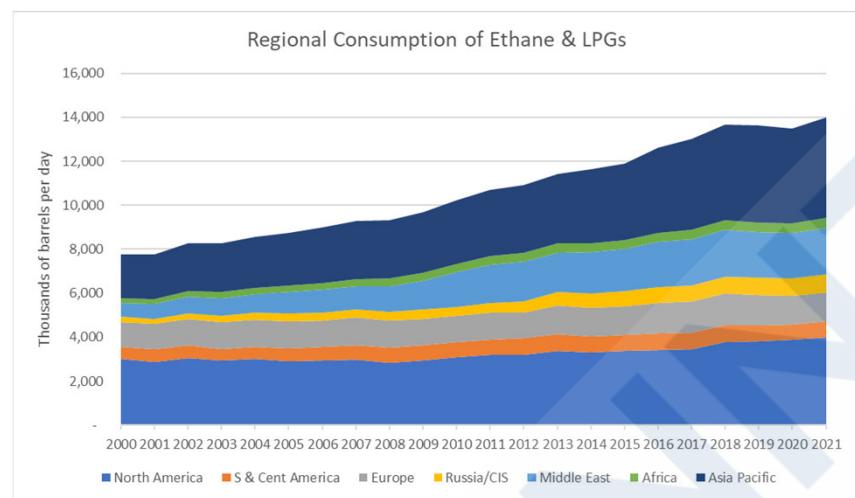
- Petrochemical demand
  - Capacity & operating rates
  - Planned & unplanned shutdowns
- Industrial demand
  - Economic growth
- Seasonality
  - LPGs – peak demand for residential heating in winter
  - Butane – gasoline blending demand higher in winter
- Regional price differences & consumption levels
- Interfuel economics



Demand for individual NGLs is also affected by their prices, as NGLs compete with each other in various sectors, such as petrochemicals.



## Consumption Trends



Asia and North America are the largest consuming regions

Top 5 LPG consumers: China, USA, India, Saudi Arabia, Japan

Demand is rising fastest in China and India

## NGL Key Markets

### Refining

- Refinery fuel
- Feedstock: butane for isomerization units, isobutane for alkylation units
- Butane is a blendstock for gasoline blending

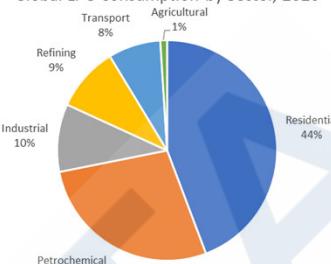
### Agricultural

- Crop drying
- Livestock housing & greenhouses
- Weed/pest control
- Agricultural vehicles

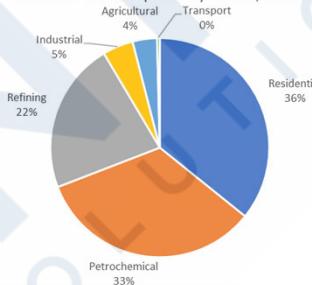
### Industrial

- Heat for boilers
- Glass blowing, ceramics manufacture
- Welding
- Food processing

Global LPG Consumption by Sector, 2020



USA LPG Consumption by Sector, 2020



There are over 1,000 applications for NGLs, ranging from portable applications (mobile heaters, caravans, BBQs), to being used as a propellant and refrigerant.

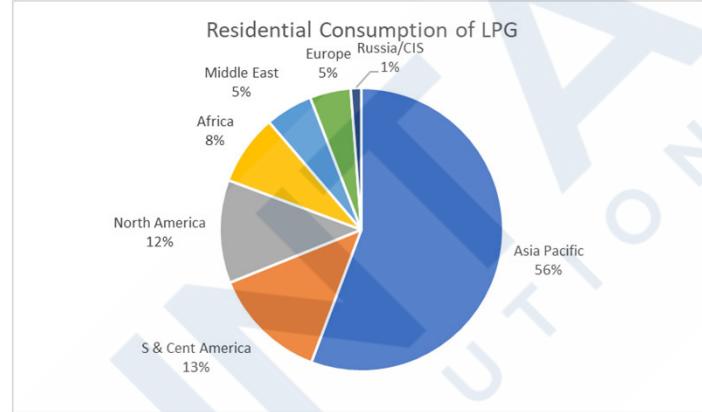
*Data source: WLPGA*



## NGL Key Markets

### Residential/Commercial

- Primarily used as a cooking fuel
- Also used for space/water heating,
- Consumption of LPG is dominated by Asia
- In some countries, e.g. China, LPG is being displaced as a household fuel by natural gas
- Significant growth potential in sub-Saharan region as a clean cook fuel
- Growth in some developing countries encouraged by subsidy programs



*Data source: WLPGA*

LPG can also be used the fuel for refrigeration, drying clothes, barbeques, gas fireplaces, and backup power generation (especially in rural homes and businesses).

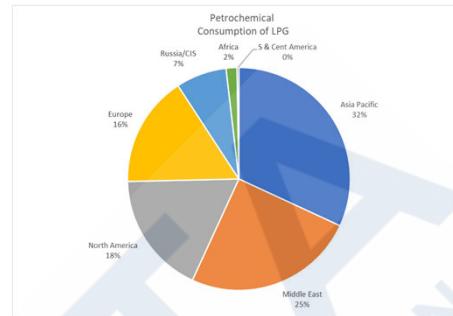
The market in Asia is dominated China, India, South Korea, Indonesia, Thailand, Vietnam, and the Philippines. LPG is an essential fuel in developing countries, and in areas where natural gas supply is not available.

The growth potential in sub-Saharan Africa is likely to be supported by infrastructure developments, for example the development of a new terminal in Richards Bay in South Africa.

# NGL Key Markets

## Petrochemicals

- NGLs are used as feedstocks for steam cracking to produce olefins (e.g. ethylene, propylene, butadiene)
- Petrochemicals value field grade NGLs as olefins can leave residue in crackers
- Some crackers (especially in Europe) have feedstock flexibility & switch between NGLs & naphtha/gasoil depending on relative price levels
- Propane is used as a feedstock for propylene dehydrogenation (PDH)



| Chemical Industry         | 2011 | 2021 |
|---------------------------|------|------|
| Hydrocarbon Feedstock Use |      |      |
| Naphtha                   | 70%  | 62%  |
| Propane/butane            | 16%  | 24%  |
| Ethane                    | 8%   | 9%   |
| Gasoil                    | 6%   | 4%   |

Data source: WPGA, ICIS

Around half of global ethylene production comes from the steam cracking of ethane, propane and butane. Cracking of naphtha is also a big contributor. China and the US have driven recent and planned capacity expansions.

Propylene comes from steam cracking of NGLs or naphtha, and from refineries, but “on purpose” propylene production from Propane Dehydrogenation (PDH) plants has been growing fast and now accounts for over 15% of supply. Steam crackers thermally crack hydrocarbons using steam, while PDH plants convert propane to propylene.





## NGL Key Markets

### Transportation

- LP-Gas / Autogas for cars, taxis, buses & light trucks
  - 27.6 mn vehicles worldwide
  - Largest markets: Turkey, Russia, South Korea
- Butane is a key blendstock for gasoline, especially in winter
- Natural gasoline can also be used for gasoline blending & as a denaturant in ethanol

Autogas (mostly propane) is used as the fuel for 27.6 mn vehicles, stocked by over 78,000 retail sites. The largest markets are Russia, Turkey and South Korea, each of which consume over 3 mn tonnes per year. Other countries with substantial fleets of Autogas vehicles are Ukraine, Poland, Italy, Mexico, Thailand and Bulgaria.



# Market Trends

## Demand

- Uneven demand recovery from the effects of the pandemic
- High prices & economic downturn have slowed growth
- Demand growing fastest in Asia-Pacific, especially China & India
- Robust growth in demand for petrochemicals
  - PDH units, ethane crackers (Europe, Asia)
- Fuels demand rising in developing regions (India, Africa, Latin America)

PDH = propane dehydrogenation (->propylene)

Demand in North America is rising primarily in the petrochemical sector. Asian consumption growth is being driven by increased residential and industrial demand. In contrast consumption by residential heating markets in the northern hemisphere is in decline, due to increasing energy efficiency and natural gas network expansions.

## International LPG Trade Flows - 2020

| Net Importers | Ktonnes |
|---------------|---------|
| China         | 18,653  |
| India         | 15,826  |
| Japan         | 9,794   |
| South Korea   | 7,906   |
| Indonesia     | 6,294   |
| Mexico        | 5,891   |
| Turkey        | 2,887   |
| Morocco       | 2,800   |
| France        | 2,392   |

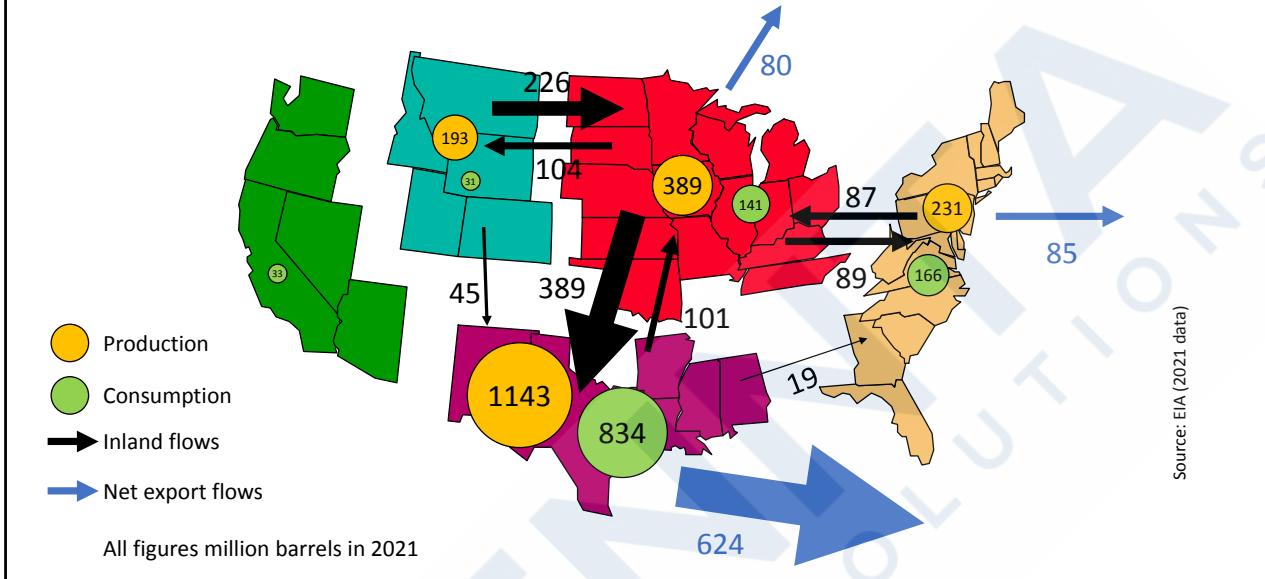
| Net Exporters        | Ktonnes |
|----------------------|---------|
| USA                  | 45,045  |
| Qatar                | 10,465  |
| United Arab Emirates | 9,226   |
| Saudi Arabia         | 6,853   |
| Algeria              | 5,628   |
| Canada               | 5,236   |
| Kuwait               | 5,110   |
| Iran                 | 4,824   |
| Norway               | 4,681   |
| Russia               | 4,350   |

Source: WPLGA

There has been significant growth in the NGL trade in the last few years, with rising exports from the USA. The development of trade between areas depends partly on logistics, including the availability of export pipelines or loading facilities. There has been a rapid development of export facilities in the US Gulf Coast.

Europe is increasingly reliant on seaborne imports, mostly from the USA. Europe competes with Asia for NGL supplies. The Middle East is the major supplier of NGLs to Asia.

## NGL Flows in USA



The chart shows 2021 annual data, in millions of barrels, for NGL production from natural gas processing plants, NGL movements between PADDs, net exports of NGL from PADDs 1, 2 and 3. It also shows the (calculated) implied consumption of NGLs within each PADD.

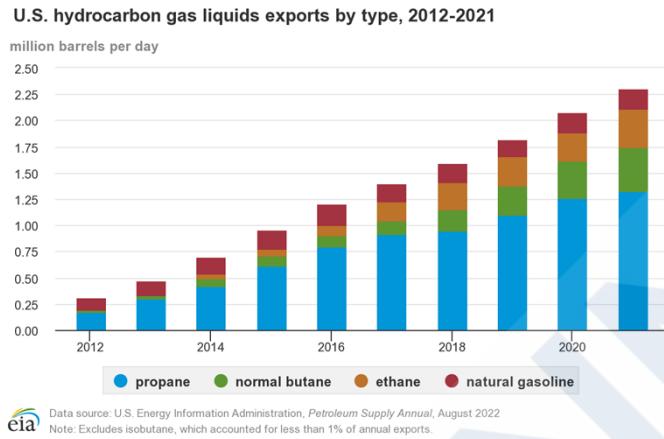
All figures are for combined NGLs. Most of the individual products have similar flow patterns, but ethane makes up most of the PADD 1 (East Coast) to PADD 2 (Midwest) movements, while other NGLs flow mostly in the opposite direction.

Most inland movements of natural gas liquids are by pipeline. Exports are by pipeline to Canada, waterborne to Europe and Asia.

PADD 3 (US Gulf Coast) dominates the industry, with around 60% of NGL production, and 70% of NGL consumption.

Nearly all flows of NGLs have increased substantially in the past five years, with exports nearly doubling since 2016.

## US Export Trade Flows



| Top Destinations for US NGLs (2021) | Thousands barrels |
|-------------------------------------|-------------------|
| Japan                               | 139,995           |
| Canada                              | 105,383           |
| China                               | 102,204           |
| Mexico                              | 67,092            |
| South Korea                         | 58,306            |
| Indonesia                           | 46,490            |
| India                               | 36,013            |
| Brazil                              | 19,631            |
| Netherlands                         | 17,806            |
| UK                                  | 17,191            |

Data source: EIA

The top destinations for US NGL exports are:

- Ethane: China (28%), Canada (23%), India (19%)
- Propane: Japan (27%), Mexico (12%), China (12%)
- Normal butane: Indonesia (14%), South Korea (12%), Morocco (9%)
- Natural gasoline: Canada (98%)

Most natural gasoline exports come back into the USA as crude oil.

The majority of US exports comprise propane from the Gulf Coast region, heading to Far East. Trade has increased since the widening of the Panama Canal. In 2021, 57% of US NGL exports were propane, 18% normal butane, 16% ethane, 9% natural gasoline, and 1% isobutane (mostly to Mexico).

The US does import NGLs (particularly propane and butanes) to meet seasonal demand. The majority of these imports occur between October and March from Canada into the Midwest and Northeastern regions.

## Trends in NGLs Trade Flows

### Rising international LPG trade

- Propane seaborne trade
- Imports of petrochemical feedstocks

### US exports growth

- Growth in US crude seaborne exports, primarily to Asia & Europe
- Increasing ethane exports

### Growth in Asian demand

- Continued rise in oil imports to Asia, especially China & India

### Russian supply disruption

- Effects of sanctions against Russia partially mitigated by rising Middle East and US output

Almost half of demand in Asia is met by imports from the USA & Middle East. China's imports NGLs largely for petrochemicals use, and India for fuels use.

# Pricing



# Pricing Mechanisms

Trades can be fully fixed, fully floating, or partly fixed & partly floating (e.g. 50:50)

## Fixed (outright/flat) price

- Futures, most forwards, some physical spot trades

## Floating (formula) price

- Some forwards, most physical trades



Fixed price contracts name a price which is agreed when the deal is struck and does not change. In fixed price deals, the price is set at the time of the deal by negotiation or by accepting a trader's bid or offer price.

Floating price contracts define a mechanism by which the deal price will be calculated, but the actual price is not known until a later date, typically when the cargo is loaded or discharged. Spot trades usually use a simple negotiated fixed premium or discount to an agreed published benchmark price (e.g. OPIS).

Many national oil companies (NOCs) publish official selling prices (OSPs) for their NGL sales, e.g. the Saudi contract price.



## Floating Pricing Mechanisms

Price formula agreed at the time of the trade

Price becomes fixed on a particular date/period

Price formula defines:

- Benchmark price
- Premium/discount to benchmark reflecting location, quantity, timing
- Source of benchmark pricing, e.g. OPIS, Argus, Platts
- Date/period when price is fixed, commonly month average

## Benchmarks

| USA                                                                                                                                                                                                                                                                                                                                             | NW Europe                                                                                                                                                                                                                                                                                                          | Middle East/Asia                                                                                                                                                                                                      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>Mont Belvieu - the world's largest processing/storage hub for NGLs &amp; key pricing benchmark</li><li>Pipeline &amp; storage market</li><li>Reference prices for different facilities, e.g. LST, Enterprise, Targa</li><li>Other key locational markets: Conway, Edmonton, Sarnia, Hattiesburg</li></ul> | <ul style="list-style-type: none"><li>Flushing is the key ARA hub for LPG cargoes</li><li>Cargo, barge &amp; railcar market</li><li>Fixed, floating or 50:50 trades</li><li>Cargoes typically trade on ToT basis</li><li>Argus North Sea Index (ANSI) benchmark</li><li>Also Black Sea and Brest markets</li></ul> | <ul style="list-style-type: none"><li>Cargo market</li><li>Fixed, floating or 50:50</li><li>Saudi Contract Price (CP), Kuwait Contract price</li><li>Japan, South China, Argus Far East Index (AFEI or FEI)</li></ul> |

In North America, Mont Belvieu, TX is the key trading and pricing hub. Smaller trading hubs include Conway and Bushton, KS, Hattiesburg, MS, Napoleonville and Sorrento, LA, Edmonton, AB and Sarnia, ON. Market hubs typically are centers for infrastructure including pipeline interconnections, fractionation capacity, and storage. Contracts reference OPIS prices. Pipeline/storage trades are for title transfer or delivery before the end of the current month, or the following month.

In north-west Europe, ARA (Amsterdam, Rotterdam, Antwerp) is the main destination for cargo trades and has active barge and railcar markets. Cargoes trade either on a fixed price, floating price or 50:50 (half fixed, half floating) basis. Floating prices are differentials to Argus CIF ARA propane/butane prices or to naphtha prices. ANSI (Argus North Sea Index) is a monthly index for North Sea loading.

In Asia, the main markets are for 23,000 tonnes of propane, butane or a 50:50 mix called 11-11. CFR cargoes trade either fixed price, floating price, or 50:50 (half fixed, half floating). Floating prices are indexed to Saudi CP or to AFEI (Argus Far East Index = Japan/China pricing) at time of loading or delivery. Contract Prices (CP) are set monthly by Saudi Aramco and Kuwait Petroleum.

ToT = traded on the basis of ten days notice of a three-day delivery window

CIF = Cargo, Insurance & Freight, a delivered price

FOB = Free On Board, a price for gas at the loading facility

CFR = Cargo & Freight, a delivered price

## Mont Belvieu (MB) NGL Pricing

|                      |                                                                                                                                                                                                                                                                                                                                |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| OPIS "TET"           | <ul style="list-style-type: none"><li>For NGLs in former Texas Eastern Transmission storage, now Lone Star NGL, owned by Energy Transfer Partners</li><li>Also called: Lone Star, LST, Energy Transfer, ETR, ETP</li><li>For NC4 ONLY: OPIS "TET N. Butane" price is for refinery grade material at any MB facility.</li></ul> |
| OPIS "Non-TET"       | <ul style="list-style-type: none"><li>For NGLs in Enterprise Products Partners storage</li><li>Also called: Enterprise, ENT, EPD, EPC</li></ul>                                                                                                                                                                                |
| OPIS "Other non-TET" | <ul style="list-style-type: none"><li>For NGLs in Targa Resources storage</li><li>Also called: Targa</li></ul>                                                                                                                                                                                                                 |

For historical reasons, the OPIS prices for propane and other NGLs at Mont Belvieu (MB) are not immediately obvious.

The TET facility is no longer owned and operated by the company of that name; it is now Lone Star (LST), a subsidiary of Energy Transfer. Most TET prices are for material in Lone Star storage, but the OPIS TET N. Butane quote, uniquely, is for ANY refinery grade material at MB. OPIS also quotes a "TET Isom N. Butane" price which is for isomerization grade (non-refinery) normal butane in Lone Star/Energy Transfer storage.

Non-TET prices refer specifically to deals for material in Enterprise storage.

"Other non-TET" prices are for material in Targa storage.

# NGL Pricing

## Price drivers

- Different price drivers for each purity product because of diverse profiles of end-user markets
- Quality:
  - *Olefin content: field grade vs. refinery product*
- Geopolitics
  - Political instability, sanctions, OPEC+ production decisions



News stories can cause significant short-term volatility

The main factor that determines the value of one LPG cargo relative to another is its olefin content (which reflects its origin from field production or as refinery output). Field grade material with low olefin content can be sold as a premium product into the petrochemical feedstock market, while refinery material with higher olefin content has value mainly as a heating fuel product.



# NGL – Price Linkage

## Natural Gas

- Long-term: gas production determines NGL supply
- Short-term: ethane rejection choice
- Frac spread

## Petrochemicals

- Price of downstream products: olefins, PE, PP, etc.
- Competition with naphtha

## Refining and blending

- Price of gasoline (RBOB)

## Heating fuel

- Long-term competition with alternative fuels

## Contract Pricing & Hedging

- RBOB, WTI
- Naphtha price (Europe)

## Export arbitrage

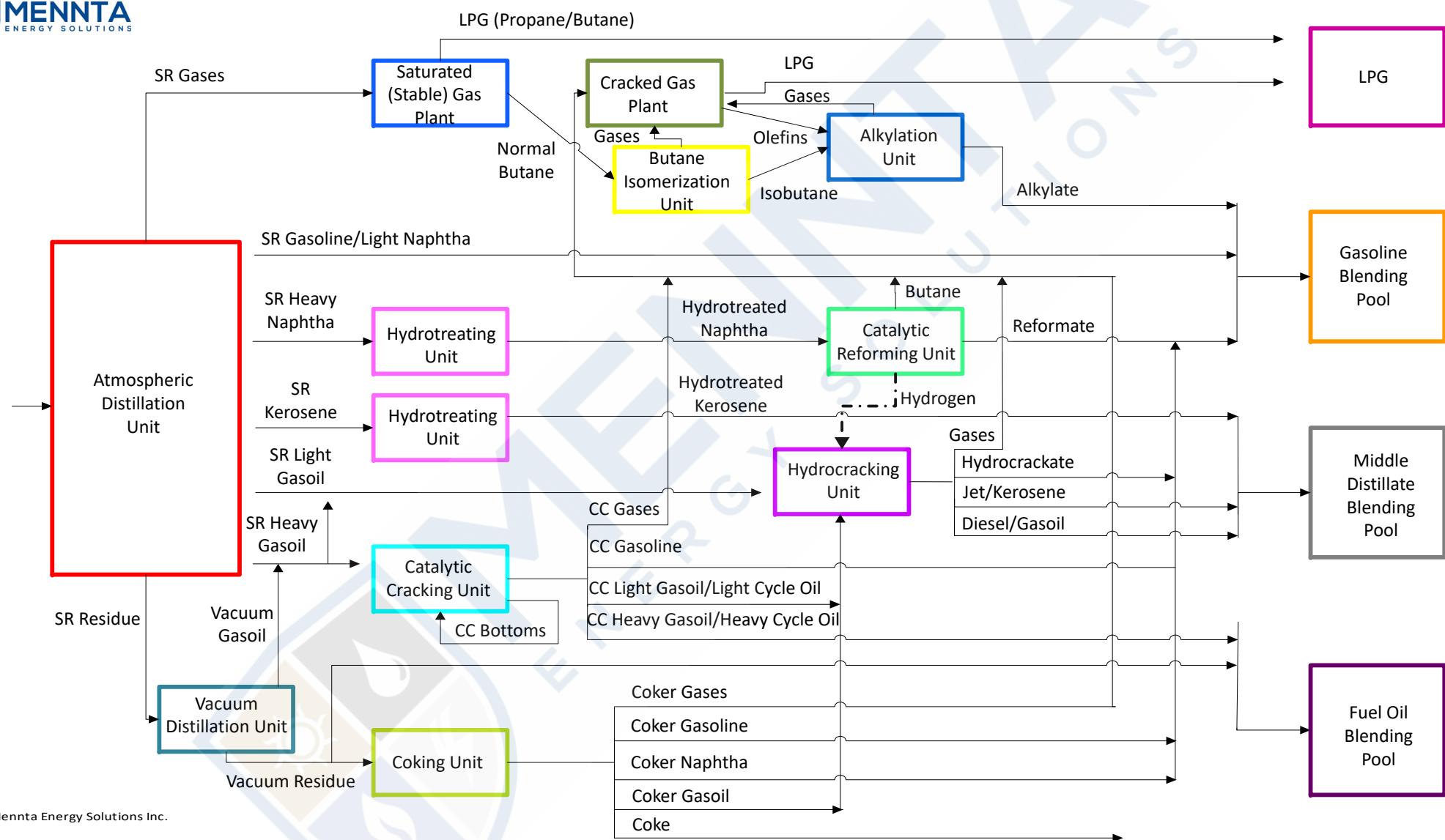
- Asian & European NGL market prices
- Middle East contract prices

Some price linkages arise from physical links between markets. The most direct is the possibility of ethane rejection into the natural gas stream, a logical choice if the value of ethane delivered as MMbtu of natural gas exceeds the value of ethane as a steam cracker feedstock, or as an export sale. Up to half the ethane produced in the USA could probably be rejected into the natural gas stream, although there are technical, quality and commercial constraints on this.

Other price linkages arise through competition between NGLs and other alternatives, either as chemical feed stocks (naphtha), as refining/blending inputs (other octane blending components), or as heating fuels (natural gas, kerosene).

Some linkages are contractual, e.g. pricing of NGL trades vs naphtha prices in Europe, or pricing or hedging of butane vs RBOB in USA. These arrangements reflect underlying physical linkage.

Price relationships between NGLs and other commodities are typically quoted as a ratio, e.g. butane as a percentage of RBOB.



## NGL Conversion Factors

### Weight to Volume

*NGLs are traded in cts/gal in USA and in \$/tonne in international markets. The density of NGLs vary with composition and temperature. These are the "industry standard" factors used in derivatives markets and by price reporting agencies.*

|                  | 1 Metric tonne<br>in Gallons | 1 Metric tonne<br>in Barrels | cts/gal to \$/t<br>multiply by |
|------------------|------------------------------|------------------------------|--------------------------------|
| Ethane           | 739                          | 17.6                         | 7.39                           |
| Propane          | 521                          | 12.4                         | 5.21                           |
| Normal Butane    | 452.8                        | 10.78                        | 4.528                          |
| Isobutane        | 469.6                        | 11.18                        | 4.696                          |
| Natural Gasoline | 420                          | 10                           | 4.20                           |

### Energy Content

*The energy content (heating value) of NGLs is needed for frac spread calculations, which compare the value of NGLs (cts/gal) with natural gas (\$/MMbtu). The heating value of NGLs varies with their composition and state. The factors here are those used by OPIS for propane and normal butane, and from GPA Midstream Association's Standard 2145-16 for others.*

|                         | btu per gallon | cts/gal to \$/MMbtu<br>multiply by |
|-------------------------|----------------|------------------------------------|
| Ethane                  | 65,897         | 0.1518                             |
| Propane                 | 90,830         | 0.1101                             |
| Normal Butane           | 102,916        | 0.0972                             |
| Isobutane               | 98,924         | 0.1011                             |
| Nat. Gasoline (Pentane) | 110,020        | 0.0909                             |

A factor of 91,500 btu per gallon is commonly used for propane in end-use markets. This reflects the approximate heating value of propane as a gas at 60°F.

### Storage Capacity

*Commercial storage is usually sold by the barrel in USA and by the cubic meter (cm or m<sup>3</sup>) elsewhere.*

|               | Barrels   | Cubic Meters | US Gallons | Litres  | Cubic Feet |
|---------------|-----------|--------------|------------|---------|------------|
| 1 Barrel      | 1         | 0.15899      | 42         | 158.987 | 5.6146     |
| 1 Cubic Meter | 6.2898    | 1            | 264.17     | 1,000   | 35.31      |
| 1 US Gallon   | 0.0238    | 0.003785     | 1          | 3.7854  | 0.13368    |
| 1 Litre       | 0.0062898 | 0.001        | 0.26417    | 1       | 0.03531    |
| 1 Cubic Foot  | 0.17811   | 0.02832      | 7.4806     | 28.317  | 1          |

## NGL Trading Glossary

**11+11:** In Asian LPG cargo trading, a standard 23,000 tonne cargo divided equally between propane and butane.

**AFEI:** Argus Far East Index, a benchmark price for Asian LPG cargoes traded for CFR delivery to Japan. Also known simply as FEI, these daily prices reflect the value of 23,000 tonne, fully-refrigerated cargoes of field-grade propane or butane for delivery 25-40 days forward. The FEI price is widely used as a reference in Asian spot LPG trading.

**AG:** Arab Gulf. Also known as Middle East. A market for FOB cargoes loading at ports including Yanbu and Ras Tanura in Saudi Arabia, and Mina al Ahmadi in Kuwait.

**Alkylation:** a refinery process that produces alkylate, a high-value, high-octane motor gasoline blending component. The feeds to an alkylation unit are isobutane (IC4) and olefinic refinery gases.

**ANSI:** Argus North Sea Index, a monthly benchmark price assessment of the value of propane and butane for FOB loading at North Sea terminals. The assessment is based on prices in the CIF ARA market during the final five days of each month, with freight cost subtracted to give a FOB price.

**Any:** in North American NGL (and refined products) trading, a deal for delivery at any time (or on any pipeline cycle) within a named month. Often the current calendar month 'any current month'.

**ARA:** the Amsterdam / Rotterdam / Antwerp region of Northwest Europe (NWE). A collection of ports on the coast of Belgium and the Netherlands, at which liquids and gases are traded. For NGLs, the key port within the ARA region is Flushing (Vlissingen) in the Netherlands.

**Arbitrage:** a trading strategy designed to profit from an existing difference in market prices, typically between one location and another. In energy markets, arbitrage is usually a physical trading activity, involving the movement of material by pipeline or cargo. Occasionally, an arbitrage profit can be captured without moving product, by buying on one price index and selling on another.

**Argus Media:** a price reporting agency whose published prices are commonly used as benchmark / reference prices in European and Asian NGL trading. The US market uses OPIS prices.

**Ask:** a motion to sell at a named price. Also called an offer.

**Associated gas:** natural gas produced from an oilfield, as a by-product of oil production.

**Autogas:** A term used in some countries for LPG, when sold as a fuel for road vehicles.

**Backwardation:** a market situation in which material for forward delivery trades at a discount to prompt or spot prices. Also called an 'inverted market'. The opposite of contango.

**Back office:** the part of a trading organization responsible for accounting, payables/receivables, financial settlement, analysis and reporting, information technology and administration.

**Barge:** barge markets are for quantities delivered via inland waterways, on small vessels that use pressurized containment. These are usually much smaller than the volumes traded in *cargo* markets, typically around 1,000 tonnes or 10,000 barrels.

**Basis Risk:** the risk that the price of a derivative instrument, such as a futures contract, used to hedge a physical price risk, changes by an amount that does not exactly match the change in value of the physical commodity being hedged, during the lifetime of the hedge. This leaves an imprecise hedge which may fail to provide full protection against losses.

**Basis Swap:** a swap whose payment at settlement is determined by the difference between two floating price indexes. Typically, one price index represents the value of physical material (e.g. OPIS Non-TET Butane), and the other a hedging instrument (e.g. NYMEX RBOB futures). Basis swaps can thus be used by hedgers to protect against *basis risk*.

**Barrel (b, bl or bbl):** a unit of volume exactly equal to 42 US gallons, and approximately equal to 159 liters. The standard unit of measurement for NGL storage and trading in the USA.

**Benchmark:** a published price that is commonly used as a reference price in floating price contracts, or widely used as an indication of the value of a commodity.

**Bid:** a motion to buy at a named price.

**Bill of lading (BOL, B/L or BL):** a document issued by a ship owner or agent on completion of loading of a cargo, which acts as a receipt for cargo received on board. In cargo trading, the date on which the BL is issued is commonly used to determine the pricing dates for a deal.

**Biopropane, BioLPG:** see *renewable propane*.

**Blendstock:** a substance that can be blended with other materials to create a finished product. The material forms part of a blended product and is not chemically transformed in the blending process. Normal Butane (NC4) is a blendstock for gasoline production.

**Book Trade:** in North American NGL trading, a trade that involves the transfer of title/ownership of material held in common storage, with no physical movement.

**Brine compensation:** a method of operating salt cavern storage in which the storage space is partly filled with brine, which is displaced as stored gas or liquid is injected. Brine is pumped back into the cavern when stored gases are withdrawn.

**British thermal unit (btu):** a unit of energy, commonly used to describe the heat content of fuels in the USA. It is the energy required to increase the temperature of one pound of water by one degree Fahrenheit.

**Broker:** an agent who facilitates trading by introducing buyers and sellers, or by placing and executing orders on an exchange. Brokers do not participate in markets as buyers or sellers, but make money by charging fees (commissions) for their services.

**Butane:** a paraffinic hydrocarbon (alkane) with four carbon atoms, which is found in natural gas. It has two isomers, *normal butane* and *isobutane*, which are used for different purposes.

**Cargo:** cargo markets are for quantities loaded on ocean-going ships, usually fully refrigerated or semi-refrigerated. These can range from small vessels (coasters) that carry only 2,000 tonnes to very large gas carriers (VLGC) that carry 44,000 tonnes or more. Cargoes of around 20,000 to 23,000 tonnes are common in European and Asian spot and forward trading.

**C2:** Ethane.

**C3:** Propane.

**C5+:** Pentanes plus, also called *natural gasoline*.

**Calendar spread:** A position created by taking a long position in one delivery month and a short position in another, for the same commodity.

**Calorific value:** the heat energy released by burning a fuel. Also called heating value. The gross calorific value (GCV) or higher heating value (HHV) of a fuel is the total heat energy theoretically available, including energy (enthalpy) recovered by condensation of produced water vapor. The net calorific value (NCV) or lower heating value (LHV) is just the heat of combustion. In natural gas trading, prices (e.g. \$/MMbtu) reflect the GCV/HHV of the gas.

**CFR – Cost & Freight:** a contractual basis for sale and purchase of a cargo, in which the price paid includes the cost of the cargo and the cost of shipping to an agreed destination. Under this *incoterm*, risk of loss or damage to the cargo passes from the seller to the buyer at the load port.

**Chiba:** A Japanese port which is the main destination for LPG cargoes travelling to Japan, and the benchmark pricing basis for the CFR Japan market.

**CIF – Cost, Insurance, Freight:** a contractual basis for sale and purchase of a cargo, in which the price reflects the cost of the cargo, insurance, and freight to its agreed destination. Under this *incoterm*, the seller is obliged to procure marine insurance against the buyer's risk of loss or damage to the cargo during the voyage. Risk of loss or damage passes from the seller to the buyer at the load port.

**Clearing:** a process by which a clearing house becomes the counterparty to a trade (acting as a buyer to the selling trader and a seller to the buying trader) and operates a system of *margin* payments and daily settlements of profits and losses, to provide mutual protection against credit risk. *Futures trades* are always cleared. *OTC* derivative trades may be cleared by mutual agreement of the traders involved, or at the insistence of a market regulator.

**CMA:** calendar month average, an average of all prices published during a specified month, used in some contracts to establish the final price paid.

**CME:** a financial and commodity exchange group, which operates the CME NYMEX exchange on which *WTI* and *RBOB* futures are traded.

**Contango:** a market situation in which material for forward delivery trades at a premium to prompt or spot prices. The opposite of backwardation.

**Conway:** the USA's second most important trading and pricing hub for NGLs, after Mont Belvieu. Located 700 miles north of Mont Belvieu, in Kansas.

**CP:** contract price. In Asian LPG trading markets, this means the contract price which Saudi Arabia sets monthly for FOB cargo sales. Kuwait uses the same contract price. The Saudi/Kuwait CP is an important benchmark for Middle East export sales and for Asian CFR import cargo trading, particularly term contracts.

**Crack spread:** a price spread between a refined product (or basket of refined products) and crude oil.

**DAF – Delivered at Frontier:** a contractual basis, used in the Eastern Europe market for rail deliveries of LPG from Russia. DAF Brest prices are for LPG delivered to the Belarus/Poland border.

**Denaturant:** a substance added to ethanol to make it unfit (and undesirable) for human consumption. Natural gasoline may be used as a denaturant for fuel ethanol in North America.

**Derivative:** any financial instrument, such as a swap or option, that derives its value from the value of an underlying security or physical commodity.

**Differential (diff):** a term traders use for the difference between two market prices. Also, the negotiated premium or discount to a benchmark price used in a trade. A cargo of propane for delivery to Japan might trade at a differential of +4 \$/t to the Argus FEI price.

**Diluent:** a substance used to dilute something else. In petroleum markets, a light material such as naphtha, natural gasoline, or natural gas condensate, that can be mixed with heavy crude oil to reduce its viscosity for pipeline transport. When Canadian oilsands bitumen is diluted, the resulting mix is called dilbit.

**Dry gas:** natural gas with a low quantity of NGL, typically the gas produced in a processing plant to meet pipeline specifications, but sometimes the direct output of fields that produce mostly methane.

**Edmonton:** a trading and storage hub, and benchmark pricing location for NGL in Alberta, in Canada's major oil and gas producing region.

**EPD:** the stock ticker of Enterprise Products Partners, sometimes used to indicate a price for NGLs traded at Enterprise's Mont Belvieu storage caverns. OPIS labels these prices 'Non-TET'.

**EP Mix:** a mixture of 80% ethane and 20% propane, traded in the USA, particularly in the Conway/Midwest markets. EP mix is easier to produce and store than purity ethane. It can be used for ethylene cracking or processed to separate the ethane and propane. Published EP Mix prices are for the ethane component only. The buyer must either pay an additional fee for the propane content, or make an offsetting sale or delivery of propane to the EP mix seller.

**Ethane (C2):** a paraffinic hydrocarbon (alkane) with two carbon atoms, which is found in natural gas. Ethane is a gas at standard conditions. It can be liquefied by pressure, but only if its temperature remains below about 90°F. Ethane is used as a petrochemical feedstock, for ethylene production.

**Ethane rejection:** the decision to allow ethane to remain in a natural gas stream (or to blend it back in after separation), for sale as heat energy (\$/MMbtu), rather than separating it for sale as a petrochemical feedstock.

**Exchange:** an organization regulated by its own rules and with external regulatory oversight, which offers trading in derivative instruments (futures and options) that are traded anonymously and are subject to mandatory clearing. CME NYMEX in the USA and ICE Futures in Europe are the main operators of exchange-based trading in energy commodities.

**Feedstock:** a substance used as an input to a process that will transform it to something else. Isobutane (IC4) is a feedstock for alkylation to produce alkylate. Ethane is a feedstock for steam cracking to produce ethylene.

**FEI:** Far East Index, an important benchmark price in Asian spot LPG trading (see AFEI).

**Field Grade:** NGL derived entirely from natural gas processing, containing no refinery gases. Field grade NGL is olefin-free, making it more valuable as a petrochemical feedstock. Refinery gases contain olefins. Field grade mixed butane is an unfractionated normal butane/isobutane mix.

**Fixed Price:** a price (in cts/gal or \$/tonne, etc.) that is agreed when a trade is entered into, and cannot contractually be changed. Cargoes can be traded on a fully fixed basis (the agreed price applies to the entire cargo quantity) or partly fixed basis (the agreed price applies to maybe 50% of the cargo volume, or to a fixed minimum quantity), with the remainder traded at a *floating price*.

**Floating Price:** a price that is defined by a formula that is agreed when a trade is entered into, but which will not be finally determined until a later date. Typically, traders agree a fixed 'differential' (premium or discount) to a published *benchmark* price, and also agree when the formula will be applied. Some deals use 'whole month average' pricing, in which the final price paid is the average of the benchmark prices published on every day of the month, plus the agreed differential. Others use shorter averaging periods, such as a five-day pricing window that starts when the cargo is loaded.

**Flushing:** a port in the Netherlands (locally 'Vlissingen') with LPG storage and handling facilities. Part of the ARA market.

**FOB – Free On Board:** a contractual basis for sale and purchase of a cargo, in which the price paid is purely the cost of the cargo. Under this *incoterm*, the buyer is responsible for arranging and paying for shipment, and bears all risks once the cargo has been loaded.

**FoF:** a standard forward contract for European CIF cargo trading of propane, which requires the seller to give fifteen days' notice of a five-day delivery window.

**Forward contract:** an agreement for a one-time purchase and sale of a commodity for delivery at an agreed future time, beyond the normal *spot* trading horizon. A *futures* contract is a standardized, exchange-traded forward contract.

**Frac spread:** a calculation of the profitability of processing and *fractionation* of natural gas, representing the difference between the value of NGLs and natural gas, usually expressed in terms of \$/mmbtu.

**Fully refrigerated:** descriptive of gas storage or vessels in which an NGL at a temperature close to its atmospheric boiling point, so that it can be held as a liquid with little or no positive pressure applied. Large vessels, such as VLCCs, are fully refrigerated, while smaller vessels may use pressure containment.

**Fungible:** descriptive of material that is interchangeable or mixable. A batch of propane that meets purity specs is fungible with, and has equal value to, other similar batches of propane. This allows them to be commingled for pipeline transport or storage.

**Futures contract:** a standardized forward contract, traded on a regulated futures exchange. Futures are traded anonymously, and buyers and sellers have contractual obligations to the exchange, rather than to each other. Credit risk protection is ensured by a system of margin payments and daily settlement of profits and losses arising from changes in contract value.

**Gallon:** a unit of volume equal to 231 cubic inches, used in the trading and pricing of NGLs and oil products in the USA. US LNG prices are in cents per gallon (cts/gal). There are 42 gallons in one barrel.

**Gas Processing:** the conversion of wellhead gas to pipeline specification natural gas, by removal of contaminants such as water, sulfur and acid gases, and by removal of NGLs from the natural gas stream. Gas plants produce two valuable hydrocarbon products: natural gas and a stream of mixed NGLs (called Y-grade or ‘raw make’ in the USA). Gas plants are usually located close to wellheads (field plants) or on pipeline systems (straddle plants). The mixed NGL stream is often transported elsewhere by pipeline for *fractionation*.

**IC4:** Isobutane.

**ICE:** Intercontinental Exchange, a financial exchange operating group, which operates the ICE Futures exchange in Europe, and also provides *clearing* services for a wide range of energy swaps and derivatives traded in North American, European and Asian markets.

**Incoterm:** one of a set of internationally recognized rules which define the responsibilities of the buyer and seller in a deal. Incoterms define who is responsible for paying for and managing the shipment and insurance, and where and when certain risks pass from the seller to the buyer.

**Isobutane (IC4):** a branched-chain paraffinic hydrocarbon (alkane) with four carbon atoms, which is found in natural gas. It is also manufactured in refinery butane isomerization (isom) units. Also called IC4. Isobutane is mostly used as a feed to refinery alkylation units, to produce a high-octane gasoline blend stock.

**Isoparaffin:** a *saturated* branched chain hydrocarbon containing only single carbon-carbon bonds. Isobutane is the smallest possible isoparaffin, as four carbons are needed to create a branched chain.

**Isomerization (isom):** a refinery process that converts straight-chain hydrocarbons (paraffins) to branched chain molecules (isoparaffins). Butane isomerization (BI) units are used to create isobutane for use as an alkylation feedstock.

**Long:** a trading position that will benefit if a price rises. A gas producer is naturally long NGL; a trader with unsold butane in storage is long butane; a trader who has bought futures contracts is long futures.

**LPG - Liquefied Petroleum Gas:** propane and/or butane, particularly when transported and sold as pressurized liquids, for use as fuel gases. In North America, LPG is synonymous with propane. In other parts of the world, LPG may be a mix of propane and butane.

**LPG Mix:** a 50:50 propane/butane mix, traded in Russia and Eastern Europe.

**LP-Gas:** a name used in some countries for LPG sold as a vehicle fuel.

**LST:** Lone Star NGL, Energy Transfer Partners’ salt cavern storage facility at Mont Belvieu. Prices for NGL traded at LST are labelled ‘TET’ by OPIS, and ‘Energy Transfer’ by other price reporting agencies.

**Margin:** money lodged with a futures exchange or clearing house to provide security against credit risk. *Initial margin* is a deposit made when a position is opened and recovered when it is closed. *Variation margin* is paid into or taken from a trader’s margin account as the value of his position rises and falls each day. A *margin call* is a request for additional cash to be added to the margin account, when, as a result of variation margin payments, it falls below a required *maintenance margin* level.

**MMbtu (also MMBtu, mmBtu, etc.):** million British thermal units. In the USA, and in some international LNG markets, natural gas is priced in US dollars per MMbtu.

**Mont Belvieu (MB):** the main trading market and benchmark pricing location for US NGL. Located close to Houston, TX, Mont Belvieu has the world's largest concentration of NGL fractionation plants and underground salt-cavern storage capacity for NGLs. Multiple pipelines bring mixed and separated NGLs to Mont Belvieu and take material off to end-use markets and to nearby export terminals.

**Naphtha:** the lightest liquid fraction (cut) produced in an oil refinery by atmospheric distillation of crude oil. Light naphtha has similar characteristics to natural gasoline. As a straight-run product, which has undergone no chemical transformations, it is *field grade*, olefin free material. Naphtha is a key feedstock and blend stock for gasoline production, but it is also an important chemical feedstock, especially in Europe.

**Natural Gasoline (C5+):** the heaviest of the natural gas liquids, consisting of the molecules that remain after ethane, propane and butanes have been removed by fractionation from a mixed NGL stream. Also known as *pentanes plus* or C5+. Natural gasoline can be used as a gasoline blend stock, as a *diluent* for heavy oil, or as a *denaturant* for ethanol.

**NC4:** Normal butane.

**Netback:** an estimate of the value of a commodity, derived from the value of another commodity and the costs of transforming one into the other. The FOB value of an LPG cargo in one location can be estimated from the known delivered price of LPG in another location, minus the cost of freight between the locations. The value of the mixed NGL stream at a gas plant can be calculated from the prices at which individual purity products are trading at a hub location, minus the costs of transportation and fractionation (T&F).

**NGL:** Natural Gas Liquid(s). Material separated from natural gas at a gas processing plant (mixed NGL), or an individual component separated from this stream at a *fractionation* plant (purity product). Almost all NGL consists of some combination of hydrocarbons with two to five carbon atoms, including ethane, propane, butanes and pentanes.

**Ningbo:** a port in Eastern China which is an important destination for LPG cargoes travelling to China.

**Non-TET:** in OPIS price reports of Mont Belvieu NGL trading, 'non-TET' prices reflect the value of material traded in storage at facilities operated by Enterprise Products Partners (ENT/EPD/EPC). The OPIS 'Other Non-TET' prices are for material traded at Targa Resources facilities.

**Normal Butane (N-Butane, NC4):** a straight-chain paraffinic hydrocarbon (alkane) with four carbon atoms, which is found in natural gas. Also called NC4. N-butane is a gas at standard conditions. It can be liquefied by pressure or by cooling to around 30°F (-1°C). N-butane is a gasoline blend stock, but because of its high vapor pressure, is used seasonally, in winter gasoline. Butane can also be a fuel gas (LPG) or a chemical feedstock.

**NWE:** North-west Europe, a trading and pricing benchmark region for NGL and oil trade. NWE is not limited to the ARA ports, and can include destinations in UK, France and Germany.

**Olefin:** a linear or branched hydrocarbon whose molecular structure includes carbon-carbon double bonds. Also called alkenes. Most plastics are made from small olefins: ethylene and propylene. Ethane and propane are used to make these olefins in ethylene crackers and propane dehydrogenation (PDH) plants. Ironically, the presence of olefins in NGL products makes them less desirable as chemical feed stocks. *Field grade* material is olefin-free, while *refinery grade* products contain olefins.

**OPIS:** Oil Price Information Service, a price reporting agency whose market prices are used as benchmarks and reference prices in floating price trades for NGLs throughout the US market. European and Asian markets use Argus pricing.

**OTC:** Over the Counter. Broadly, any form of trading that results in a direct legal contract between the buyer and seller. This definition would include physical trading of gases and liquids, together with bilateral and broker trading of swaps and options. It would exclude exchange-based futures and options trading. More narrowly, OTC refers to the trading of derivative instruments, in a multilateral market where deals result in a direct contract between buyers and sellers. This could be a market facilitated by brokers, or an electronic trading platform for OTC instruments.

**Other Non-TET:** in OPIS price reports of Mont Belvieu NGL trading, 'Other non-TET' prices reflect the value of material traded in storage at facilities operated by Targa Resources.

**Paraffin:** a *saturated* straight or branched chain hydrocarbon containing only single carbon-carbon bonds. Pure ethane, propane, normal butane, and isobutane are all paraffins.

**PDH:** Propane dehydrogenation, a process that converts propane to propylene, which is used to make polypropylene (PP) and other petrochemicals. PDH technology is relatively recent (compared to *steam cracking*) and capacity is growing strongly around the world.

**Pentanes Plus (C5+):** see *natural gasoline*.

**Propane (C3):** a paraffinic hydrocarbon (alkane) with three carbon atoms, which is found in natural gas. Propane is a gas at standard conditions. It can be liquefied by pressure or by cooling to -44°F (-42°C). Propane is used as a petrochemical feedstock, as a heating fuel (LPG), or as a motor fuel. In the North American market, LPG is synonymous with propane.

**Purity:** an NGL product that consists almost entirely of a single substance. In the US market, the minimum purity level for ethane, normal butane and isobutane is 95%, while propane is 90%. Ethane is often described as Purity Ethane, to distinguish it from EP Mix.

**Ratable / Rateable:** spread equally over a period of time. Ratable delivery means supply of material on a continuous or daily basis, with the same quantity being delivered each day. Ratable unwinding of a futures hedge position involves closing a portion of the hedge quantity each day, such that the entire hedge is gradually closed over a calendar month or other defined period.

**Raw Make:** see *Y-Grade*.

**RBOB:** Reformulated Blendstock for Oxygenate Blending, a 'suboctane' gasoline grade traded in the New York Harbor market, which requires the addition of ethanol to convert it to finished product. The CME NYMEX exchange offers RBOB futures which can be used for pricing and hedging of butane.

**Refinery Grade:** NGL products produced at a refinery, typically propane or normal butane. Refinery gases usually contain quite high levels of olefins (propylene, butylene) and are unsuitable for use as petrochemical feed stocks, so trade at a lower value than *field grade* material. LPG traded in Europe is often refinery grade, containing up to 20% olefins in propane and 30% in butane.

**Renewable Propane:** propane produced as a by-product of renewable diesel production. Also called biopropane or bioLPG. Renewable diesel (called HVO in Europe) is a drop-in replacement fuel for petroleum diesel, produced from vegetable oils or waste. Its production is rapidly growing in USA and Europe, as refiners switch from petroleum diesel production.

**Salt Cavern:** an underground storage facility created by dissolving away parts of a natural underground salt formation (a salt dome or bedded salt deposit). The resulting caverns can be hundreds of feet in diameter and over 1000 feet tall. They are deep below ground, so their natural pressure is high enough to keep NGLs in liquid form. *Brine compensation* is used to move NGLs in and out of storage.

**Sarnia:** a trading and storage hub, and benchmark pricing location for NGL in Ontario, an important refining and consumption region of Canada.

**Saturated:** a saturated hydrocarbon molecule is one that carries the maximum number of hydrogen atoms that its carbon backbone can accommodate. It contains only single bonds between carbon atoms and no double bonds. Paraffins and naphthenes are saturated, olefins and aromatics are not.

**Semi-Refrigerated:** descriptive of a gas carrier ship that uses a combination of refrigeration and pressure to contain NGLs. The pressure containment means the cargo does not have to be cooled to as low temperature as on a fully refrigerated vessel.

**Short:** a trading position that will benefit if a price falls. A steam cracker operator is naturally short ethane; a refiner who needs butane for gasoline blending is short butane; a trader who has sold some futures contracts (without any previous position) is short futures.

**Speculation:** trading that aims to capture a profit from a predicted or expected change in market prices that may or may not actually occur.

**Spot Contract:** a contract for a one-time purchase and sale of a commodity for delivery as soon as reasonably possible. In some markets, spot trades can result in almost immediate transfer (a *book trade* or a *wet trade* for NGL in the US market); in some international cargo markets, physical delivery may not occur until several weeks after the trade is agreed.

**Spread:** any difference between two prices. Spread trading is the simultaneous buying of one commodity or contract and selling of another, to create exposure to the spread between their prices. A spread swap is one whose payment at settlement is determined by the difference between two prices.

**Steam Cracking:** a chemical process that converts *paraffins* (alkanes) to *olefins* (alkenes). With an ethane feed, steam cracking creates ethylene. With heavier feed stock (propane, naphtha), it can also be used to create propylene and butylenes, or aromatics such as benzene. North American steam crackers are often *ethylene crackers* optimised to crack ethane. European and Asian steam crackers often use heavier feeds. Some steam crackers have the flexibility to use either NGL or naphtha feed stocks, depending on their price.

**Straddle Plant:** a gas processing plant located on a pipeline system, rather than at the producing field.

**Swap:** a derivative instrument used to manage price risk, settled by a cash payment at maturity. The settlement payment of a fixed-for-floating or outright swap reflects the difference between a defined price index (e.g. OPIS TET Propane) and a fixed price, negotiated when the swap was entered. The settlement is usually determined by the calendar month average of the index price.

**Targa:** Targa Resources, an operator of NGL storage caverns at Mont Belvieu. Some price reporting agencies use 'Targa' as a label for the price of NGLs traded in Targa storage. OPIS labels these prices 'other non-TET'.

**Term Contract:** an agreement for the purchase and sale of a commodity for continuous pipeline delivery, or for multiple rail, barge or cargo deliveries, usually on a regular repeated basis, over a period of weeks, months, or years.

**TET:** in OPIS price reports of Mont Belvieu NGL trading, 'TET' prices reflect the value of material traded in storage at facilities operated by Lone Star NGL, a subsidiary of Energy Transfer Partners. Other price reporting agencies call these Lone Star (LST) or Energy Transfer (ETR/ETP) prices.

**Tonne (Metric Ton, t, MT):** a unit of weight, equal to 1,000 kilograms and approximately 2,205 pounds. One tonne is approximately 521 gallons of propane or 453 gallons of butane.

**ToT:** a standard forward contract for European CIF cargo trading of propane, which requires the seller to give ten days' notice of a three-day delivery window.

**VLGC:** Very Large Gas Carrier, a ship capable of carrying a *fully refrigerated* cargo of 50,000 cubic meters or more of NGL. The standard traded VLGC quantity is 44,000 tonnes, around 550,000 barrels of propane or 475,000 barrels of butane.

**Wet:** in North American NGL pricing, a price for immediate delivery.

**WTI:** West Texas Intermediate crude oil, a light, sweet (low sulfur) crude produced in the Permian Basin. This grade is the main benchmark and pricing reference for all North American pipeline crude oil trading. The CME NYMEX exchange offers crude oil futures, which are commonly referred to as WTI, although the contract allows settlement by delivery of other grades. These 'WTI' futures can be used in pricing and hedging of NGL, particularly natural gasoline.

**Y-Grade:** in the US market, the mixed, unfractionated NGL stream produced from a natural gas processing plant. Also known as mixed NGL or 'raw make'. The composition of Y-grade varies from plant to plant, but a traditional US industry assumption is 42% ethane, 28% propane, 11% n-butane, 6% isobutane and 13% natural gasoline.