INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Natural Gas Liquids from the Associated Flare Gas Stream: Monetized in Real-Time via Various Qualitative Products

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Abstract:
Typically, the raw natural gas, released from underground porous reservoir rocks and passed through well bore system, that brings it to the surface wellhead is much different from the sweetened natural gas used by consumers. Conventionally, starting at the wellhead, down to the gas processing plants, the natural gas is purified to yield pure methane –rich stream and sweetened natural gas liquids (NGLs) comprising mostly, molecules that are heavier than methane like ethane, propane, butanes, pentanes and hexane plus hydrocarbon components. Consumers use natural gas in either of the two streams in various forms, such as, residential fuel for domestic heating, cooking, refrigeration and air conditioning; energy source which competes with petroleum products like fuel oil, diesel and liquefied petroleum gas (LPG); and feedstock to both petrochemical and chemical industries for manufacturing various intermediate chemicals and finished products such as ammonia (synthetic nitrogen fertilizer), methanol, chloromethanes, oxalcohols polythene, textiles, paints, synthetic drugs, toys, solvents, car tyres, explosives, soles of shoes et cetera. This investigation on the real-time monetization of natural gas liquids (NGLs) from the flared associated stranded natural gas in Nigeria, theoretically, reviewed the purification, recovery and separation of NGLs from a bulk natural gas stream, starting at the well head, to the gas processing plants, which normally entail, change of phase using either an Energy-Separating Agent(ESA) such as refrigeration for partial and total liquefaction/ fractionation or a Mass-Separating Agent (MSA) such as, the adsorption and absorption processes. It showed that the NGL volume extractable depends on the amount of gas available (flow rate), the NGL contained in the gas (composition), the processing technique employed by the processing plant et cetera. Usually, NGLs can comprise from 5% to over 50% of the natural gas stream. With a flow rate of 20million scfd (20MMscfd) on a sweetened composition of the flared associated stranded natural gas stream in Nigeria (table 3), the real-time daily NGLs component by component was obtained table 4, which indicates that about 160 bpd of ethane, 122 bpd propane, et cetera, would be available for monetization in various qualitative products that are in very high demand.

Keywords: *Extractable Sweetened liquid fractionation, Flare stream monetization, Natural gas liquids, Useful end products*

1. Introduction

Each natural gas, like each crude oil is a unique mixture of hydrocarbons (Gatlin, 1960). However, the major components in most or all-natural gases are the light members of the paraffin or alkane series hydrocarbons (general molecular formula C_nH_{2n+2}), with smaller amounts (usually only trace) of olefin hydrocarbons, naphthenic hydrocarbons, and non-hydrocarbon compounds.
The simplest member of the series, methane, with chemical formula CH_4- one atom of carbon combined with four hydrogen atoms, is the most abundant or predominant component and is always present in gaseous form (Ikoku, 1980).
The other hydrocarbons components normally found in natural gas include ethane (C_2H_6), propane (C_3H_8), and butane (C_4H_{10}) whose components may occur in either gaseous or liquid form, depending on the pre-existing temperature and pressure conditions, while the pentanes ($C_5 H_{12}$), hexanes (C_6H_{14}), heptanes ($C_7 H_{16}$), and heavier hydrocarbons, if present, are always in liquid form.
The non- hydrocarbons components of natural gas (Katz et al., 1959) are Nitrogen (N_2), carbon Dioxide (CO_2), Hydrogen sulfide (H_2S), Helium (H_e), water vapour (H_20), carbonyl sulfide (COS), carbon Disulfide (CS_2), sulfur (S), and Mercaptans (RSH). Methyl mercaptan and Ethyl mercaptan are the two mercaptan compounds most commonly found in natural gas. Since most of the trace components of natural gas are insignificant, the common analyses do not report them, however, the presence of traces can be of extreme, significance in process designs (Donnelly, 1982).

1.1. Produced Gas Classification

Produced gases are characterized by the volume or weight of the condensable (extractable liquid hydrocarbon components, ethane and the higher paraffin homologues) contained in a given volume of total gas produced. This figure, computed for volumes at $15^{O}C$ (59^{OF}) and 750 mm of mercury, is usually expressed either in gallons per 1,000 cubic feet or ingrams per cubic feet (Encyclopedia

Britannica). Where the proportion of extractable liquid hydrocarbon components is very small (less than 0.1 gal/Mcf of gas stream), the natural gas is termed "DRY"; if the proportion lies between 0.1 gal/Mcf and 0.3 gal/Mcf, the natural gas is termed "LEAN" and if it is 0.3 gal/Mcf or more, the natural gas is termed "WET". While "RESIDUE GAS" is natural gas from which the vapors of natural gas liquids (NGLs) have been extracted (Levorsen, 1967). Thus, NGLs are those portions of reservoir gas that are liquefied at the surface in lease separators, field facilities, or gas processing plants. They include but are not limited to ethane, propane, butanes, pentanes, natural gasoline and condensates. NGLs, can comprise 5 to 50% of the natural gas stream depending on its thermal maturity (Pennsylvania state University, 2017). Also (Salvadar, 2015) stated that the content of NGLs of Natural gas varies widely from essentially none in dry gas to more than 200 bbl (barrels) of NGLs per MMcf (million cubic feet) of gas in rich wet gas (8.4 gallon/1000 cubic feet).

1.2. NGLs Operations

The processing of natural gas works on the same principle as the refining of crude oil, where the different boiling point of the gas components facilitate their separation (International Energy Agency, 2010). Natural gas conditioning and processing (gas treatment) usually termed dehydration and sweetening is basically aimed at producing very high purity methane. The purification processes, removes condensable water vapor, and undesirable compound such as hydrogen sulfide, carbon dioxide, nitrogen as well as recover hydrocarbon vapors (i.e. saleable hydrocarbon liquids) mostly the ethane, propane, butanes and heavier fractions.

There are basically three categories involved in gas purification, absorption into liquid, adsorption on a solid and chemical conversion to another compound; while the other unit operations that may be encountered in the overall processing scheme include distillation, crystallization and filtration.

Natural gas liquids are also extracted from crude petroleum refinery gases, consisting mainly, hydrogen, methane, ethane, ethene, propane, propene, butanes and butenes or the additional alkenes obtained by the catalytic cracking of C_5-C_{25} Liquid hydrocarbon fractions (figure 1 and figure 2).

Methane Ethane	Dry Gas or Natural gas or LNG	
Propane i-butane n-butane	LPG	Pentanes Natural Gas Liquids
Naphtha Natural Gasoline Condensate	Heavier Fractions	

Figure 1: Sources of Natural Gas Liquids (NGLs)
Source: Adapted from the International Energy Agency

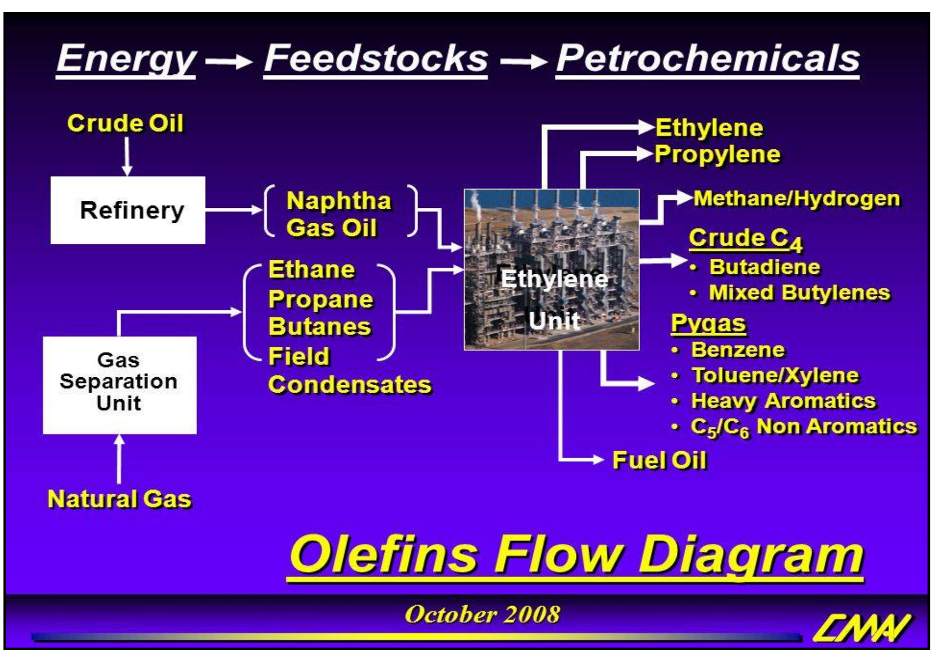

Figure 2: Petrochemicals from crude oil and natural gas
Source: Adapted from images of Olefin Flow Diagram for production of petrochemicals

Conventionally, NGLs have high market valves as gasoline blending stock and petrochemical/ chemical plants raw feedstock.

1.3. Study Objectives

This investigation is focused on the evaluation of real-time extractable quantities of the various components of the Natural gas liquids for any flare stream composition and flow rate, of the flared associated stranded natural gas in Nigeria. Furthermore, the study outlined in details, all the possible useful values and end products from the recovered NGLs.

2. Background

Most of the stranded natural gas currently being flared are natural gases that were originally associated with crude oil, that is, either dissolved in the crude oil (dissolved gas) or co-existed with the crude oil in the formation (free gas). As the temperature and pressure decrease from the reservoir conditions to the well head conditions, the natural gas disassociates (separates) from the crude oil, figure 3.

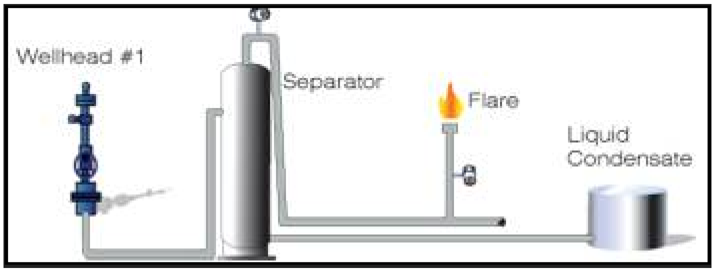

Figure 3: Typical Associated Natural Gas Flare Stream Layout.
Source: Adapted From images of the complete flare line from wellhead to the flare stack.

2.1. Raw Natural Gas Purification

Conventionally, gas treatment/purification usually start at or near the well head with heaters and scrubber's installations (field processing). The heaters ensure that the temperature of the gas does not drop too low, otherwise, there is a tendency of hydrate formation alone the gas pipeline. While the scrubbers serve primarily to remove sand and other large-particles impurities, such as entrained oil, condensate water, that is any liquid accumulated in the gas stream are removed (Lyons, 1996).

Subsequently, the gas is piped to either a gas gathering facility or a gas processing plant for the complete processing of the natural gas. In either of the facilities, the associated natural gas undergoes four main processes to remove the various impurities (Ikoku, 1980, Natgas, 2013), oil and condensate removal; water removal (dehydration); sulfur, carbon dioxide, Nitrogen, Mercury removal; and recovery of Natural Gas Liquids (NGLs), figures 4,5, and 6.

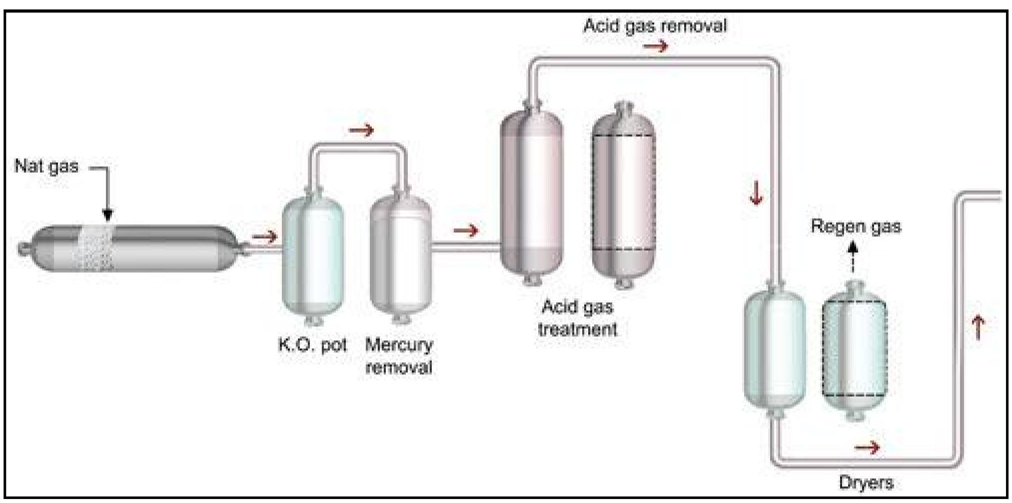

Figure 4: Mercury and Acid Gas Removal Layout
Source: Adapted from images of Natural gas treatment units

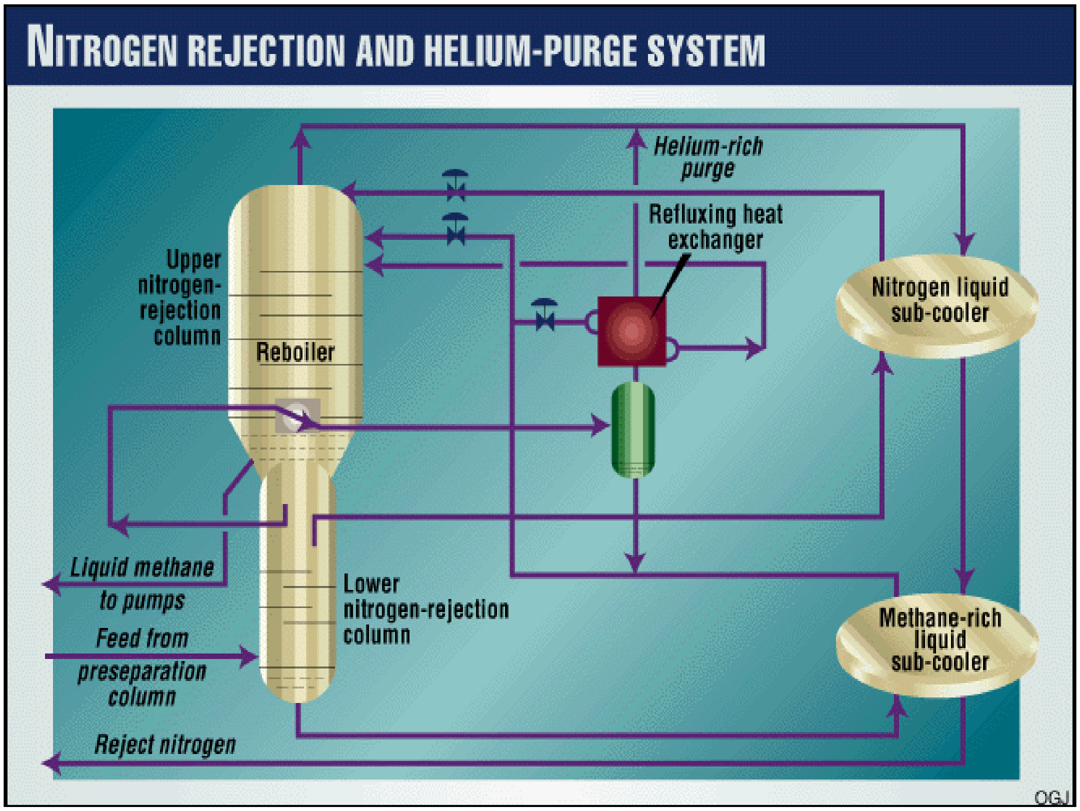

Figure 5: Nitrogen and Helium Extraction Layout
Source: Adapted from images of Natural gas treatment units

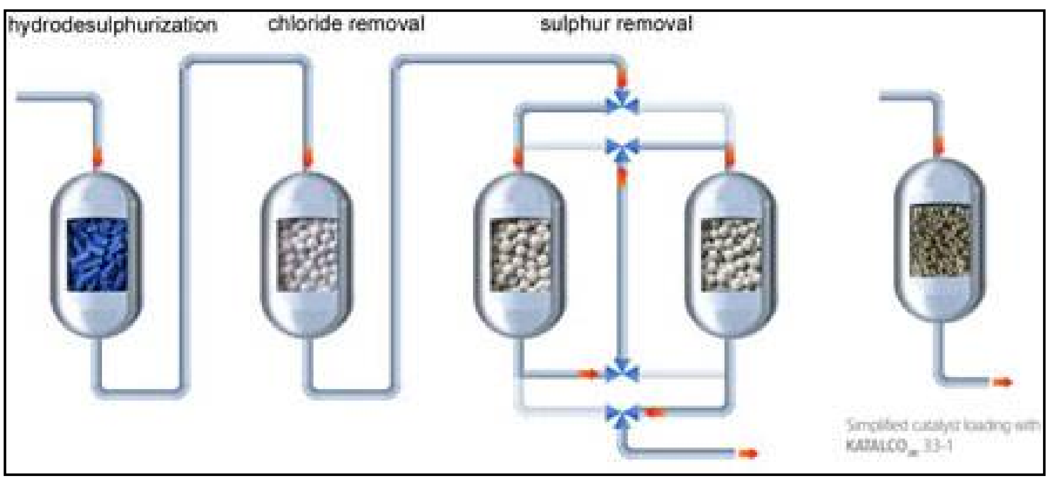

Figure 6: Chloride and Sulfur Removal Layout
Source: Adapted from images of Natural gas treatment units.

2.2. Natural Gas Liquids Recovery/Extraction

The above purification process, yields two major products: methane rich stream (almost pure methane 95 to 98%) and sweetened natural gas liquids stream, mainly ethane 95% and above, propane 98% and above, butanes 100% and pentanes plus 100%, figure 7 for hot high-pressure gas, figures8 and 9 for different routes such as via propane heat exchanger, cold separator or direct to the NGLs recovery unit.

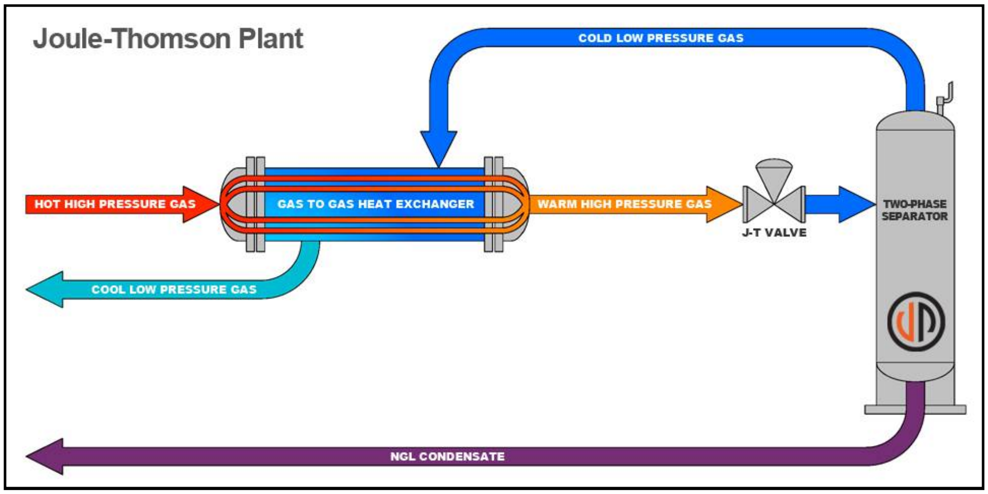

Figure 7: The Layout for the two major products for hot high-pressure gas stream
Source: Adapted from images of Natural gas liquids recovery units

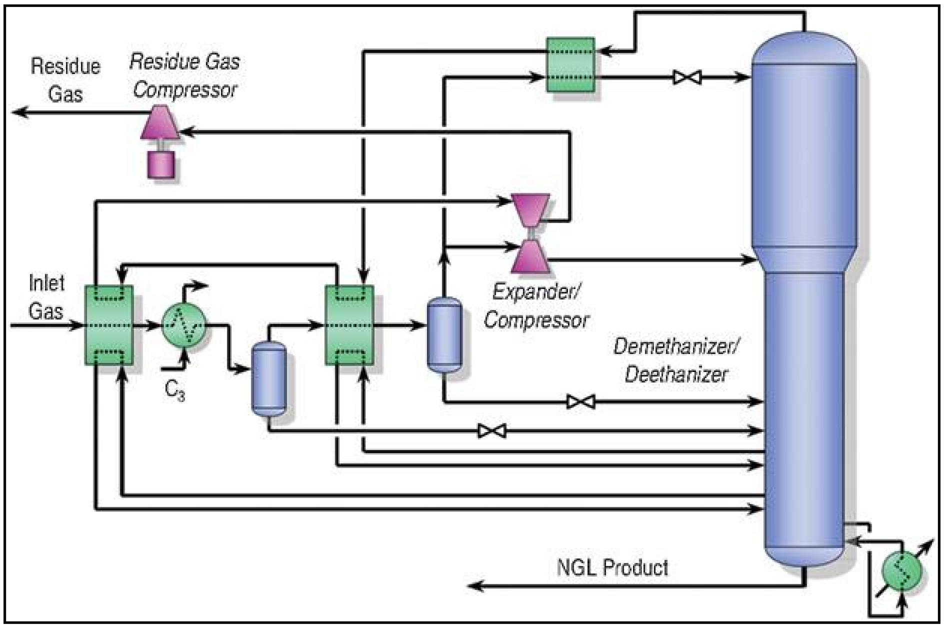

Figure 8: The Layout for the two major products via propane heat exchanger
Source: Adapted from images of Natural gas liquids recovery units

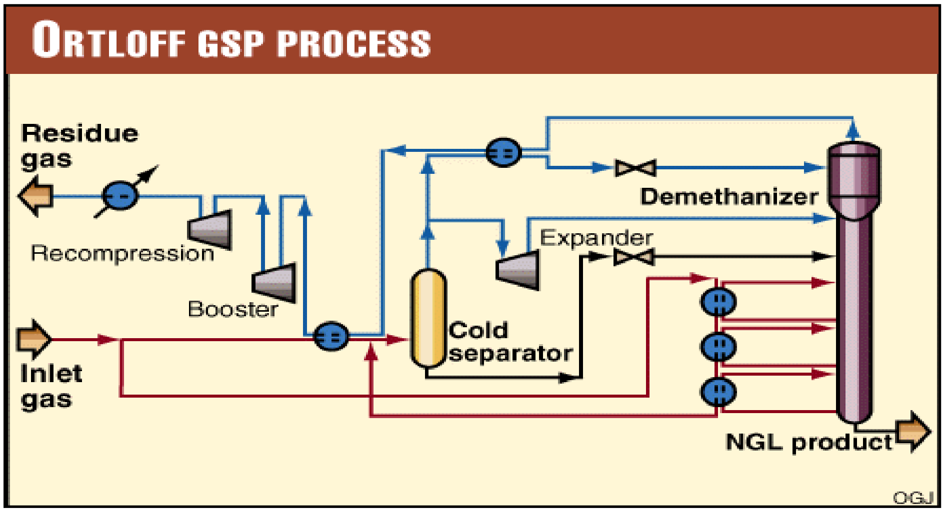

Figure 9: The Layout for the two major products via cold separator or direct to the NGLs recovery unit
Source: Adapted from images of Natural gas liquids recovery units

2.3. NGLs Separation by Boiling Point

For the extracted NGLs to be useful, it must be separated into its individual products. Usually, fractionation of NGLs is based on varying boiling point of the different hydrocarbons that constitutes the NGLs stream.

The fractionation process is a step-wise process which start with the removal of the lighter NGLs from the stream, down to the heavier components. Fractionators are distinguished according to the particular hydrocarbon boiled off, figure 10.

* De- ethanizer – removes ethane
- De –propanizer- removes propane
- De – butanizer- removes both the iso butane and the normal butane. De- isobutanizer or butane splitter-separate the isobutene and normal butane.

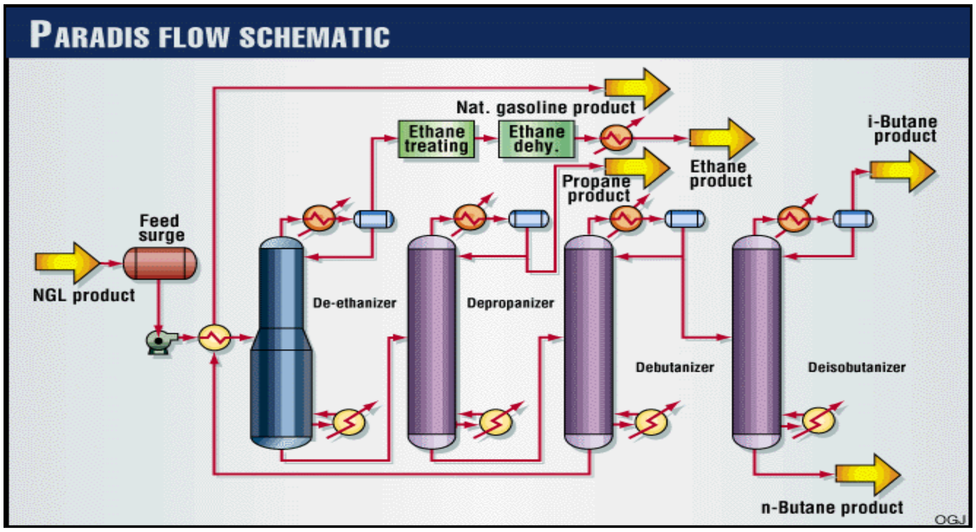

Figure 10: NGLs Fractionators layout
Source: Adapted from images of the fractionation units

The NGLs volume extractable depends on the amount of gas available (flow rate), the NGLs contained in the gas (composition), the processing technique employed by the processing plant et cetera.

NGLs can comprise from 5% to well over 50% of the natural gas stream.

3. Theoretical Model

Usually, once the gas stream has been stripped off, acid gases and water vapor, it is classified as dry- sweet gas and is ready for the NGLs extraction and fractionation based on the different boiling points of the different hydrocarbons in the NGLs stream, figure 11.

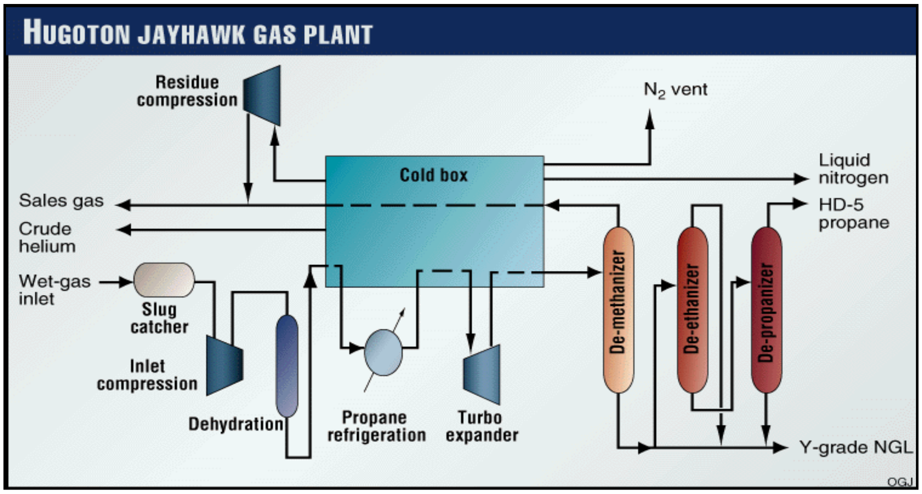

Figure 11: Straight NGLs Extraction and Fractionation
Source: Adapted from images of Natural gas liquids recovery units

Any gas can be liquefied at atmospheric pressure if it is cooled sufficiently (Heys, 1980). Precisely every gas has its critical temperature, and if the gas is at any temperature below its critical and pressure is gradually increased, the molecules come closer together, and attract each other more strongly, hence liquefy.

On the other hand, the same result can be achieved by keeping the pressure constant and cooling the gas.

Theoretically therefore, the recovery and separation of NGLs from a bulk of a gas stream would normally require a change of phase (Abdel-Aal et al., 2003; Basic Separation Concepts), which involves control of one or more of the following three parameters.

- Operating pressure, P
- Operating temperature, T
- System composition or concentration.

The new phase can be achieved by using either an Energy- Separating Agent (ESA) or a Mass-Separating Agent (MSA).

(1) For the ESA, pressure is maintained by direct control, while temperature, on the other hand, is reduced by refrigeration using one of the following techniques.
  (a) Compression refrigeration
  (b) Cryogenic separation; expansion across a turbine,
  (c) Cryogenic separation; expansion across a valve.

(2) For separation using MSA, a control in the composition or the concentration of the hydrocarbons to be recovered (NGLs); is obtained by using adsorption or absorption methods.

In adsorption, the components desired as liquid are either entrained, adsorbed or deposited on the surface of the selected solid desiccants, and subsequently regenerated off in a high concentration (figure 12), while absorption, presents a similar function by providing a surface or contact area of liquid-gas interface.

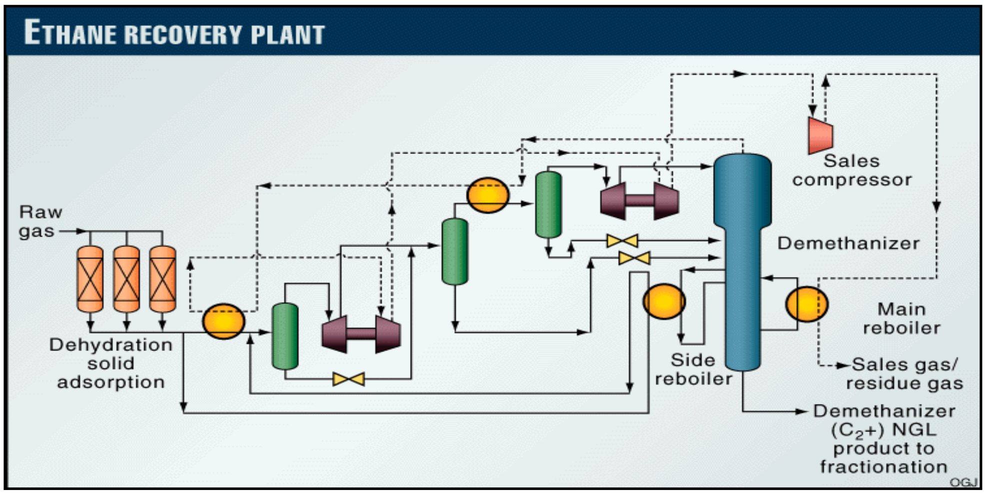

Figure 12: Solid adsorption dehydration component in ethane recovery plant
Source: Adapted from images of Natural gas liquids recovery units

Other processes developed include.

(1) The Randall Gas Technologies, Iso Pressure Open Refrigeration-IPOR (Huebel and Malsam, 2012). This process, recover hydrocarbon components from inlet gas at pressures in excess of 850 psig and up to 1500 psig i.e. tailored for high inlet gas pressure, the “High pressure Absorber (HPA) Process” (Foglietta and Mowery, 2003, Foglietta, 2004).

(2) The Twister Tube Gas Processing Technology (Schinkelshock and Epson, 2006) which operates at supersonic velocity, in combination of known physical processes, aero- dynamics, thermo-dynamics and fluid dynamics in a compact tubular device.

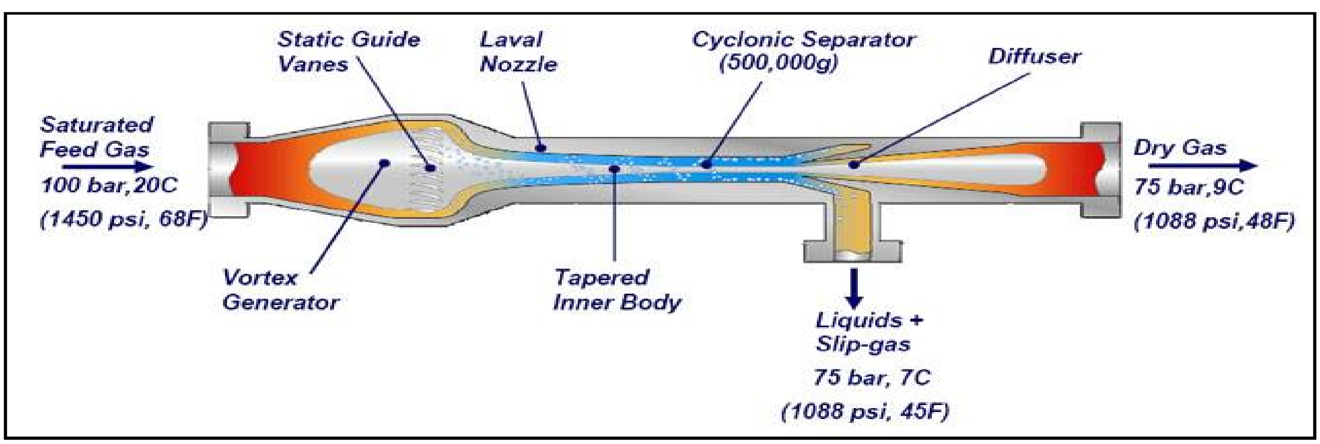

Figure 13: A cross-section view of the tube shows separation elements.
Source: Adapted from Arash, 2016, Betting and Marco, 2007

The Twister is a novel gas dew pointing device in which natural gas flows through a separation section at supersonic velocity extracting water and hydrocarbon liquids (Shell, Nigeria). Due to the low static pressure and the resulting low temperature at these supersonic conditions, liquid formation occurs inside the Twister. Liquid droplets in the submicron range are separated from the gas stream in the Twister tube due to extremely high rotational force (> 500, 000 times gravitational acceleration) (Janssen and Betting, 2006).

4. Material

Table (1), courtesy SPE- Back to Basic 2011, shows the typical compositions (mole percent) for the difference categories of gases.

Component	Dry Gas	Rich Gas	Wet Gas (Reservoir Comp.)	Solution Gas	Sales Gas
H_2	0.02	0.01	0.00	0.01	0.01
N_e	0.00	0.00	0.00	0.00	0.00
N_2	0.68	0.94	0.23	0.51	0.55
CO_2	0.89	0.86	1.08	0.82	0.88
H_2S	0.00	0.00	0.00	0.00	0.00
C_1	92.32	81.62	70.10	77.70	87.92
C_2	3.25	8.17	10.10	10.35	5.25
C_3	1.80	4.49	5.28	6.85	3.34
iC_4	0.43	1.44	1.40	0.77	0.71
nC_4	0.61	1.54	2.15	1.73	1.02
iC_5	0.00	0.45	0.99	0.41	0.08
C_6	0.00	0.11	2.91	0.25	0.00
C_7+	0.00	0.09	4.75	0.24	0.00
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 1: Typical Gas Compositions, Mole Percent (Source: Adapted from SPE – Back to Basic 2011)

Table 2 shows the typical representative composition of the flared associated stranded natural gas stream in Nigeria, obtained from statistical analysis of 36 flare streams, selected from 150 flare line data samples. And table 3 contains the average operational parameters of the Nigeria flare gas stream.

Component	Mole %
Methane	78.5375
Ethane	78.5375
Propane	5.9625
i-butane	1.4842
n-butane	1.8882
i-pentane	0.6964
n-pentane	0.4982
Hexane plus	0.7550
Nitrogen	0.1729
Carbon dioxide	2.0105
Other undesirables	0.2066
	100.0000

Table 2: A Typical Representative Composition of Flare Associated Stranded Natural Gas in Nigeria
Source: Adapted from Ekejiuba, 2017

Parameter	Range	Value for the Study
Gas Gravity (air)	0.607 to 0.996	0.755
Flow rate MMscfd	5 to 63	20
Pressure Psig	7 to 75	10
Pressure	21.7 to 89.7	25
Temperature ^{O}F	60 to 115	80
Base Temperature During Analysis	-	60^{O}F
Base Pressure During Analysis	-	14.7psia

Table 3: Flare Conditions of the Associated Stranded Natural Gas in Nigeria
Source: Adapted from Ekejiuba, 2017

5. Model Application

Conventionally, processing the flared associated stranded natural gas to remove undesirable components such as, carbon dioxide, hydrogen sulfide and other sulfur components, and nitrogen is termed sweetening (Campbell, 1976). Figure 14, is the proposed design process layout for the overall sweetening of the associated flared natural gas and the detailed NGLs finished end products.

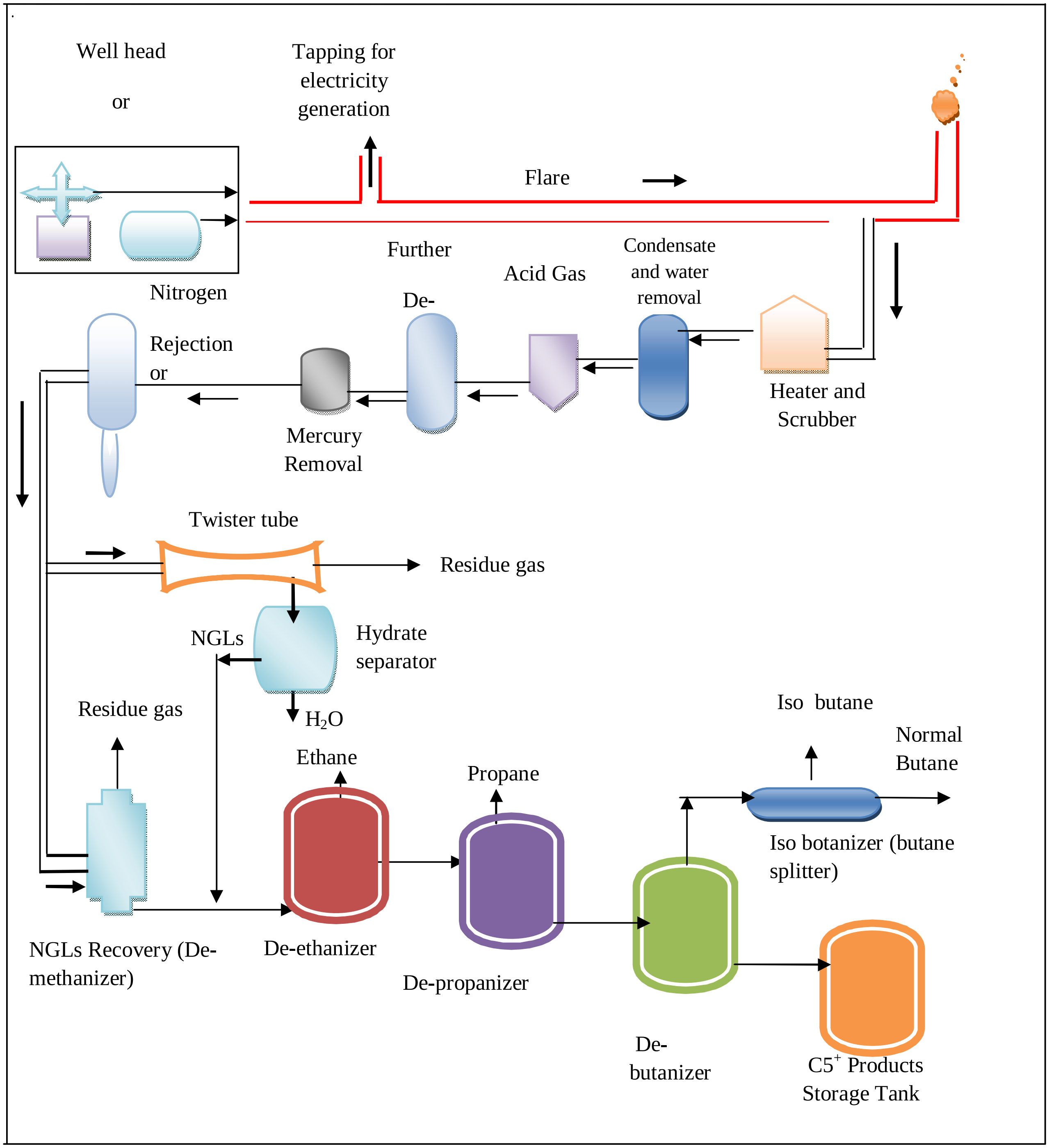

Figure 14: Process Layout for NGLs Real-Time Monetization from the Flare Stream

6. Results and Discussion

Sweetening the typical representative flared associated stranded natural gas table (2) for NGLs entails removing the undesirable components, which in this case, constitutes 2.39% of the flare gas stream. Assuming that each molecular component release exactly, equal amount (moles) of the undesirable in sweetening the stream, that is (2.39/97.61 = 0.0244) per mole. It implies that the sweetened compositional (mole %) for methane becomes 78.5375 +(78.5375 x 0.0244) = 80.4538.And the overall compositional (mole %) for the entire flare stream on component by component basis is as shown in table (4).

Component	Mole %
Methane	80.4538
Ethane	7.9780
Propane	6.1079
i-butane	1.5204
n-butane	1.9343
i-pentane	0.7134
n-pentane	0.5104
Hexane plus	0.7734
Permissible undesirable	0.0084
	100.0000

Table 4: Sweetened Composition of the Typical Flared Associated Stranded Natural Gas
Source: Adapted from Ekejiuba, 2017

Conventionally, on the average, GTL converts every 10,000 cu ft to 1-barrel (42 US gallons) or (160 liters), thus Table 5 shows the estimated real-time component by component quantity of natural gas liquids (barrels) production based on the sweetened typical, natural gas composition table 4 and 20MM scfd flow rate. For instance, Ethane's 1.596 MMscfd will yield 159.6 barrels.

Component	Fractional Composition	Daily MMscf	Daily Liquid Equivalent: Barrels	Daily Liquid Equivalent: US Gallons	Daily Liquid Equivalent: Litres
Methane	0.8045	16.090	1,609.0	67,578	257,440
Ethane	0.0798	1.596	159.6	6,703.2	25,536
Propane	0.0611	1.222	122.2	5,132.4	19,552
i-butane	0.0150	0.300	30.0	1,260	4,800
n-butane	0.0193	0.386	38.6	1,621.2	6,176 NGLs
i-pentane	0.0071	0.142	14.2	596.4	2,272
n-pentane	0.0051	0.102	10.2	428.4	1,632
Hexane plus	0.0077	0.154	15.4	646.8	2,464

Table 5: Real-Time Daily Flare Stream Component by Component NGLs Quantities for 20 MM scfd. Flow Rate

7. Valuable Products from the Extracted NGLs

The extracted natural gas liquids (NGLs) which includes; ethane, propane, butanes and natural Gasoline (pentanes and heavier hydrocarbons C_5 +) are recovered in scrub column, where heavier hydrocarbons liquids C_5 +) are separated from the lighter hydrocarbon liquids (C_2, C_3 and C_4).

The recovered NGLs have multiple usage

(A) It could be used directly as:

(i) Ethane
(ii) Commercial propane
(iii) Commercial butane
(iv) Propane-butane mixture referred to as Liquefied Petroleum Gas (LPG).
(v) Natural gasoline (C_5 –C_9) which is a mixture specified by vapor pressure, and contains pentanes with heavier hydrocarbons liquid removed from the natural gas plus that amount of propanes and butanes the vapor pressure specification will permit.
(vi) Used as blending stock for conventional gasoline from crude oil refineries et cetera.

Which of these, products will be recovered for sale will depend on price and demand for each. Catalytic cracking (Brown, et al., 2005) of alkanes (saturated hydrocarbons such as ethane, propane butanes et cetera) yields alkenes (unsaturated hydrocarbons) as well as aromatic hydrocarbon on an industrial scale i.e., ethene, ethyne, propene, butene et cetera for use as raw materials for the chemical industry, plus hydrogen for the fuel cell or for the production of other inorganic compounds such as ammonia fertilizer, ammonium nitrate (liquid fertilizer) and nitric acid.

For instance, ethane at temperatures of over 800^{OC}- 900^{OC}cracks to ethene (ethylene) and hydrogen (Brown et al 2005).

$$CH_3\,CH_3 \longrightarrow CH_2 = CH_2 + H_2, \quad (1)$$

And in a similar reaction propane yields propene and hydrogen.

$$CH_3\,CH_2\,CH_3 \longrightarrow CH_3CH = CH_2 + H_2 \quad (2)$$

Ethene is one of the most versatile petrochemical raw materials (Bankole and Ogunkoya, 1978). Ethene is the starting material for the manufacture of epoxyethane (i.e. ethylene oxide), ethanol, ethanoic acid (anhydride), polythene, chloroethane and styrene.

(B) It could be used as feedsocks to over twenty different primary petrochemical plants, named after their various products.

(i) Ethylene plant.
(ii) Propylene plant.
(iii) Butane-1 plant
(iv) Ethylene oxide plant
(v) Ethylene glycol plant
(vi) Polyethylene (low density polyethylene, LDPE) plant.
(vii) Polyethylene (High density polyethylene HDPE) plant.
(viii) Polyethylene Terephthalate (fibre) pant.
(ix) Polypropylene (PP-resin) plant et cetera.

(C) Subsequently the Petrochemical Products could be used as feedstock to a host of chemical industries for the production of different end products (figure 15), such as:
(i) Agriculture – Pesticides
(ii) Pharmaceutical – Synthetic drugs
(iii) Textile – Nylon terglene suit cases, kitwear, suiting et cetera.
(iv) Plastics – Pail, bowels, soap cases, food packaging, toys wash – bottles et cetera.
(v) P.V.C - Electrical insulator cables, flexes, sheeting and flooring materials.
(vi) Solvents gaskets, e.g. propan-2-ol, ethyl and butyl ethanoates for industrial and laboratory use.
(vii) Ethanol amines (Mono., Di, and Tri).
(viii) Synthetic rubber- crepe soles for shoes, car tyres, hoses at petrol service stations, rubber-based paints, gaskets

(D) On the other hand, stream reforming (Wikipedia n.d) of the NGLs, ethane (i.e. propane and butane) yields gaseous hydrogen and carbon monoxide which can be combined with nitrogen to produce ammonia via the Haber-Bosch process, and subsequently urea.

Stream Reforming Using the relation (Wikipedia, n.d.)

$$C_nH_m + nH_20 \longleftrightarrow (n + m/2)\ H_2 + nCO \qquad (3)$$

Ethane:

$$C_2H_6 + 2H_20 \longleftrightarrow 5H_2 + {}_2CO \qquad (4)$$

Propane:

$$C_3H_8 + 3H_20 \longleftrightarrow 7H_2 + 3\ CO \qquad (5)$$

Butane:

$$C_4H_{10} + 4\ H_20 \longleftrightarrow 9H_2 + 4\ CO \qquad (6)$$

Pentane:

$$C_5H_{12} + 5H_20 \longleftrightarrow 11H_2 + 5\ CO \qquad (7)$$

Ammonia Synthesis:

$$3H_2\ (g) + N_2\ (g) \longleftrightarrow 2NH_3\ (g) \qquad (8)$$

Water - gas- shift:

$$CO + H_20 \longleftrightarrow H_2 + CO_2 \qquad (9)$$

Urea Synthesis:

$$2NH_3 + CO_2 \longrightarrow (NH_2)_2\ CO + H_20 \qquad (10)$$

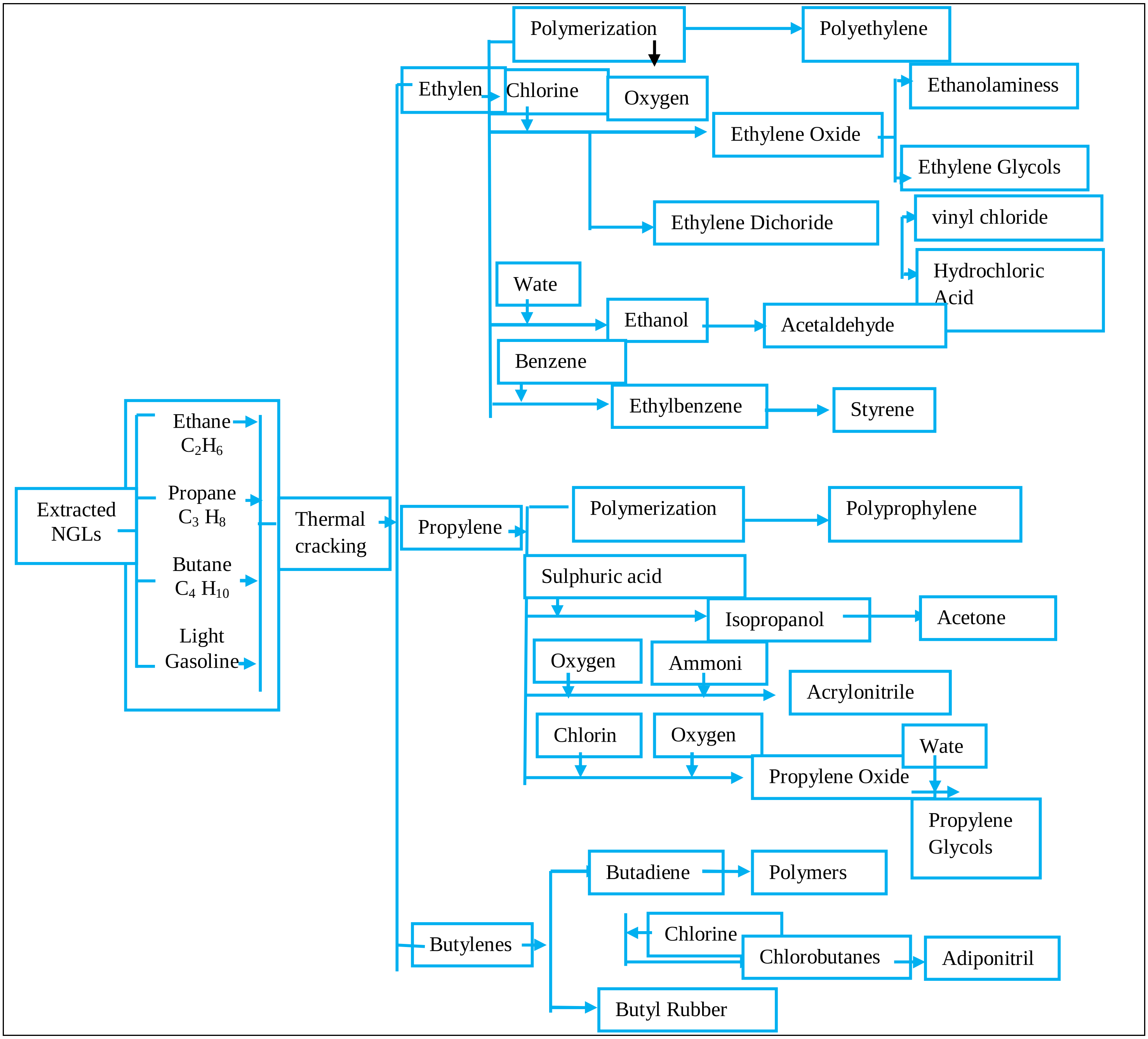

Figure 15: NGLs Qualitative end Products Route
Source: Adapted From Adams, 1989

8. Conclusion

Generally produced gas are characterized by the volume or weight of the condensable contained in a given volume of total gas produced, and is expressed either in gallons per 1,000 cubic feet or in grams per cubic feet, hence we distinguish between, dry, lean and wet gases. Therefore, Natural Gas Liquids (NGLs) are those portions of produced gas that are condensed (liquefied) at the surface in field facilities or gas processing plants, such as ethane, propane, butanes, pentanes, natural gasoline and condensates.

Gas purification (treatment) usually termed dehydration and sweetening is basically aimed at producing very high purity methane rich stream 98-99% and sweetened NGLs stream, ethane 98%, propane 100%, butanes 100% and pentanes plus 100%. This process, most often start near the well head with heaters and scrubbers to maintain temperature and remove sand plus other large – particles impurities respectively.

NGLs can comprise between 5% to well over 50% of the natural gas stream, which can naturally condense at the well head when pressure is reduced, or they can be induced by distillation and refrigeration at gas processing plants.

Precisely, every gas has its critical temperature, and if the gas is at any temperature below its critical and pressure is gradually increased, the molecules come closer together and attract each other more strongly, hence it liquefies (a change of phase). Usually the change of phase involves control of one or more of the following three parameters: operating pressure, (P); Operating Temperature, (T) and system composition or concentration, using either an Energy-Separating Agent (ESA) or a Mass-Separating Agent (MSA). Usually, the extracted NGLs are separated into its individual products with the help of fractionators, based on the various boiling points. And based on the sweetened composition of the flared associated stranded natural gas in Nigeria, table (4), the real- time daily quantity, component by component table (5), of NGLs for a gas flare stream with 20MMscfd flow rate is obtained.In this case, about 160 barrels of ethane, 122 barrels of propane etc. are recovered on daily basis.

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