

**Tikrit University**

**College of Petroleum Processes Engineering**

**Department of Petroleum and Gas Refining  
Engineering**

**Gas Technology**

**Forth Class**

**Lectures 1 and 2**

**By**

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## Historical Overview

- Use of natural gas, as fuel was already known in ancient times. According to Aristotle the Greek philosopher, the kings of Persia would have installed their kitchen in locations where fires went out from the ground. However the practical use of natural gas as fuel remained limited until the beginning of the 20th century.
- Although naturally occurring gas has been known since ancient times, its commercial use is relatively recent. In about 1000, B.C., the famous Oracle at Delphi, on Mount Parnassus in ancient Greece, was built where natural gas seeped from the ground in a flame. Around 500 B.C., the Chinese started using crude bamboo “pipelines” to transport gas that seeped to the surface and to use it to boil sea water to get drinkable water.
- The first commercialized natural gas occurred in Britain. Around 1785, the British used natural gas produced from coal to light houses and streets. In 1816, Baltimore, Maryland used this type of manufactured natural gas to become the first city in the United States to light its streets with gas.
- In the United States, the properties of natural gas were discovered by Native Americans, who would ignite the gases that seeped into and around Lake Erie. French explorers witnessed this practice around 1626. In 1821, William Hart dug the first successful natural gas well in the U.S. in Fredonia, New York. Eventually, the Fredonia Gas Light Company was formed, becoming the first American natural gas distribution company.
- In 1836, the City of Philadelphia created the first municipally owned natural gas distribution company. Today, U.S. public gas systems number more than 900, and the Philadelphia Gas Works is the largest and longest operating public gas system in the U.S.

- During most of the 19th century, natural gas was used almost exclusively as a source of light, but in 1885, Robert Bunsen's invention of what is now known as the Bunsen burner opened vast new opportunities to use natural gas. Once effective pipelines began to be built in the 20th century, the use of natural gas expanded to home heating and cooking, appliances such as water heaters and oven ranges, manufacturing and processing plants, and boilers to generate electricity.



## Gas Today

- Today, natural gas is a vital component of the world's supply of energy. Natural gas currently supplies more than one-half of the energy consumed by residential and commercial customers, and about 41 percent of the energy used by U.S. industry. It is one of the cleanest, safest, and most useful of all energy sources.
- Because natural gas is the cleanest burning fossil fuel, it is playing an increasing role in helping to attain national goals of a cleaner environment, energy security and a more competitive economy. The two million-mile underground natural gas delivery system has an outstanding safety record.



Coal



Wind Energy



Uranium



Petroleum



Hydropower



Solar Energy



Geothermal



Hydrogen



Electricity



Natural Gas



Biomass

## Natural Gas (NG)

- Natural gas is a fossil fuel formed when layers of buried plants, gases, and animals are exposed to intense heat and pressure over thousands of years, It is a subcategory of petroleum that is a naturally occurring, complex mixture of hydrocarbons, with a minor amount of inorganic compounds. Table 1 shows composition of a typical natural gas.
- Natural gas is the gas obtained from natural underground reservoirs either as free gas or gas associated with crude oil. It generally contains large amounts of methane ( $\text{CH}_4$ ) along with decreasing amounts of other hydrocarbons. Impurities such as  $\text{H}_2\text{S}$ ,  $\text{N}_2$ , and  $\text{CO}_2$  are often found with the gas. It also generally comes saturated with water vapor.



Table 1 shows composition of a typical natural gas.

Major Hydrocarbon Components of "Typical" Natural Gas		
Methane	C <sub>1</sub>	65% to above 95%
Ethane	C <sub>2</sub>	2% to 15%
Propane	C <sub>3</sub>	0.25% to 5%
Butane	C <sub>4</sub>	≈0 to 5%
Pentane	C <sub>5+</sub>	0.05% to 2%
Non-hydrocarbon Components produced with Natural Gas		
Nitrogen	N <sub>2</sub>	≈0 to 20%
Hydrogen sulfide	H <sub>2</sub> S	≈0 to above 15%
Carbon dioxide	CO <sub>2</sub>	≈0 to above 20%

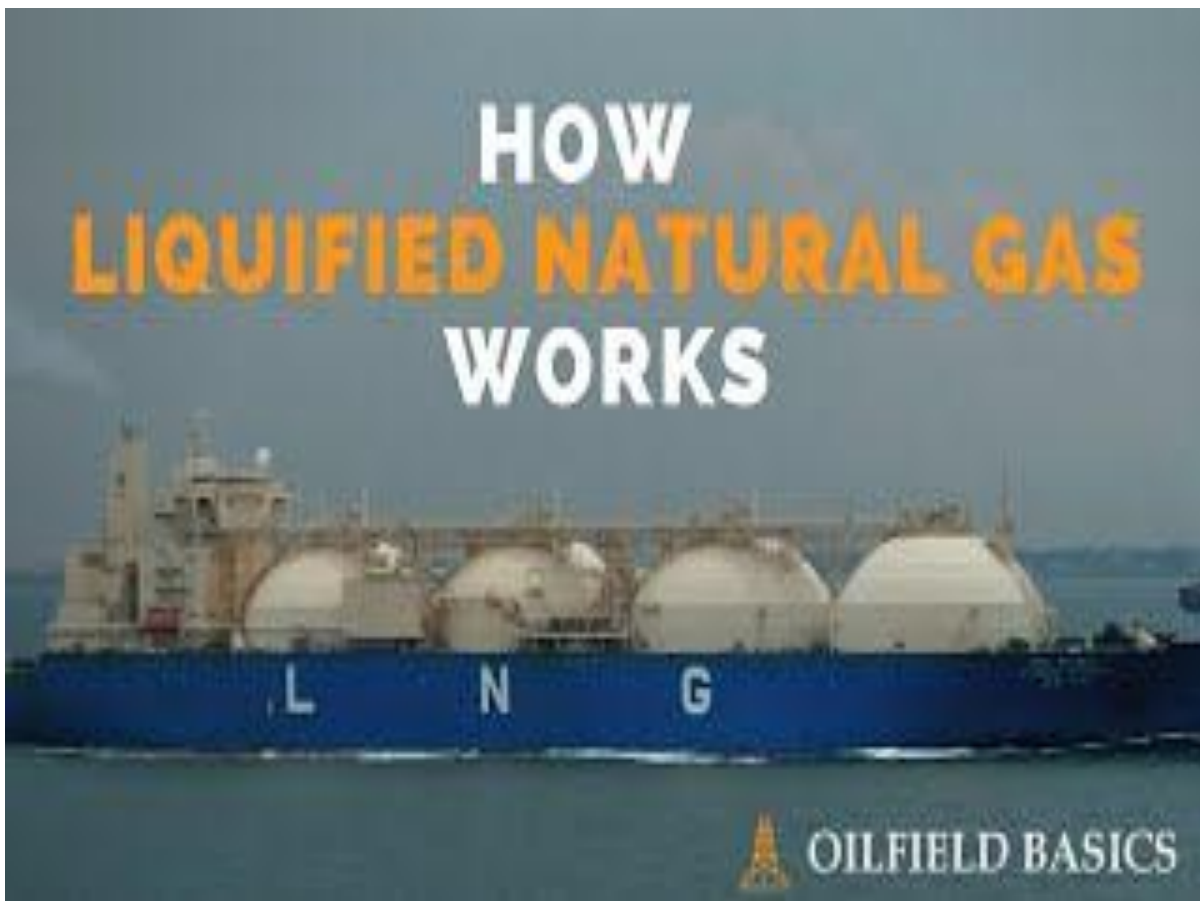
- Natural gas often contains hydrogen sulfide and carbon dioxide in concentrations, which make the gas unsuitable for use as fuel. The gas may also contain other sulfur materials, which must be removed before the gas can be utilized as fuel. Gas which is produced during the refining of crude oil often contains complex sulfur compounds which must be removed before the gas can be used for fuel.
- Natural gas is the most sought after fuel source because of its clean combustion (reduction of the atmosphere pollution). It is also a base for LPG (propane, butane) manufacture. It can be used also as a feedstock to petrochemical plants.
- Production and distribution of natural gas are non-negligible agents of the world economy.
- Natural gas or associated gas produced with crude oil-contain acid components, mainly carbon dioxide (CO<sub>2</sub>) and hydrogen sulfide (H<sub>2</sub>S) and sometimes traces of other compounds: Carbonyl sulfide (COS) carbon disulfide (CS<sub>2</sub>) and mercaptans.

**TABLE 2**  
**COMPOSITIONAL ANALYSIS OF NATURAL GASES**  
**(From Natural Reservoirs)**

Country	Iran				
Field	Kangan	Nar	Khangiran	Assaluyeh	Sarkhon
Components	Mole%	Mole%	Mole%	Mole%	Mole%
N <sub>2</sub>	5.95	4.61	0.55	3.474	4.89
CO <sub>2</sub>	1.83	1.46	6.41	1.860	0.65
H <sub>2</sub> S	681 ppm	59.6 ppm	3.85	0.555	0.02
COS	---	---	17 ppm	3.1 ppm	---
C <sub>1</sub>	85.29	87.98	88.35	85.086	87.76
C <sub>2</sub>	4.14	3.65	0.56	5.448	3.75
C <sub>3</sub>	1.32	1.09	0.09	1.991	1.39
IC <sub>4</sub>	0.29	0.24	0.02	0.379	0.32
NC <sub>4</sub>	0.40	0.32	0.03	0.573	0.48
IC <sub>5</sub>	0.20	0.16	0.02	0.178	0.19
NC <sub>5</sub>	0.14	0.11	0.02	0.159	0.15
C <sub>6</sub> +	0.44	0.38	0.01	0.273	0.21
RSH	59.6 ppm	17.1 ppm	---	159.4 ppm	---

## Liquefied natural gas (LNG)

- When natural gas is cooled to a temperature of approximately  $-260\text{ }^{\circ}\text{F}$  ( $-160\text{ }^{\circ}\text{C}$ ) at atmospheric pressure it condenses to a liquid called liquefied natural gas (LNG).
- One volume of this liquid takes up about 1/600th the volume of natural gas at a stove burner tip.
- LNG is only about 45% the density of water.
- LNG is odorless, colorless, non-corrosive, and non-toxic.
- When vaporized it burns only in concentrations of 5% to 15% when mixed with air.
- Neither LNG, nor its vapor, can explode in an unconfined environment.





## Liquid petroleum gas (LPG)

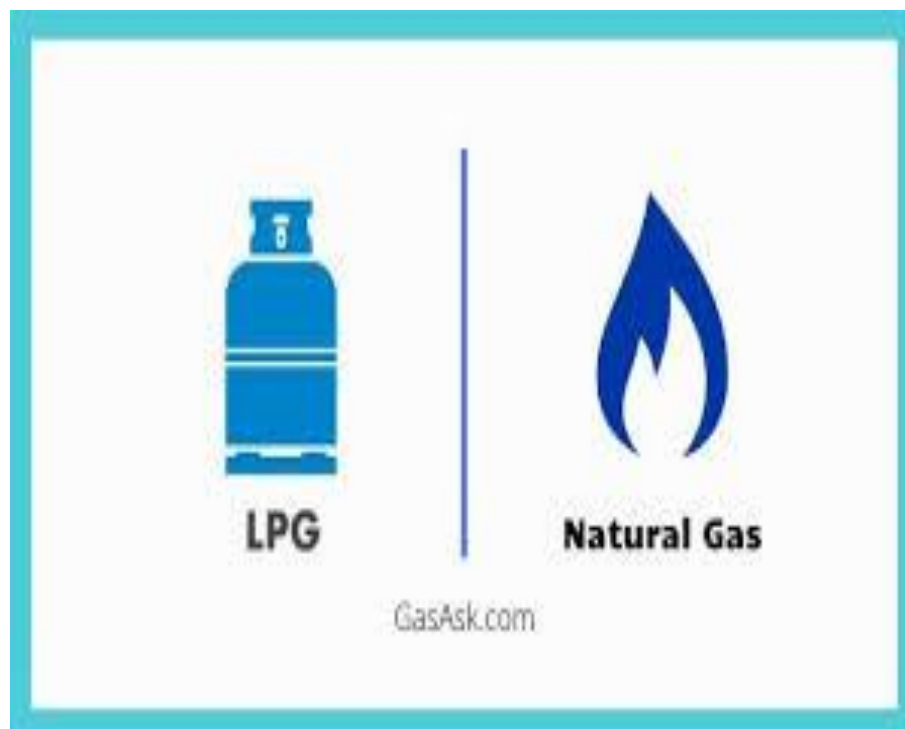
- Sometimes called **propane** is often confused with LNG and vice versa. They are not the same and the differences are significant.
- Varieties of LPG bought and sold include mixes that are primarily propane, mixes that are primarily butane, and mixes including propane, propylene, n-butane, butylene and iso-butane.
- Depending on the season—in winter more propane, in summer more butane. Vapor pressures, at 30°C, are for commercial propane in the range 10-12 barg (1 to 1.2 MPa), for commercial butane, 2-4 barg (0.2 to 0.4 MPa). In some countries LPG is composed primarily of propane (upwards to 95%) and smaller quantities of butane.

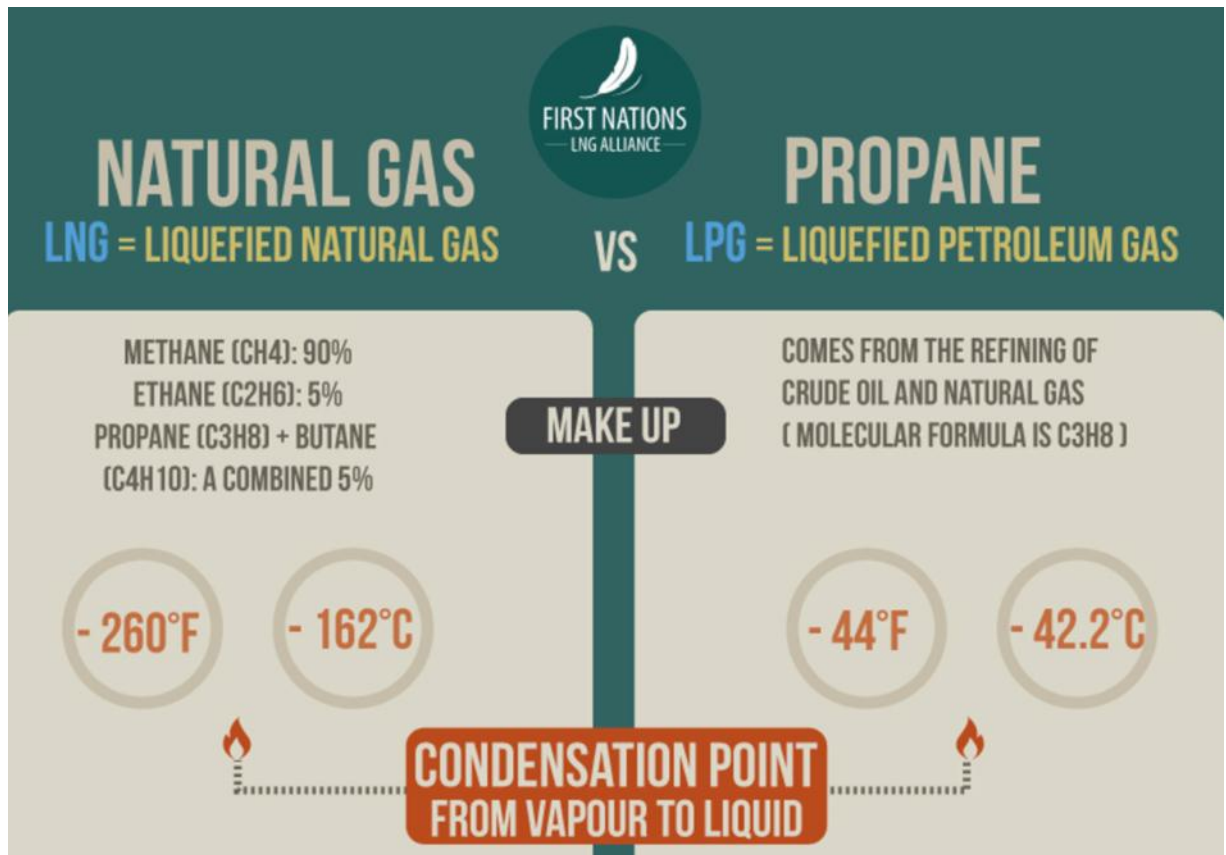


## LPG compared to natural gas

- Has a significantly higher heating value
- Requires a different air-to-gas mixture (propane: 24:1, butane: 30:1) for good combustion.
- LPG can be stored as a liquid in tanks by applying pressure alone. While the distribution of LNG requires heavy infrastructure investments (pipelines, etc.), LPG is portable. This fact makes LPG very interesting for developing countries and rural areas.

LPG (sometimes called autogas) has also been used as fuel in light duty vehicles for many years. An increasing number of petrol stations around the world offer LPG pumps as well. A final example that should not be forgotten is that the "bottled gas" can often be found under barbecue grills.



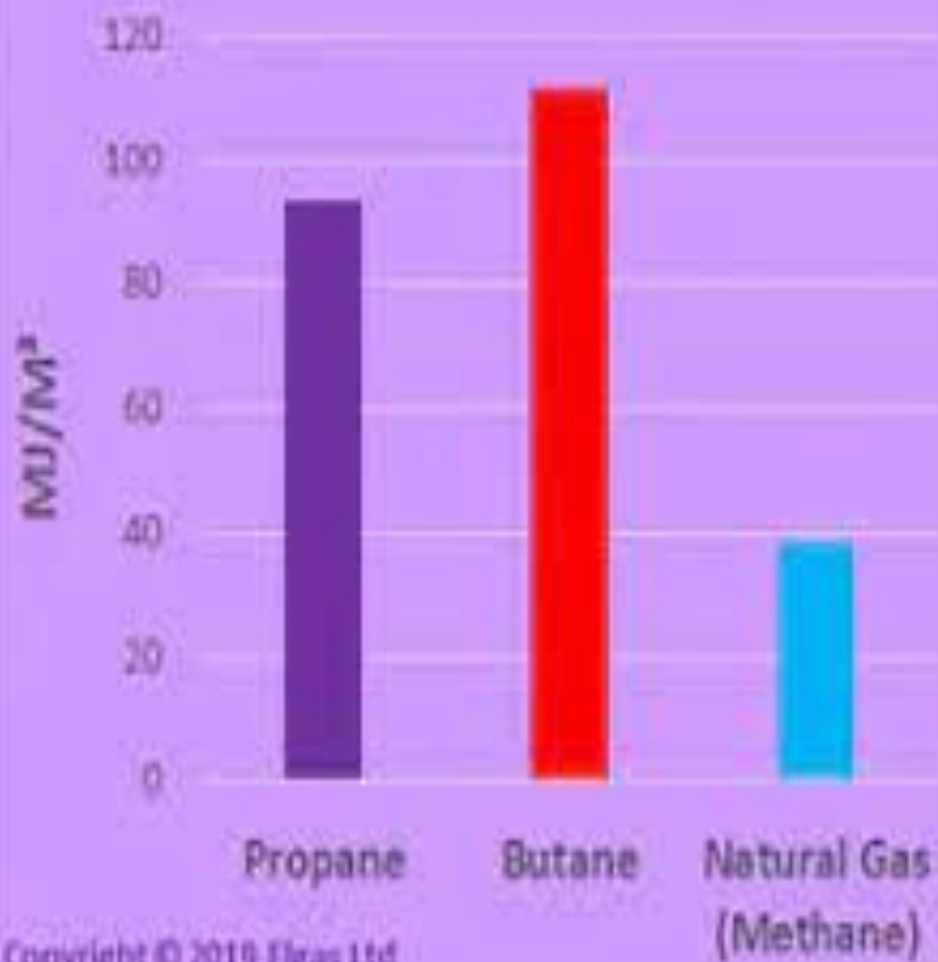


# Natural Gas vs. Propane

<b>Greenhouse gas</b>	<b>Clean-burning fuel</b>
<b>1030 BTUs/cubic foot</b>	<b>2516 BTUs/cubic foot</b>
<b>Higher upfront cost</b>	<b>Lower upfront cost</b>

**PROPANE**  
SPECIALTY SERVICES

## Energy Content



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## General Definitions

- **Pipeline Gas** is the gas which has the quality to be used as a domestic or industrial fuel. It meets the specifications set by a pipeline transmission company, and/or distributing company.
- **Sour Gas:** Gas that contains more than 1 grain of H<sub>2</sub>S/100 SCF
- **Sweet Gas:** Gas in which the H<sub>2</sub>S content is less than 1 grain /100 SCF.
- **Wet Gas:** Gas that contains more than 0.1US gallons of condensates per1000 CF of gas.
- **Dry Gas:** Gas that contains less than 0.1 US gallons of condensates per 1000 CF of gas.
- **Rich Gas:** Gas containing more than 5 to 7 US gallons of compounds heavier than ethane (C<sub>3</sub>+) per 1000 CF of the gas.
- **Lean Gas:** Gas containing 1 US gallons or less of compounds heavier than ethane (C<sub>3</sub>+) per 1000 CF of the gas.
- **Pentanes+:** The pentane and heavier fraction of hydrocarbon liquid.
- **Compressed natural gas (CNG):** is natural gas pressurized and stored in welding bottle-like tanks at pressures up to 3,600 psig (25 MPa). Typically, it is same composition of the local "pipeline" gas, with some of the water removed.