Serving the LNG Industry

Overview of Gas Treatment and Liquefaction Processes

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Presentation Outline

- Summary of the different components making up an LNG export facility and liquefaction process
- Application of different process technologies and emerging trends

Components of an LNG export facility

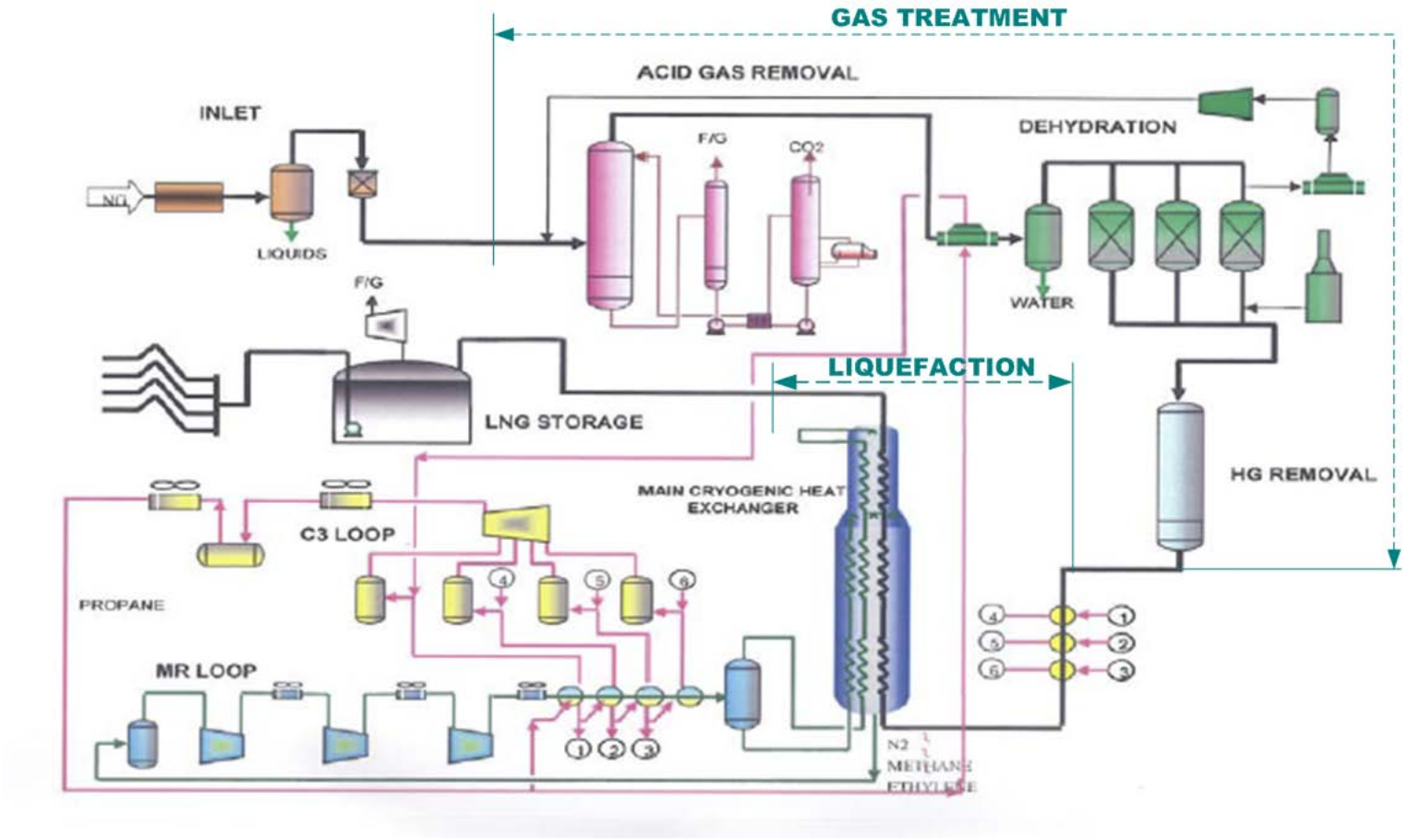
- Plant inlet: receipt of gas from upstream production facilities
- Gas treatment units: removes NGLs, CO2, H2S, H2O and Hg
- Liquefaction : cool and liquefy treated gas
- Storage tanks in BC (LNG, condensate): provides buffer storage
- Jetty and berth: ship loading facilities
- Utilities: power, nitrogen, instrument air, fire water, etc.
- Offsites: flares

Most of the impurities found in the plant inlet gas would freeze at low temperatures in the liquefaction process so they must be largely removed

- LNG facilities require a high degree of impurity removal to avoid freezing in the cryogenic components of the plant and sludge carry over to the storage

Impurity	Process Technology	LNG Specification
Benzene	Fractionation	≤ 1 ppm
CO2	Amine based	≤ 50 ppm
H2S	Amine based	≤ 1 ppm
H2O	Mole sieve	≤ 5 ppm
HG	Mercury trap	Negligible (HE protection)

LNG export facilities treat and cool inlet gas to -160ºC to produce, store and transfer LNG to ships



LNG plants consist of one or more LNG trains, each of which is an independent gas liquefaction unit

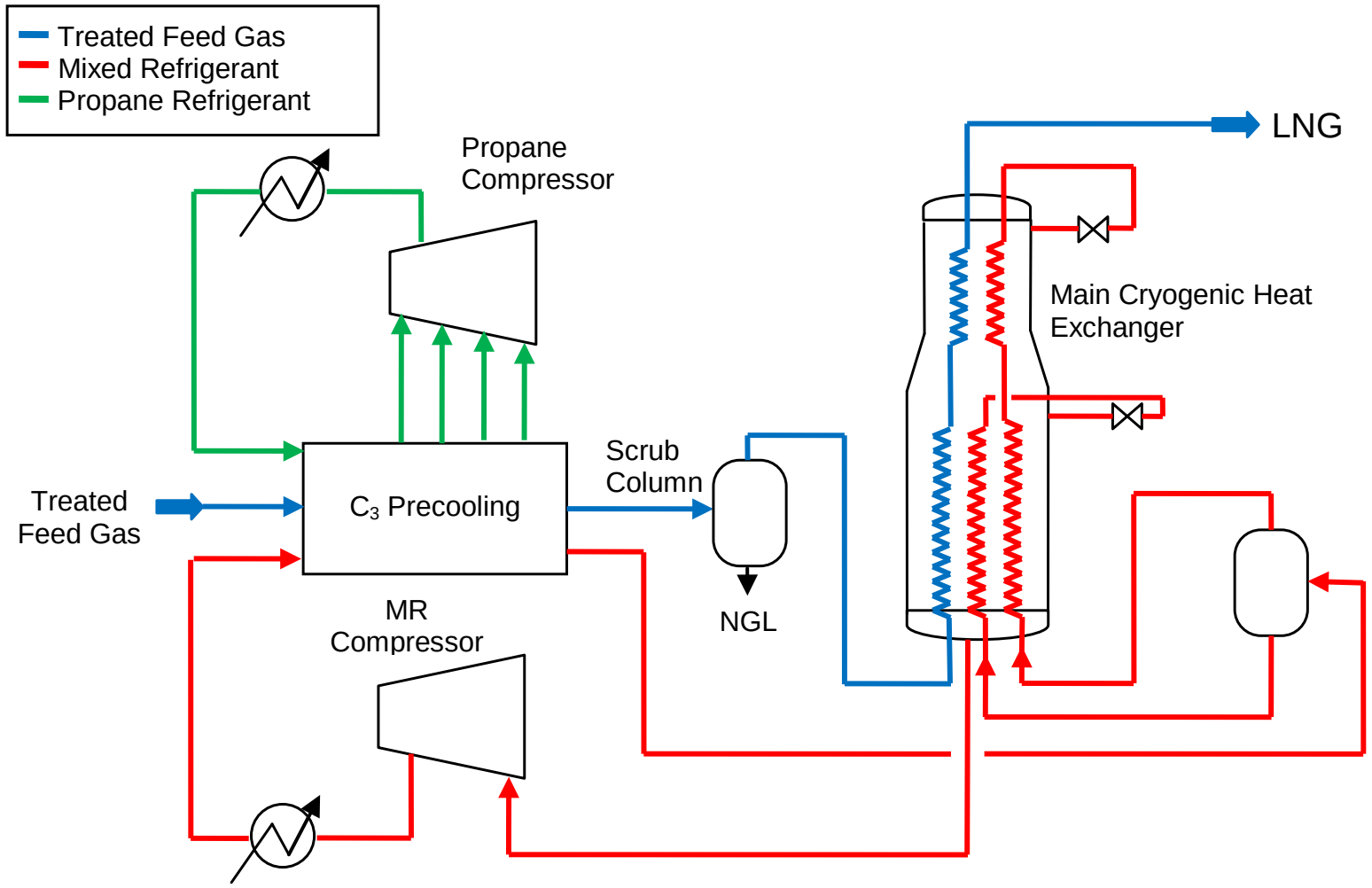
- An LNG train is a self contained processing unit
- Most LNG plants consist of two or more trains (Indonesia's Bontang plant is currently developing its ninth and Qatar's two LNG plants have seven each)
- Darwin (Australia), SEGAS (Egypt), Equatorial Guinea and Snohvit (Norway) currently are single train projects
- Number of trains is dependent on proven reserves volume and project economics
- Size of trains has been increasing

  - Earliest trains 0.3mtpa capacity
  - Largest trains in operation – 7.8mtpa in Qatar

There are two predominant LNG process technologies in operation. Others include DMR and SMR processes.

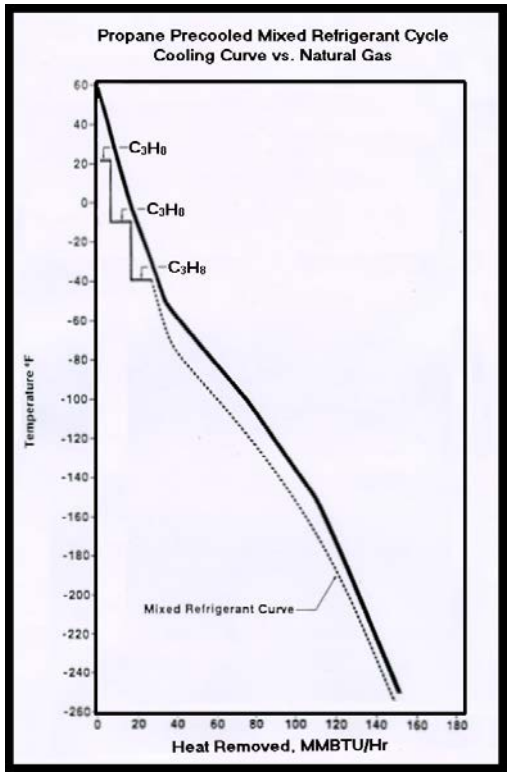
- **APCI Propane Pre-cooled Mixed Component Refrigerant (C3-MCR)**
  - Feed gas pre-cooled to –35 deg C using propane
  - Mixed refrigerant (propane, ethylene, methane and nitrogen) used in the main heat exchanger
  - Main cooling in a spirally wound heat exchanger
- **CoP Improved Cascade**
  - Feed gas cooled in three stages
  - Propane cools the gas to –35 deg C
  - Ethylene cools to –105 deg C
  - Methane cools to –161 deg C
  - Plate fin heat exchangers

Propane Pre-cooled Mixed Component Refrigeration Process

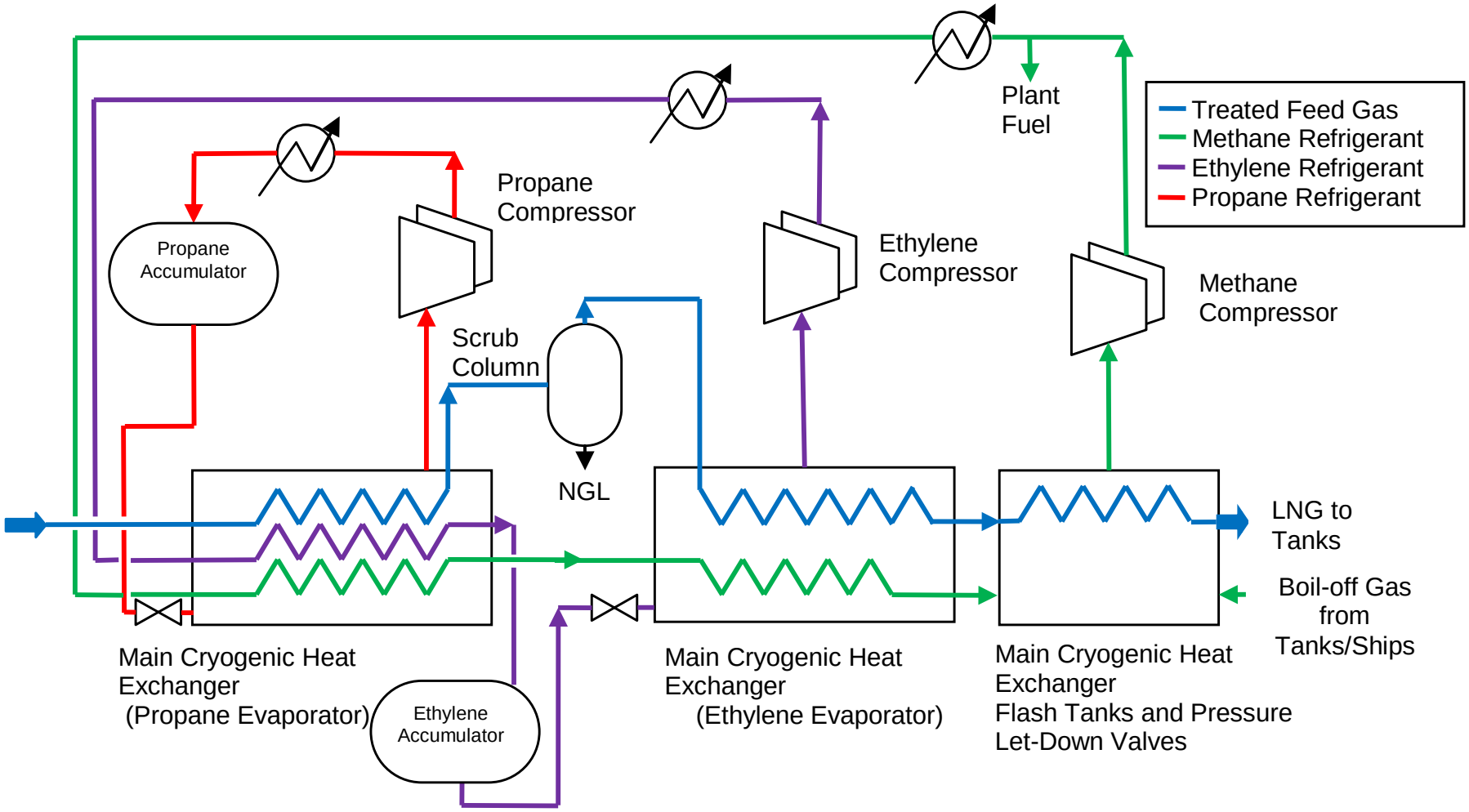


Propane Pre-cooled Mixed Component Refrigeration Process

- Mean temperature differences between the cooling and heating streams of a liquefaction process are wider for a pure component cascade process relative to a C3MR or DMR process
- Process licensors know how to balance efficiency and heat exchanger area.



Cascade Refrigeration Process

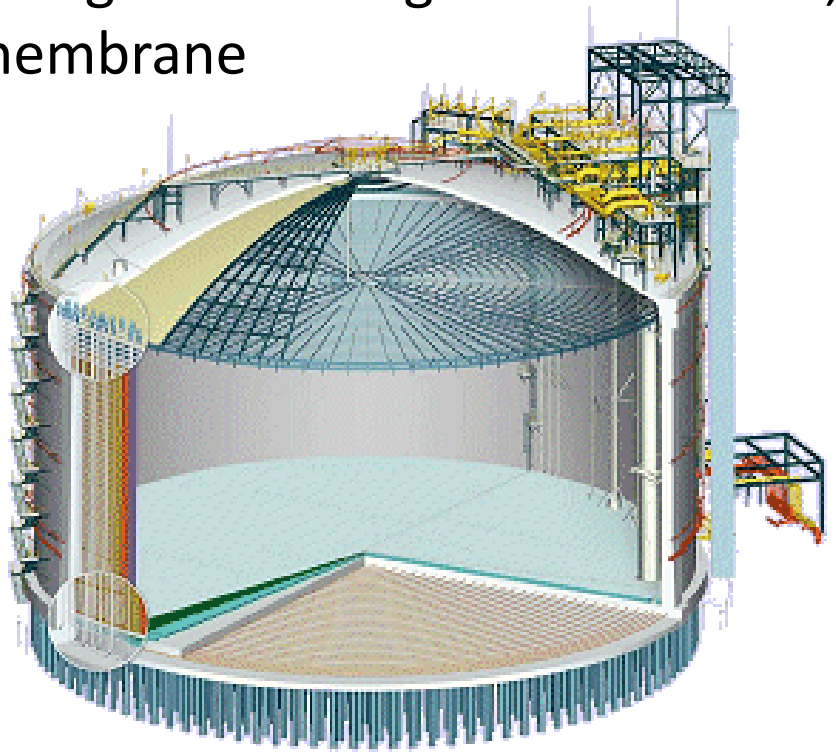


The selection of the refrigerant compressor driver plays an important role in defining the project

	Industrial GT	Aero-derivative GT	Electrical Drive
Description	Allowing for de-rating And fouling efficiency is approx. 30%. Typical plant consump: ~8.5-10% of feed gas	Increased efficiency to 40 - 45% May not suit compressor train line up for all liquefaction processes	Efficiency of electric motor: 95% + Approx. LNG plant consump: approx. 4 - 6.5% of feed gas depending on supply

LNG storage provides buffer between LNG production and shipping

- LNG Storage provides enough buffer to avoid delays to ships or plant shutdown due to full tanks
- Types of LNG storage tanks: single containment, full containment, membrane



LNG Tanker Loading

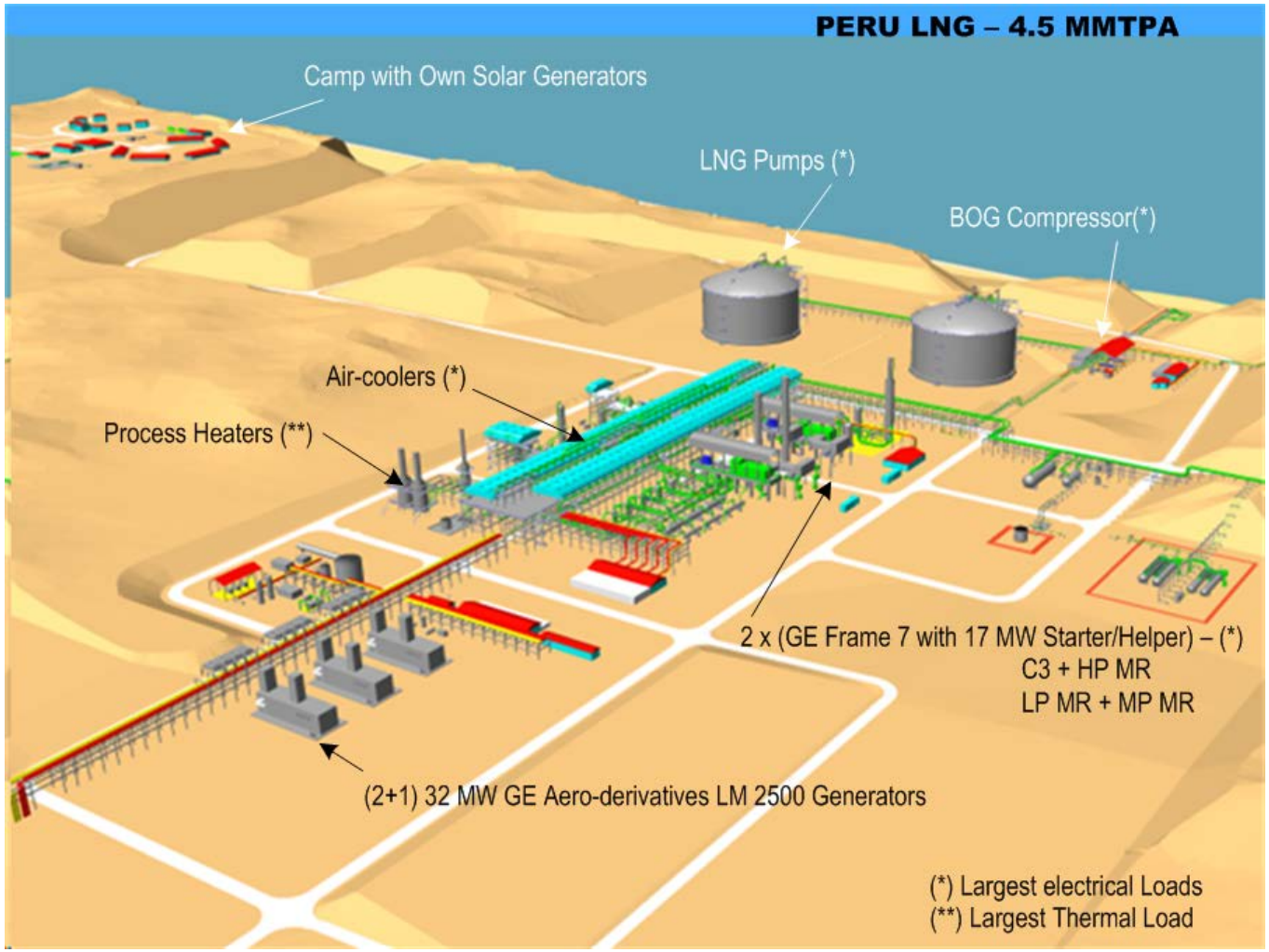
LNG tanker loading at North West Shelf plant

Loading arms

Emerging Trends in LNG Export Facilities

- Broad consensus that emissions from LNG plants need to come down
- Process design and operation alone unlikely to achieve significant impact
- Traditionally LNG plants self-generate their electrical power
- All LNG plants require process heat
- Some sites require winterization
- Options being considered:
  - Aero-derivatives without waste heat recovery
  - Aero-derivatives with waste heat recovery
  - Electrical drives + aero-derivatives + waste heat recovery
  - Electrical drives + combined cycle power generation
  - Combination of the above.

Main Electrical and Thermal Loads – C3MR Process



Electric Drives - Site Specific Factors to be Considered

- Redundancy requirements to maintain plant design availability
  - Electrical power demand
  - Process heat
  - Winterization load

- Other factors
  - Regulatory regime in LNG plant jurisdiction
  - Corporate philosophy on greenhouse gas emissions
  - Corporate risk culture (perceptions that electrical drive may present higher risks)

LNG Standards Used in BC

- CSA Z276 is the governing LNG standard in Canada
- CSA Z276 generally adopts the provisions of NFPA 59A
- CSA Z276 release schedule lags NFPA 59A
- CSA Z276-11 is prescriptive only
- NFPA 59A-13 allows prescriptive and risk-based approaches.

Regulatory Process

- Meets the needs of diverse proponents
- Creates framework that compensates for CSA Z276 weaknesses
- Facilitates adoption of key technologies such as membrane tank
- Where required, key provisions of EN 1473 are adopted
- A key link between LNG developers and CSA Z276
- CSA is now in synch. with regulatory process to expedite revisions.

CSA = Canadian Standard Association
EN 1473 = European LNG standard
NFPA 59A = US LNG standard

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Thank you

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