Northern Technical University
Technical Collage – Kirkuk
Fuel and Energy Engineering Technologies Department
Subject: Gas Technology/3 rd Class

Gas Technology

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Syllabus:

- **Introduction:**
  General look on the importance of natural gas and its reserve.
- **Natural Gas:**
  Natural Gas kinds and gas reservoir characteristics, Phase Behavior, Chemical and Physical Properties.
- **Gas Compression:**
  Compressions of Natural Gas, Types of gas compressors: Rotary, Jet, and Reciprocating natural gas compressors
- **Gas Physical Separation:**
  Separators, The removal of solid, water and condensates, Stabilization process, Drying of gaseous fuel by adsorption and absorption.
- **Sweetening of Gaseous fuel:**
  Sweetening by adsorption and absorption, Gas Flaring Reduction
- **Natural Gas Liquefaction(NGL):**
  NGL fractionation: de-ethanizer, de-propanizer, de-butanizer
- **Liquefied Petroleum Gas (LPG):**
  LPG methods, process, and description. Some problems associated with Natural Gas treatment and production. Hydrate control in gas production causes. Occurrence and control.
- **Law Temperature Separation:**
  Methods, process, and description.
- **Gas Gathering and Transportation:**
  Pipe Line Design Calculation and Economics, Gas flow in serious, Parallel and Looped Pipeline.
- **Hydrogen production:**
  Hydrogen production, methods, process, and description.

References:

1. Shreve's "Chemical Process Industries" 5th edition (2001).
2. Joseph F. Hilyard "The Oil and Gas Industry, a nontechnical guide" (2012)
3. Arthur J. Kidnay and William R. Parrish "Fundamentals of Natural Gas Processing" (2006).

Natural Gas Fundamentals

Origin & Composition

Natural gas (NG) is a fossil fuel used as a source of energy for heating, cooking, and electricity generation. Fossil fuel based natural gas is a non-renewable resource.

Natural gas was discovered accidentally in ancient China, as it resulted from the drilling for brines. Natural gas was first used by the Chinese in about 500 BC (possibly even 1000 BC. They discovered a way to transport gas seeping from the ground in crude pipelines of bamboo to where it was used to boil salt water to extract the salt.

NG is also used as a fuel for vehicles and as a chemical feedstock in the manufacture of plastics and other commercially important organic chemicals.

For example, natural gas is used:

- ✓ As a raw material in petrochemical manufacturing. Ethylene, an important petrochemical.
- ✓ To produce hydrogen, sulfur, carbon black, and ammonia. The ammonia is used in a range of fertilizers and as a secondary feedstock for manufacturing other chemicals, including nitric acid and urea.

M*ethane* (CH_4)— considers the primary component of natural gas. In addition to methane, raw natural gas may also contain other hydrocarbons (see table 1), as

well as water, carbon dioxide, oxygen, nitrogen, hydrogen sulfide, and even helium as impurities.

Table 1: Typical hydrocarbon composition of raw natural gas

Hydrocarbon	Composition, %
Methane	70–98
Ethane	1–10
Propane	Trace to 5
Butane	Trace to 2

Source: Hyne, N. J.

Before natural gas can be used as a fuel, most, but not all, must be processed to remove impurities, including water, to meet the specifications of marketable natural gas. The by-products of this processing include: ethane, propane, butanes, pentanes, and higher molecular weight hydrocarbons, hydrogen sulfide (which may be converted into pure sulfur), carbon dioxide, water vapor, and sometimes helium and nitrogen.

Natural gas is considered as ***an environmentally friendly clean fuel***, offering important environmental benefits when compared to other fossil fuels.

Natural gas exists in nature under pressure in rock reservoirs in the Earth's crust, either in conjunction with and dissolved in heavier hydrocarbons and water or by itself. It is produced from the reservoir similarly to or in conjunction with crude oil accumulated in the past millions of years.

Natural gas is found also associated with other hydrocarbon reservoirs in coal beds which is another source of natural gas.

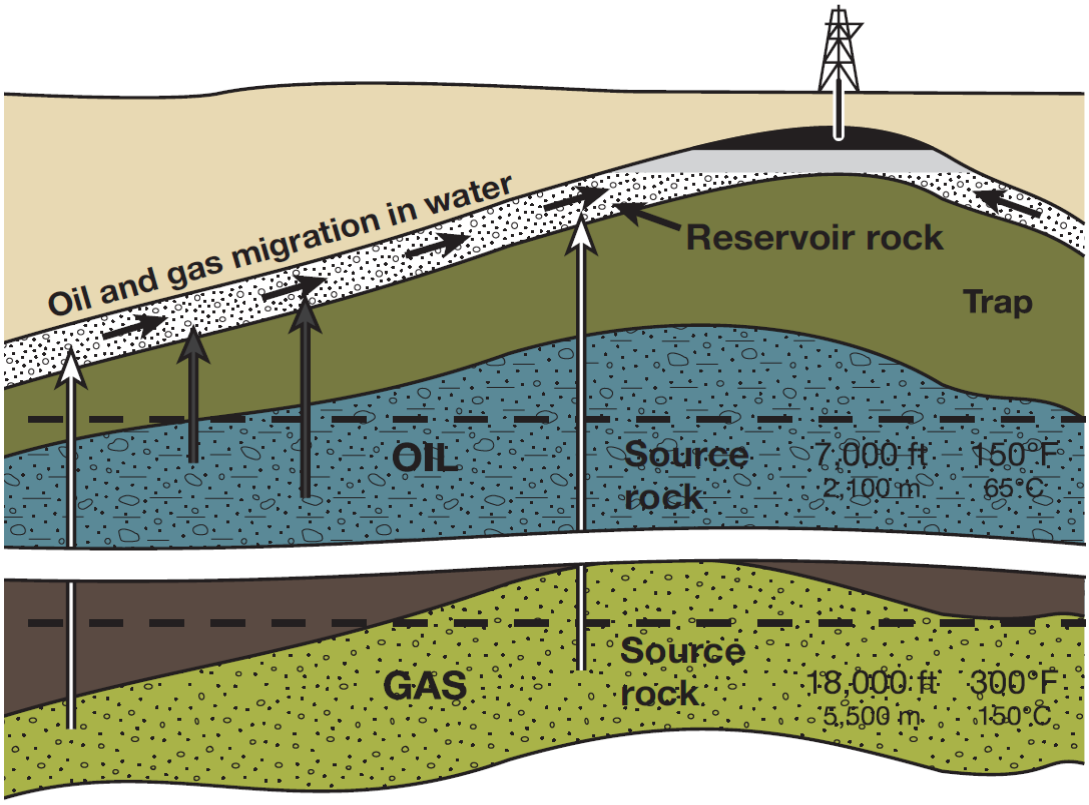


Figure 1: Generation and movement of oil and gas (*Source:* Hyne, N. J.)

Natural gas has been formed by the degradation of organic matter buried in layers of sedimentary rocks created over eons (fig. 1). The organic matter changes to oil and gas under the influence of temperature and pressure, and a portion of the hydrocarbons migrate through the rock to eventually collect in geologic structures called ***traps*.**

Most natural gas was created over time by two mechanisms: **biogenic and thermogenic**. Biogenic gas is created by methanogenic organisms in marshes, bogs, landfills, and shallow sediments. Deeper in the earth, at greater temperature and pressure, thermogenic gas is created from buried organic material.

Natural gas also may contain heavier hydrocarbons in the gaseous state, such as pentane, hexane, and heptane. At surface conditions, these will condense out of the gas to form ***natural gas condensate***.

Condensate resembles gasoline in appearance and is similar in composition to some volatile light crude oils.

Conventional and Unconventional Natural Gases

There are several types of geological formations that trap naturally occurring gas. They are categorized as either 'conventional' or 'unconventional' gas reserves.

Conventional Natural Gas

Conventional gas is trapped in naturally porous reservoir formations that are capped with impermeable rock strata. When intercepted by a well, gas is able to move to the surface without the need to pump.

Conventional natural gas generally occurs in deep reservoirs and produced as associated gas and nonassociated gas.

Associated Gas: Is conventional gas that is produced during the extraction of crude oil. This gas is separated at the casinghead or wellhead. Gas produced in this fashion is also referred to as casinghead gas, oil well gas, or dissolved gas.

Nonassociated Gas: Nonassociated gas is sometimes referred to as gas-well gas or dry gas in reservoirs that contain little or no crude oil.

Unconventional Natural Gas

Is gas that cannot be economically produced unless one or more technologies are used to stimulate the gas-bearing formation and to expose more of the formation to the well bore. An unconventional gas reservoir can be deep or shallow, of high or low pressure and temperature, and can contain single or multiple layers.

Unconventional gas is formed in more complex geological formations which limit the ability of gas to migrate and therefore different methods are required to extract the gas.

Today, there are six main categories of unconventional natural gas:

- Deep gas
- Tight gas
- Shale gas
- Coal-bed methane
- Gas in geopressurized zones
- Methane hydrate

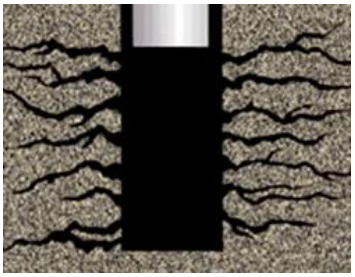
Deep gas:

Deep gas is typically found 15,000 feet or deeper underground, considerably deeper than conventional gas. Therefore, deep gas is relatively expensive to find and produce.

Tight gas:

Tight gas is trapped in unusually impermeable hard rock or in sandstone or limestone that is highly nonporous (tight sand). Extraction of gas from tight formations typically requires expensive techniques such as fracturing and acidizing.

Acidizing is performed below the reservoir fracture pressure in an effort to restore the natural permeability of the reservoir rock as shown ın fıgure below. Here, acid is pumped into the well and into the pores of the reservoir rocks. In this form of acidization, the acids dissolve the sediments and mud solids that are inhibiting the permeability of the rock, enlarging the natural pores of the reservoir and stimulating flow of hydrocarbons. A common type of acid employed on wells to stimulate production is hydrochloric acids (HCI), which are useful in removing carbonate reservoirs, or limestones and dolomites, from the rock. Also, HCI can be



combined with a mud acid, or hydrofluoric acid (HF), and used to dissolve quartz, sand and clay from the reservoir rocks.

Shale gas

It is natural gas exist in deposits of shale, a fine-grained and soft sedimentary rock that breaks easily into thin, parallel layers. Gas is typically found in sections where two thick, black shale deposits "sandwich" a thinner area of shale. This gas can be held in naturally occurring fractures or in pore spaces, or it can be adsorbed onto the surface of the organic components of the shale.

Ordinarily, shales are not permeable enough to let significant amounts of gas or other fluids flow to a wellbore; for this reason, most shales are not commercially viable sources of natural gas.

Coal-bed methane

Historically, methane was a nuisance and a safety hazard in the coal-mining industry.

Coal-bed methane is a popular form of unconventional natural gas source where the methane held within the coal leaks out into the coal mine as a coal mine is being built and coal extracted.

This coal-bed methane is trapped underground, and poses a safety threat because too high a concentration of methane creates dangerous conditions for coal miners. Thus, in the past, accumulating methane was intentionally vented to the atmosphere. Today, with many projects put in place around the world to extract and market it. In April 2011, the Potential Gas Committee (PGC) estimated that about 158.6 trillion cubic feet (tcf) of technically recoverable (probable, possible, and speculative) coal-bed methane existed in the United States at the end of 2010.

Geopressurized Gas:

It is a source of unconventional natural gas which presents in the geopressurized zones or natural geologic (underground) formations in which the pressure is higher than would be expected for a given depth.

These zones are formed by layers of clay that are deposited and compacted very quickly on top of more porous, absorbent material such as sand or silt. Water and natural gas that are present in this clay are squeezed out by the rapid compression of the clay, and enter the more porous sand or silt deposits. The natural gas, due to the compression of the clay, is deposited in this sand or silt under very high pressure. In addition to having these properties, geopressurized zones are typically located at great depths, usually 10,000-25,000 feet below the surface of the earth. The combination of all these factors makes the extraction of natural gas in geopressurized zones quite complicated. However, of all of the unconventional sources of natural gas, geopressurized zones are estimated to hold the greatest amount of gas.

Methane hydrate

Another unconventional gas resource under evaluation for potential production in the longer term is methane hydrate. *Hydrate* is typically a cold, slushlike, crystalline structure consisting of methane molecules trapped in a lattice of water molecules.

Such hydrates are abundant in the Arctic (where they were first discovered) and in marine sediments, below the seabed. Estimates of the worldwide methane hydrate resource vary from 7,000 to more than 73,000 tcf; however, these numbers are far from certain.

In summary, unconventional natural gas constitutes a large proportion of the natural gas that is left to be extracted in North America and is playing an ever-increasing role in supplementing the U.S. natural gas supply.

A study conducted by ICF International concluded that, in 2007, about 42% of total U.S. natural gas production was from unconventional sources, and this figure is expected to rise to 64% in 2020.

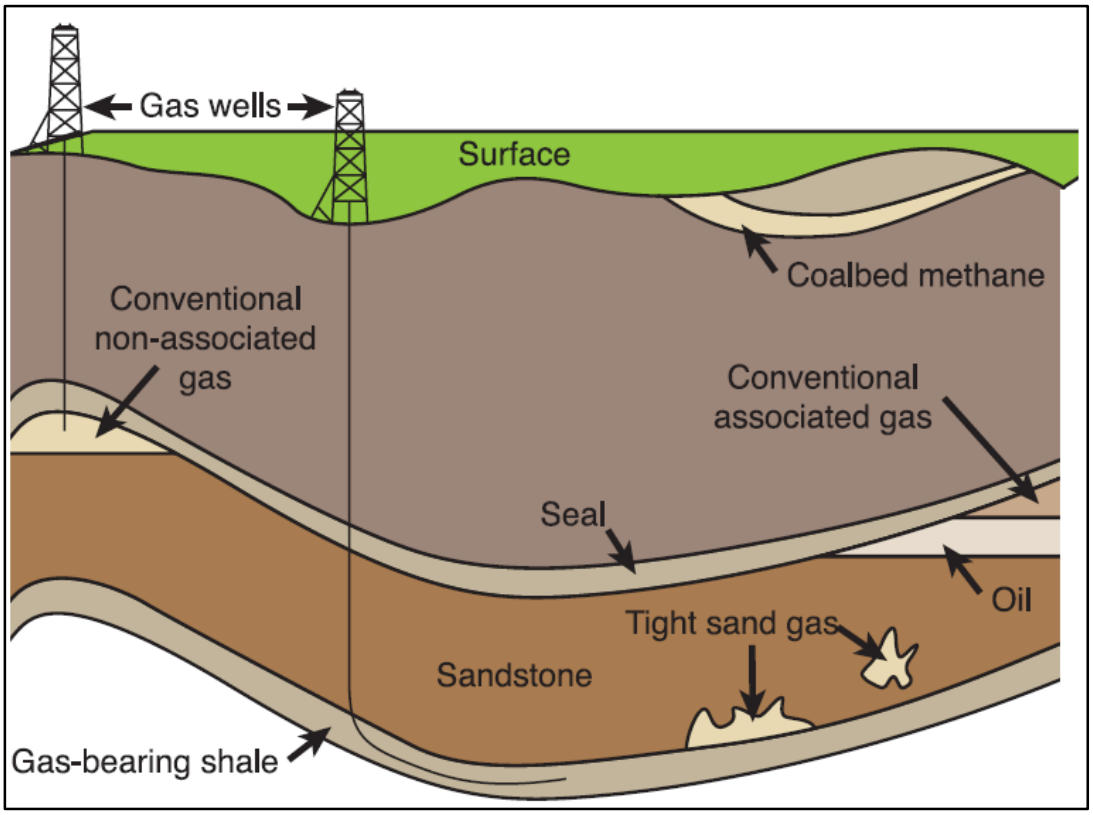


Figure 2: Geology of natural gas resources

Table 2 lists those nations with significant estimated natural gas reserves, as of January 1, 2012.

Table 2: Nations with largest estimated natural gas reserves, 2012

Country[a]	Estimated proved gas reserves as of January 1, 2012,[b] tcf
Russia	1,680.0
Iran	1,168.0
Qatar	890.0
Saudi Arabia	283.0
United States	272.5
Turkmenistan	265.0
Abu Dhabi[c]	200.0
Venezuela	195.1
Nigeria	180.5
Algeria	159.0
Indonesia	141.1
Iraq	111.5
China	107.0
Kazakhstan	85.0
Malaysia	83.0
Egypt	77.2
Norway	70.9
Uzbekistan	65.0
Kuwait	63.0
Canada	61.0
Libya	52.8

Definitions:

It is desirable to define several of the terms that will be used in this lecture. Some of the main ones as follow:

Raw Gas (natural gas) is the untreated gas obtained from natural underground reservoirs either as free gas or gas associated with crude oil. It generally contains large amounts of methane (CH_4) along with decreasing amounts of other

hydrocarbons. Impurities such as H_2S, N_2, and CO_2 are often found with the gas. It also generally comes saturated with water vapor.

Pipeline Gas: It 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. It is also known as residue gas or sales gas.

Sour Gas: Gas that contains more than 1 grain of H_2S/100 SCF. *Grain*, *unit* of weight equal to 0.065 gram. SCF (Standard Cubic Foot)

Sweet Gas: Gas in which the H_2S content is less than 1 grain /100 SCF.

Wet Gas: Gas that contains more than 0.1 US gallons of condensates per 1000 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 (C3+) per 1000 CF of the gas.

Lean Gas: Gas containing 1 US gallons or less of compounds heavier than ethane (C3+) per 1000 CF of the gas.

Pentanes+: The pentane and heavier fraction of hydrocarbon liquid.

Condensates: The hydrocarbon liquid fraction obtained from a gas stream containing essentially pentanes.