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Design Analysis of Natural Gas Liquid and the Utilization, Fractionation of Lpg Production

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ABSTRACT
Ethane, propane, butane, and other heavier hydrocarbons are present in natural gas. They are called natural gas liquids (NGL) and must be recovered from the gas in order to manage the dew point and generate cash by selling them as products to various businesses. LPG is made by fractionating NGL. This paper will look at how to fractionate various NGLs to make LPG. These procedures are explored in detail. A fractionation technique for LPG manufacture from NGL is also discussed. The simulation of fractionation columns looked at the material and energy balance. The study gives a summary of LPG transportation through canisters and pipeline, which is novel. The future market for LPG is being studied to determine whether it can replace excessive fuel usage.
Keyword: LPG, NGL, Fractionation, Transportation, Production

I. INTRODUCTION

Natural gas is a popular and potential fuel. Converting gas into liquid streamlines and relieves the transportation procedure. Liquefied Petroleum Gas (LPG) is a kind of natural gas that is kept in liquid form in tanks or canisters.

Like natural gas, LPG is a combustible combination of hydrocarbon gases using it as a fossil fuel. The remainder is made from petroleum extracted from wells.

Fig 2. LPG batch reactor 1

Fig 1. LPG cylinder

LPG is a combination of two combustible nontoxic gases: propane (C3H8) and butane (C2H2) (C4H10). Propylene and butylene are also found in trace amounts. Because LPG has no smell, it is difficult to detect leaks, thus a pungent gas such as ethanethiol is added to assist consumers notice potentially harmful gas leaks.

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Fig 3. LPG batch reactor 2

1.1 Properties

LPG is two and a half times heavier than air, but only one-half the weight of water. LPG may be compressed 1:250, allowing it to be stored in liquid form in portable containers. LPG emits less pollutants and carbon dioxide than most other fuels, reducing annual CO2 emissions by over 1.5 tonnes. LPG also lowered black carbon emissions, the second largest contributor to global warming and major health risks.

LPG has a high heating value of 12,467 kcal/m3, which is substantially greater than most natural gas (9350 kcal/m3). LPG also has a high Wobbe index (a measure of fuel gas interchangeability: $WI = \frac{GrossHeatValue}{\sqrt{SpecificGravity}}$)of 73.5-87.5 MJ/Sm^3which generates a lot of heat.

Household, industrial and commercial uses, as well as vehicle fuel, may utilize LPG as an alternative to natural gas (methane). It can also be used as a feedstock in petrochemical operations. propane and butane are hydrocarbon gases at normal temperatures and atmospheric pressure (15 degrees Celsius). Propane and butane, on the other hand, may be kept and delivered in liquid form at temperatures below -42 degrees Celsius and -2 degrees Celsius. The characteristics of LPG are shown in the following figure.

Table 1: LPG's Typical Characteristics

Property	Propane	Butane
Liquid Density	0.50-0.52	0.58-0.59
Conversion(Ltr per ton)	1969	1733
Gas Density/air	1.40-1.55	1.90-2.10
Boiling Point (C)	-45	-2
Latent Heat of Vaporization	358 KJ/Kg	372 KJ/Kg
Specific Heat(as liquid)	0.60 Btu/deg	0.57 Btu/deg
Sulfur Content	0-0.03%	0-0.03%
Calorific Value	2,500 Btu/ft^3	3,270 Btu/ft^3

1.2LPG Uses

LPG is often used as a fuel, primarily for automobiles and motorbikes, as well as an aerosol propulsion and refrigerant. LPG is better for automobiles than gasoline and diesel since it burns cleaner.

It's also a refrigerant. Hydrocarbon refrigerants are made from propane and butane. Hydrocarbons are considered to be more energy efficient and cost effective than other compounds, making them ideal refrigerants.

Cooking fuel is another prominent usage. LPG is widely common throughout Asia, notably in India. LPG is used to cook in businesses and homes such as restaurants. Propane is more often used for barbecues and portable stoves. It vaporizes soon it is discharged from the container due to its low boiling point. Butane is notably bottled as a lighter and deodorant fuel. LPG is formed by combining propane and butane.

LPG may be used as a backup or secondary fuel to provide domestic energy. For example, to heat water in the winter, LPG is being used in conjunction with solar panels.

1.3LPG's Future

LP Gas has been vital in satisfying global energy demands. As in future, LPG might play a bigger role in combating climate change. LPG is a greener and healthier alternative to gasoline and diesel since it emits less hazardous emissions.

With its portability and clean-burning properties, bottled LPG seems to be an early winner in bringing modern energy to people who have lived without it.

LPG's clean-burning, low-carbon benefit is accessible immediately, so most enterprises may surpass Kyoto greenhouse gas emission reduction commitments by converting to LPG. LPG emits less greenhouse gases than other energy sources in all uses, from water heating to transportation.

II. NATURAL GAS LIQUIDS PROCESSING

The heavier hydrocarbons in natural gas are removed from the well head. Ethane, propane, butane, and natural gasoline are heavier hydrocarbons associated with raw natural gas (condensate from). These hydrocarbons are termed NGLs. They must be recovered to manage the dew point of natural gas streams and to sell the separated components for profit. The following procedures are used to separate contaminants:

- Condensate removal
- Drainage
- Separation of NGLs
- Sulfur and CO_2 removal

This report's goal is to examine the fractionation of natural gas liquids to make LPG (Abdel-Aal, H. K et.al 2003). First, we'll look at LPG production methods.

2.1Recovery Processes of LPG

In addition to methane, natural gas includes minor quantities of other hydrocarbons as well as water vapor, carbon dioxide, sulfur compounds and some other non-hydrocarbons. Associated gases include ethane, butane, and propane. The separation of these gases from gas streams is required to fulfill consumer standards and to obtain valuable products like LPG. Recovery of LPG from natural gas/oil uses many procedures.

1. Refrigeration
2. Adsorption
3. Re-contacting-compression
4. Absorption
5. A combination of above

2.1.1Refrigeration

This method is used to extract LPG from flue gases. This method works by refrigerating the gas stream to produce LPG fractions. The recovered fractions are separated to generate LPG. The method is used in three stages:

- Separation at low temperatures
- Plants that produce new leaves as they grow

2.1.2Adsorption

Adsorbents are utilized to attach gas molecules to the surface. Adsorbents include silica gel, activated carbon, and alumina. This technique recovers less LPG than the other two.

2.1.3Re-contacting-compression

This method is used to extract LPG from crude oil fractionators. This method is seldom utilized in gas. The main product of a crude oil fractionator is methane, ethane, propane, and butane. This high product stream is compressed, chilled, and sent to the separator. In a deethanizer, the liquid phase contains certain LPG fractions and is utilized as fuel gas. It produces LPG as a liquid. This method recovers 75% of LPG. (Barbara, 2008).

2.1.4Lean oil absorption

The hydrocarbon oil is used to extract lighter fractions. This method is employed in refineries and gas plants. This method recovers 98 percent LPG.

2.2LPG Manufacturing

From natural gas liquids and from crude oil, LPG is made using distillation, catalytic cracking, delayed cokers, and hydrocrackers The LPG production process includes acid gas removal and extraction, fractionation, and product treatment. The straightforward technique is shown in the block diagram below. (Surinder, Parkash, 2009)

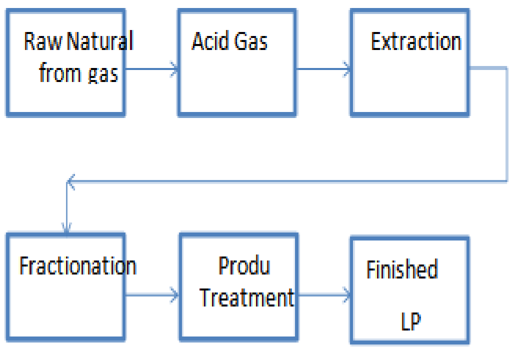

Fig1:LPG Manufacturing Blockdiagram 1 (Parkash ,Surinder,2009)

2.2.1removal of Acid gas

This is done by separating the gas and liquid components in knockout drums. CO2 and H2S are corrosive acid gases found in oil fields. These gases must be removed before processing the gas into LPG or other products. The amine or Benfield methods eliminate the acid gases. It is then transferred to an extraction unit.

2.2.2Extraction Unit

The extraction unit receives both related gases and condensate. The product streams have three stages. Three streams are delivered to the fractionation tower for LPG generation, and two to the gaseous products unit for further processing.

2.2.3Fractionation Unit

The fractionator trains divide the liquid stream into ethane, propane, butane, and pentane.

Figure 2 depicts the whole process flow. There are three columns: Deethanizer, Depropanizer, and Debutanizer. It goes like this.

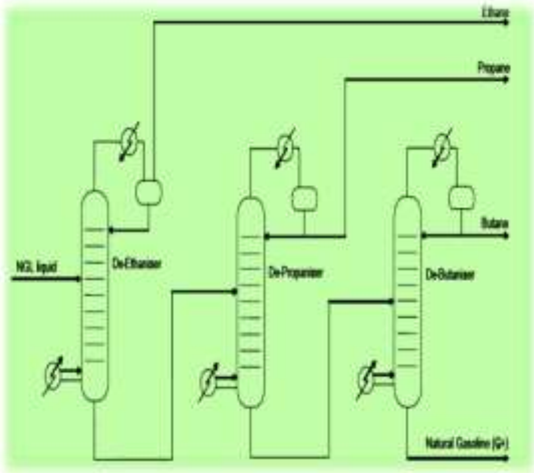

Fig 2: NGL Typical Fractionator train (Parkash,Surinder, 2009)

2.2.3.1Deethanizer Section

The Deethanizer receives raw gas from the top. Deethanizer ran at 390lb/in2. This column contained ethane. Ethane vapors are condensed in the condenser utilizing propane at 20oF and deposited in the reflux drum. Recycled condensed product goes to the Deethanizer tower, non-condensed vapors go to the fuel gas system. The reboiler heats the interior of the tower. Deethanizer's bottom product, depropanizer, follows.

2.2.3.2Depropanizer Section

To enter the depropanizer, the bottom product pressure is decreased to 290 lb/in2. This column's overhead product is propane-rich and condensed in a condenser with cooling water. The reflux drum collects the condensed product. Some of it returns to the column. Direct fired heaters provide heat.

2.2.3.3Debutanizer Section

The depropanizer's bottom product is enlarged to 110 lb/in^2 and sent to the tower. Propane is isolated as the product stream and condensed with cooling water. Heavy hydrocarbons are bottom products. Different kinds of fractionators are used in gas plants. The table below lists common LPG fractionators.

Table 2: Types for Fractionator LPG Production (Abdel-Aal, H. K.et al 2003)

Type of fractionator	Feed	Top product	Bottom product
Demethanizer	C1/C2	Methane	Ethane
Deethanizer	LPG	Ethane	Propane plus
Depropanizer	Deethanizer bottoms	Propane	Butanes plus
Debutanizer	Depropanizer bottoms plus)	Butanes	Natural gasoline(pentanes

Deisobutanizer	Debutanizer top	Isobutane	Normal butane

2.2.4Product Treatment Plant

The fractionated propane and butane include contaminants such as effluents, H_2S, carbon disulfide, and sulfur compounds. To achieve product standards, these contaminants must be eliminated. The table below lists the pollutants and their causes for removal.

Table 3:LPG Different Contaminants (Abdel-Aal, H. K.et al 2003)

Contaminants	Reasons for Removal
• **Hydrogen sulfide** • **Carbon dioxide** • **Carbonyl sulfide** • **Carbon disulfide** • **Mercaptans** • **Organic sulfides** • **Nitrogen** • **Water**	• Safety and Environmental • Corrosion control • Product specification • Prevention of freeze out at low temperatures • Prevention of catalyst • poisoning in downstream facilities

Many techniques exist to remove pollutants, but two are the most essential and widely employed.

a. Absorptive Purification
b. Adsorptive Purification

2.3NGL Fractionation Feed Specifications

Upstream processing facilities feed NGL fractionation units directly from gas sources. Reservoir feed composition varies. Design concerns rely on feed composition. Methane, ethane, propane, butane and other NGLs are fed to NGL fractionation trains. The table below shows the NGL fractionation feed composition.

Table 4: **Feed for NGL fractionation unit (Manley,D.B.)**

Liquid volume%	**Feed**	**Ethane**	**Propane**	**Iso-Butane**	**N-Butane**	**Gasoline**
Methane,C1	0.5	1.36				
Ethane,C2	37.0	95.14	7.32			

Propane,C3	26.0	3.50	90.18	2.0		
Isobutane,iC4	7.2			96.0	4.50	
N-Butane,C4	14.8			2.0	95.0	
Butanes,			2.50			3.0
Iso-pentane,iC5	5.0					33.13
Pentanes	3.5				0.50	23.52
N-pentane,NC5						
N-hexane,NC6	4.0					26.90
N-heptane,NC7	2.0					13.45

2.4Specifications of Product

The table below shows the LPG plant product specification. The US Gas Producers Association contributed this data. To sell quality gas, product standards must be satisfied. The most critical factors to regulate during operation are vapor pressure and temperature.

Table 5:**LPG Product specifications (Manley, D.B, 1996)**

Product characteristics	**Commercial propane**	**Commercial butane**	**Commercial propane – butane mix**	**Propane HD-5 a**
Composition	mainly propane and propene	mainly butane and butene	mainly mixes of propane – propene and butane – butene	not less than 90 % propane; not more than 5 % propene

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Vapor pressure (max.) at 100°F, psig b	208	70	208	208
Temperature of volatile residue: °F b	– 37	36	36	– 37
Butane and heavier, vol%	2.5			2.5
Pentane and heavier, vol%		2.0	2.0	
Residual matter, , mL	0.05			0.05
Oil stain observation	pass c			pass c
Volatile sulfur,grains/100 cu ft	15	15	15	10
Moisture content	pass d			pass d
Free water content		none	none	

III. SIMULATION

Aspen Hysys is used to simulate LPG extraction from NGL fractionation. The procedure has five stages. Sections: Deethanizer, depropanizer, debutanizer, and butane splitter. The sections are as follows:

3.1Conditioning of Feed

The first feed is from the well stream separation unit, and the second from the dehydration unit. The feeds are 25°C and 30 bar, however their flow rates vary.

These feeds will be processed to extract propane, isobutane, and n-butane. The items were chosen based on market demand. Condition the feeds before the Deethanizer column. Conditioning comes in three flavors.

The first option is to combine both meals before the Deethanizer column. A separator is being used to extract methane and ethane. Figure 3 depicts this option.

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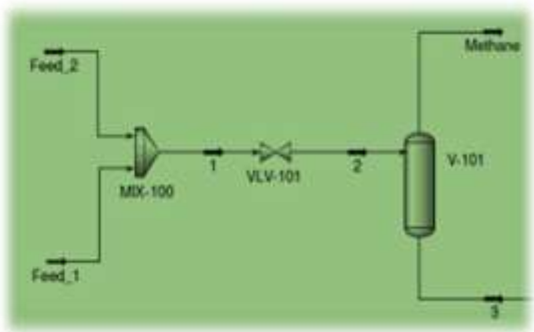

Fig3: Conditioning of Feed alt.1

The second option is to expand and separate each stream's methane. The bottom flow from each separator is combined in a mixer and then routed to a deethanizeras shown in figure (4).

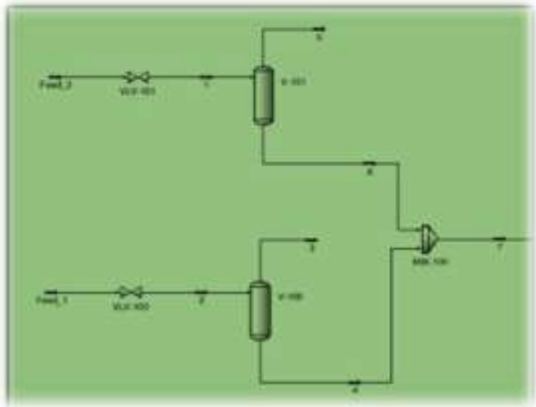

Fig 4: Conditioning of Feed alt.2

The final option is to combine both feeds, expand it and feed it into the Deethanizer column as shown in figure (5). The third option was chosen for this project.

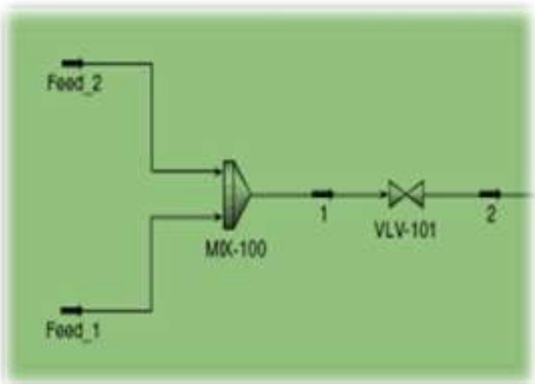

Fig 5: Conditioning of Feed alt.3

3.2Fractionation columns

3.2.1Deethanizer

To save money, no refrigeration is employed in this project. The first column is a deethanizer, which uses no condenser and draws the product gases (methane and ethane) from the top. The feed is supplied from the top. Figure (6).

The column has a 26 bar pressure and 15 trays. The deethanizer specification is chosen to converge the column. No condenser means just one specification is needed to converge the column. Because methane and ethane are light, they would be difficult to keep in the bottom stream. However, other requirements like component recovery and component fraction were employed with difficulty.

The number of trays in the column is vital because the more steps there are, the taller the column and the more costly it is, but the purer the output. This project should include 15 phases.

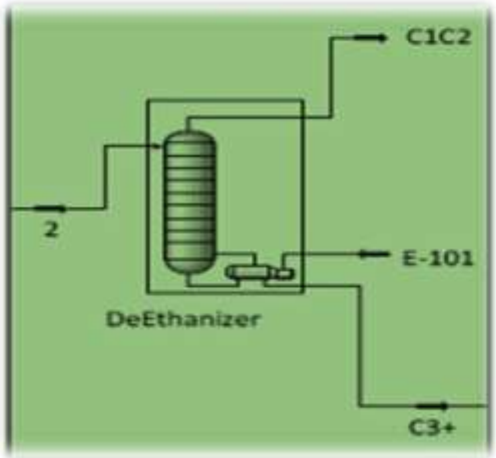

Fig 6: Deethanizer column

3.2.2Debutanizer

To make the next separation simpler and the depropanizer smaller, the debutanizer was employed before the depropanizer for economic reasons. Higher hydrocarbons are removed from bottom of debutanizer as bottom products, whereas butane is extracted as top product from debutanizer. Figure 7 shows a debutanizer model.

Condenser and reboiler need two parameters in the debutanizer model. Propane and butane component recovery rates are chosen in this scenario. With a top product purity of over 99.9% propane and 966 percent butane, the debutanizer's specification has an impact on the top product purity.

The stages were 15, 16 and 17 bar top and bottom pressure respectively.

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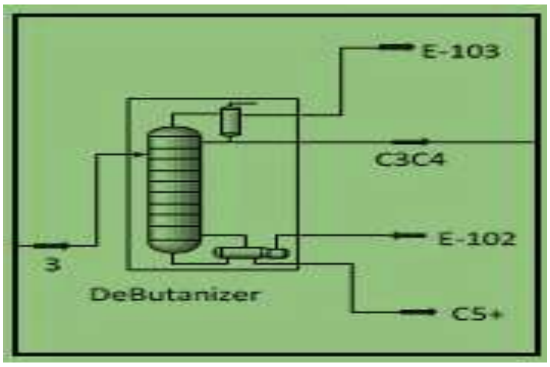

Fig 7: Debutanizer column

3.2.3Depropanizer

Similar to debutanizer, depropanizer separates propane from butane. After condensing, propane is removed from the top and butane from the bottom. (8) Depropanizer column Modeling is simpler with simply butane and propane in the supply. Component retrieval and component ratio are specified. With these characteristics, the best product recovered over 99.8% propane. The column requirement is as follows: 15 stages, 9 and 10 bar top and bottom pressure respectively.

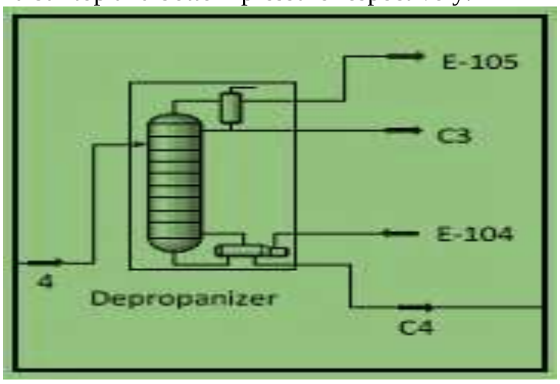

Fig 8: Depropanizer column

3.2.4Butane splitter

The final column is a butane splitter that separates butane into iso-butane and nbutane. Butane splitter specifies distillate rate and component recovery. Because iso and n-butane separation is more difficult, there are more steps than in depropanizer. With these specs and adjusting the column pressure, 96.6 percent iso-butane recovery was accomplished. Figure 9 depicts a butane splitter.

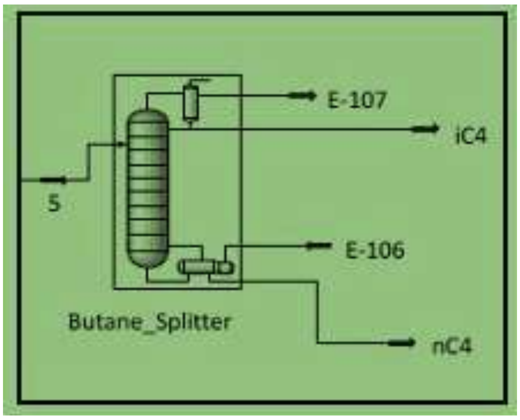

Fig 9: Butane splitter

IV. TRANSPORTATION OF LPG

LPG demand is increasing. Used in all energy-consuming areas, especially residential and commercial, in established and emerging nations. With rising population and rising energy demand, the usage of clean liquid and gaseous fuels is predicted to rise. At same time, high oil costs are increasing LPG transportation needs. Modern transportation projects are projected, and several are already planned. With more access to LPG and new market opportunities, complicated and innovative transportation solutions will be critical in these projects. Due to LPG's gaseous nature (1 bar, 20°C), inequality in the distribution in area, seasonal consumption, and static, highly concentrated production, several issues had to be addressed and a vast transportation network built. To meet market demands, two forms of LPG distribution were created:

- Gas flow is steady and simple, requiring modest initial investments, localized storage terminals, and a broad distribution network.
- "Discrete" way of transporting LPG in pressurized canisters through vehicles, trains, and ships.

Each of the two sections has unique transport methods and safety procedures. Due to their intricacy, the next paragraphs must be explained.

4.1Continuous flow of LPG – Pipe system

LPG flow via pipes at a specific moment. Although the initial costs are substantial, the end effect is significant if built and maintained properly. There are several benefits to using this kind of LPG transportation such as:

- More LPG in hard-to-reach regions
- Reduction in LPG transport costs
- Reduction of exhaust emission levels

The LPG transmission system is not as large as the NG and oil pipeline systems, but it nevertheless follows the same stages. It also varies by geography and end use.

The most prevalent system is in Europe, where LPG is utilized for water heating. The pipes are 1" to 6" diameter and primarily carbon steel.

In the USA, LPG is utilized for distributed power production. This reduces the pipe network but increases gas flow to oil and gas projects. Mid-America Pipeline, a twin pipeline from New Mexico to Minnesota and Wisconsin. First LPG-only system. It is a 3540 km ANSI900 pipeline system with 6 delivery, 2 operational terminals, 14 pumping stations, and underground storage.

In 2001, 33.6 million Nigerian homes used LPG for cooking, a similar but distinct target. Due to lack of infrastructure and huge unsupplied regions, a 1900 km LPG pipeline network was built. The 3.8 MMTPA LPG transmission system.

4.2Transporting LPG in discrete (bulk)

Discrete transport is the polar opposite of continuous travel. Unlike the pipe system, the discrete system is adjustable in terms of location, quantity, and time. In terms of cost, early investments are lower, but total costs are greater. As a consequence, when pipes are uneconomical, alternate methods are adopted. Below is a breakdown of each kind.

4.2.1transportation of Vessel tanker

The great bulk of LPG shipment is through water. Globally, there are around 1000 tankers. These aren't LPG-only tankers. To transport pressurized, semi-pressurized, or chilled LPG qualifies as an LPG tanker. Because it is safer to carry large volumes at moderate temperatures than high pressures, there are three sizes of LPG tankers.

- Short- to medium-haul pressurized tankers (18 bar, ambient temps). Transport capacity ranges from 3000-10000 m^3.
- Semi-pressurized tankers (10 000 – 30 000 m^3) for medium haul trades (5-8 bar, 15±5°C).
- These tankers are utilized for long-haul trades with high LPG consumption, e.g. Japan. These range from 30 000 to 100 000 m^3.

A large fleet of tiny boats is employed for coastal, short sea, and interior river commerce.

Because LPG fumes are very combustible, odorless, and invisible to the human eye, various safety procedures were established to prevent leaks. It has thick walls and is protected from the outside by an inner layer of inert gas (mainly nitrogen). Also, to transport other gases, CNG vapors are blown before loading.

Compared to on-loading and off-loading, vessel transfer is straightforward and safe. Modern transfer technologies include static shore terminal (SST) and single point mooring (SPM) (SPM).

Onshore and offshore LPG storage facilities are linked via flexible pipes. SPM is a pipeline-connected intermediate stage among pipe and vessel transfer. Tankers may moor from all sides based on bathymetry and environmental factors. SPM allows for faster transmission, regardless of weather, and cheaper maintenance expenses. Fig.A5 shows both SST and SPM.

Post-shipment distribution occurs after goods is offloaded.

4.2.2 transportation ofRail, Truck and Car

Rail alongside truck transportation replaces ship on land. LPG is delivered from ship ports to local storage depots for further delivery by smaller vehicles or directly to users, primarily industry. In Italy, for example, LPG is only delivered by rail since no pipeline network exists.

Precautions were required due to the higher frequency of single shipments and population density than pipe or ship. Because pressure keeps LPG liquid, all canisters must be strong enough to withstand substantial damage without leaking. Second, canisters may never be filled to more than 40% water equivalent. This is required due to large temperature variations. So the gas within the canister evaporates without much pressure rise. Canisters must also include overpressure valves and a mechanical safety cover. International standards require white or red color, and precise signage in conspicuous areas, showing the canister capacity.

4.3Economic analysis

LPG supplies are growing, as are prices. And the forecasts indicate a bright future. The market demand for LPG has been constant for years, which would suggest a price reduction. But the market scenario is different. For example, propane went from $500/ton to 900/ton in late 2007 and then to 1500/ton in 2011. This rise is unavoidable. It is caused by various variables, one of which being the strong relationship between crude oil and the dollar. Price increases have previously stifled LPG consumption. The recovery came with increasing costs, largely due to steady petrochemical demand and rising gasoline prices.

4.3.1 Main LPG sources

- Refinery output rises
- Processing of COGs - modest rise

- Non-associated natural gas processing — substantial amounts from Qatar, Iran, UAE, and Nigeria.

The petrochemical sector is expected to be unable to utilize the rising supplies, resulting in lower LPG prices. Sadly, as prices demonstrate, that didn't happen. This is a bad forecast for the future.

4.3.2 Demand

- Western Europe and the Middle East – booming in petrochemical industry
- Middle East, Asia, and Africa – increasing
- Transport (autogas) in Europe and Asia-Pacific
- 2,3 Mt/yr in North America

Demand growth is greatly segmented by time, geography, and industry. Appendix Fig.A7

Domestic growth is consistent due to simple access to LPG cylinders, expanding infrastructure, and LPG's displacement of other fuels. Also, the Asian domestic market is encouraging. Request for flexible LPG is expanding faster than demand for grid-based energy sources.

LPG consumption is growing because of similarities with natural gas. For industry, the ease of switching from NG to LPG is a huge benefit, especially when predicting future NG costs. LPG is utilized as a backup for NG users and significant capital investors.

The autogas industry grew the fastest in recent years. Consumption is up 6% year on year. Only 7 nations account for 2/3 of this consumption. This trend is caused by automobile makers, not only increasing petrol and diesel costs. Their new autogas automobiles are also driving demand. The South Korean example shows the boom. Domestic automobile manufacturers launched over 80% of autogas consumption autos. In Turkey, government-carmaker collaboration led to a 16% increase in LPG usage. Appendix Fig.A8

Despite increasing costs, clean-burning LPG is a growing energy source. Undeniably, its expanding importance in an energy-hungry world has been predicted.

V. CONCLUSIONS AND DISCUSSIONS

- LPG is a cleaner burning fuel that reduces greenhouse gas emissions. So it can help fight global warming.
- Various technologies exist for recovering LPG from NGLs. The refrigeration technique is the most frequent since it recovers 98 percent.
- There are three ways to prepare the feed stream for fractionation. It is better to combine the two feed streams from separate wells before feeding them to the deethanizer.
- Fractionation costs may be decreased by refrigerating....
- Debutanizer was used before depropanizer to save money and make separation easier.
- The separation of iso and n-butane is more complex and requires additional steps, increasing the final cost.
- Pipeline technology may cut LPG transportation costs. Although these initiatives are ongoing, they are safe and cost effective.

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