PERP Program – Gas Processing and NGL Extraction: Gas Conditioning

New Report Alert

May 2006

Nexant's *ChemSystems* Process Evaluation/Research Planning program has published a new report, ***Gas Processing and NGL Extraction: Gas Conditioning (04/05S8)***. To view the table of contents or order this report, please click on the link below:
http://www.nexant.com/products/csreports/index.asp?body=http://www.chemsystems.com/reports/show_cat.cfm?catID=2

Introduction

Natural gas is a commonly occurring gaseous hydrocarbon mixture that is either produced in conjunction with crude oil ("Associated Gas") or in the exclusion of crude oil ("Non Associated Gas"). Natural gas is a gaseous hydrocarbon mixture which is primarily composed of methane with lesser amounts of other paraffin hydrocarbons, including ethane, propane, and butanes.

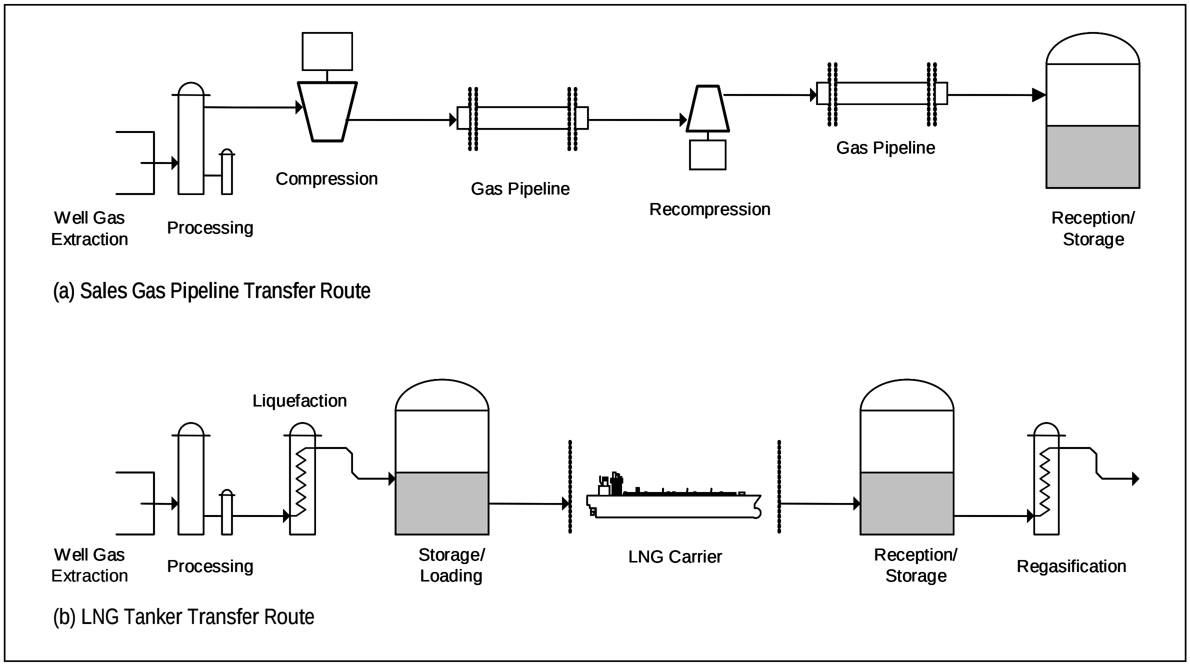
Since its discovery, natural gas has become an indispensable fuel resource throughout most of the industrialized world. The value of natural gas lies in the combustion properties of methane, a colorless, odorless gas that burns readily with a pale, slightly luminous flame. Natural gas is the cleanest burning fossil fuel, producing by-product water vapor and carbon dioxide on combustion. Methane is also a key raw material for making solvents and other organic chemicals. It is an important fuel for the generation of electric power, running residential and industrial equipment. Value is also derived from the hydrocarbon liquids that can be extracted from the gas.

The scope of this report will be limited to "Gas Conditioning" processes and will not cover "Natural Gas Liquids" (NGL's) extraction for its use in downstream product derivatives. The report therefore aims to provide an overview of various gas conditioning processes available and identify the technologies and licensed processes available on the market today. As gas treatment is highly dependent on well fluids (natural gas from the field) received at a gas processing terminal and on the treated gas specification, certain assumptions will be made on both well gas and sale gas specifications for the purpose of the economic analysis. A commercial assessment for natural gas will also be touched upon.

The Gas Chain

There are two main ways of transporting natural gas, by gas pipelines and via low temperature tankers in the form of Liquefied Natural Gas (LNG). The two transportation routes are shown in Figure 1.

Figure 1
Gas Transportation Routes



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In pipelines, gas is moved under pressure differentials. For onshore pipelines, 70–100 bars is a standard inlet pressure; whereas, for offshore pipelines, the pressure at the entry of the pipeline typically ranges from 100–150 bars depending to the distance from the offshore facilities to the gas user. During transportation, pressure drops will occur over long distances, and, therefore, recompression stations are sometimes required.

In the form of LNG (Liquefied Natural Gas), natural gas is transported at a temperature close to its boiling point at atmospheric pressure, which is approximately –160°C, as the boiling point of methane is –161.49°C. The gas is liquefied in a liquefaction plant. Before being liquefied, the gas must be treated. The treatment specifications are more severe than in the case of pipeline transport, as it is necessary to avoid any risk of solid-phase formation during the liquefaction process. LNG is transported in a liquid state to overseas receiving terminals. At the reception terminal, LNG is re-gasified and sent to the distribution grid at the specified pressure and caloric value.

Natural Gas Properties

Natural gas composition at the field source (well gas) depends on whether it originates from associated or non-associated fields. Comprising mainly methane, well gas also contains ethane, propane, butane and minor quantities of heavier hydrocarbons. Gaseous non-hydrocarbons such as nitrogen, sulfur compounds, carbon dioxide, helium, trace metals (mercury) and water vapor can also be found in well gas streams.

The single most useful combustion property of natural gas is the Wobbe index or Wobbe number, as it is a measure of how a gas will burn. As Wobbe number increases, the rate of energy delivered to a burner increases until a point where there is insufficient time and oxygen for complete combustion to occur. Gas must be treated to ensure that the Wobbe index is maintained within an optimal range for combustion.

Because carbon dioxide and nitrogen do not burn, they reduce the heat value of the gas and therefore are often removed as by-products. When heavy hydrocarbons are removed, they reduce the heat value of gas. These heavy hydrocarbons can in turn be sold as condensate, a co product of natural gas. Helium is valuable in electronics manufacturing. Hydrogen sulfide is very poisonous and extremely corrosive, which means in the presence of water, it can damage gas equipment and piping, so it must also be removed before the natural gas can be delivered to the pipeline. The water component in well gases can form hydrates (an “ice-like” structure) which, under certain conditions, can lead to pipeline blockages. Therefore it is necessary to remove water prior to gas transmission.

Gas Specification

The degree to which natural gas will be treated will depend on its ultimate use. Various gas specifications for pipeline gas, compressed gas and LNG exist, and treatment will therefore ensure that the natural gas delivers satisfactory combustion performance for the application. Additional treatment is often required for long distance gas transportation purposes, whether it is by pipeline to convey sales gas or liquefied natural gas (LNG).

Gas conditioned for transmission and distribution via pipelines is regarded as sales gas specification. The characteristics of sales gas can vary dependent on requirements of the gas purchaser and/or contractual obligations imposed to protect the pipeline itself.

Table 1 shows typical specifications for gas transmission and distribution systems in France, Italy, the United Kingdom, Canada, California USA, and Japan.

The general purpose pipeline gas quality standards do not necessarily serve the needs of engines and vehicles, which operate within much wider ranges of pressure and temperature than conventional gas burning appliances. To accommodate the requirements of NGV engine and vehicle application, a number of international standards have been established, i.e. SAE J1616 and ISO 15403. These will not be discussed within the scope of this study.

LNG specification tends to be more stringent than sales gas specification as it is set for plant operation reasons, particularly for the liquefaction plant. CO_2, water and aromatics can freeze on exchanger surfaces (“riming”), reducing efficiency and possibly causing blockages in the heat exchanger. Mercury, a common trace contaminant of gas, attacks aluminum, the favored construction material for low temperature exchangers. Table 2 lists the typical specifications on levels of impurities contained in the gas feeding a liquefaction plant.

Table 1
Typical Sales Gas Specifications

Country Specification	Limitation	France	Italy	UK	Canada *(GTN System)*	USA *(California)*	Japan	Units *SI*
Hydrogen Sulphide	maximum	7*	6.6	5	6	6	1 to 5	mg/Nm^3
Total Sulphur	maximum	75	150	50	240	18	8 to 30	mg/Nm^3
Sulphur from Mercaptan	maximum	16.9	15.5	n/a	n/a	7.3	n/a	mg/Nm^3
Carbon Dioxide	maximum	3	3	2	2	3	n/a	volume %
Oxygen	maximum	n/a	0.6	n/a	0.4	n/a	n/a	volume %
Water Dew Point	maximum	n/a	- 5 at 70 bar	-10 at any pressure	4 lbs/MMscf [+]	4 lbs/MMscf [+ ¥]	-10 at 80 bar	deg C
Hydrocarbon Dew Point	maximum	n/a	0 at 1 to 70 bar	-2 at 1 to 70 bar	-10 up to 55 Bar	- 10 at op. Pressure [¥]	-1 at 1 to 80 bar	deg C
Gross Calorific Value	minimum	990 - 1,160	885 - 1145	1 065	995	1 065	1 090	BTU/scf
Gross Calorific Value	minimum	39-46	35 - 45	42	39	42	43	MJ/m^3

* Average over 8 days

[+] Water content

[¥] Alliance USA Pipeline

n/a Non Available

Nm^3 = normal cubic metres at 0 deg C and 101.325 kPa

Table 2
Typical LNG Product Specifications

Component	Maximum Limit
Hydrogen Sulfide	3-3.5 ppmv
Total Sulfur	30 milligrams per standard cubic meter
Carbon Dioxide	50 ppmv
Mercury	0.01 milligrams per standard cubic meter
Water Vapor	1 ppmv
Benzene	1 ppmv
Pentanes and heavier	0.1 mole percent

Gas Conditioning and Technologies

Processing Requirements of Natural Gas

The objective of "Gas Conditioning" is to separate well streams into saleable gas and liquid hydrocarbon products. This involves recovery of the maximum amounts of each component at the lowest overall cost; however, the extent of gas conditioning required is dictated by the well stream quality, the end uses of the sales gas, and extent of liquid hydrocarbon recovery.

Stated simply, "Gas Conditioning" usually means the removal of undesirable components from well streams to reach pre-established specifications prior to processing, pipeline transportation, or liquefaction. This stage typically includes the extraction of impurities and contaminants, but it can also include the separation of gas from heavier liquid hydrocarbon components using a process known as "Dew Point Control".

To achieve sales gas quality, gas conditioning will include these four basic processes:

- Dehydrating the gas to remove condensable water vapor, which under certain conditions might cause hydrate formation
- Separating gas from free liquids, such as crude oil, condensate, and water, and entrained solids
- Processing the gas to remove condensable and recoverable hydrocarbon vapors (Dew Point Control)
- Treating the gas to remove other undesirable components, such as hydrogen sulfide or carbon dioxide.

Some of these processes can be accomplished in the field, but in most cases, the gas undergoes further processing at a gas treatment facility and/or liquid extraction plant.

It should be noted that the "Gas Conditioning" process is sometimes referred to as "Open Art" with regard to sizing and design of gas conditioning equipment. Typically contractors use API equipment standards and process simulations, and, together with equipment vendor consultations, they are able to design gas processing facilities without the need to use licensed technologies. Licensed technologies, however, do exist for gas operations and are mainly for specific unit processes where design has been optimized or proprietary materials (adsorbents, membranes) are used. The specific areas in which process optimization has occurred are listed below:

- Gas reception facilities (condensate recovery in a slug catcher)
- Gas dehydration and water dew point control
- Hydrocarbon dew point control
- Acid gas removal (hydrogen sulfide and carbon dioxide)
- Nitrogen rejection and

- Mercury removal.

Work on process optimization has included increased control over the gas specification, reduction in energy consumption and waste generation, and reduction of capital costs through improved technologies and design. Technology advancements have been seen in the areas of: hydrate prevention and dehydration, with the development of kinetic inhibitors such as Gas Treat™ HI and Hydrablock; acid gas removal, with the development of proprietary solvent technologies such as the Morphysorb® process and membrane technology such as the Engelhard – Molecular Gate® . Such technologies and technology advancements are detailed in this report.

Gas Economics

This study aims to determine the cost of conditioning well gas to sales gas specification. A feed gas composition, pressure and temperature were chosen based on Nexant's industry knowledge and a basic process was chosen to meet hydrocarbon dew point specification of -5°C, High Heating Value higher than 950 Btu/scf, and 99.9 percent acid gas removal.

This basic process comprises gas reception facilities (which include slug catcher, bulk condensate separation, and filtration of particles and fines); stabilization of condensate using LP separation; an amine (MDEA) unit for selective acid gas removal; a sulfur recovery unit with tail gas treatment for disposal of the resulting sour gas; gas cooling; water removal by TEG contacting; and finally hydrocarbon dew point control by mechanical refrigeration to meet dew point specifications.

Process simulation allowed the evaluation of project capital costs and utility consumptions for a 650 MMCFD plant capacity base case, representing a world scale single train gas processing facility (such as one currently being built in the Middle East).

Average wellhead extraction, utility, and condensate product costs for early 2008 (planned start date of the project) were used to evaluate the cost of production of sales gas.

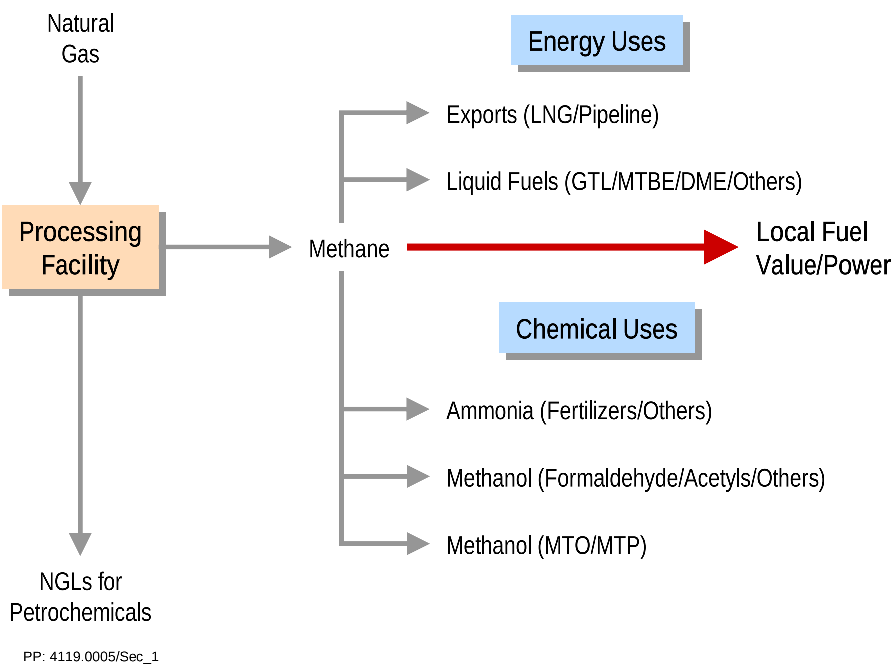
Commercial Analysis

Commercial Applications of Natural Gas

Natural gas can be utilized as an energy source (for power generation, liquid fuel generation as GTLs and/or space heating) or as a petrochemical feedstock particularly for methanol and ammonia production. This is demonstrated in Figure 2.

Natural gas is transported to consumers by pipeline, or, in the case of more distant users, via insulated tankers in liquid form as liquefied natural gas, LNG. The gas is cooled to –160°C at which temperature it becomes a liquid. Compared to crude oil and petroleum products, natural gas is relatively expensive to transport by pipeline or in dedicated LNG carriers.

Figure 2
Natural Gas Uses



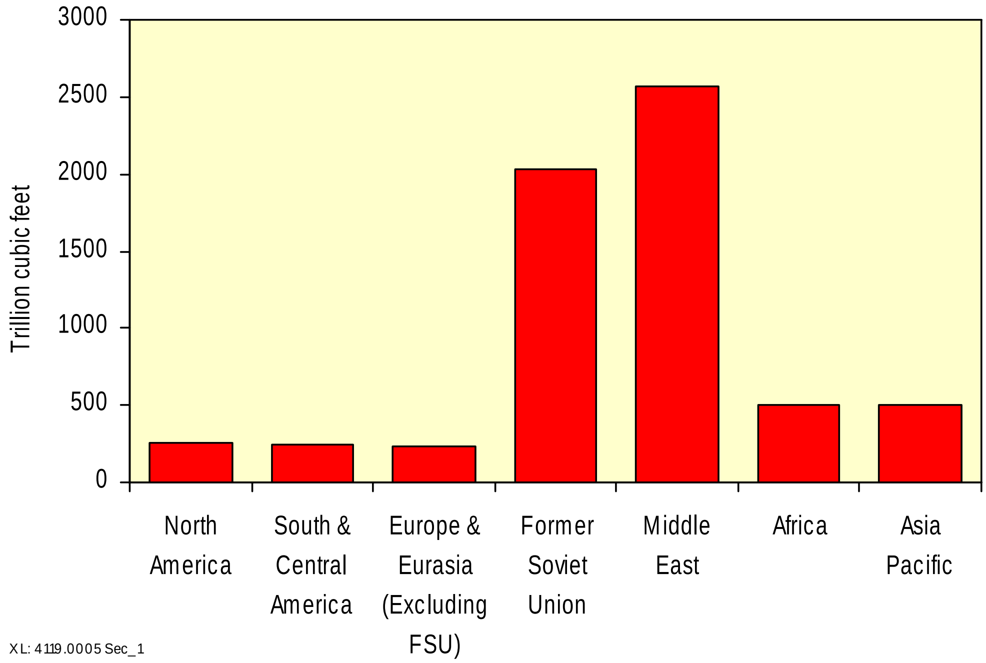
Condensates are co-products of natural gas conditioning, which consist of pentanes and heavier components. By virtue of being liquids, condensates are easier to transport as compared to natural gas. Condensates typically have very low sulfur levels in comparison with most crude oils and typically have API gravity of greater than 50. Condensates generally have four possible dispositions:

- Sale to a Steam Cracker as Ethylene Feedstock
- Sale to a Refiner
- On-Site Splitting and Sale of Straight Run Cuts
- Third Party Splitting and Sale of Straight Run Cuts

Global Natural Gas Market

Global natural gas reserves have almost doubled over the last 20 years. The increases proved gas reserves have been dynamic in several regions: the Former Soviet Union (FSU) gas reserves increased by more than 50 percent, those in Africa registered an increase of 125 percent, and those in the Middle East increased by more than 160 percent. The breakdown of natural gas reserves by region for 2004 is shown in Figure 3.

Figure 3
Regional Natural Gas Reserves
(tcf, at the end of 2004)

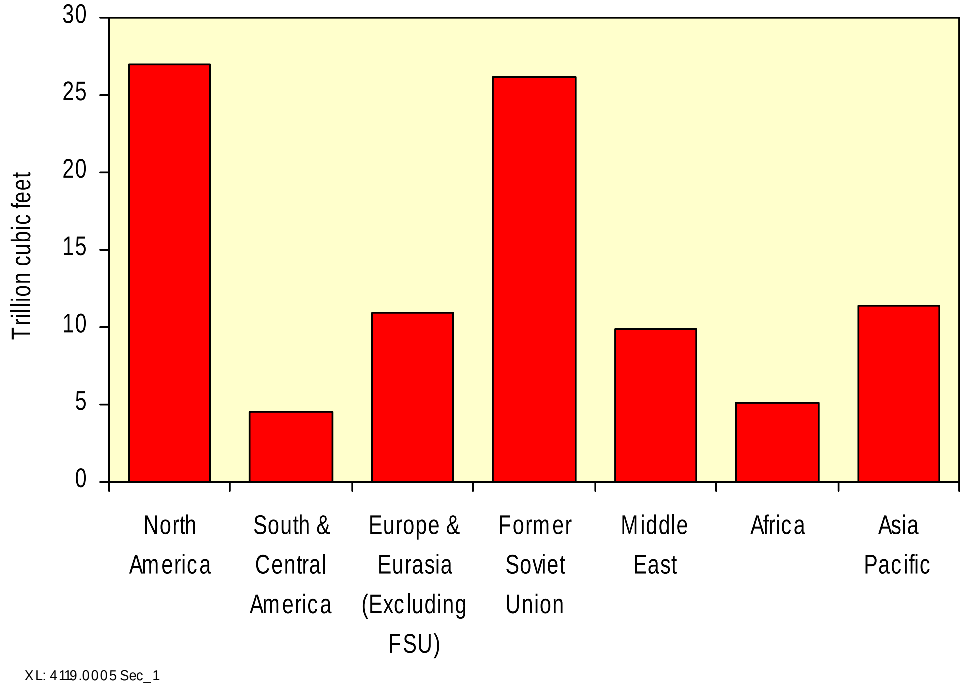


The greatest concentration of natural gas reserves are in the Middle East and the Former Soviet Union, which together account for more than 72 percent of the global reserves.

Global gas reserves, however, are not matched to global gas production. For example, North America, which has one of the lowest overall reserves currently, actually has the highest marketed production for any region (refer to Figure 4).

Out of a total marketed production of almost 95 tcf (2,700 BCM) in 2004, North America represented 28 percent, South and Central America 5 percent, Europe and Euroasia 12 percent, FSU 28 percent, Middle East 10 percent, Africa 5 percent, and Asia 12 percent. Production of natural gas is therefore greatest in North America, where demand is highest, followed by the FSU, then Europe and Asia.

Figure 4
Regional Natural Gas Marketed Production
(tcf, at the end of 2004)



In general terms, the mismatch between reserves and production rates is in part a reflection of the high cost of transporting gas. This means that gas reserves relatively close to markets are most economic to develop and are preferentially produced. Thus, with the exception of FSU, the regions of highest consumption, North America and Europe, have the lowest reserves to production ratio.

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