LNG Plant Overview

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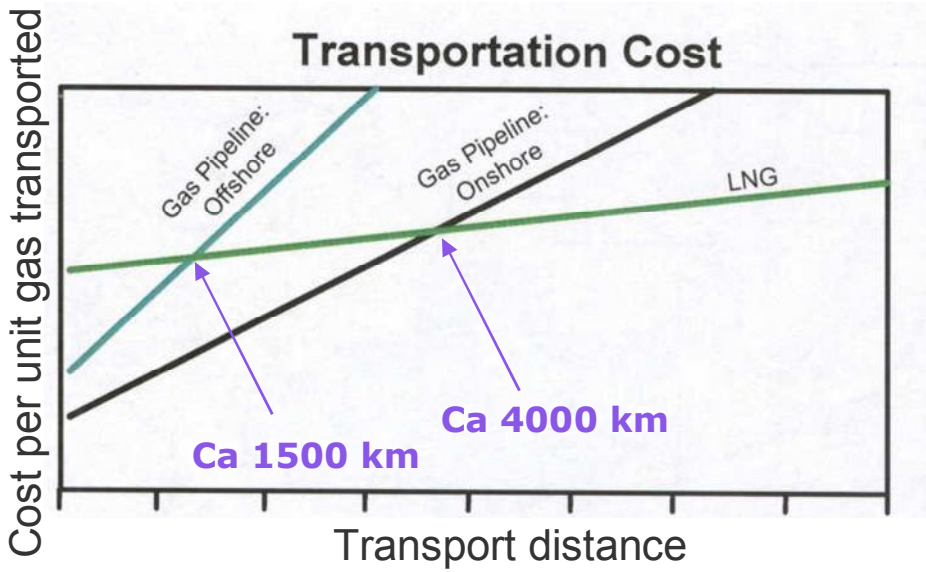
Why produce Liquefied Natural Gas (LNG)?

LNG is mainly produced for transportation purposes

- **Gas market is far from the source of the natural gas: More economical to transport the gas as LNG instead of in a natural gas pipeline.**
- **LNG also offers greater flexibility than pipeline gas**



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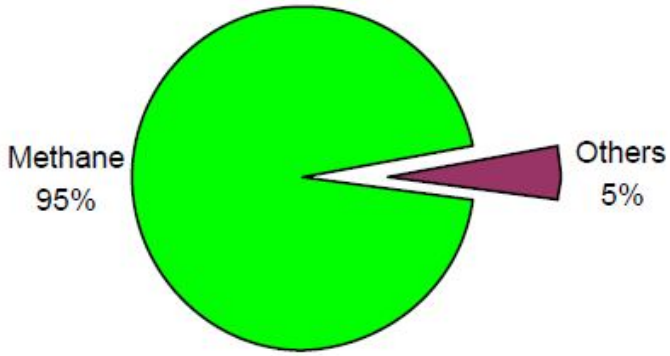
What is LNG ?

LNG is a cryogenic liquid

A cryogenic liquid liquefies at a temperature below –73 °C (-100 °F) at atmospheric pressure.

Common cryogenic liquids are; Nitrogen, Oxygen, Helium, Hydrogen and LNG

- LNG is natural gas that has been cooled and condensed to a liquid
- At atmospheric pressure LNG has a temperature of about –162ºC
- LNG contains about 85-95 % methane
- LNG is colorless, odorless, non-corrosive and non-toxic
- Evaporated LNG can displace oxygen and cause human suffocation
- Flammability range, 5-15 vol % concentration in air
- Autoignition temperature, 540°C



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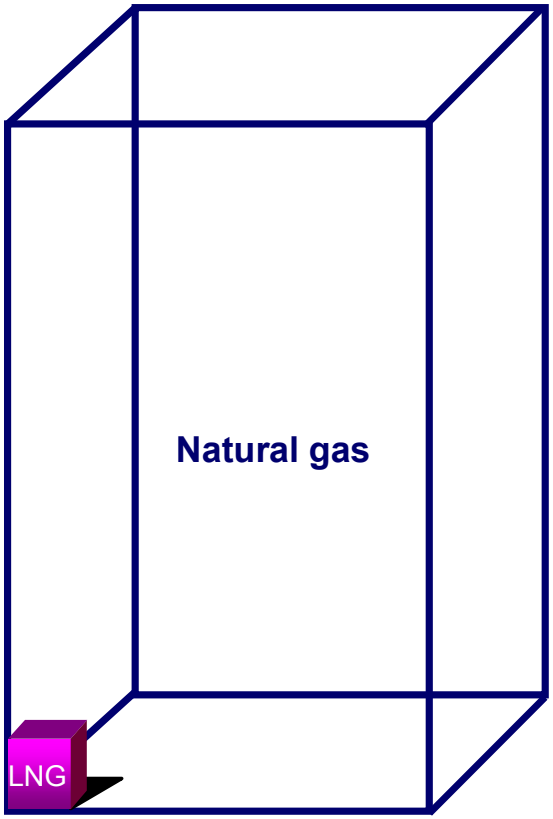
LNG Density



1 m^3 LNG corresponds to ca 600 Sm^3 natural gas

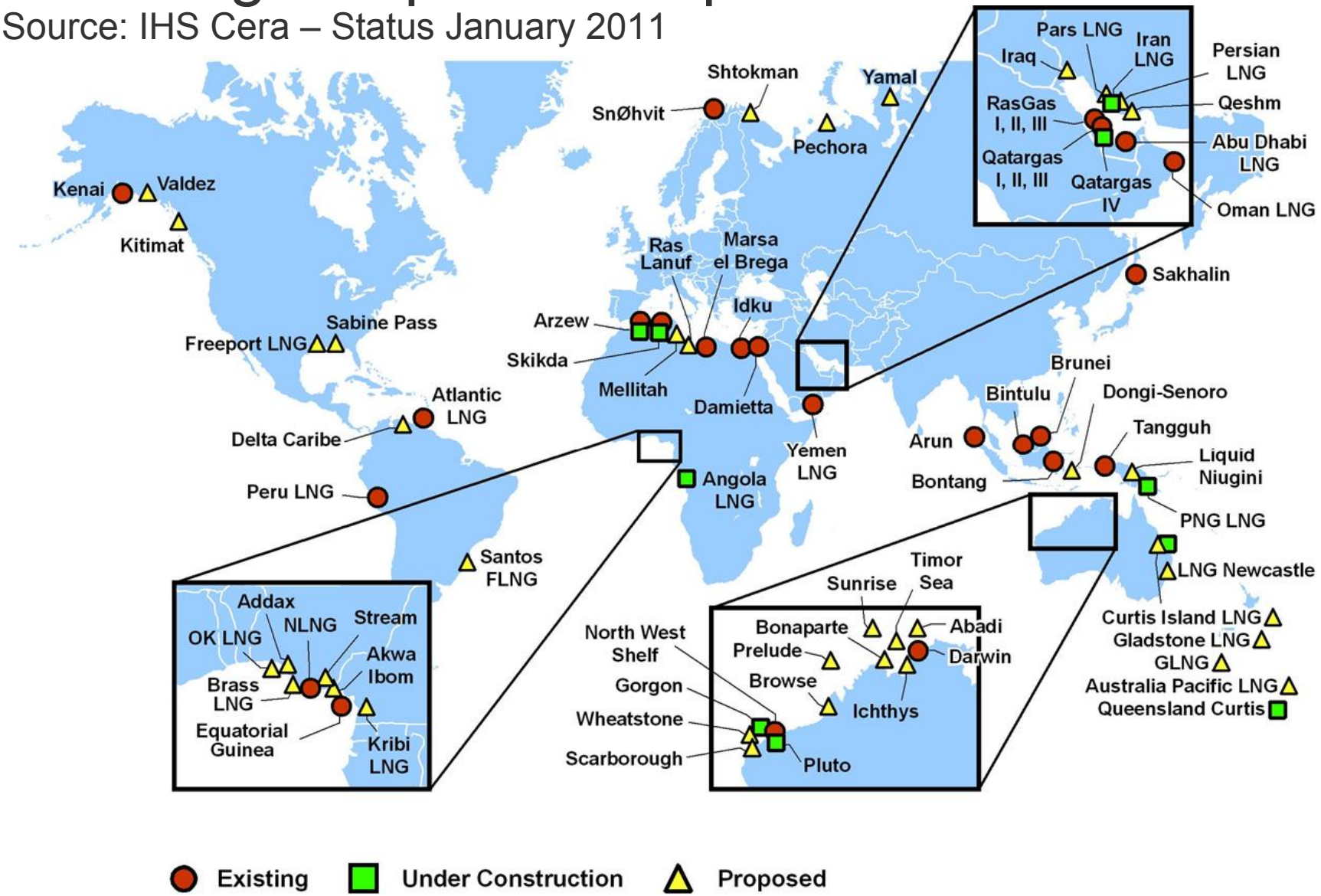
S = Standard state, 15°C, 1 atm

At temperatures above -110 ºC LNG vapour is lighter than air

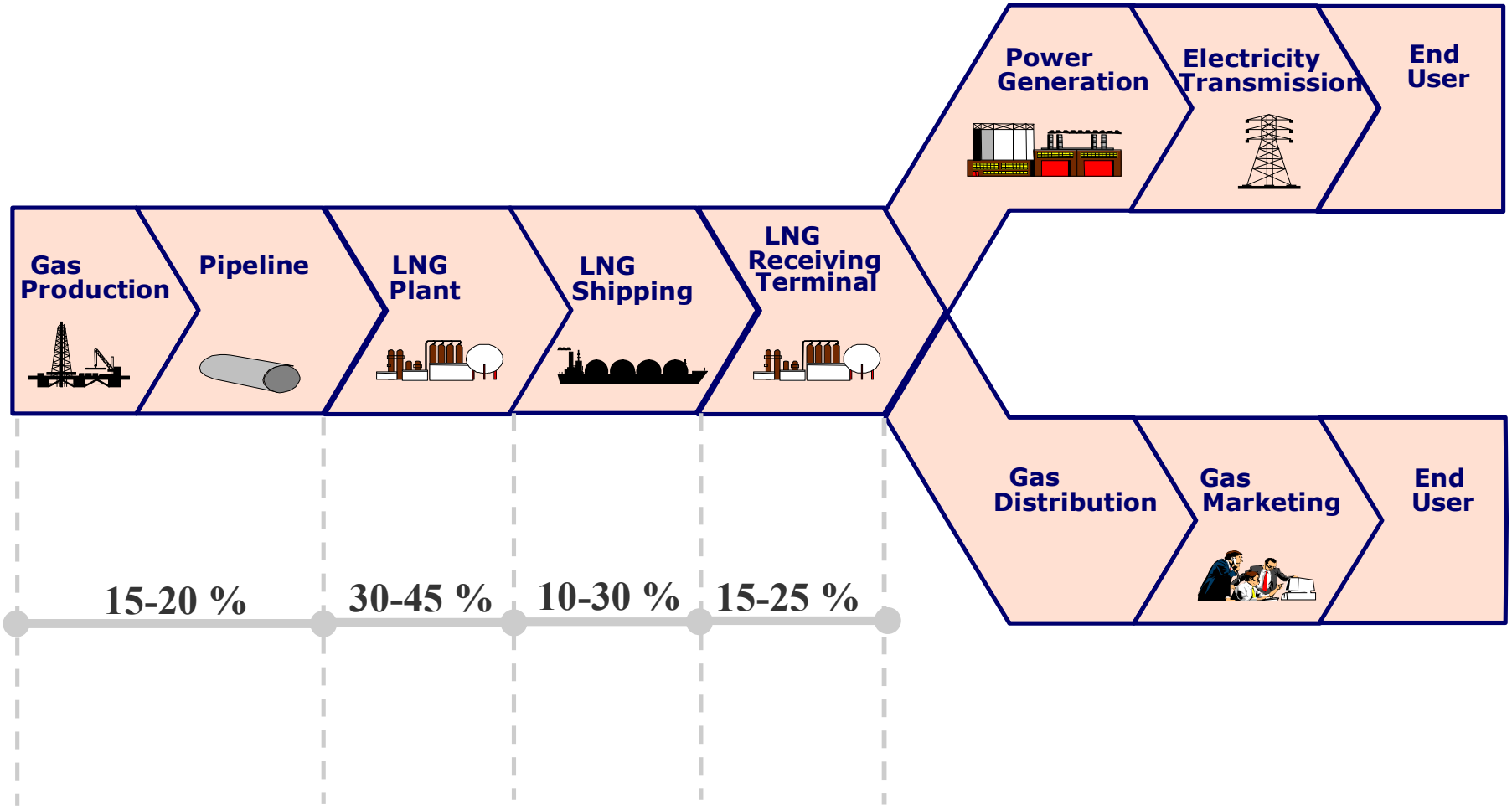
LNG is lighter than water
LNG Density: 450 kg/m^3
Water density: 1000 kg/m^3

Natural gas liquefaction plants

Source: IHS Cera – Status January 2011



LNG Value Chain



Typical cost Distribution in the LNG value Chain – (numbers are confirmed by different sources)

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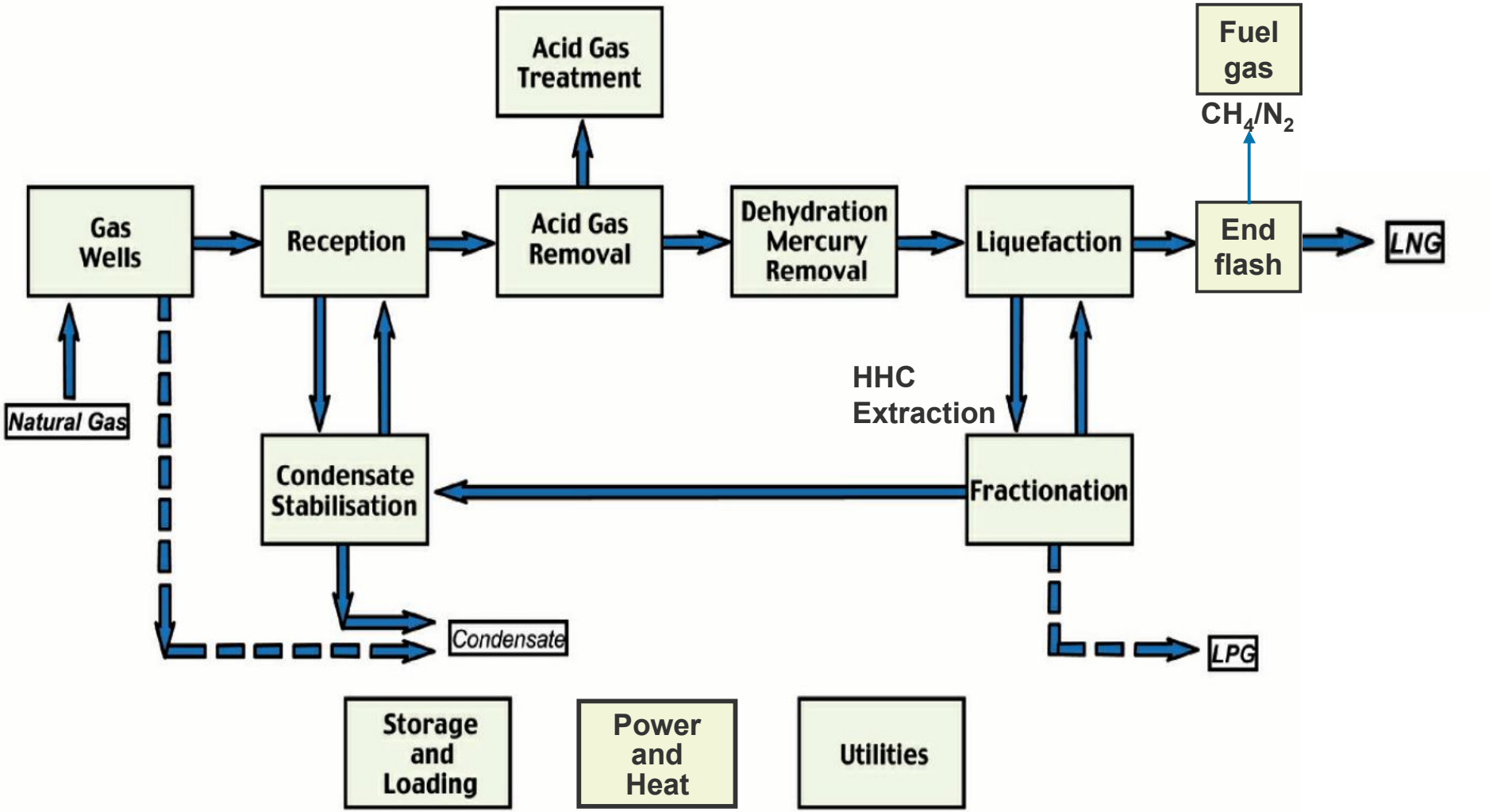
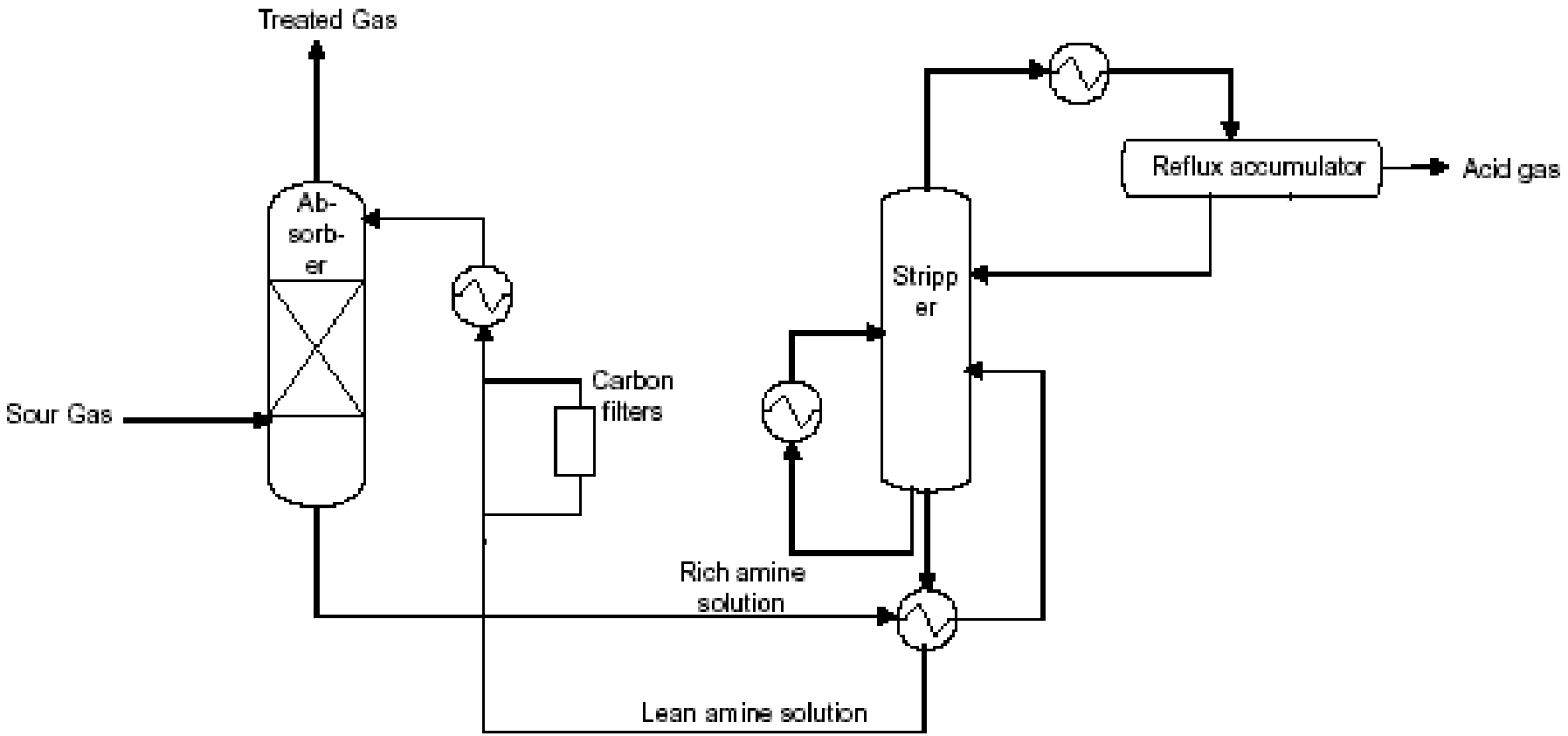
LNG plant block diagram



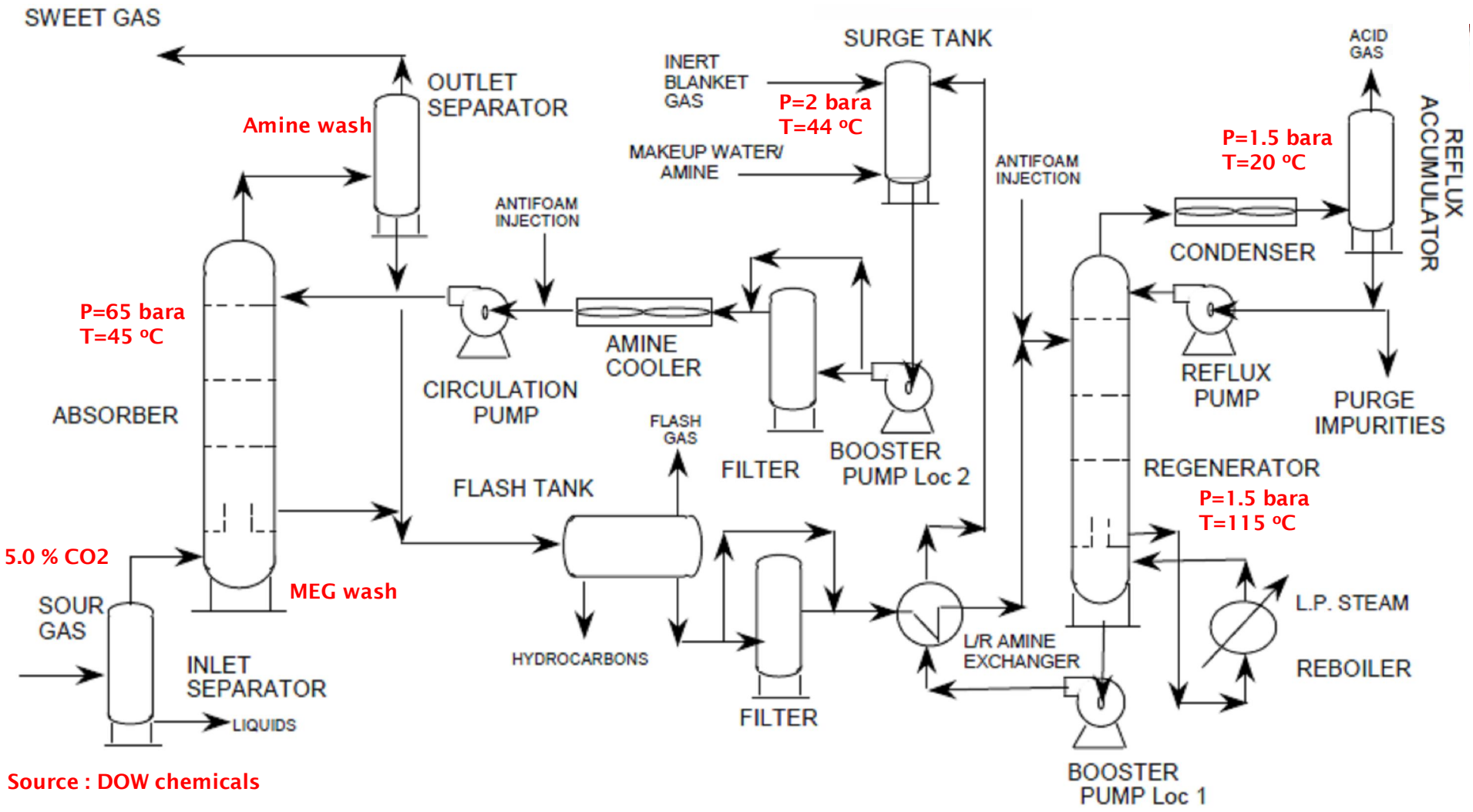
Gas conditioning (pre-treatment)

- Acid Gas (CO_2 and H_2S) removal
  - Acid gas causes corrosion, reduces heating value, and may freeze and create solids in cryogenic process
  - Typical requirements for LNG: Max 50 ppmv CO_2, Max 4 ppmv H_2S (ppmv - parts per million by volume)
- Dehydration (water removal)
  - Water will freeze in cryogenic process
  - Typical requirement: Max 1 ppmw (weight) H_2O
- Mercury removal
  - Mercury can cause corrosion problems, especially in aluminium heat exchangers
  - Requirement: Max 0.01 $\mu g/Nm^3$

MDEA (Amine) process for acid gas removal

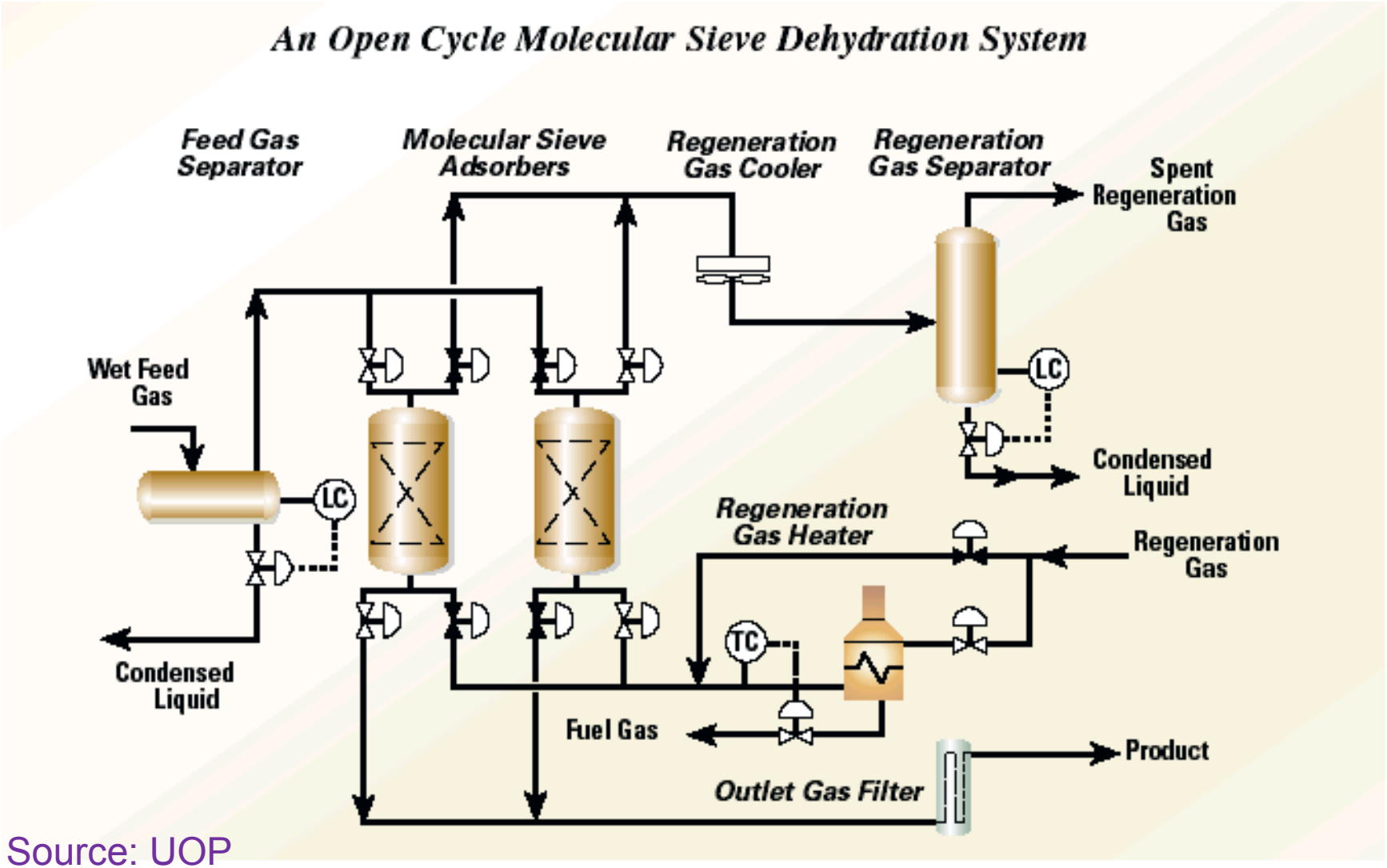


Typical amine sour gas removal process



Source : DOW chemicals

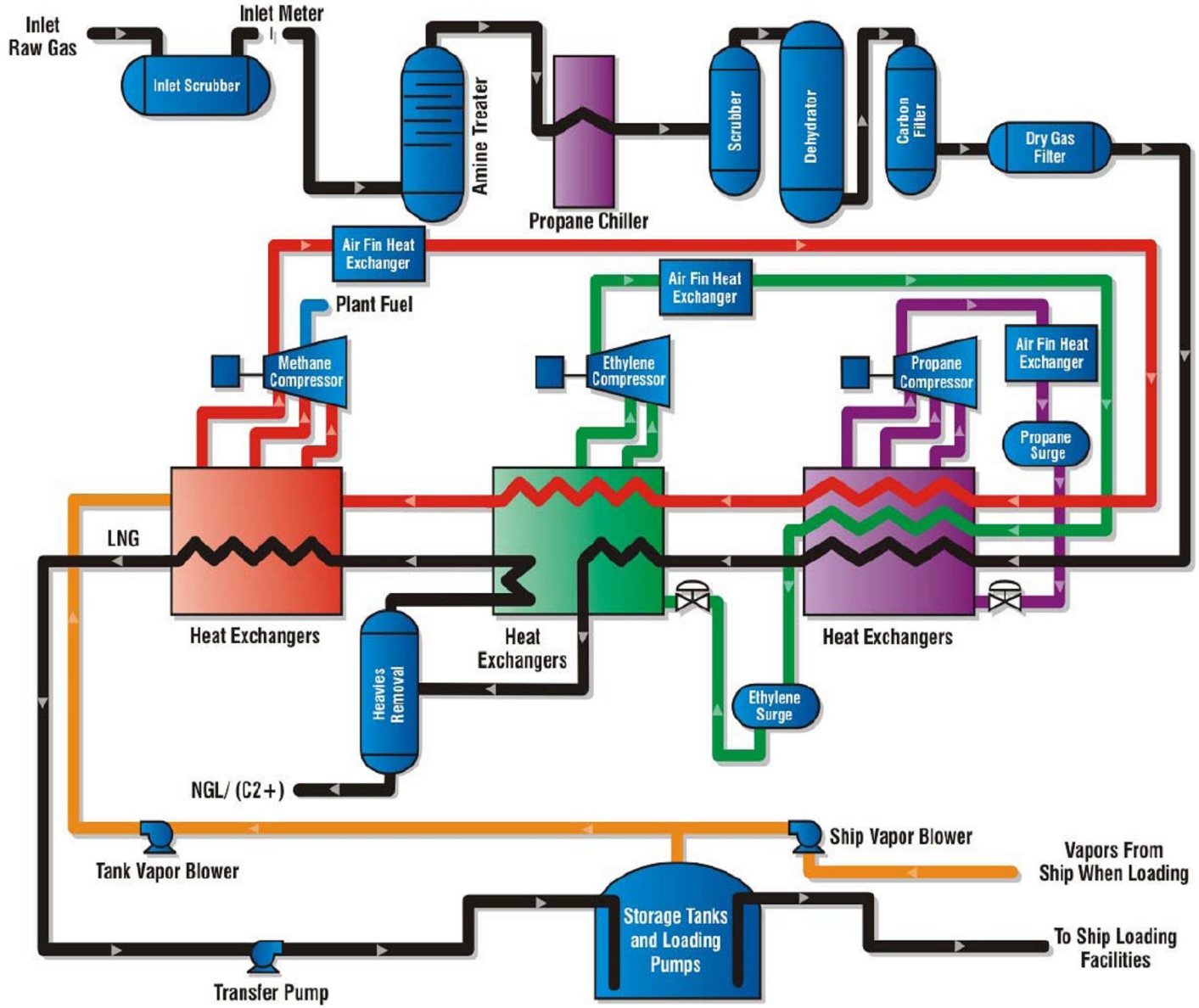
Water removal by adsorption



Source: UOP

Cascade Liquefaction Process

(Licensor: ConocoPhillips)



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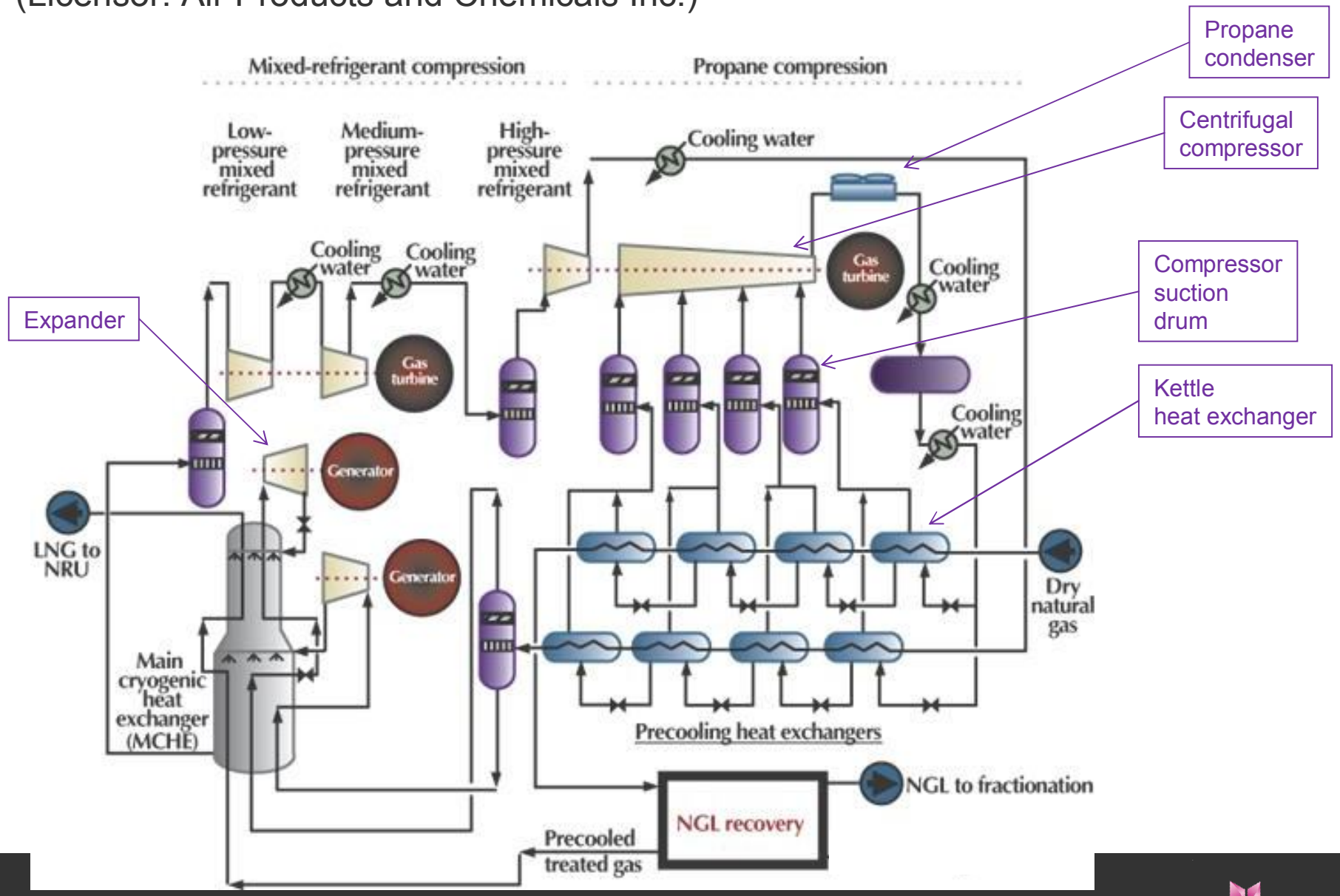
Propane-precooled Mixed Refrigerant Process (C3MR)

(Licensor: Air Products and Chemicals Inc.)



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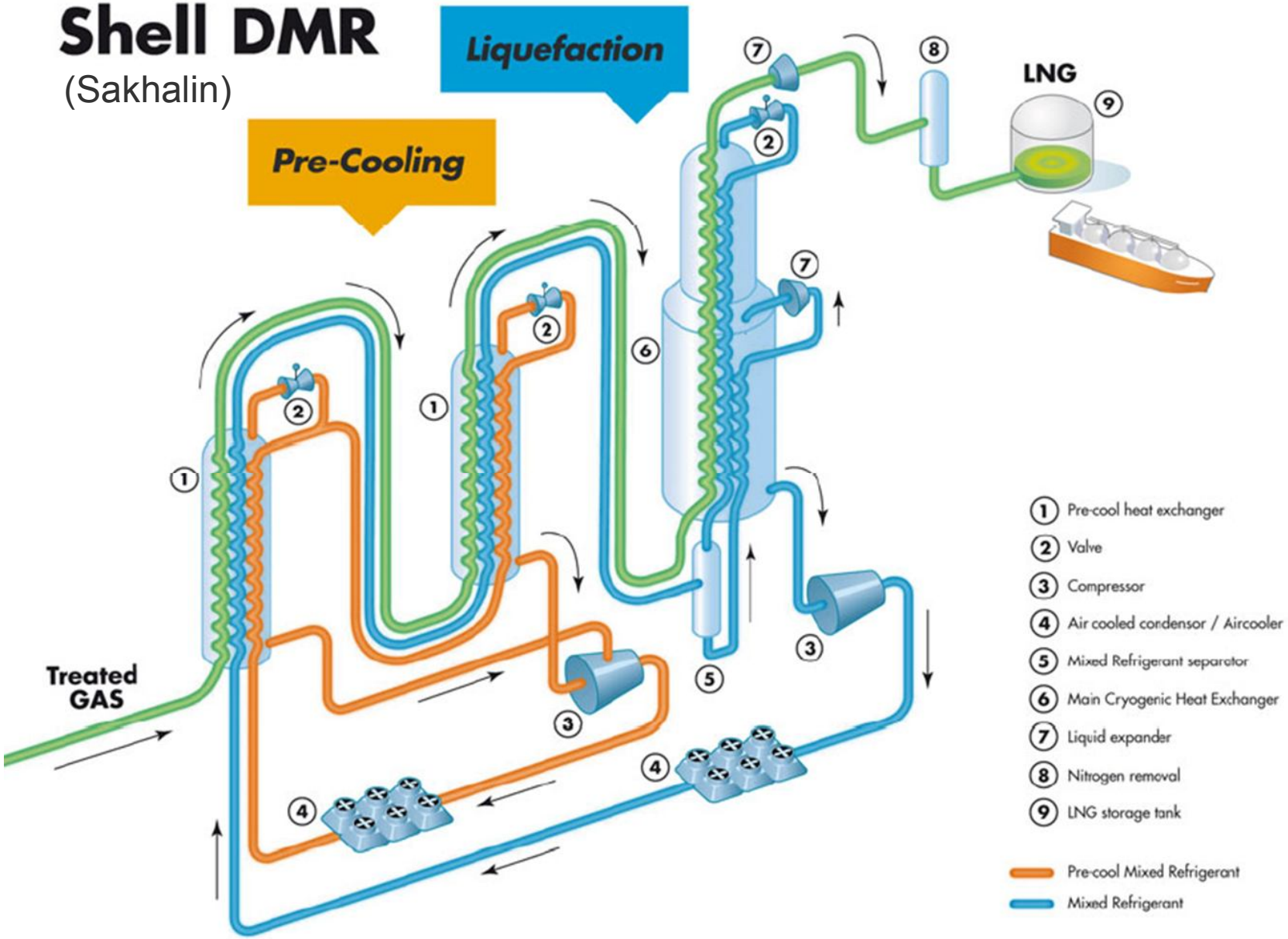
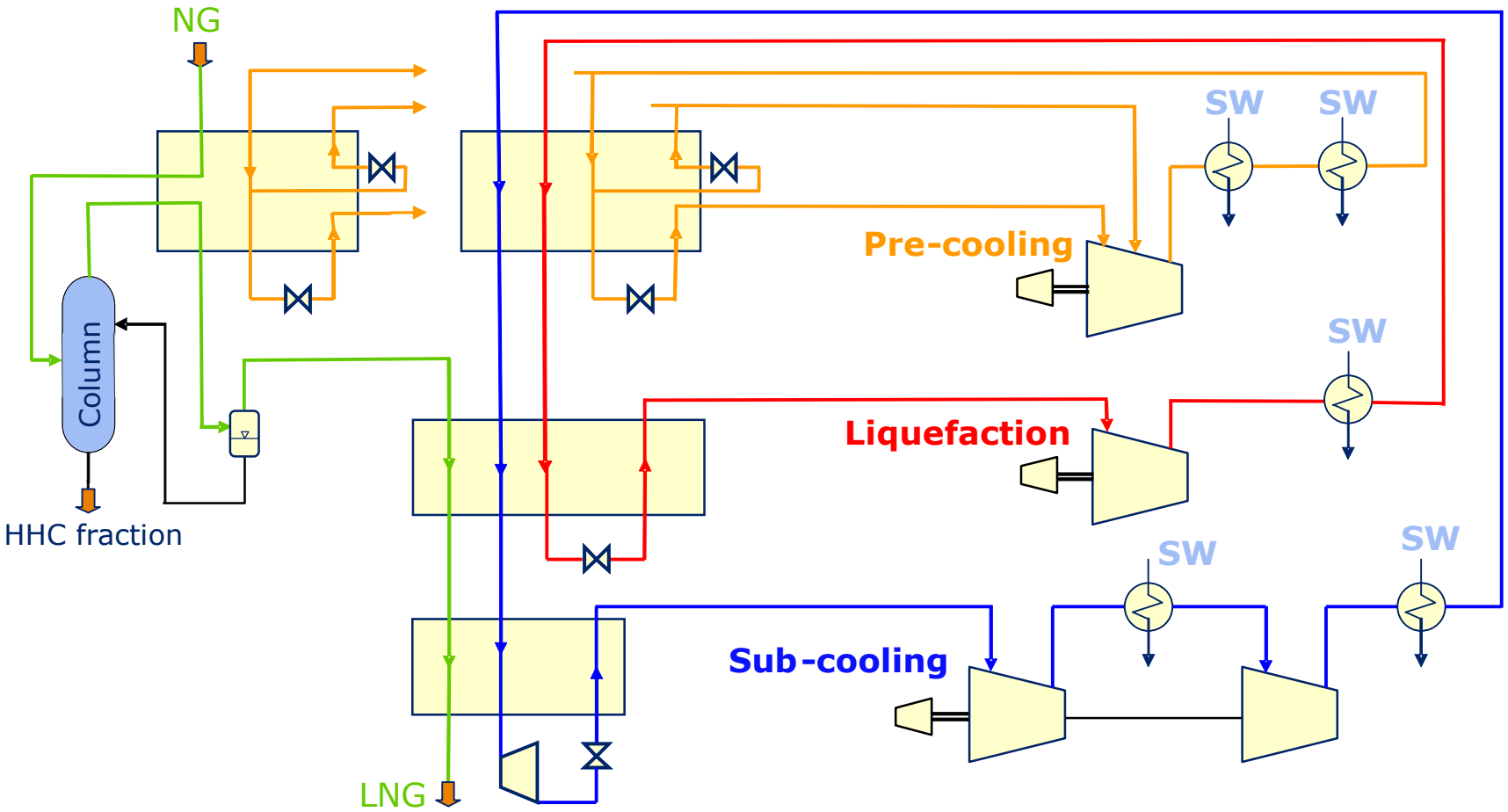
Shell DMR

(Sakhalin)



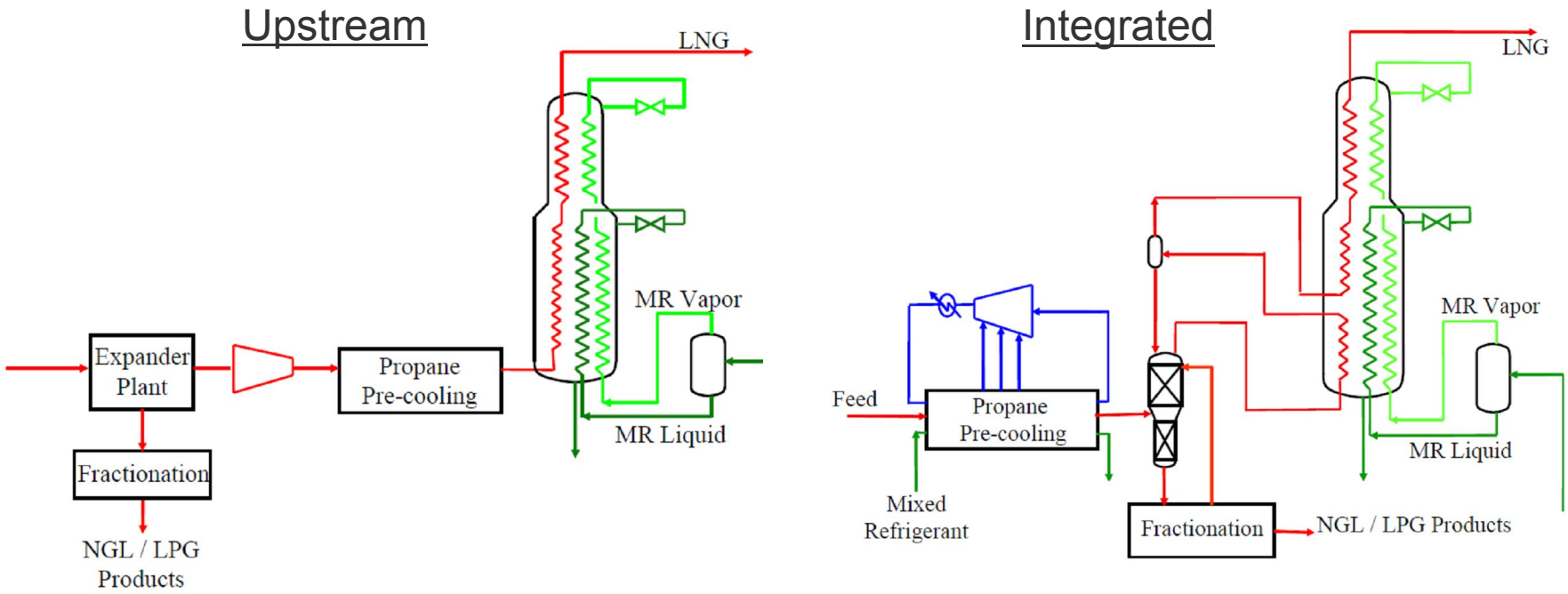
Mixed Fluid Cascade Process (Linde)

(Hammerfest LNG plant)



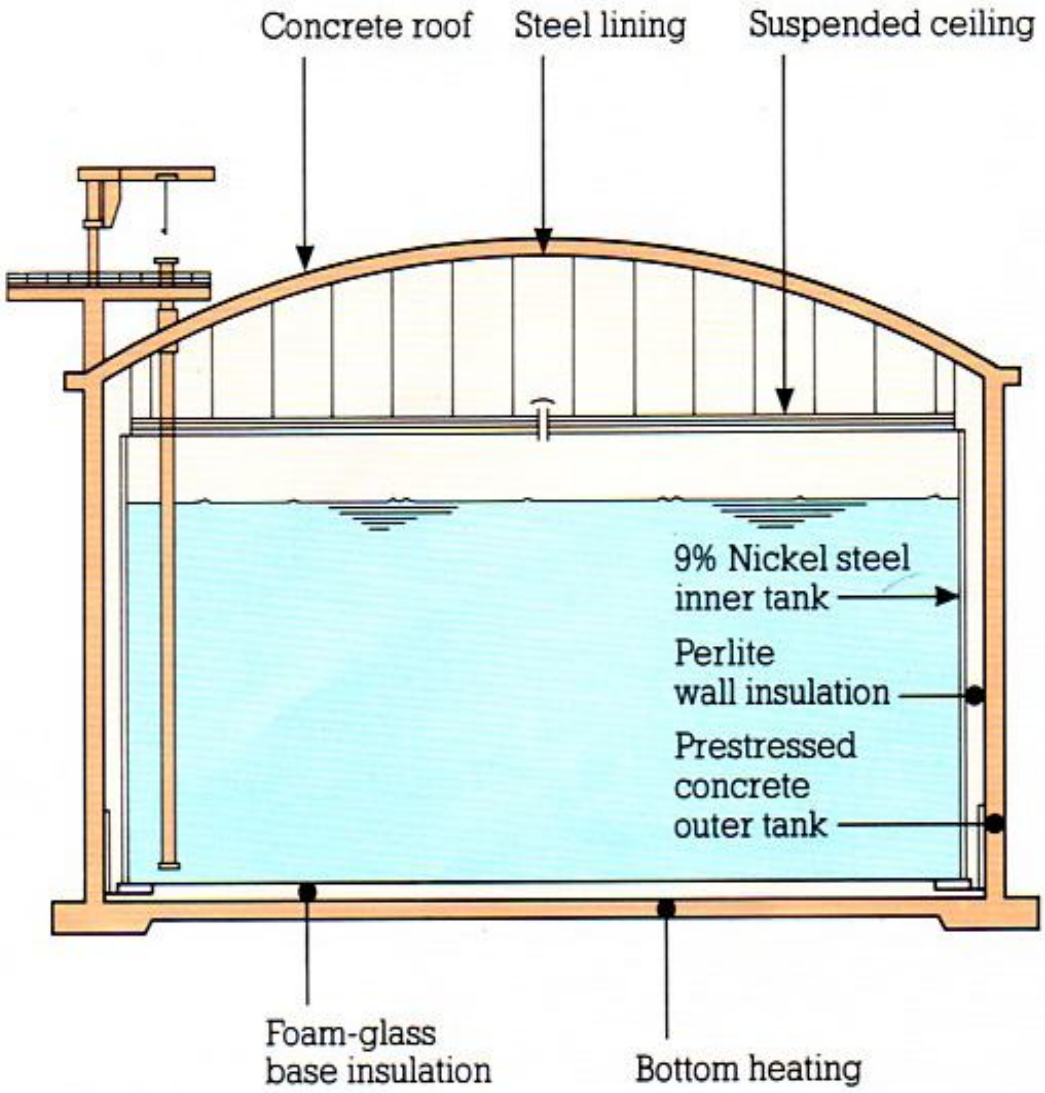
LPG extraction

(Example based on C3MR process, Source: Air Products)



- Why LPG extraction?:i) LNG heating value adjustment, ii) remove components that may freeze out in liquefaction process, iii) generate valuable LPG product, iv) produce refrigerant make-up (C1, C2, C3)
- Upstream LPG extraction usually based on expander process. Can provide ”deep” extraction of C3 and C2. Feedgas need to be recompressed before liquefaction. Liquefaction pressure can be high.
- Integrated process usually based on scrub column – i.e. feed gas pressure need to be sub critical. Scrub column reflux temperature determines degree of extraction. Pressure restricted by p_{crit}

Above-ground full-containment LNG tank design



- Pre-stressed concrete outer walls constructed by slipforming, sheathed internally with a gas-tight layer of nickel-alloyed steel.
- Inner tank in nickel-alloyed steel, separated from the outer walls by a layer of perlite - a variety of volcanic obsidian highly suitable for insulation
- Extra layer of steel and insulation at the transition between outer wall and tank bottom to protect it against strong local stresses should the inner tank begin to leak.
- Heating cables under the tanks will ensure that the ground remains above 0°C in order to prevent frost heaving.

Loading of LNG Carrier

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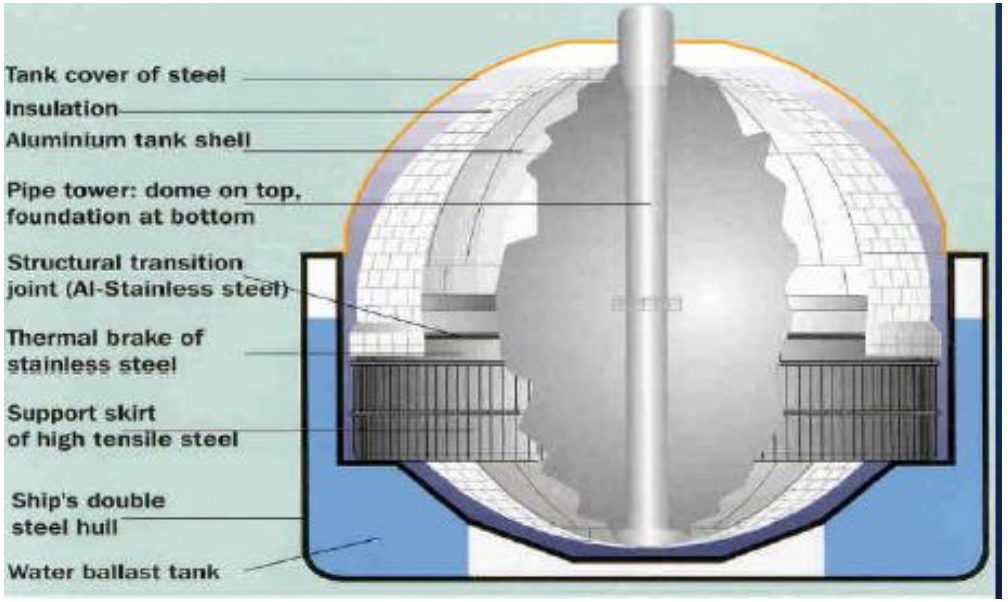
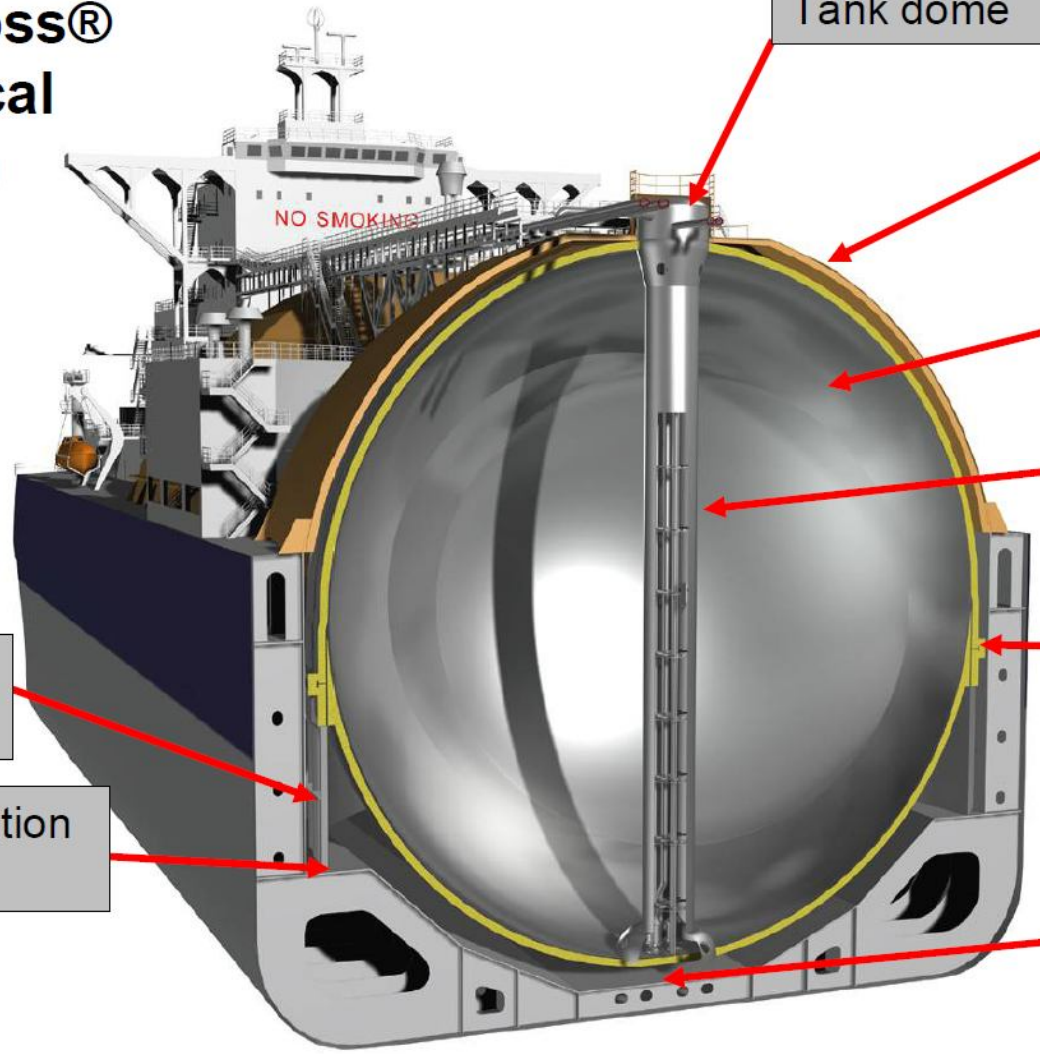
Spherical tank cargo containment systems (Moss Rosenberg)



Moss spherical LNG tank – key elements

The Moss® spherical system



Tank dome

Steel tank cover

Tank plating = primary barrier

Pipe tower

Insulation (outside)

Drip tray (partial 2nd barrier)

Cylindrical skirt

Steel foundation deck

A compa

Eni Sai

mossmaritime

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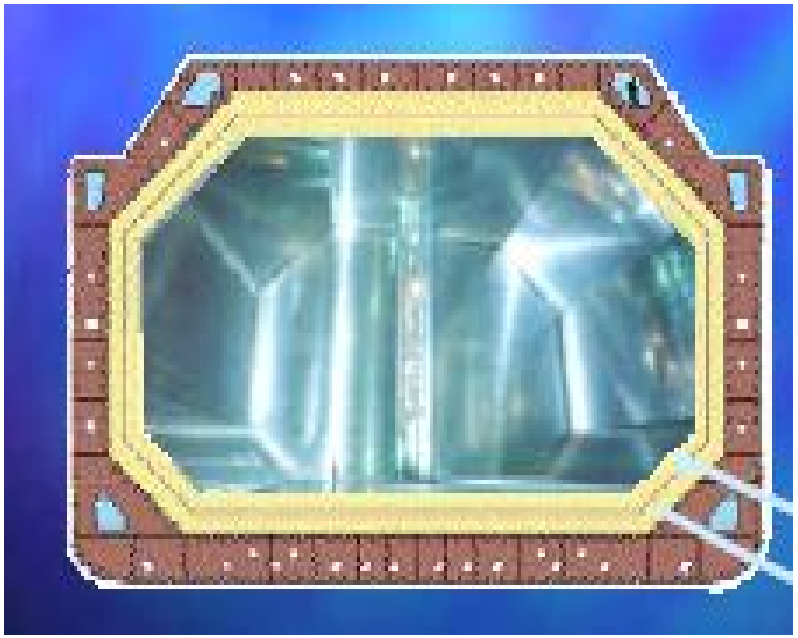
LNGC – Membrane cargo containment system (GT No. 96, MK I and MK III, and CS1)



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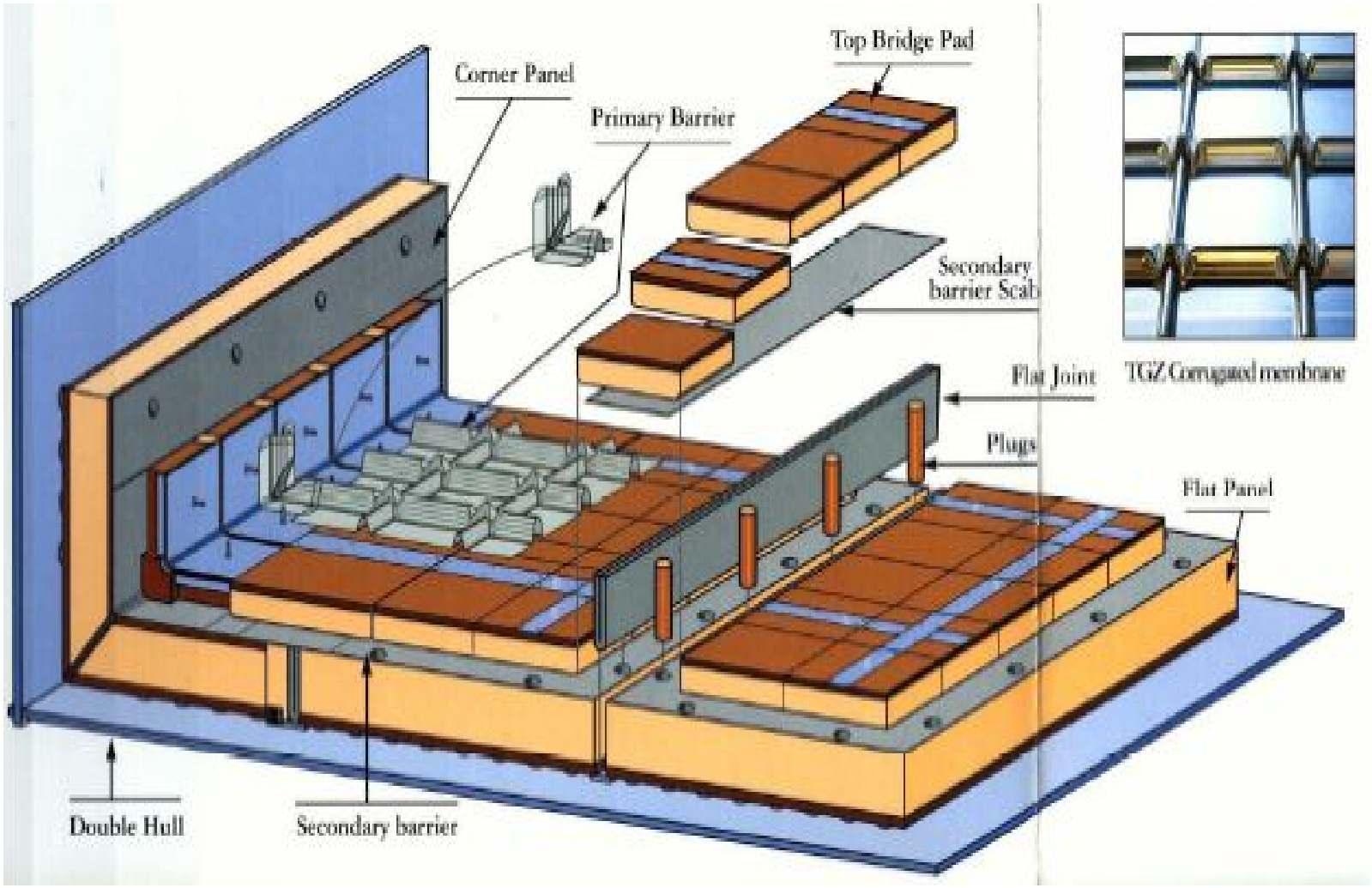
Mark III (Technigaz) Membrane system



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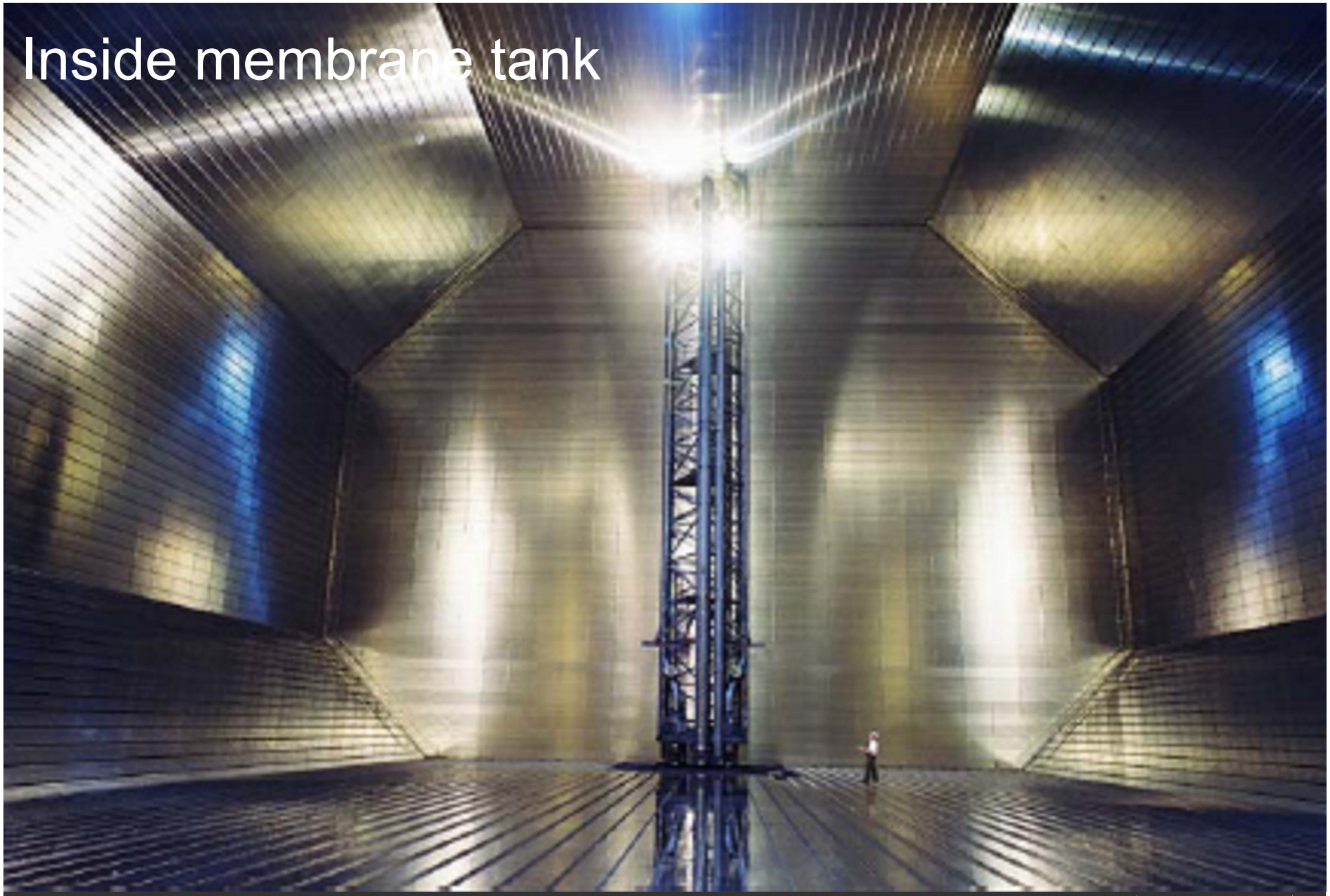
Inside membrane tank



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Hammerfest LNG Plant – Melkøya

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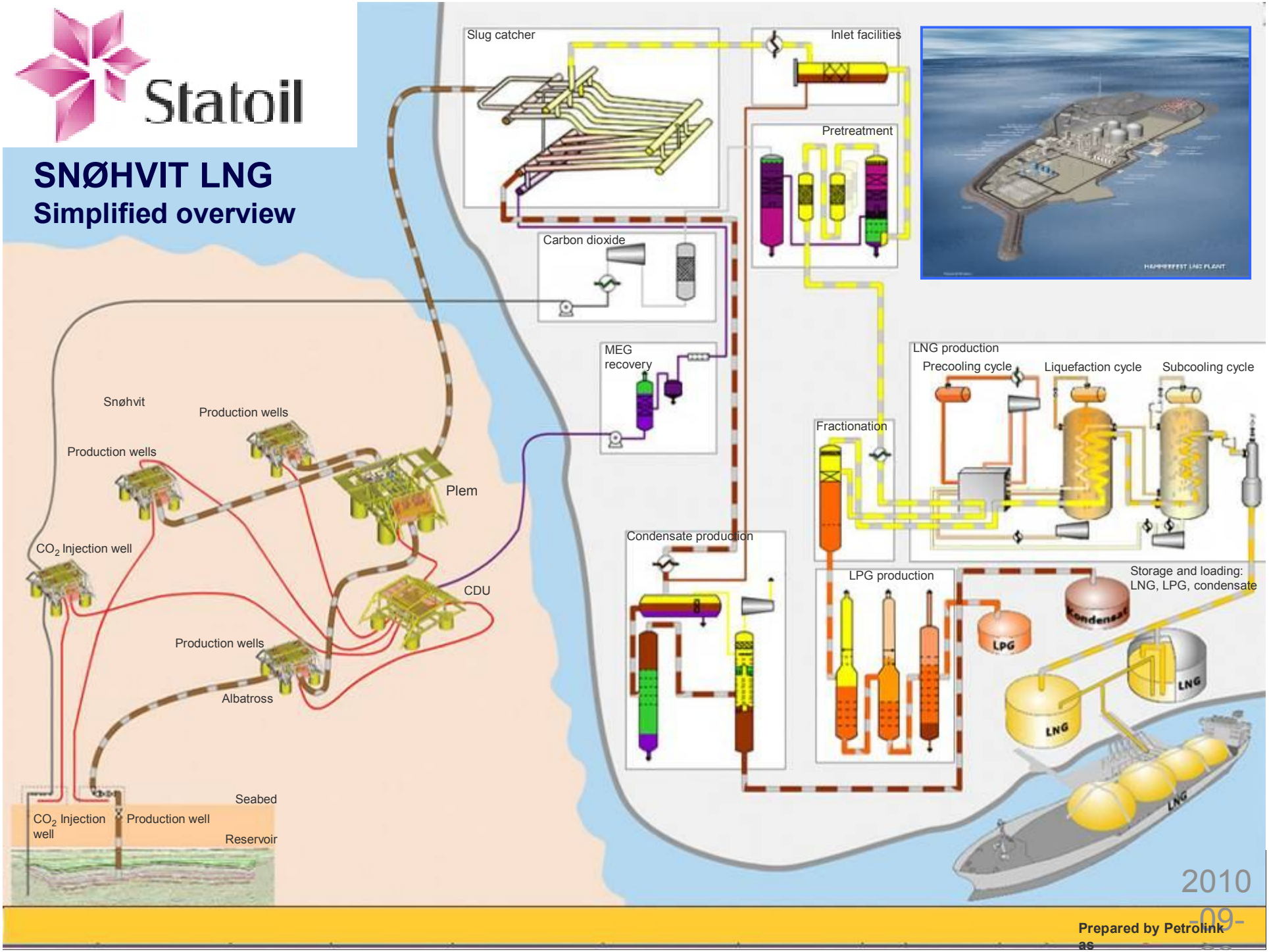
SNØHVIT LNG
Simplified overview



2010

Hammerfest LNG onshore plant

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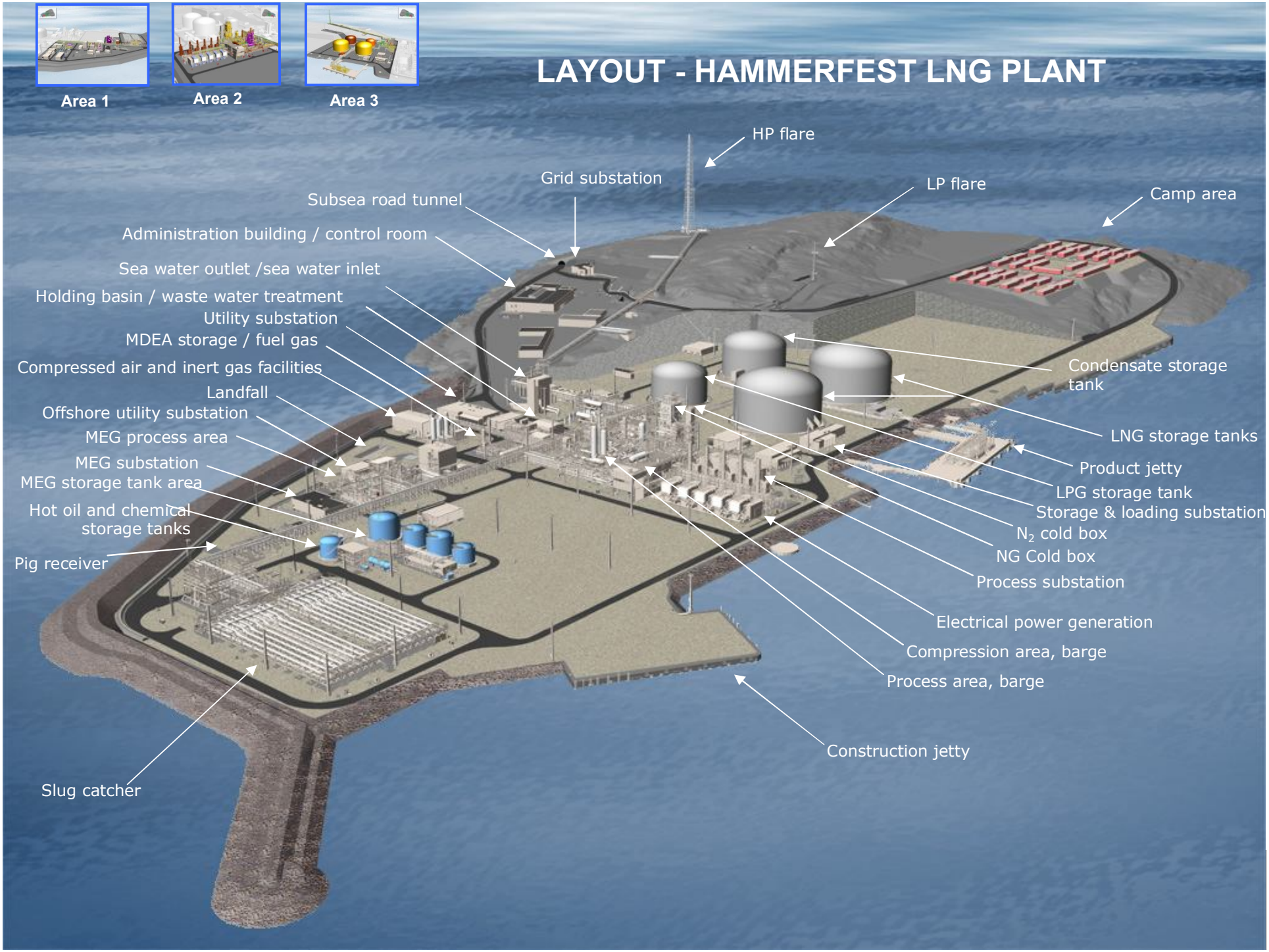
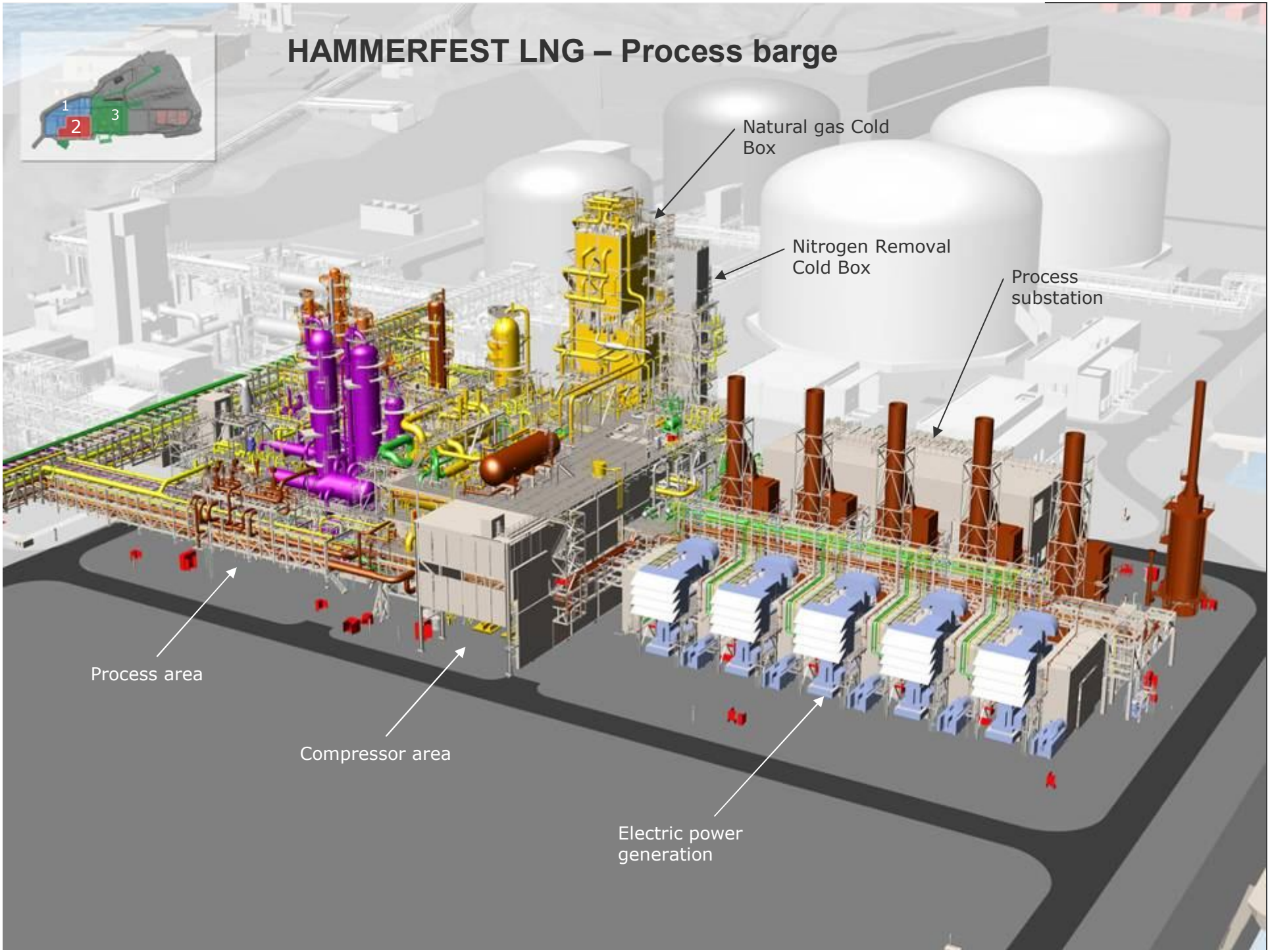

Area 1
Area 2
Area 3
LAYOUT - HAMMERFEST LNG PLANT
HP flare
Grid substation
LP flare
Camp area
Subsea road tunnel
Administration building / control room
Sea water outlet /sea water inlet
Holding basin / waste water treatment
Utility substation
MDEA storage / fuel gas
Compressed air and inert gas facilities
Landfall
Offshore utility substation
MEG process area
MEG substation
MEG storage tank area
Hot oil and chemical storage tanks
Pig receiver
Slug catcher
Condensate storage tank
LNG storage tanks
Product jetty
LPG storage tank
Storage & loading substation
N_2 cold box
NG Cold box
Process substation
Electrical power generation
Compression area, barge
Process area, barge
Construction jetty

HAMMERFEST LNG – Process barge



Atlantic LNG - Trinidad

Source: www.comenco.it

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Darwin LNG (Australia)

Source: www.lngfacts.org

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Yemen LNG

Sources:
www.yemenlng.com
www.yemenfox.net
www.nationalyemen.com

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Oman LNG

Source: www.ebaraintl.com

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Sakhalin LNG

Source: www.gazprom-sh.nl

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There's never been a better time for good ideas

LNG Plant Overview

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