Presentation
on
A to Z of Natural Gas & LNG
Oragnized by Petrofed, Lovraj kumar Memorial Trust & PLL

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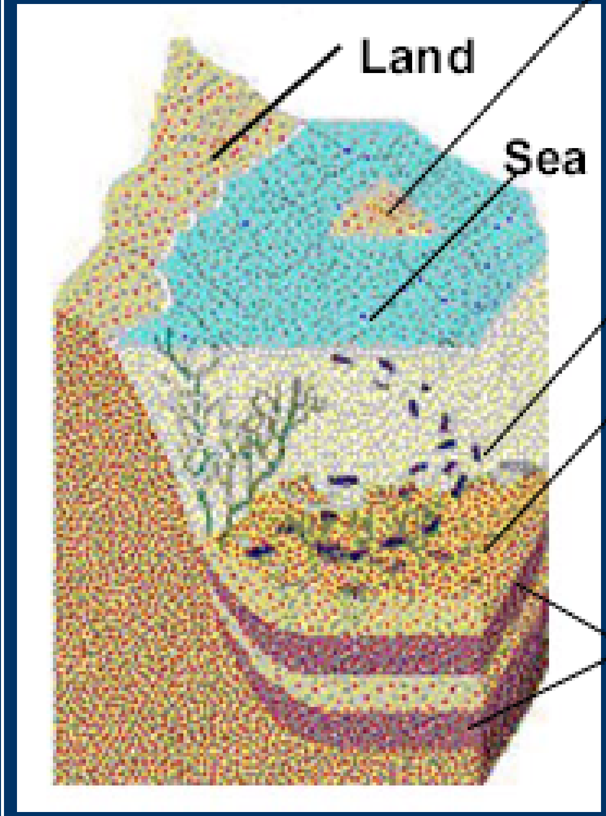
Presentation on A to Z of LNG

Contents

- Natural Gas Production, Treatment, Processing and utilization
- Liquefaction of natural gas
- Regasification- Processes & equipments

Origin of Petroleum



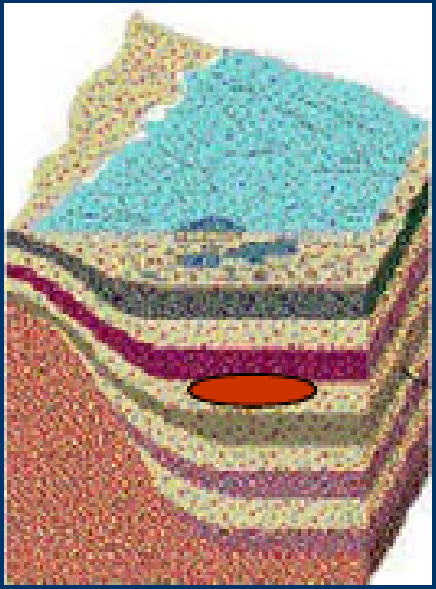
Living material gets washed into the sea from the land

Living material dies

Remains of plankton, tiny forms of sea life

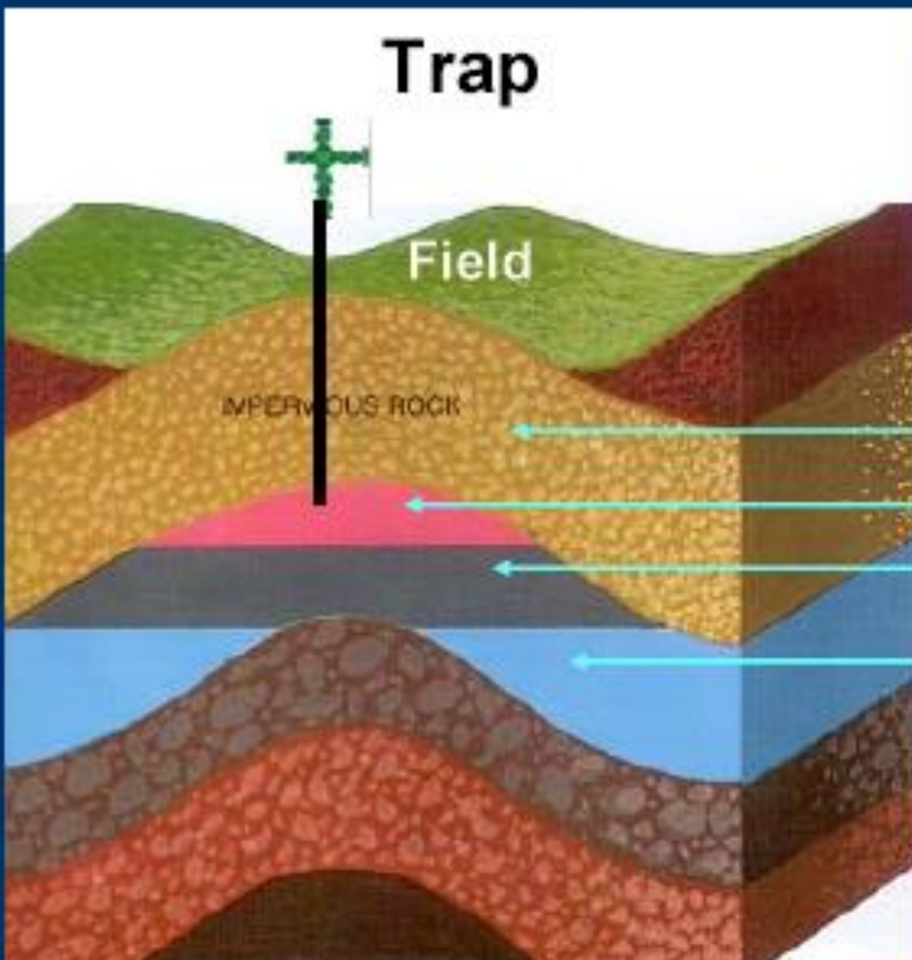
Layers of sediment form when material such as sand, and remains of living things, settle on the ocean floor

Layers become more and more compressed as further layers settle on top.



Part of dead material change to Hydrocarbons under heat and pressure.

Origin of Petroleum Contd...



Material depositing sediment forms hard impervious layer, called the **Cap Rock.**

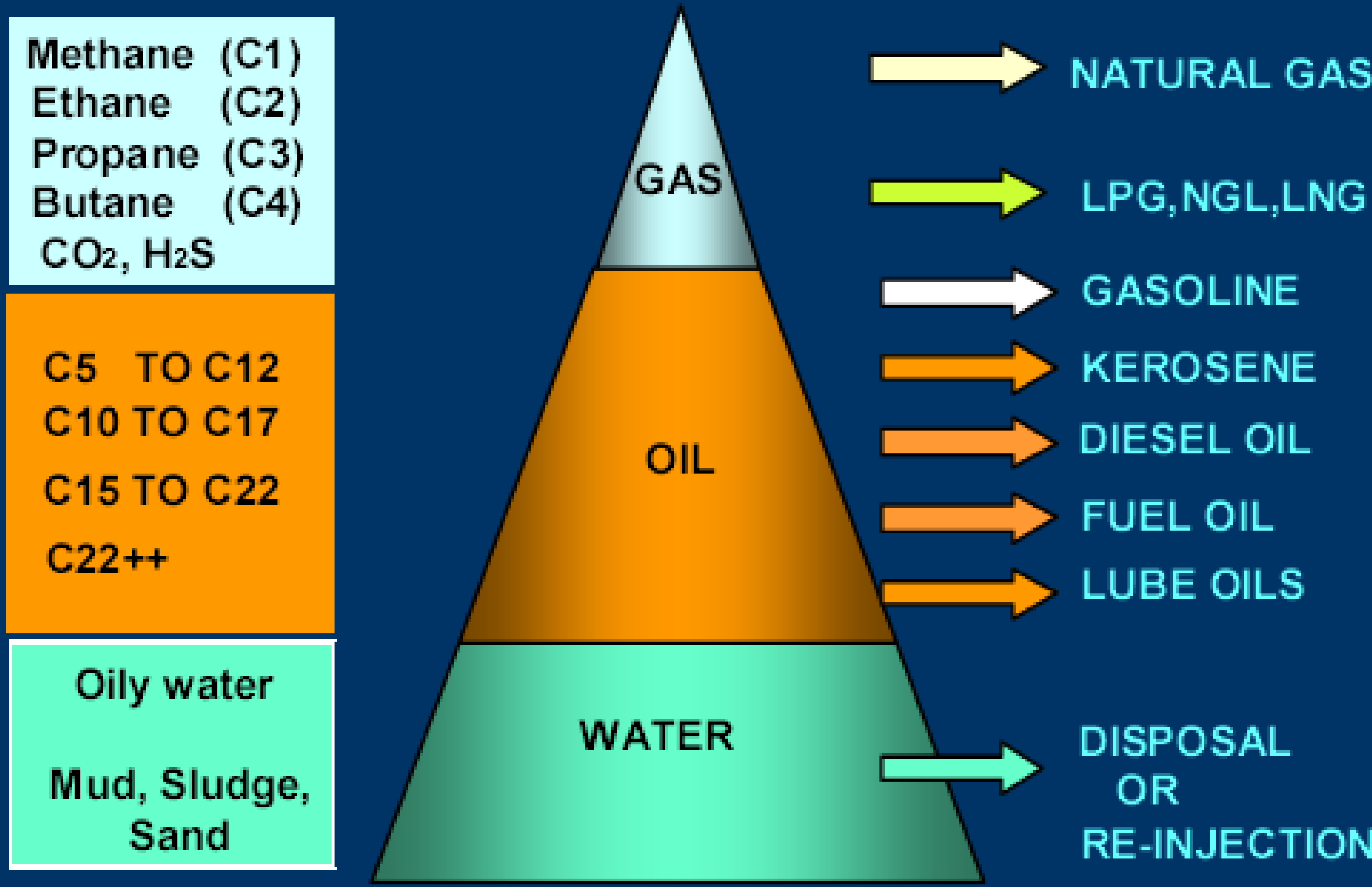
Earth movements cause folds in earth crust.

Oil and gas in the 'pores' of sedimentary rocks **trapped** by the cap rock layer. The porous rocks are called **Reservoir Rocks.**

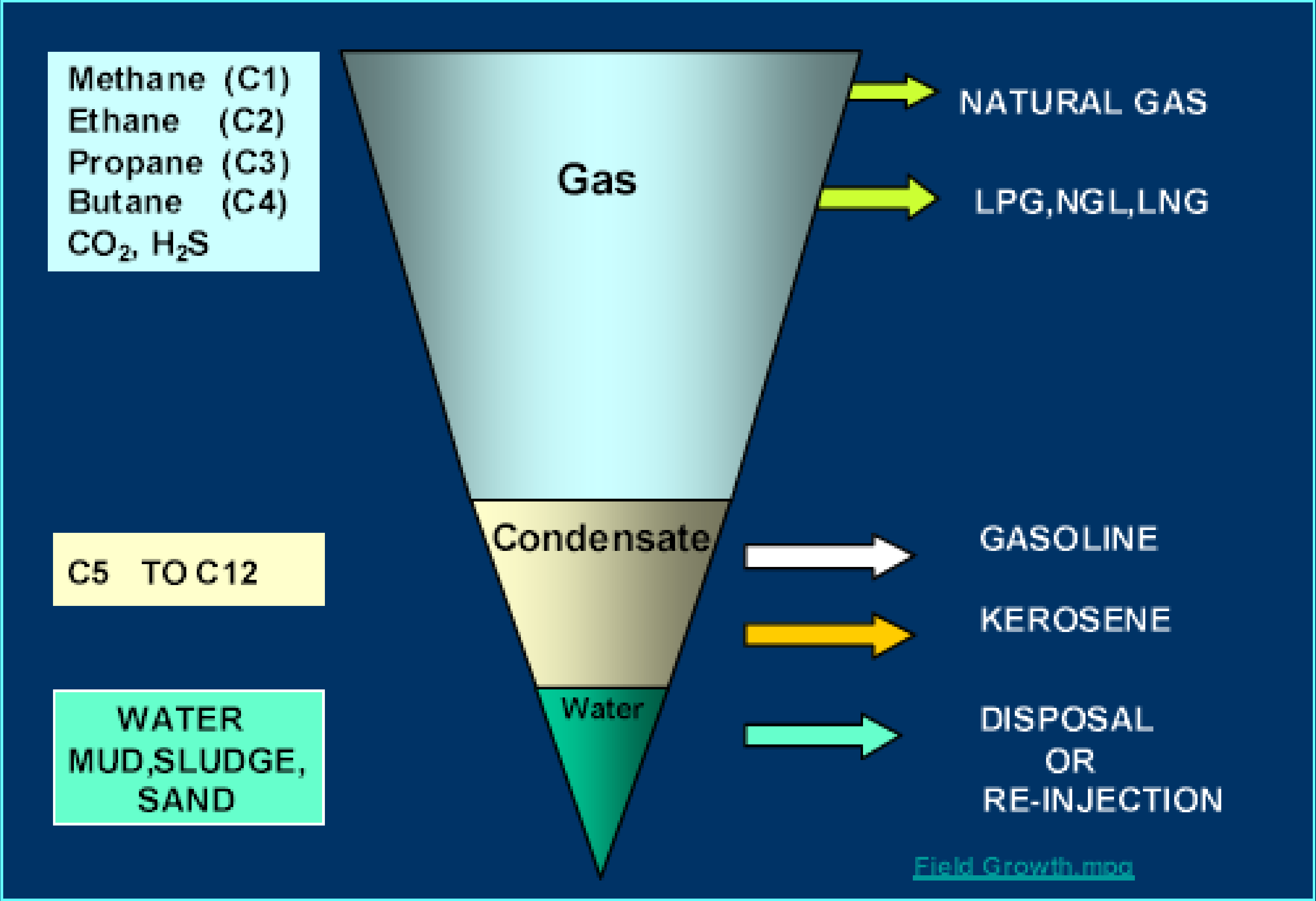
Formation of Oil, Gas and Coal

- Whether oil, gas or coal is formed depends partly on the starting materials.
- Biotic Theory - Oil and gas are derived almost entirely from decayed plants and bacteria.
- Oil forms from the buried remains of minute aquatic algae and organisms.
- But gas forms if these remains are deeply buried.
- The stems & leaves of buried plants are altered to coal.
- Generally buried vegetation yield no oil, but may produce gas on deep burial.
- Abiotic theory – Gas comes from carbonaceous material at deep core of the earth.

Composition of Well Fluid in an Oilfield



Composition of Well Fluid in a Gas Field



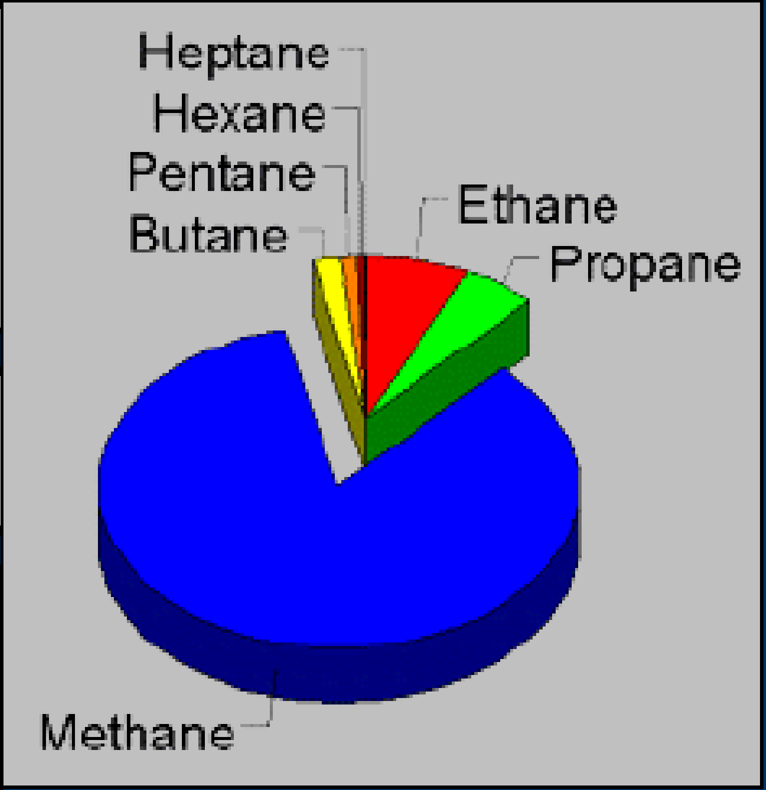
What is Natural Gas?

Natural gas is made of mainly light hydrocarbons. It may also contain H_2S, CO_2, N_2, Helium and Mercury.

It is saturated with moisture.

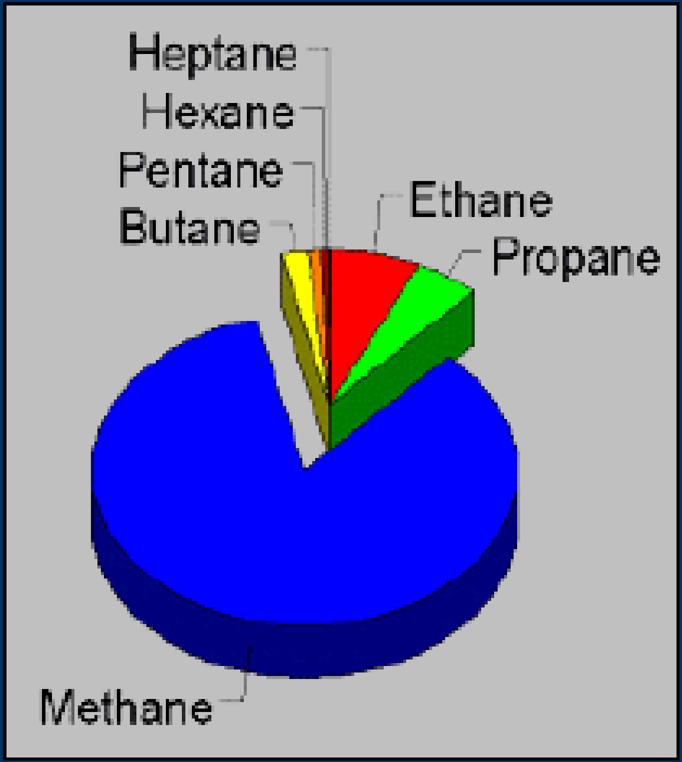
Associated gas is produced along with crude in an oilfield.

If it is a gas field, the well produces mainly gas with some condensate. It is called free gas or NANG.



When acid gases like CO_2 and H_2S are present, the gas is called sour gas. Otherwise it is called sweet gas.

Natural Gas Composition Range



Component	Range Vol%
Methane	50 – 96
Ethane	5 – 15
Propane	3 – 10
Butane	0.5 – 3
C5+	0.1 – 1
H_2S	0.0 – 15
CO_2	0.1 – 20
N_2	0.1 – 40
Helium	Trace-1
Water	Saturated

Physical Properties of Natural Gas

- Odorless, colorless, and tasteless. For safety reasons, however, an odourant called Mercaptan is added.
- Liquefies at -161 ^{O}C (-258 ^{O}F) at atmospheric pressure.
- Highly flammable but not a toxic gas, unless H_2S is present.

- Specific gravity of a gas is defined as the weight of a given volume of gas compared to the weight of the same amount of air at the same temperature and pressure.
  - Specific gravity of air = 1.00
  - Specific gravity of methane = 0.55
  - Specific gravity of natural gas = typically 0.60
  - Specific gravity of propane = 1.56
  - Specific gravity of butane = 2.00

Combustion Properties

Fire Hazard Information:

- Flash Point : Less than -18 °C
- Auto-ignition Temp: 475 °C
- Flammable Limits : Depends on gas Composition.

Typical Values are :

L.E.L. (Lower Explosive Limit) : 4- 5 % volume

U.E.L. (Upper Explosive Limit) : 14-15 % volume

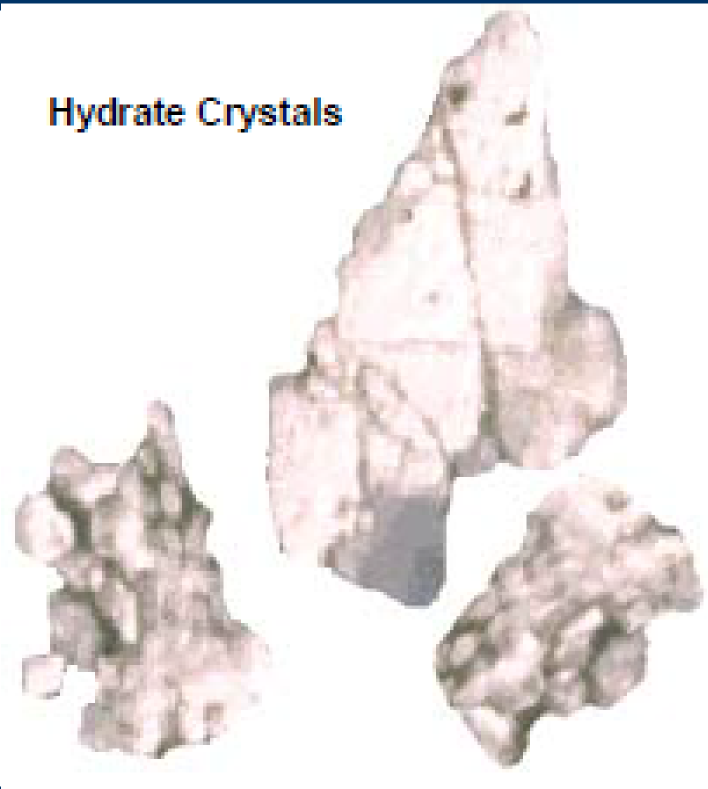
Calorific Value of Fuels

Type of fuel	Fuel	Calorific value kJ/g	BTU/lb
Solid	Carbon	32.2	13,850
Liquid	Kerosene	46	19,800
	Petrol	48	20,600
	Diesel	45	19,300
Gaseous	Butane	50	21,500
	Methane	55	23,650
	Hydrogen	150	64,500

- Hydrogen gas has the highest calorific value in the table given above.
- Since methane has higher percentage of hydrogen than butane, its calorific value is more (By weight).

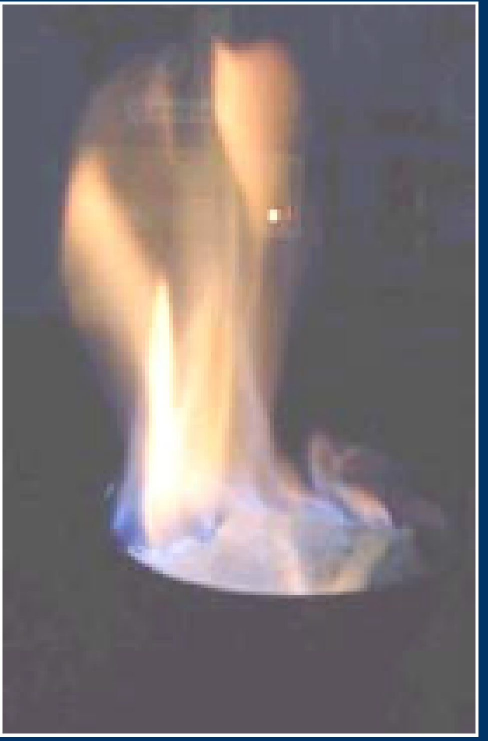
Hydrates - Introduction

- Gas Hydrates are ice-like solids that form when:
  - a sufficient amount of water is present
  - a hydrate former like methane is present
  - the right combination of temperature and pressure is existing.
- Normally it is grayish white. Presence of hydrogen sulfide makes it yellow.



Hydrate on Fire

- **Perhaps the most dramatic hydrate demonstration is to take a sample of methane hydrate and set it on fire.**
- **It has the appearance of burning ice.**
- **1 m^3 of hydrate contains about 170 m^3 [std] of methane.**



There are huge deposits of hydrates below the sand beds in the oceans, which may be future source of enregy.

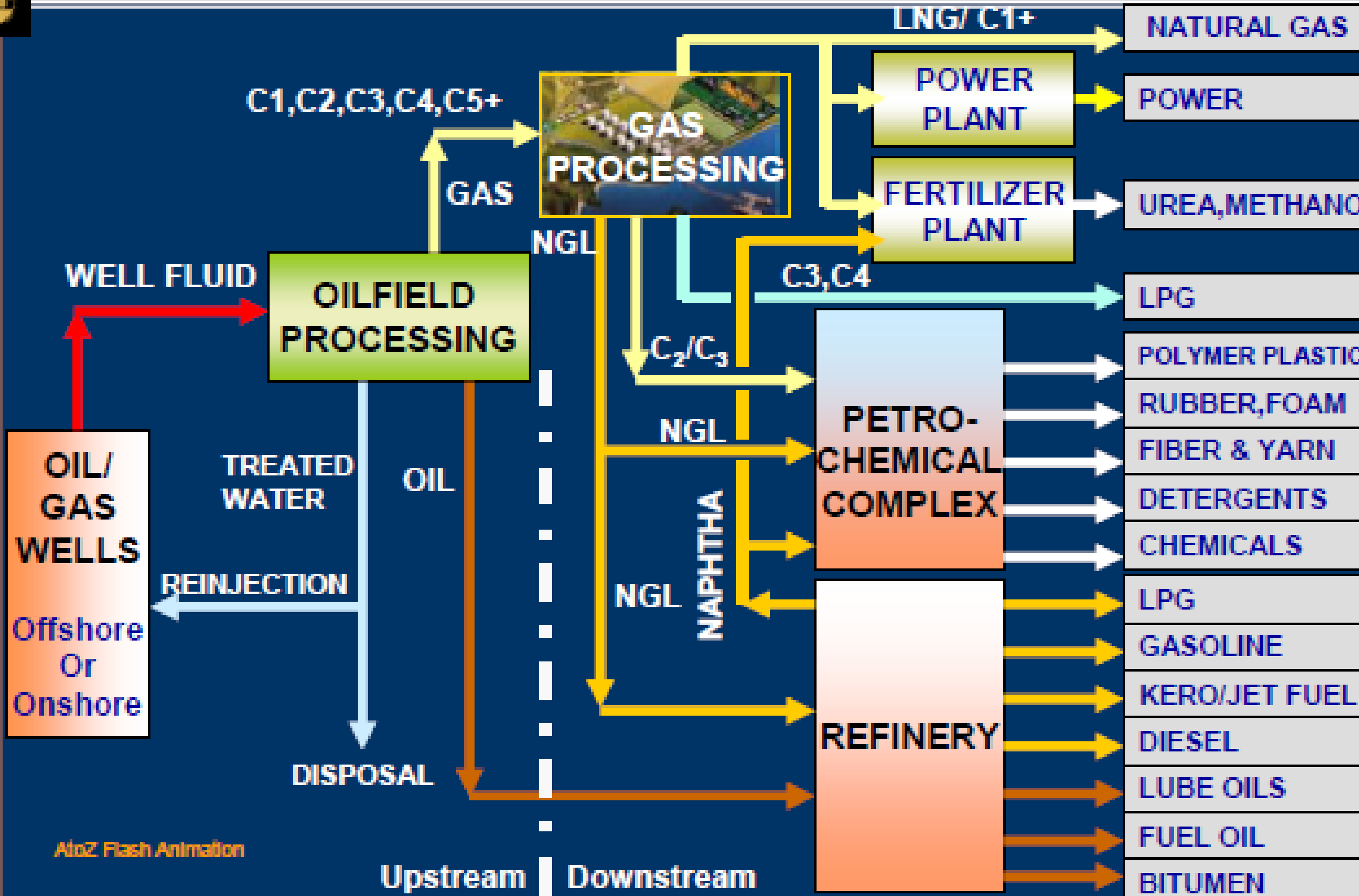
Overcoming Hydrate Problem

The formation of hydrates in processing facilities and pipelines causes pressure drop, loss of efficiency, choking and shutdown.

- Dehydrate the gas
- Operate above hydrate formation temperature
- Operate below hydrate formation pressure
- Inject inhibitor (methanol, glycol)

The picture shows a skid-mounted Methanol injection system

THE MACROSYSTEM



The Four G's - LPG, CNG, NGL and LNG

LPG : The propane/ butane component of the gas is liquefied under moderate pressures and is supplied as cooking gas.

This is called **LPG (Liquefied Petroleum Gas)**

CNG : Natural gas is compressed to high pressures for use as automotive fuel or for transportation in small quantities.

It is called **CNG (Compressed Natural Gas)**

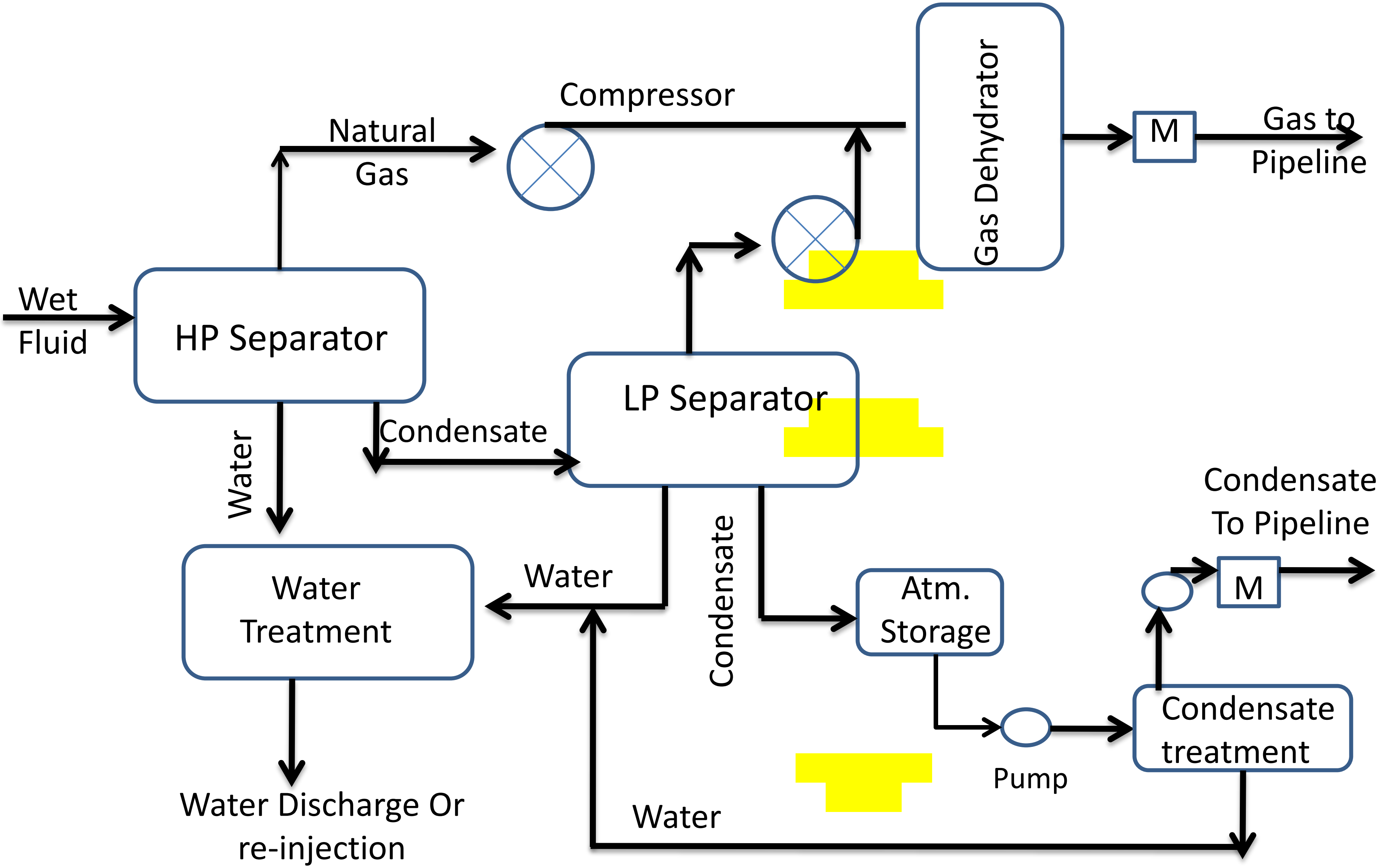
NGL: During production or transportation of gas, the heavy part such as pentane or hexane, condense due to natural cooling and separate out as liquids.

This is called **NGL (Natural Gas Liquids)**

LNG: Natural gas in bulk is liquefied under cryogenic temperature for export by marine tankers.

This is called **LNG (Liquefied Natural Gas)**

NATURAL GAS PRODUCTION



Objectives of Gas Processing

The purpose of gas processing operation .....

(1) Gas Treatment or Removal of Impurities - to make it suitable for transportation and consumer acceptability.

- ▶ Moisture ▶ H_2S ▶ CO_2 ▶ Nitrogen ▶ Mercury

(2) Liquefaction and Recovery of Hydrocarbons

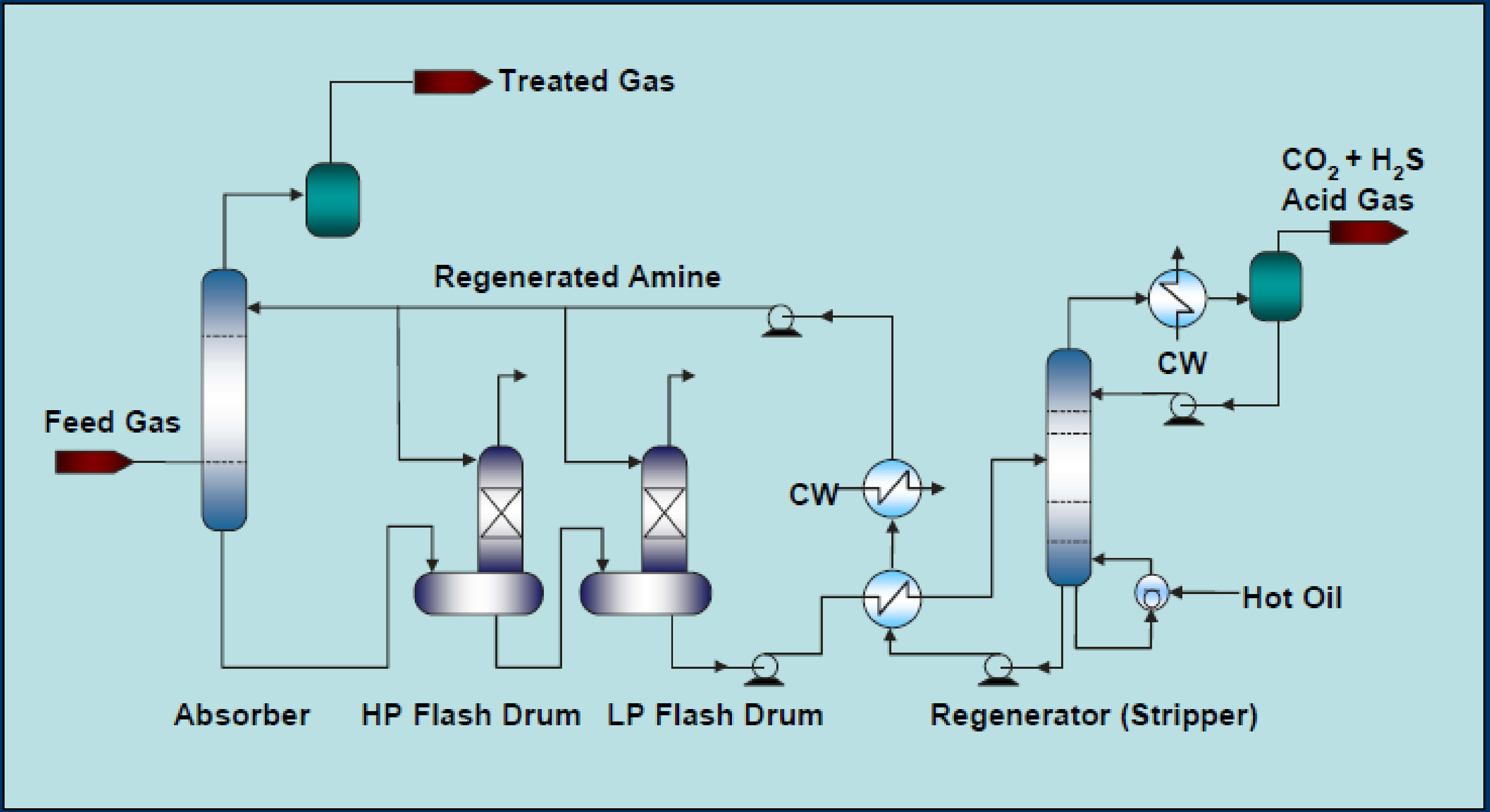
- Ethane, propane, LPG are condensed and recovered by low temperature refrigeration or cryogenic processes.
- Liquefaction of the entire gas to LNG under temperatures below -160 ^{0}C for transportation purpose.

Gas Sweetening Processes

There are numerous processes of gas sweetening – each suited for specific operating condition, composition and product specification.

Physico-Chemical (Amines)	MEA, DEA, DGA	MDEA	Activated & mixed amines	Proprietary Amines
Chemical Solvents	Benfield Process	Hot Potassium		
Physical Solvent	Sulfinol	Ifpexol	Selexol	Other proprietary
Solid Adsorbents	Molecular Sieve	Silica Gel	Sponge Iron	Others
Direct Oxidation	Stretford Process	Lo-Cat Process	Others	
Batch Processes	Iron Sponge	Sulfa-check	Chemsweet	Others
New Technologies	Membrane			

Amine Gas Sweetening Process



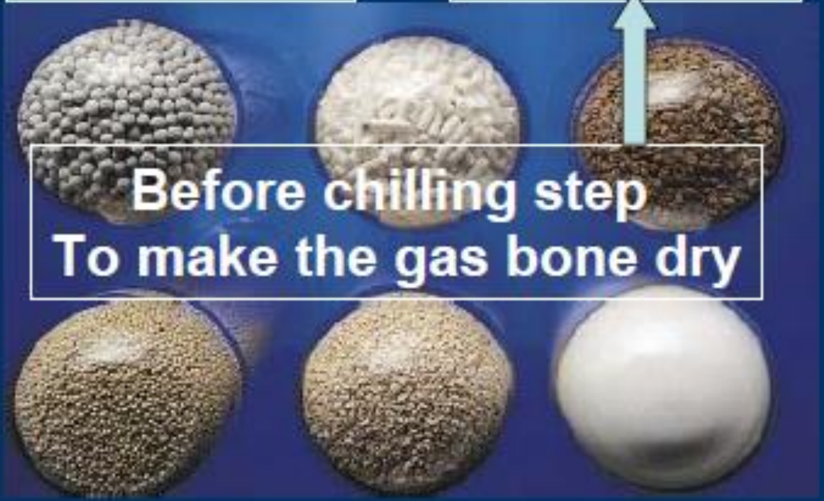
Gas Dehydration Processes

Absorption Processes

- Glycols (EG, DEG)
- Tri-Ethylene Glycol (TEG)
  - Offshore - to meet pipeline moisture specification

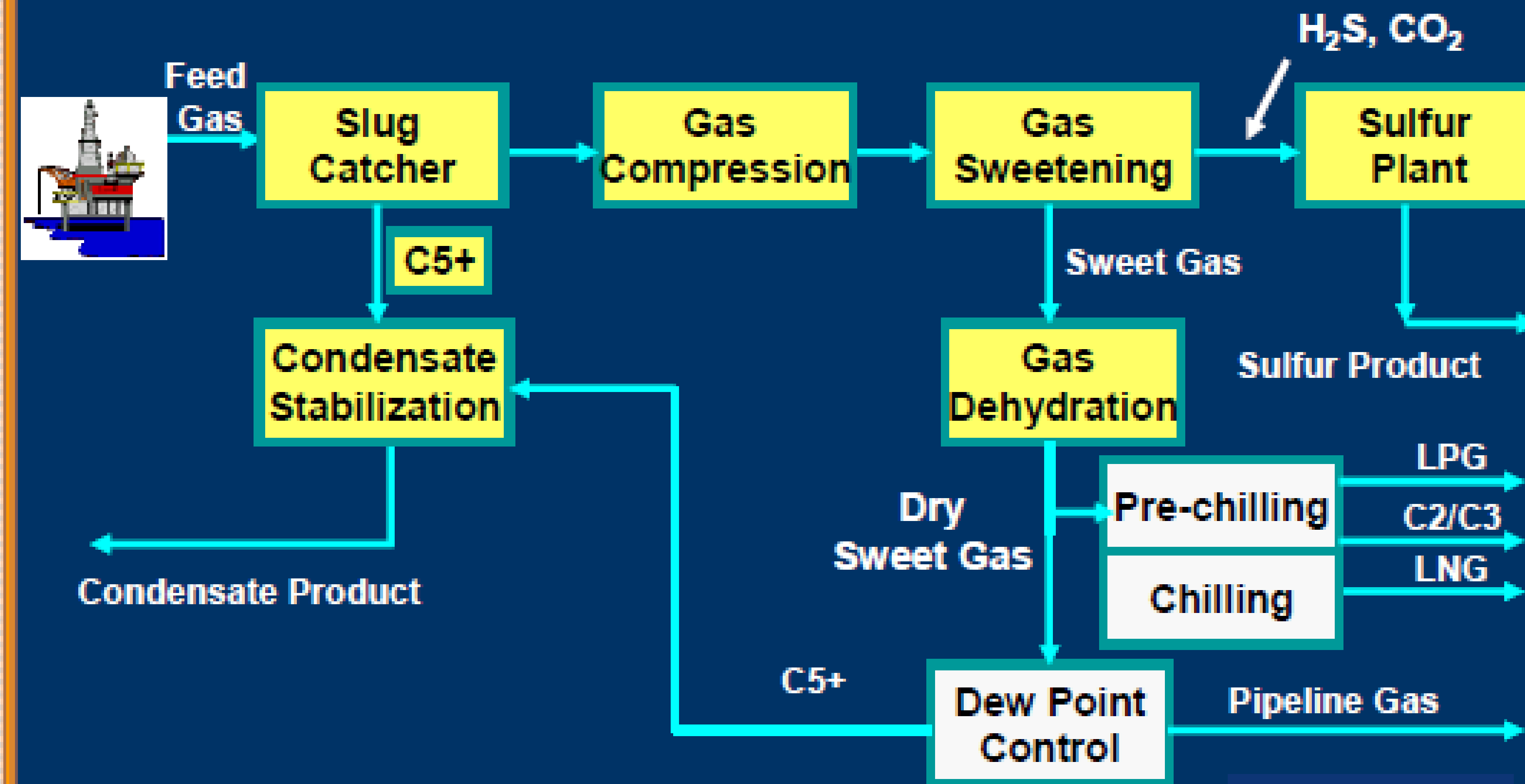
Dry (Solid) Bed Adsorption Processes

- Alumina, Silica Gel
- Molecular Sieve
  - Before chilling step
  - To make the gas bone dry

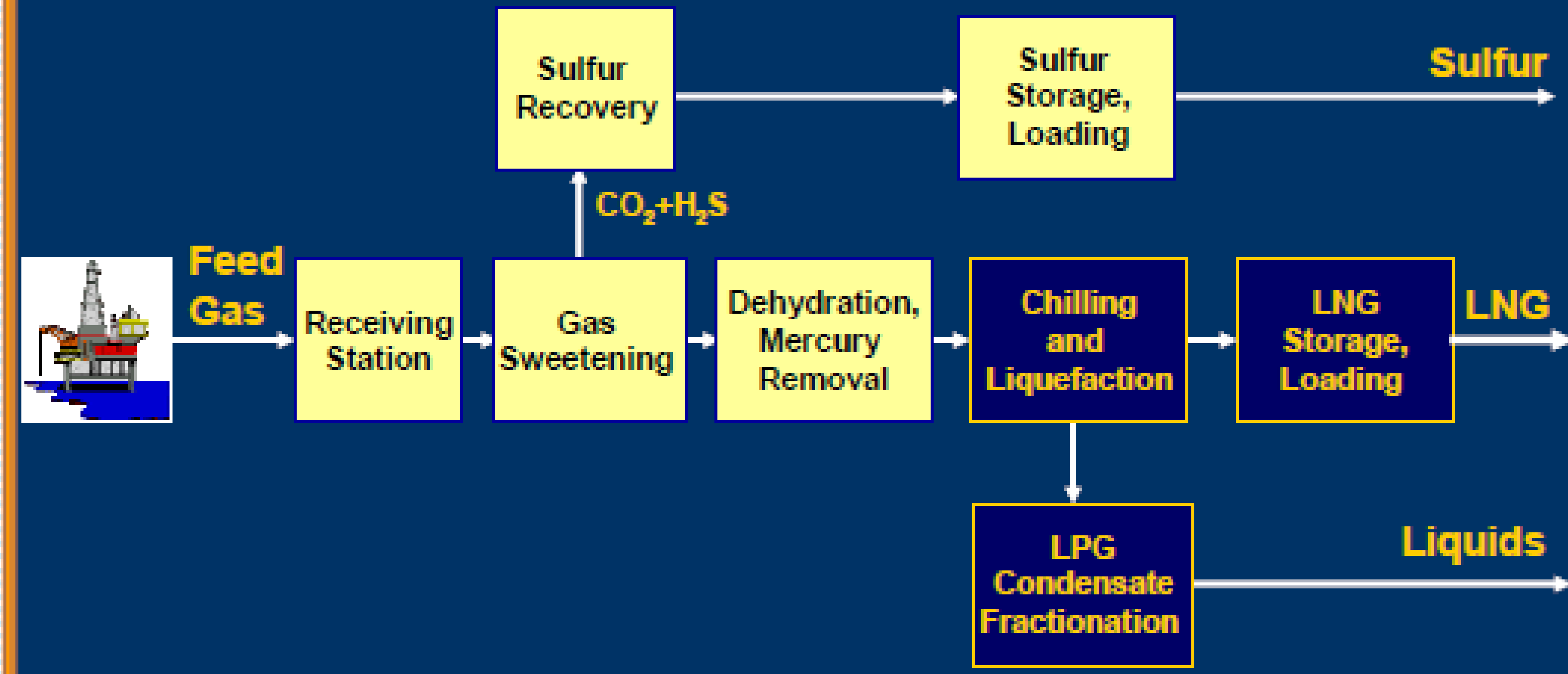


Gas Processing Blocks

Gas from Oil/Gas field → C1,C2,C3,C4, C5+, H_2S, CO_2



LNG Upstream - Block Diagram



LNG – Green and Safe

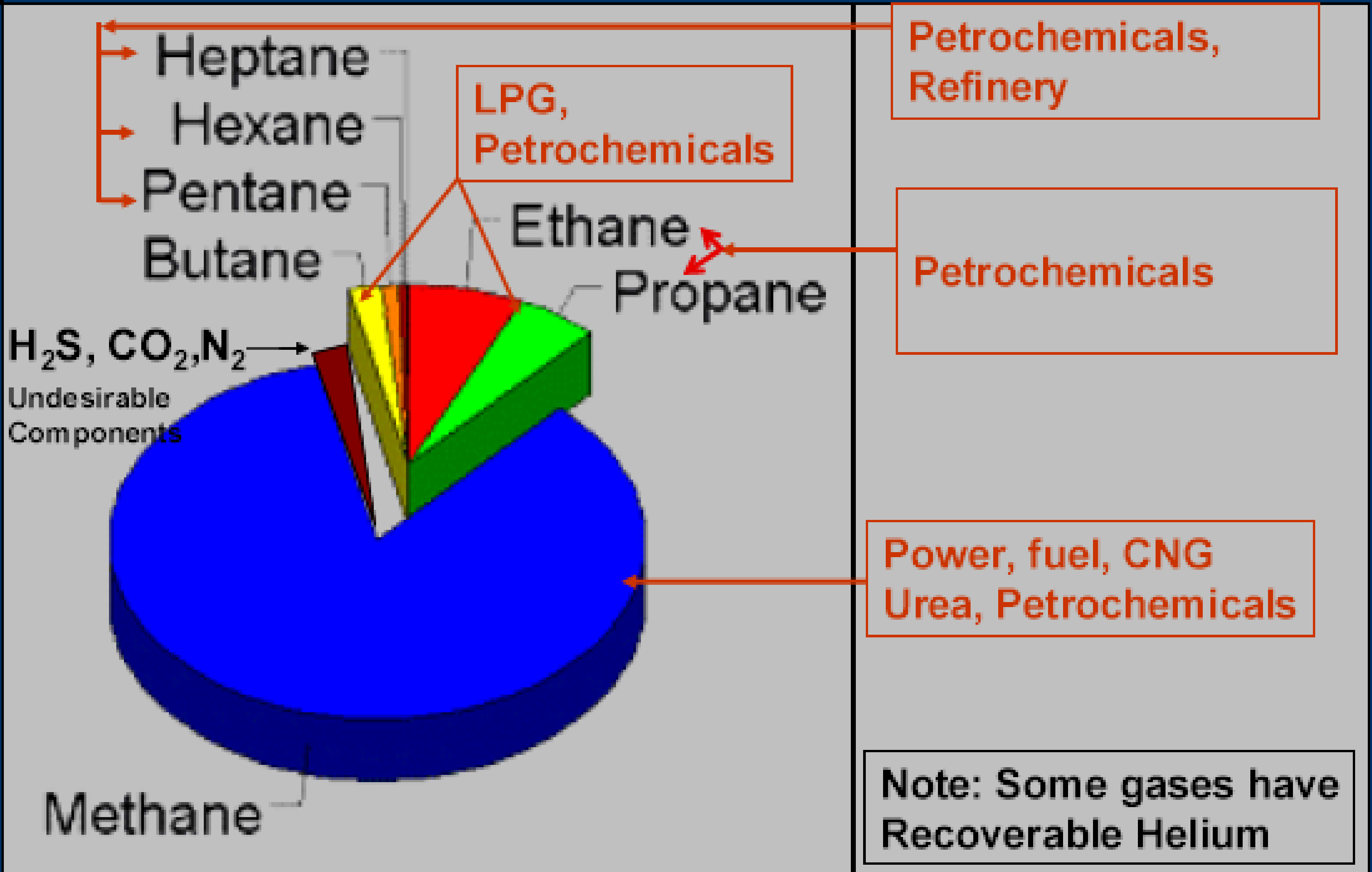
- LNG is ….
  - odorless,
  - non-toxic (harmful components removed)
  - and non-corrosive.
- Less dense than water - evaporates if spilled in ocean or water bodies.
- LNG vapors are lighter than air - less chance of ignition if emitted.
- LNG is not under pressure for shipping and storage. LNG does not explode.
- Natural gas burns more efficiently and cleaner than any other fuel. ..\..\Training Video LNG\LNG is Green and Safe.wmv

Natural Gas- Environment Friendly Fuel

- Fossil Fuel Emission Levels - Pounds per Billion Btu of Energy Input Pollutant

	Natural Gas	Oil	Coal
Carbon Dioxide	**117000**	164000	208000
Carbon Monoxide	**40**	33	208
Nitrogen Oxides	**92**	448	457
Sulfur Dioxide	**11**	1222	591
Particulates	**7**	842	744
Mercury	**0.0**	0.007	0.016

Natural Gas End Uses



Note: Some gases have Recoverable Helium

LIQUEFACTION OF NATURAL GAS

LIQUEFACTION OF NATURAL GAS

Major Steps Involved

- ✓ Gas Condensate Water Separation
- ✓ Gas Treatment
- ✓ Refrigeration (Gas Chilling)
- ✓ Flashing & Compression
- ✓ LNG Storage

REFRIGERATION SYSYEM

- ✓ Methane Cycle
- ✓ Nitrogen Cycle
- ✓ Cascade Refrigeration
- ✓ Mixed Refrigeration Process
- ✓ Turbo-expander Process

METHANE CYCLE

- ✓ High Pressure Compression (1000 Psia)
- ✓ Cooling (-10^0 c)
- ✓ Gas Expansion (-80^0 c)
- ✓ Separation of LNG and Gas
- ✓ Recovery of Refrigeration from - 80^0 c Gas
- ✓ Gas Compression & Recycle
- ✓ LNG Flashing (200 Psia to Atm Pressure)
- ✓ Vapor Recycle

NITROGEN CYCLE

- ✓ High Pressure Nitrogen Cooling (1200 Psia, - 30^0 C to - 90 ^{0} C)
- ✓ High Pressure Nitrogen Expansion (200 Psia, -162^0 C)
- ✓ Cooling of Natural Gas with Low Temp. Nitrogen in Cold Box
- ✓ Low Pressure Nitrogen Compression (200 Psia, 15^0 C to 1000 Psia , -75^0 C)
- ✓ HP LNG Expansion;

  - **LNG TO STORAGE TANK AT ATM. PRESSURE**
  - **LOW PRESSURE NATURAL GAS TO COLD BOX FOR REFRIGERATION RECOVERY**

TECHNOLOGIES FOR LIQUEFACTION

- ✓ APCI Propane Pre-Cooled mixed Refrigerant Process
- ✓ Philips Optimized Cascade Process
- ✓ Black & Veatch Prico Process
- ✓ Stat Oil / Linde Mixed Fluid Cascade Process
- ✓ Axens Liquefaction Process
- ✓ Shell Double Mixed Refrigerant Process

PROCESS SELECTION

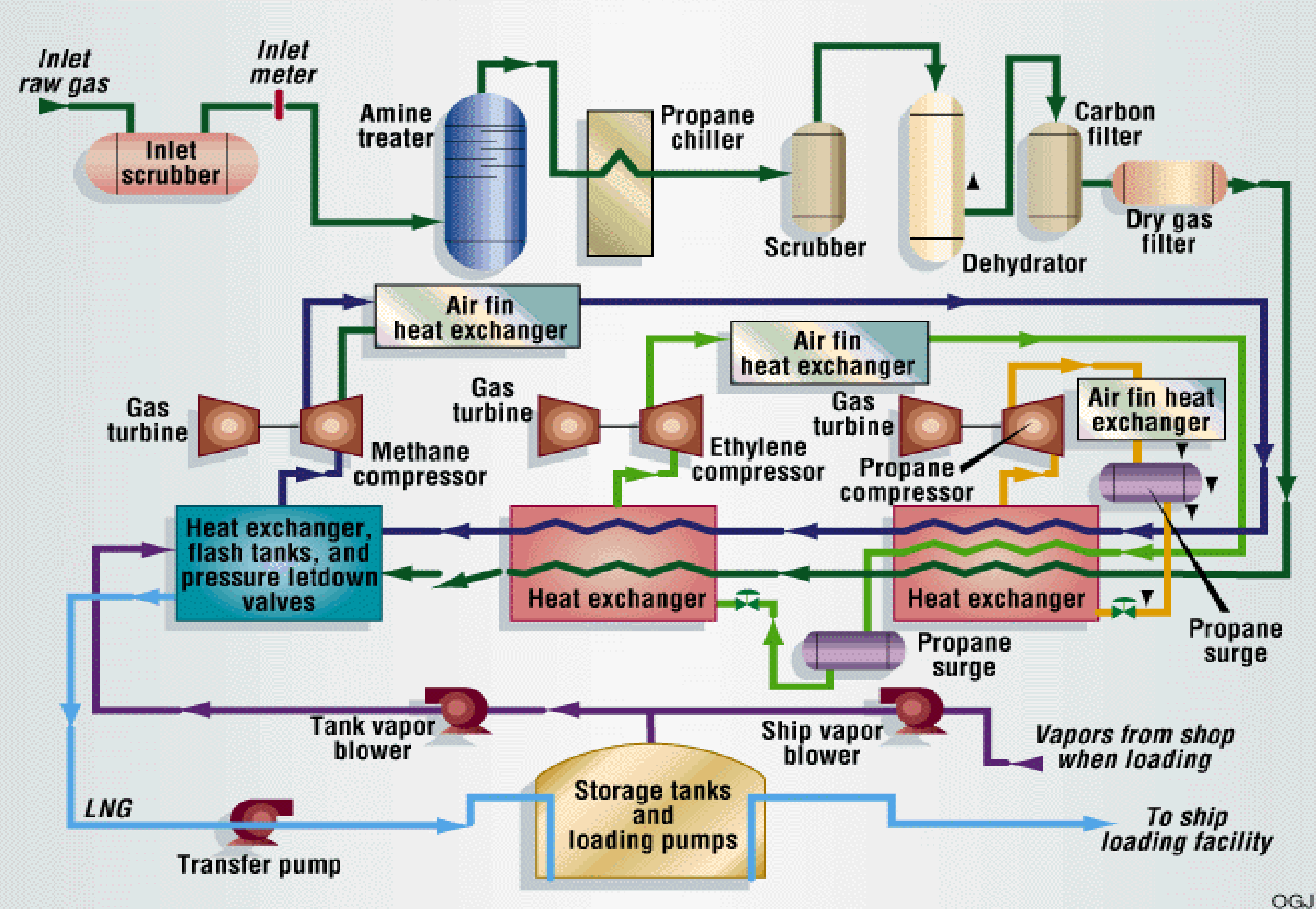
- ✓ Process Selection Based On The Technical & Economic Consideration
- ✓ Process And Equipment Selection Depends Upon;
  - ➢ Gas Pressure
  - ➢ Gas Composition
  - ➢ Ambient Conditions

LIQUIFACTION PLANTS

EQUIPMENTS USED; PROS & CONS

SPIRAL WOUND EXCHANGERS	ROBUST & FLEXIBLE IN OPERATION	PROPRIETARY & MORE EXPENSIVE
PLATE FIN HEAT EXCHANGERS	COMPETITIVE, LOW PRESSURE DROP AND GOOD TEMP. APPROACH	VULNERABLE TO PLANT UPSET. NEED CAREFULL DESIGN. NOT SUITABLE FOR HP APPLICATIONS
AXIAL COMPRESSORS	PROVEN EFFCIENT COST EFFECTIVE	SUITABLE FOR HIGH CAPACITY
GAS TURBINES	PROVEN EFFCIENT COST EFFECTIVE	STRICT MAINTENANCE CYCLE COMPLICATED CONTROL SYSTEM
LARGE MOTOR DRIVERS	EFFICIENT FLEXIBLE	NORMALLY NOT TRIED IN LNG REQUIRE VERY LARGE POWER PLANT
AIR COOLING (compared to water)	LOWER CAPITAL COST MORE SUITABLE WHERE AMB. TEMP. IS LOW)	LESS EFFICIENT HIGH OPERATING COST

Phillips optimized cascade LNG process



Thank You