Evolution of Oil & Gas Industry in India

- The origin of oil & gas industry in India can be traced back to 1867 when oil was struck at Makum near Margherita in Assam.
- At the time of Independence in 1947, the Oil & Gas industry was controlled by international companies. India's domestic oil production was just 250,000 tonnes per annum and the entire production was from one state - Assam.

Evolution of Oil & Gas Industry in India

- The foundation of the Oil & Gas Industry in India was laid by the Industrial Policy Resolution, 1954, when the government announced that petroleum would be the core sector industry.
- Following this National Oil Companies ONGC (Oil & Natural Gas Commission), IOC (Indian Oil Corporation), and OIL (Oil India Ltd.) were formed.
- During 1960s, a number of oil and gas-bearing structures were discovered by ONGC in Gujarat and Assam.
- Discovery of oil in significant quantities in Bombay High in February, 1974 opened up new avenues of oil exploration in offshore areas.

Evolution of Oil & Gas Industry in India

- During 1970s and till mid 1980s exploratory efforts by ONGC and OIL India yielded discoveries of oil and gas in a number of structures in Bassein, Tapti, Krishna-Godavari-Cauvery basins, Cachar (Assam), Nagaland, and Tripura. In 1984-85,
- Exploration and Production was controlled by the National Oil Companies (NOC), ONGC and OIL.
  - 70s Nearly 70% of the domestic requirement.
  - 80s Production declined, Steady increase in consumption.
  - Today The NOCs meet about 35% of domestic requirement.
- In 1984, Gas Authority of India Ltd. (GAIL) was set up to look after transportation, processing and marketing of natural gas and natural gas liquids.

Evolution of Oil & Gas Industry in India

- The Indian oil and gas sector is one of the six core industries in India and has very significant forward linkages with the entire economy.
- India has been growing at 8-9 per cent annually and is committed to accelerate the growth momentum in the years to come.
- This would translate into India's energy needs growing many times in the years to come.

Major Players in India

- Indian Oil
- Reliance
- Bharat Petroleum
- HP
- ONGC
- BP
- BG Group
- Gaz de France
- Chevron

Major Players in India

ONGC

- Public sector company; Contributes 77% of India's crude oil production; Revenue: $ 10.5 billion; Employees: 41000

IOCL

- India's largest commercial enterprise; sales turnover of US $36.537 billion
- IndianOil Technologies Ltd.(a wholly owned subsidiary company) is the 19th largest petroleum company in the world

BPCL

- 3rd largest oil company in India; Owned by the Government of India; Revenue $17.613 billion

Major Refineries in India

S.NO.	Name of the company	Location of the Refinery	Capacity(MMTPA)*
1.	Indian Oil Corporation Limited (IOCL)	Guwahati	1.00
2.	IOCL	Barauni	6.00
3.	IOCL	Koyali	13.70
4.	IOCL	Haldia	6.00
5.	IOCL	Mathura	8.00
6.	IOCL	Digboi	0.65
7.	IOCL	Panipat	6.00
8.	Hindustan Petroleum Corporation Limited (HPCL)	Mumbai	5.50
9.	HPCL	Visakhapatnam	7.50
10.	Bharat Petroleum Corporation Limited (BPCL)	Mumbai	6.90
11.	Chennai Petroleum Corporation Limited (CPCL)	Manali	9.50
12.	CPCL	Nagapattnam	1.00
13.	Kochi Refineries Ltd. (KRL)	Kochi	7.50
14.	Bongaigaon Refinery & Petrochemicals Ltd. (BRPL)	Bongaigaon	2.35
15.	Numaligarh Refinery Ltd.(NRL)	Numaligarh	3.00
16.	Mangalore Refinery & Petrochemicals Ltd. (MRPL)	Mangalore	9.69
17.	Tatipaka refinery (ONGC)	Andhra Pradesh	0.078
18.	Reliance Petroleum Ltd. (RPL).Pvt. Sector	Jamnagar	33.00

Crude Oil Components

- **Crude oil** consists mainly of hydrocarbons with carbon numbers between one and forty. The petroleum refinery takes this product and refines it into several fuel fractions that are optimized for their intended application.

- **Liquid hydrocarbons**- commonly known as oil, or crude oil, to distinguish it from refined hydrocarbon products.

Crude Oil Components

- **Solid hydrocarbons**- coal and kerogen- (kerogen strictly defined is dessimenated organic matter in sediments that is insoluble in normal petroleum solvents.

- **Natural gas-** a fossil fuel like oil and coal containing a mixture of hydrocarbons primarily of methane but including significant quantities of ethane, propane, butane, and pentane

- **Gas Hydrates-** Solids composed of water molecules surrounding gas molecules, usually methane, but also H_2S, CO_2, and other less common gases.

Natural Gas

- **Natural gas** is a gaseous fossil fuel consisting primarily of methane but including significant quantities of ethane, propane, butane, and pentane—heavier hydrocarbons removed prior to use as a consumer fuel —as well as carbon dioxide, nitrogen, helium and hydrogen sulfide

- May be defined as a mixture of hydrocarbons and varying quantities of nonhydrocarbons that exists either in the gaseous phase or in solution with crude oil in natural underground reservoirs

Types of Natural Gas

- **CNG** (Compressed Natural Gas) is usually around 70-90% methane with 10-20% ethane, 2-8% propanes, and decreasing quantities of the higher HCs up to pentane.

- **LPG** (Liquefied Petroleum Gas) is predominantly propane with iso-butane and n-butane. It has one major advantage over CNG, the tanks do not have to be high pressure, and the fuel is stored as a liquid.

- **LNG** (Liquefied natural gas) is natural gas (primarily methane, CH4) that has been converted to liquid form for ease of storage or transport.

Natural Gas

- The common gasses in reservoirs can be divided based on their origins:
- **Inorganic**- Helium, Argon, Krypton, Radon
- **Mixed inorganic and organic**- CO2, H2S
- **Organic**- Hydrogen (???), Methane, Ethane, Propane, Butane

Non-hydrocarbon gases

- **Noble Gases**- Helium, Argon, and Radon
- These gases are inert- do not take part in **chemical** reactions. They originate from decay of radioactive isotopes of various elements, predominately the U series elements. They can be quite concentrated in natural gas (>1% of the gas present)

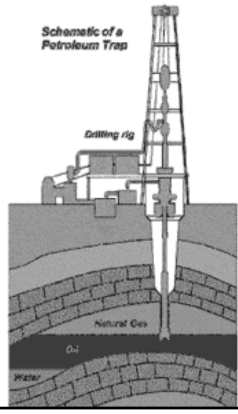
Typical Composition of Natural Gas

• Methane	CH_4	70-90%
• Ethane	C_2H_6	0-20%
• Propane	C_3H_8	0-10%
• Butane	C_4H_{10}	0-5%
• Carbon Dioxide	CO	20-8%
• Oxygen	O	20-0.2%
• Nitrogen	N	20-5%
• Hydrogen sulphide	H_2S	0-5%
• Rare gases	Ar, He, Ne, Xe	trace

Formation of Natural Gas

- Although there are several ways that methane, and thus natural gas, may be formed, it is usually found underneath the surface of the earth.
- As natural gas has a low density, once formed it will rise towards the surface of the earth through loose, shale type rock and other material.
- Most of this methane will simply rise to the surface and dissipate into the atmosphere. However, a great deal of this methane will rise up into geological formations that 'trap' the gas under the ground.
- These formations are made up of layers of porous, sedimentary rock, with a denser, impermeable layer of rock on top. This impermeable rock traps the natural gas under the ground. If these formations are large enough, they can trap a great deal of natural gas underground, in what is known as a **reservoir**.

Natural Gas Under the Earth



Types of Natural Gas

- **Dry gas**- contains largely methane, specifically contains less than 0.1 gal/1000ft3 of condensible (at surface T and P) material.
- **Wet gas**- contains ethane propane, butane. Up to the molecular weight where the fluids are always condensed to liquids
- **Condesates**- Hydrocarbon with a molecular weight such that they are gas in the subsurface where temperatures are high, but condense to liquid when reach cooler, surface temperatures.

Natural Gas

Various descriptive terms for natural gas:

- **Dissolved gas-** That portion of natural gas that is dissolved in liquid phase in the sub- surface. It can be (and usually is) physically separated from the liquid when the fluids are produced.
- **Associated gas-** Also known as the "gas cap" is free gas (not dissolved) that sits on top of, and in contact with, crude oil in the reservoir.
- **Non-associated gas-** Free gas that is trapped without a significant amount of crude oil.

Natural Gas Processing

- Natural gas processing consists of separating all of the various hydrocarbons and fluids from the pure natural gas, to produce what is known as 'pipeline quality' dry natural gas
- While the ethane, propane, butane, and pentanes must be removed from natural gas, this does not mean that they are all 'waste products'.

Natural Gas Processing

- In fact, associated hydrocarbons, known as 'natural gas liquids' (NGLs) can be very valuable by-products of natural gas processing.
- NGLs include ethane, propane, butane, iso-butane, and natural gasoline.
- These NGLs are sold separately and have a variety of different uses; including enhancing oil recovery in oil wells, providing raw materials for oil refineries or petrochemical plants, and as sources of energy.

Natural Gas Processing

The following steps are involved

- **Oil and Condensate Removal**
- **Water Removal**
  - **Glycol Dehydration**
  - **Solid-Desiccant Dehydration**
- **Separation of Natural Gas Liquids**
  - **The Absorption Method**
  - **The Cryogenic Expansion Process**
- **Sulfur and Carbon Dioxide Removal**

Oil and Condensate Removal

- The equipment used for this purpose is called Low-Temperature Separator. These separators use pressure differentials to cool the wet natural gas and separate the oil and condensate.
- Wet gas enters the separator, being cooled slightly by a heat exchanger. The gas then travels through a high pressure liquid 'knockout', which serves to remove any liquids into a low-temperature separator.
- The gas then flows into this low-temperature separator through a choke mechanism, which expands the gas as it enters the separator.
- This rapid expansion of the gas allows for the lowering of the temperature in the separator. After liquid removal, the dry gas then travels back through the heat exchanger and is warmed by the incoming wet gas.
- By varying the pressure of the gas in various sections of the separator, it is possible to vary the temperature, which causes the oil and some water to be condensed out of the wet gas stream.
- This basic pressure-temperature relationship can work in reverse as well, to extract gas from a liquid oil stream.

Water Removal

Glycol Dehydration

- In this process, a liquid desiccant dehydrator serves to absorb water vapor from the gas stream.
- Glycol, the principal agent in this process, has a chemical affinity for water. This means that, when in contact with a stream of natural gas that contains water, glycol will serve to 'steal' the water out of the gas stream.
- Essentially, glycol dehydration involves using a glycol solution, usually either **diethylene glycol** (DEG) or **triethylene glycol** (TEG), which is brought into contact with the wet gas stream in what is called the 'contactor'.
- The glycol solution will absorb water from the wet gas. Once absorbed, the glycol particles become heavier and sink to the bottom of the contactor where they are removed

Water Removal

Solid-Desiccant Dehydration

- Solid-desiccant dehydration is the primary form of dehydrating natural gas using adsorption, and usually consists of two or more adsorption towers, which are filled with a solid desiccant.
- Typical desiccants include **activated alumina** or a **granular silica gel** material.
- Wet natural gas is passed through these towers, from top to bottom. As the wet gas passes around the particles of desiccant material, water is retained on the surface of these desiccant particles. Passing through the entire desiccant bed, almost all of the water is adsorbed onto the desiccant material, leaving the dry gas to exit the bottom of the tower.

Separation of Natural Gas Liquids

The Absorption Method

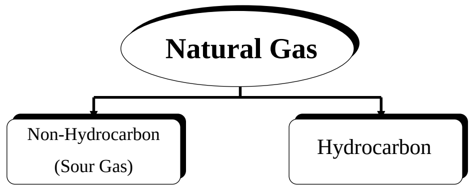
- The absorption method of NGL extraction is very similar to using absorption for dehydration. The main difference is that, in NGL absorption, an absorbing oil is used as opposed to glycol.
- This absorbing oil has an 'affinity' for NGLs in much the same manner as glycol has an affinity for water. Before the oil has picked up any NGLs, it is termed 'lean' absorption oil.
- As the natural gas is passed through an absorption tower, it is brought into contact with the absorption oil which soaks up a high proportion of the NGLs.
- The 'rich' absorption oil, now containing NGLs, exits the absorption tower through the bottom. It is now a mixture of absorption oil, propane, butanes, pentanes, and other heavier hydrocarbons.
- The rich oil is fed into lean oil stills, where the mixture is heated to a temperature above the boiling point of the NGLs, but below that of the oil. This process allows for the recovery of around 75 percent of butanes, and 85 - 90 percent of pentanes and heavier molecules from the natural gas stream.

Separation of Natural Gas Liquids

The Cryogenic Expansion Process

- Cryogenic processes consist of dropping the temperature of the gas stream to around -120 degrees Fahrenheit.
- This is achieved by a process known as the turbo expander process. In this process, external refrigerants are used to cool the natural gas stream.
- Then, an expansion turbine is used to rapidly expand the chilled gases, which causes the temperature to drop significantly.
- This rapid temperature drop condenses ethane and other hydrocarbons in the gas stream, while maintaining methane in gaseous form..

Sulfur and Carbon Dioxide Removal



What is Sour Gas?

Sour Gas is acidic gases such as Carbon dioxide and hydrogen sulphide.

Sulfur and Carbon Dioxide Removal

- The process for removing hydrogen sulfide from sour gas is commonly referred to as 'sweetening' the gas.
- The primary process for sweetening sour natural gas is quite similar to the processes of glycol dehydration and NGL absorption.
- In this case, however, amine solutions are used to remove the hydrogen sulfide. This process is known simply as the 'amine process', or alternatively as the Girdler process.

Sulfur and Carbon Dioxide Removal

- The sour gas is run through a tower, which contains the amine solution. This solution has an affinity for sulfur, and absorbs it much like glycol absorbing water. There are two principle amine solutions used, **monoethanolamine** (MEA) and **diethanolamine** (DEA). Either of these compounds, in liquid form, will absorb sulfur compounds from natural gas as it passes through. The effluent gas is virtually free of sulfur compounds, and thus loses its sour gas status.
- Although most sour gas sweetening involves the amine absorption process, it is also possible to use solid desiccants like iron sponges to remove the sulfide and carbon dioxide.
- The acid gases removed by amine treating are then routed into a sulfur recovery unit which converts the hydrogen sulfide in the acid gas into elemental sulfur. There are a number of processes available for that conversion, but the Claus process.

Natural gas processing