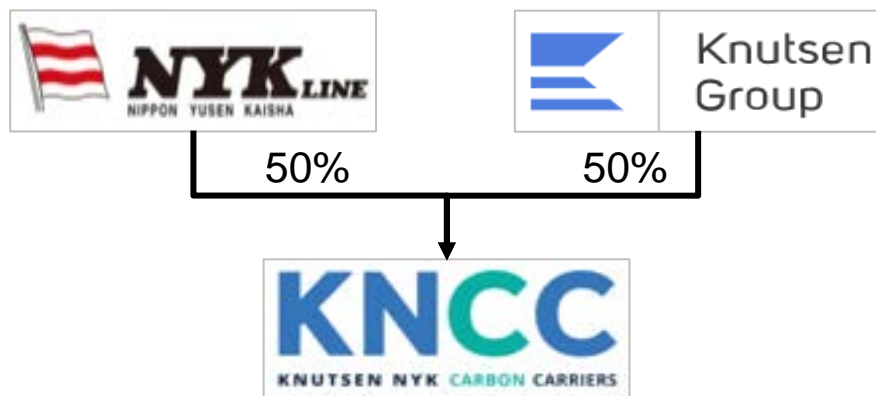


Knutsen NYK Carbon Carriers (KNCC) Liquified CO₂ at Elevated Pressure

KNCC
KNUTSEN NYK CARBON CARRIERS

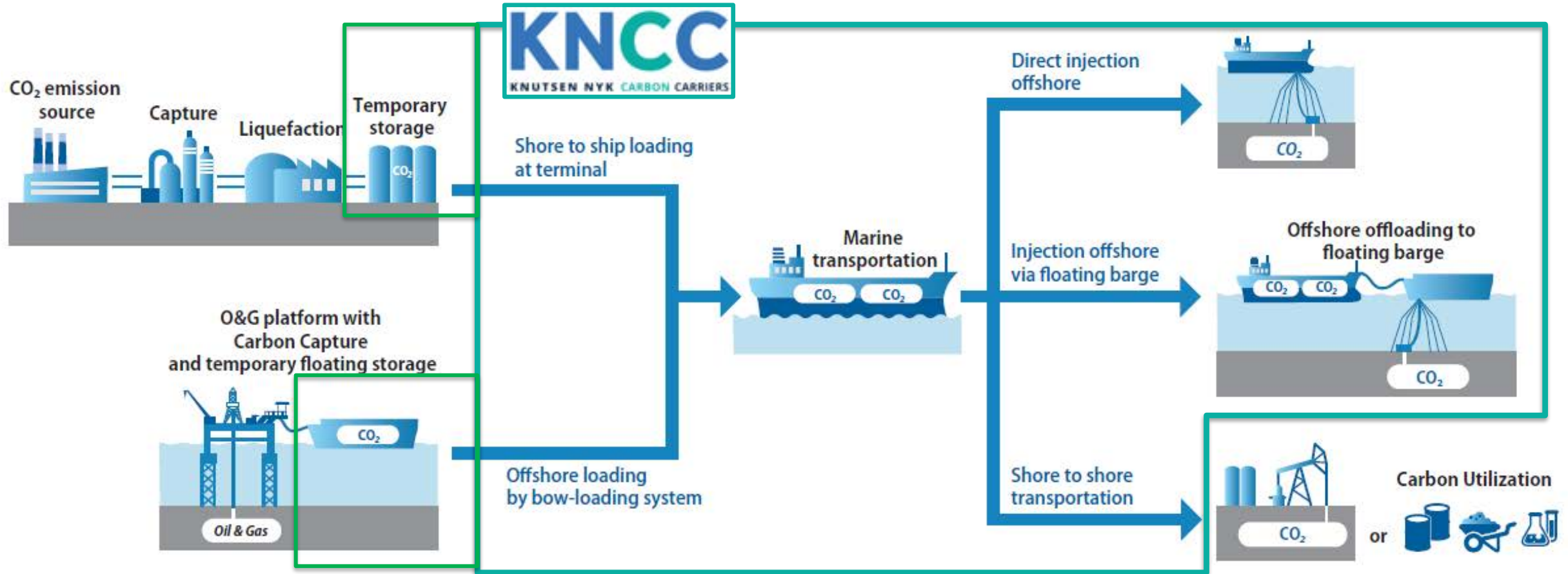


**Kveldsseminar CCS Haugalandet
26 Oktober 2023**



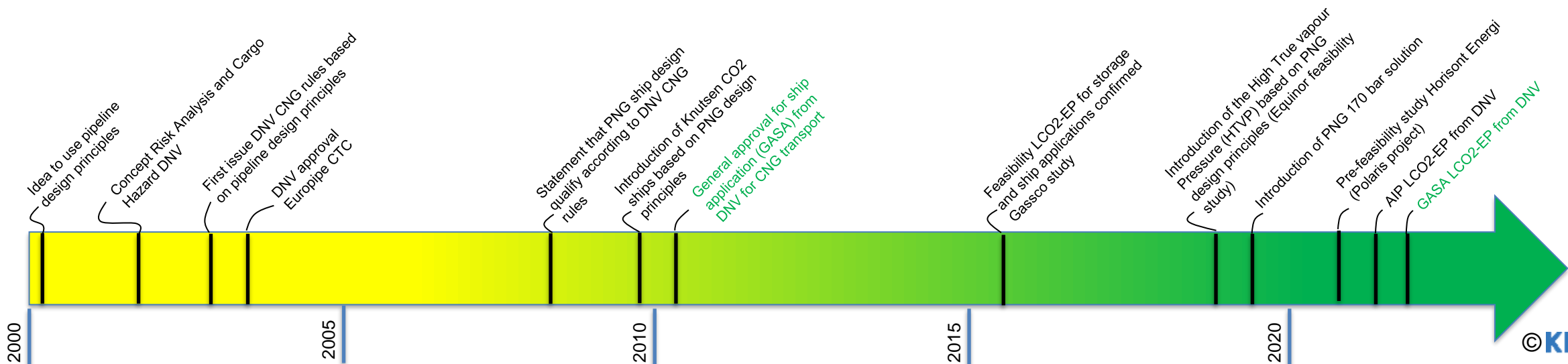
Company	Knutsen NYK Carbon Carriers AS
CEO	Anders Lepsøe
Location	Haugesund, Norway
Scope of business	Liquefied CO2 marine transportation & storage service (incl R&D)

- Our Owners
 - Knutsen Group: Pioneer in the offshore shuttle tankers business and a major LNG transport provider
 - NYK: Global logistics enterprise centered on various forms of marine transport operating over 800 vsls.
- Our Approach
 - Unique technology “LCO2-EP (Liquefied CO2 – Elevated Pressure)” based on our PNG technology
 - Wholistic approach across the CCS value chain



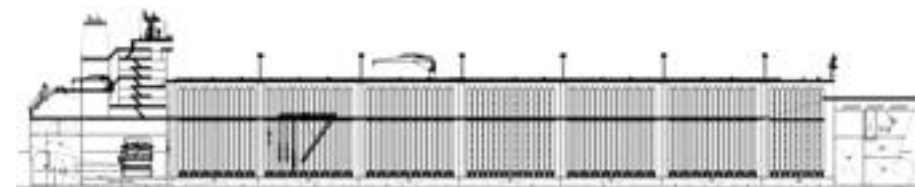
KNCC LCO₂-EP technology is based on more than 20 years development work

- The KNCC LCO₂ transport is based on more than 20 years development for transport of pressurized gasses, an innovative technology developed by Knutsen OAS Shipping in close cooperation with EUROPIPE GmbH using vertical positioned pipeline cylinders as tanks, the best known and explored cylindrical design available.
- **The unique technology will be able to transport LCO₂ at elevated pressure (LCO₂-EP) at temperatures above freezing (34 bar)**
- To operate above freezing has many advantages considering the entire value chain from capture to final storage into onshore and offshore sinks

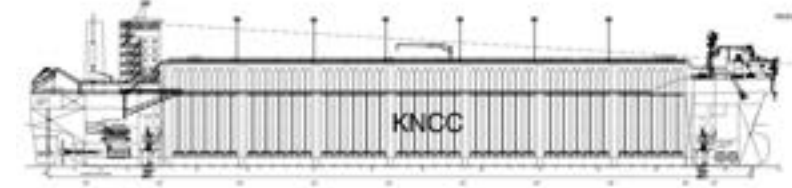


Status of the KNCC LCO2-EP Technology in brief

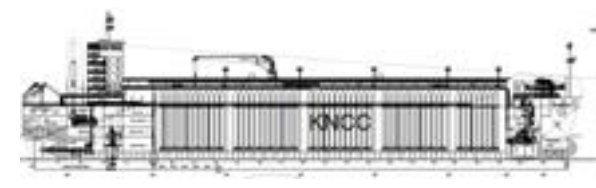
- Approval in Principle (AIP) from DNV received April 2022
- General Approval for Ship Application (GASA) from DNV awarded JUN 2023
- Detail discussion ongoing with yards and sub-suppliers.
- Can also offer technology for offshore intermittent storage, onshore storage and inshore barges based on same technology
- KNCC can also offer ships with other containment designs(middle pressure/low pressure) if requested by client.



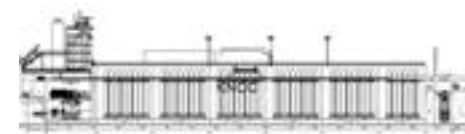
80 000 m3



40 000 m3



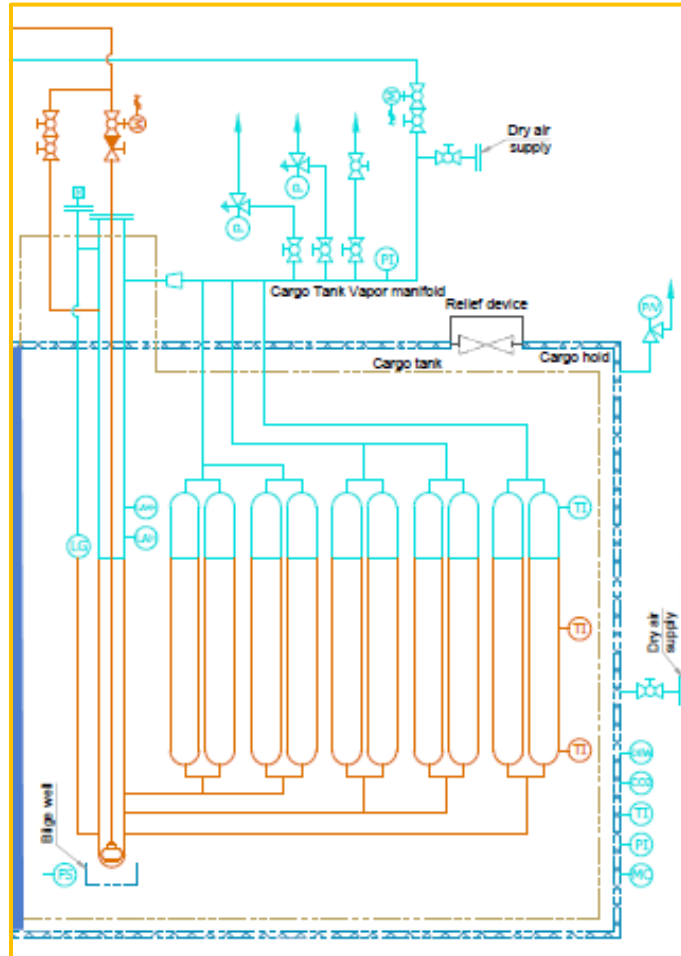
20 000 m3



12 000 m3



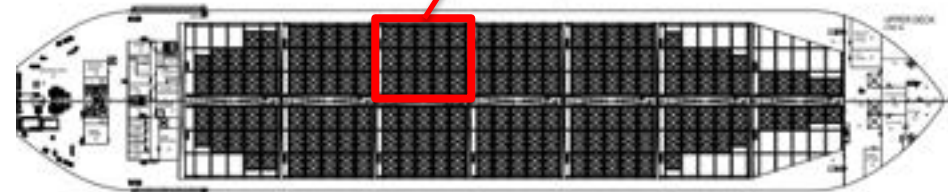
Cargo Tank

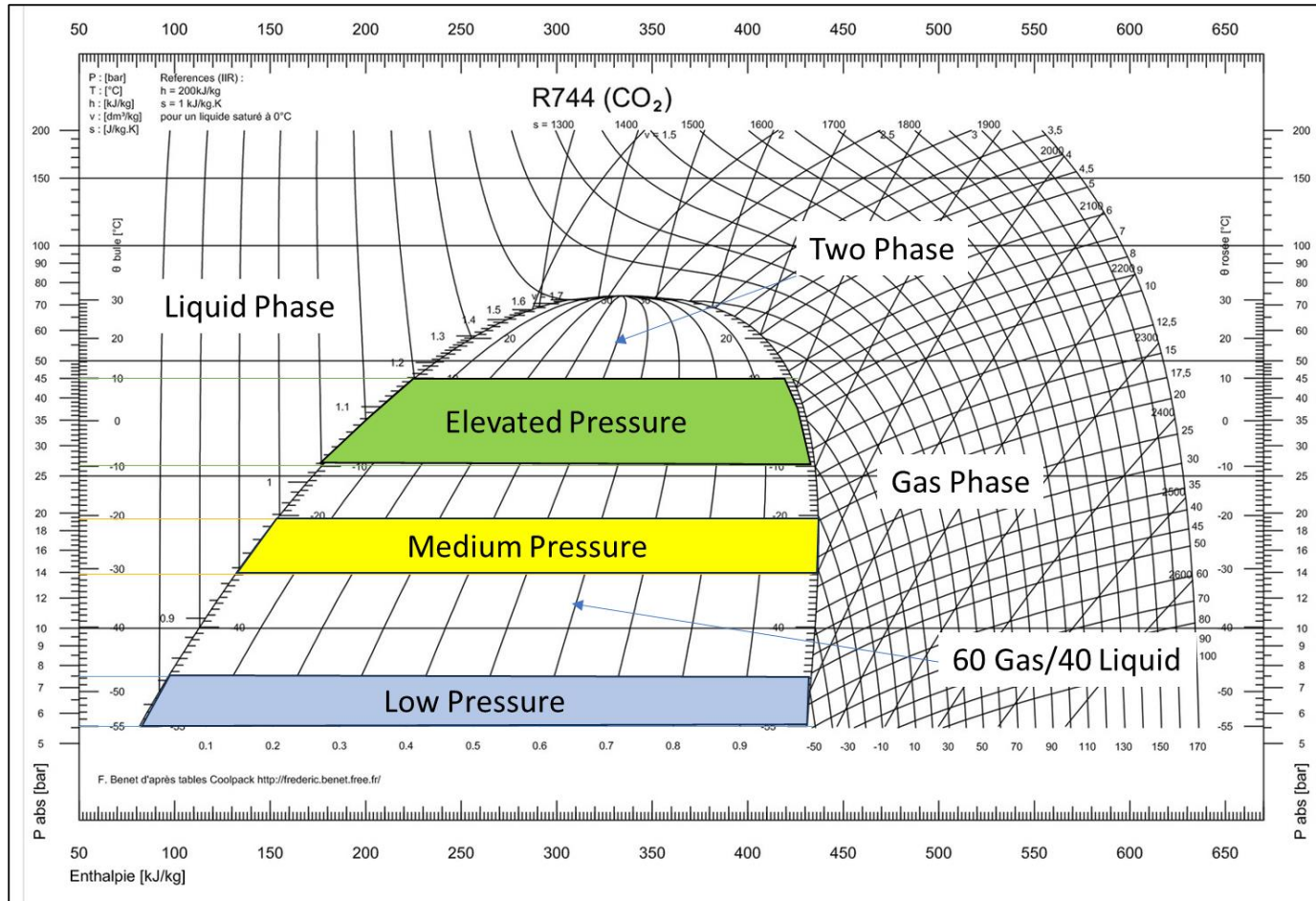


Cargo Hold



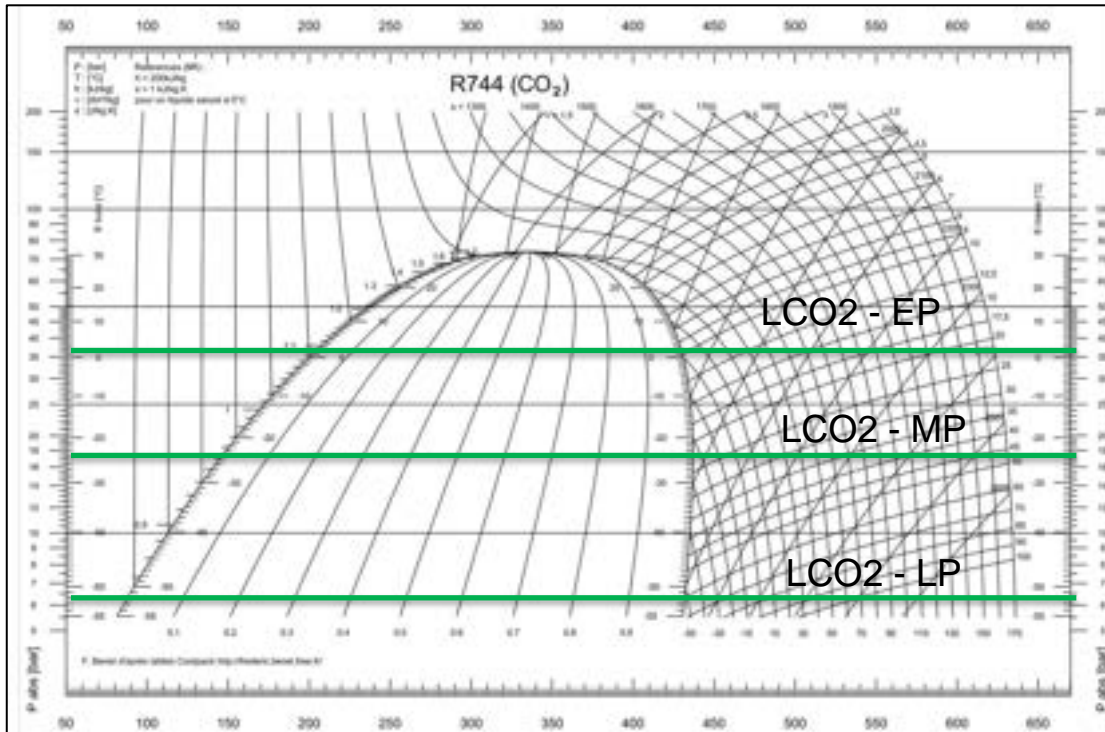
Cassette



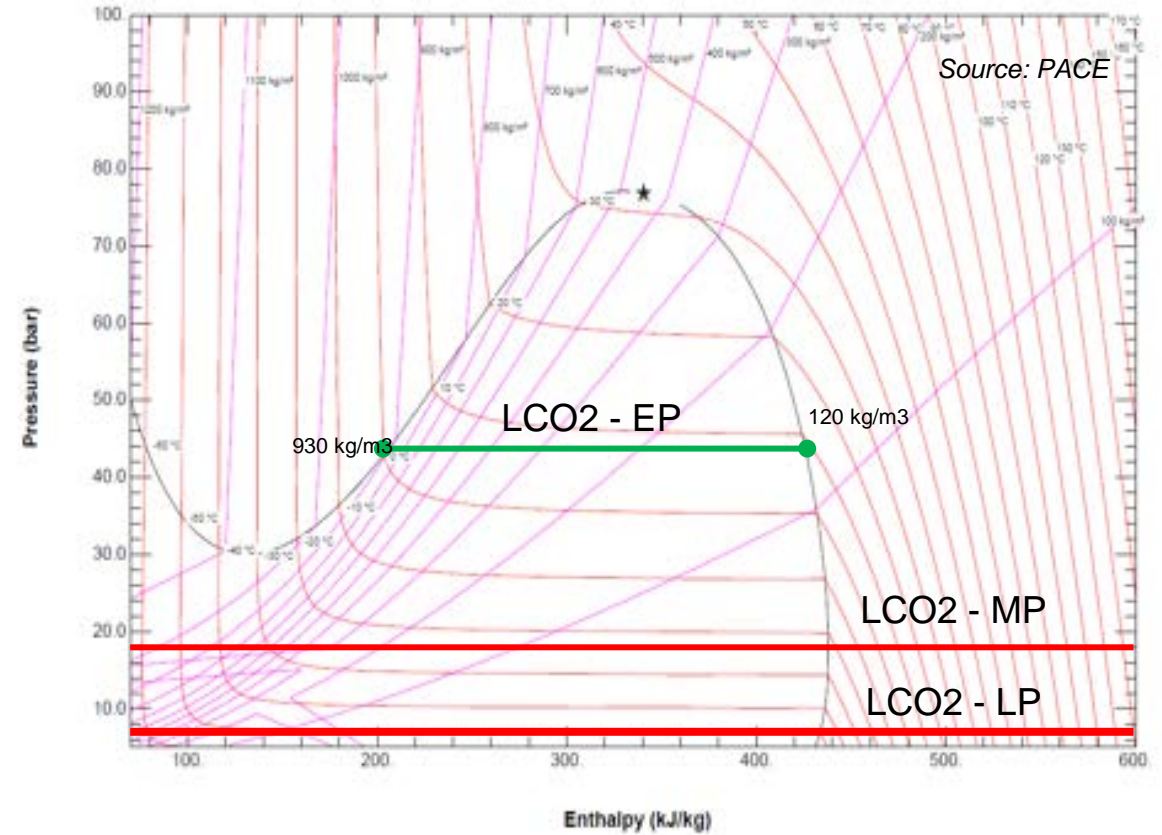


Operating envelope different transport modes

$\text{CO}_2=0,99259$, $\text{CO}=0,00010018$, $\text{H}_2=0,0072049$, $\text{N}_2=0.0010018$



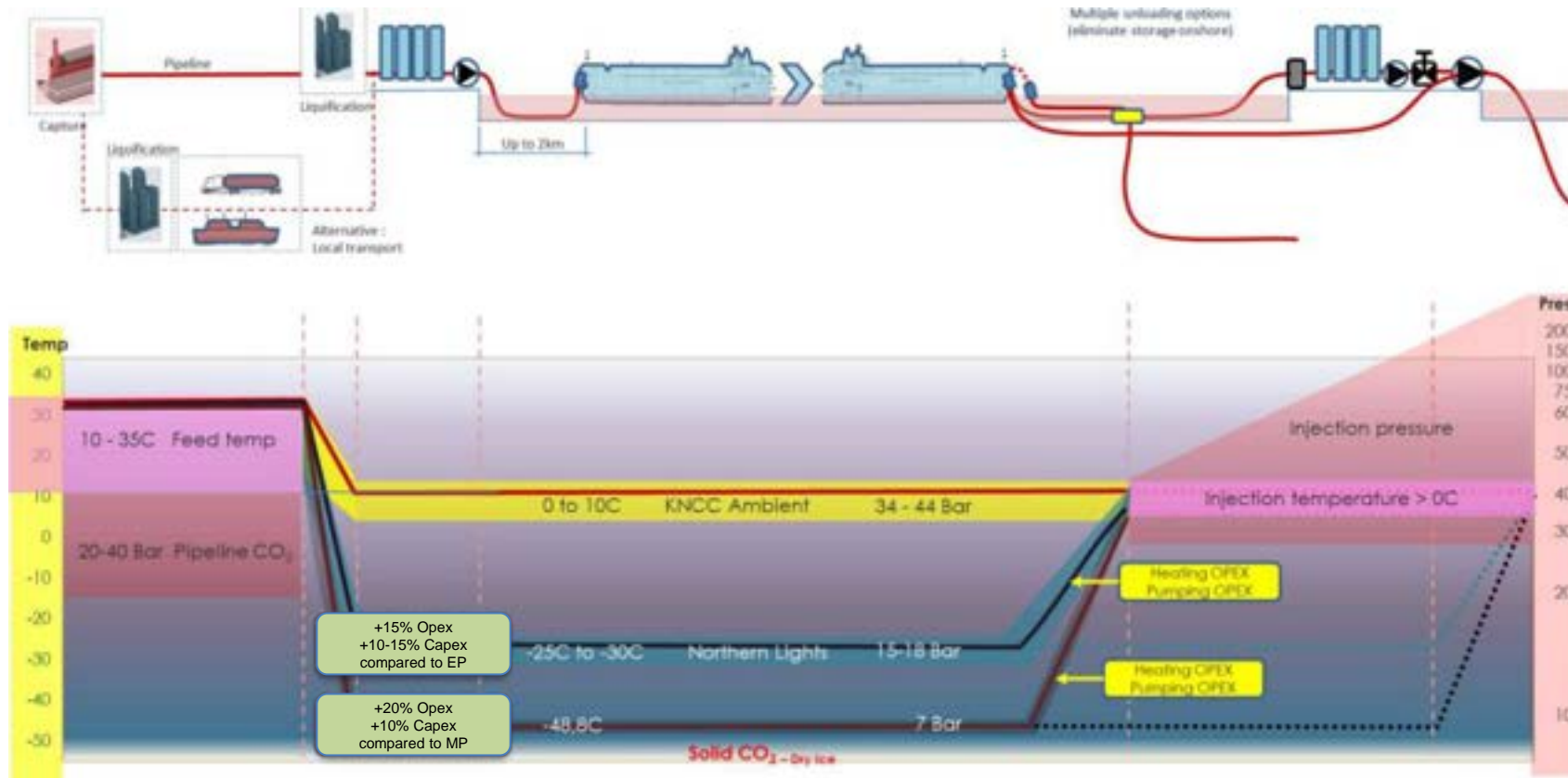
Pure CO2



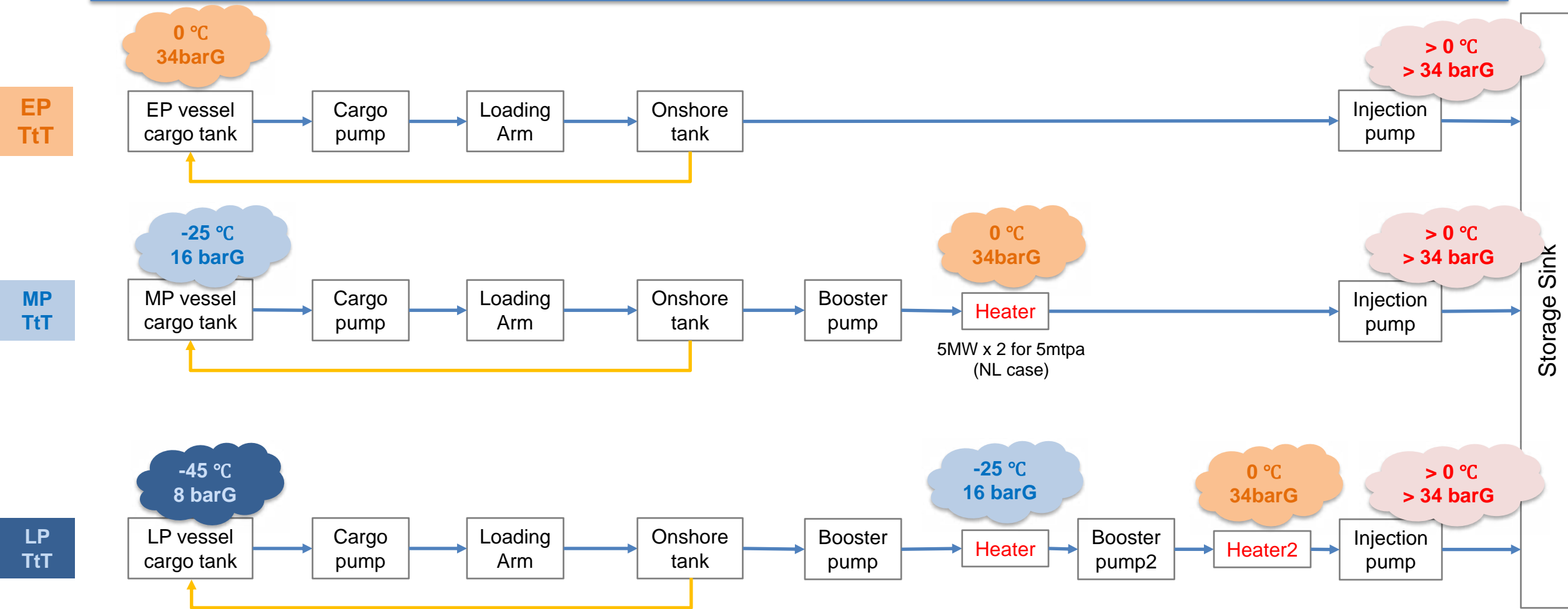
Pure CO2 with impurities

Why operate at elevated pressure ?

Smaller energy loss compared to other “LP” and “MP” modes throughout the CCS Value Chain which allows cheaper CAPEX & OPEX. (less cooling at liquefaction and temporary onshore storage, and reheating before injection)



Process/block flow diagram(2) - Vessel to injection-

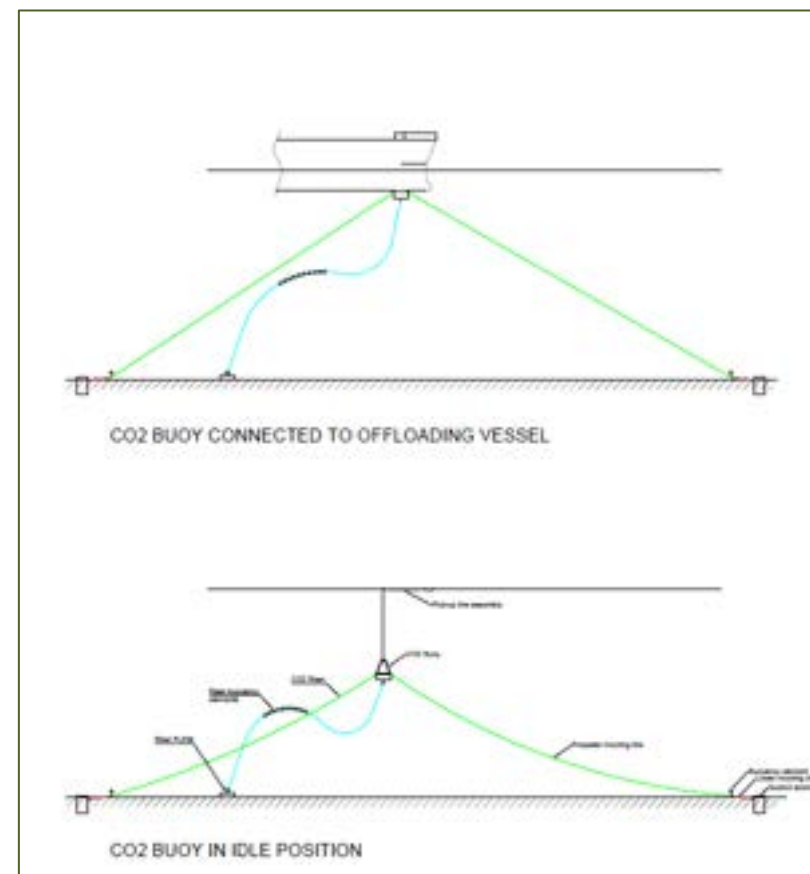
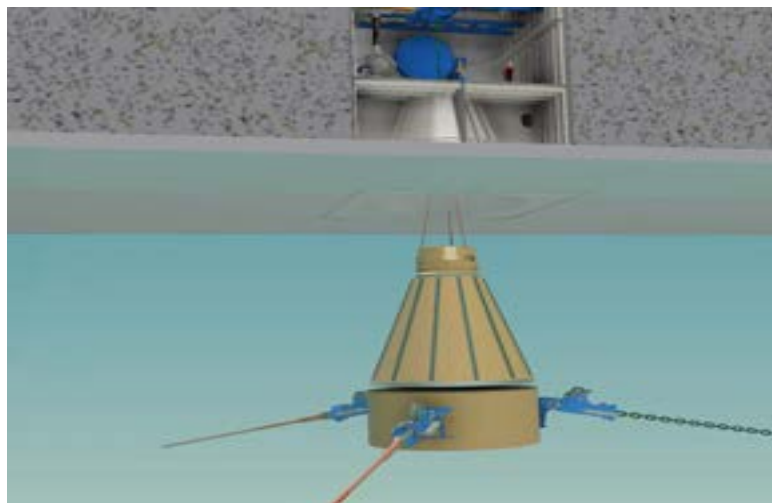


LCO2-EP with Submerged Turret Offloading arrangement



LCO2-EP applied for direct CO2 injection Turret solution

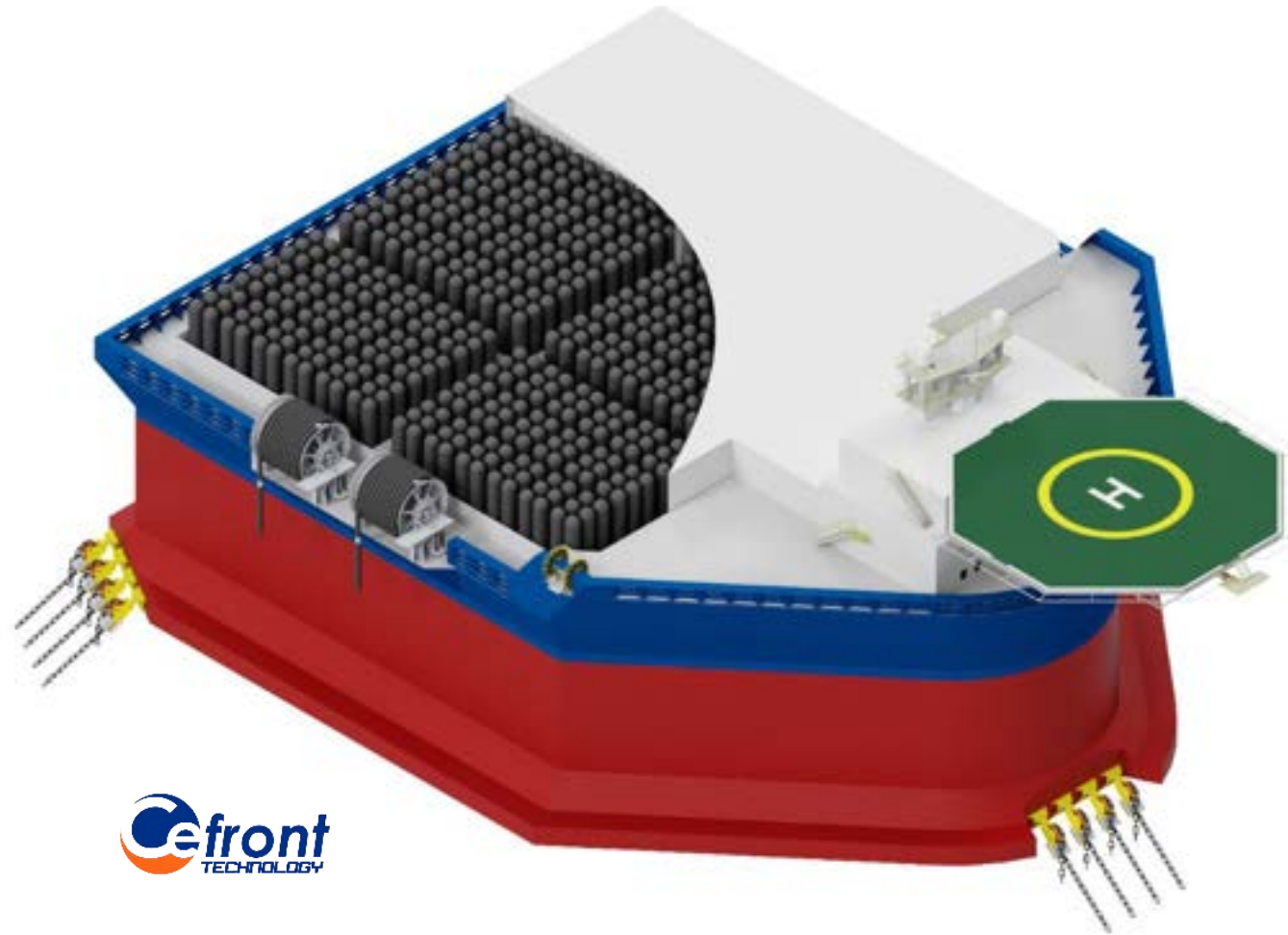
- Less compression and heating required prior to injection compared to “LP” and “MP”.
- No need for onshore CO2 receiving terminal. (=Faster and flexible instalment to projects)
- ➔ Lower CAPEX & OPEX achieved with more flexible operation. (Most terminals/ports are already congested.)



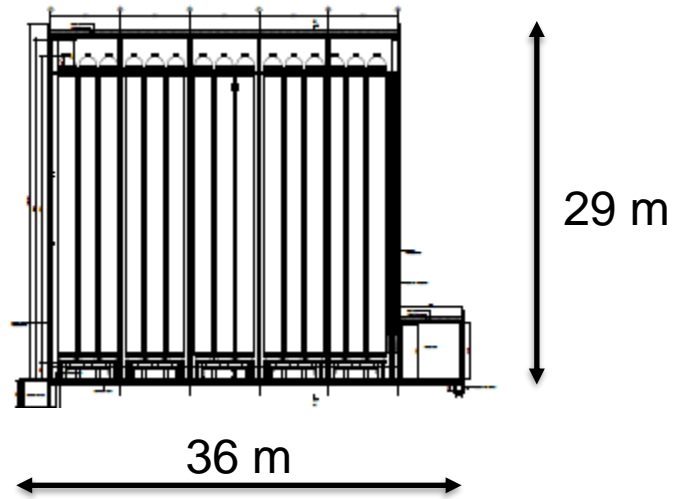
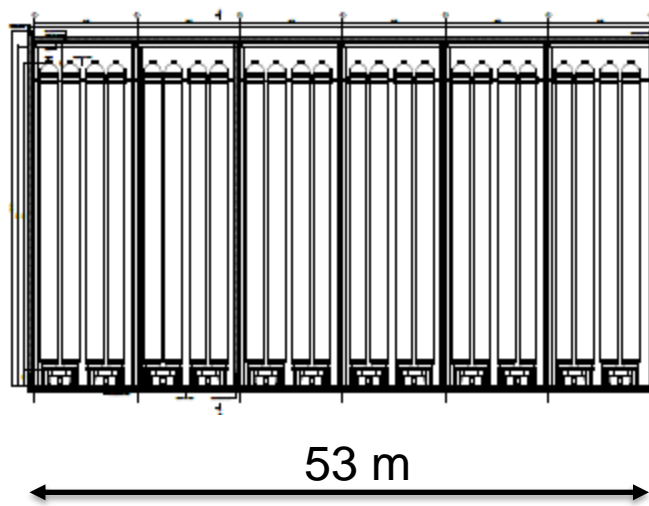
LCO2 – EP Carrier with Bow Offloading arrangement



LCO2 Floating Storage and Injection Unit

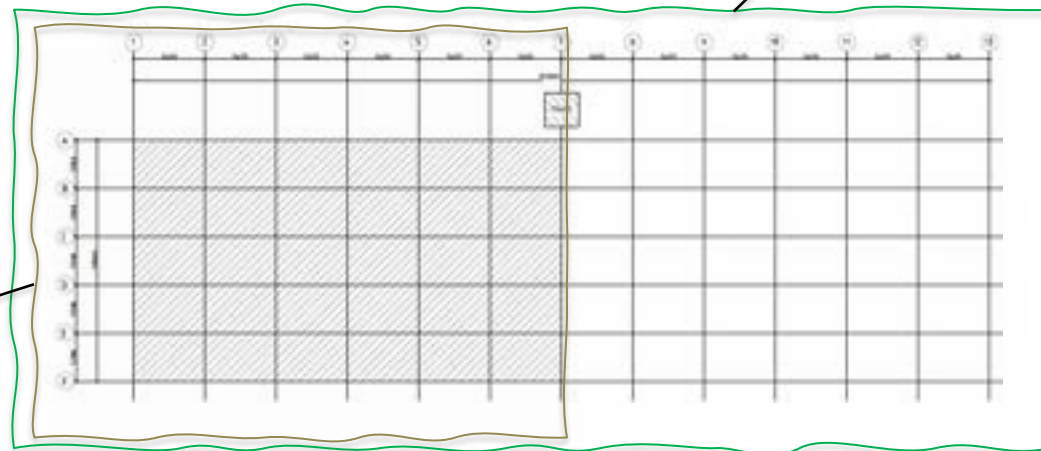






CTC length 25 m
 Total cargo volume 13204 m³
 Number of CTC's 360

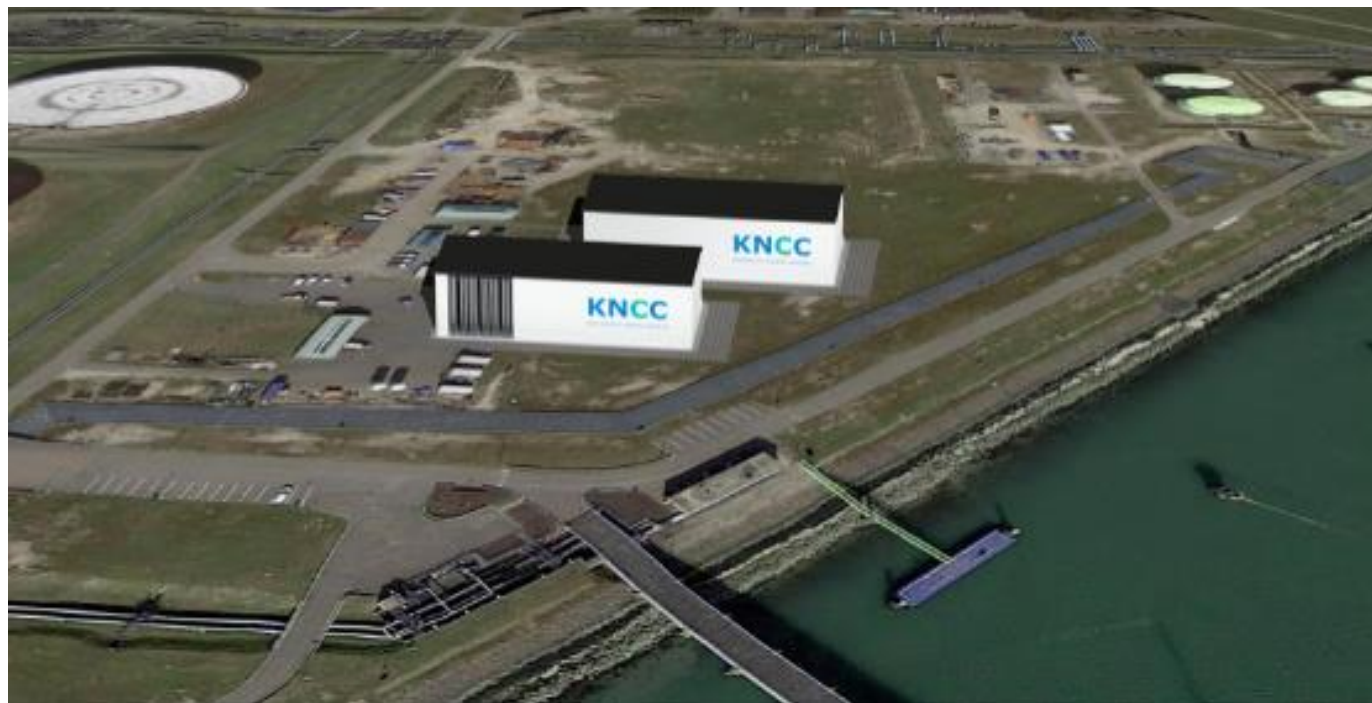
1908 m²



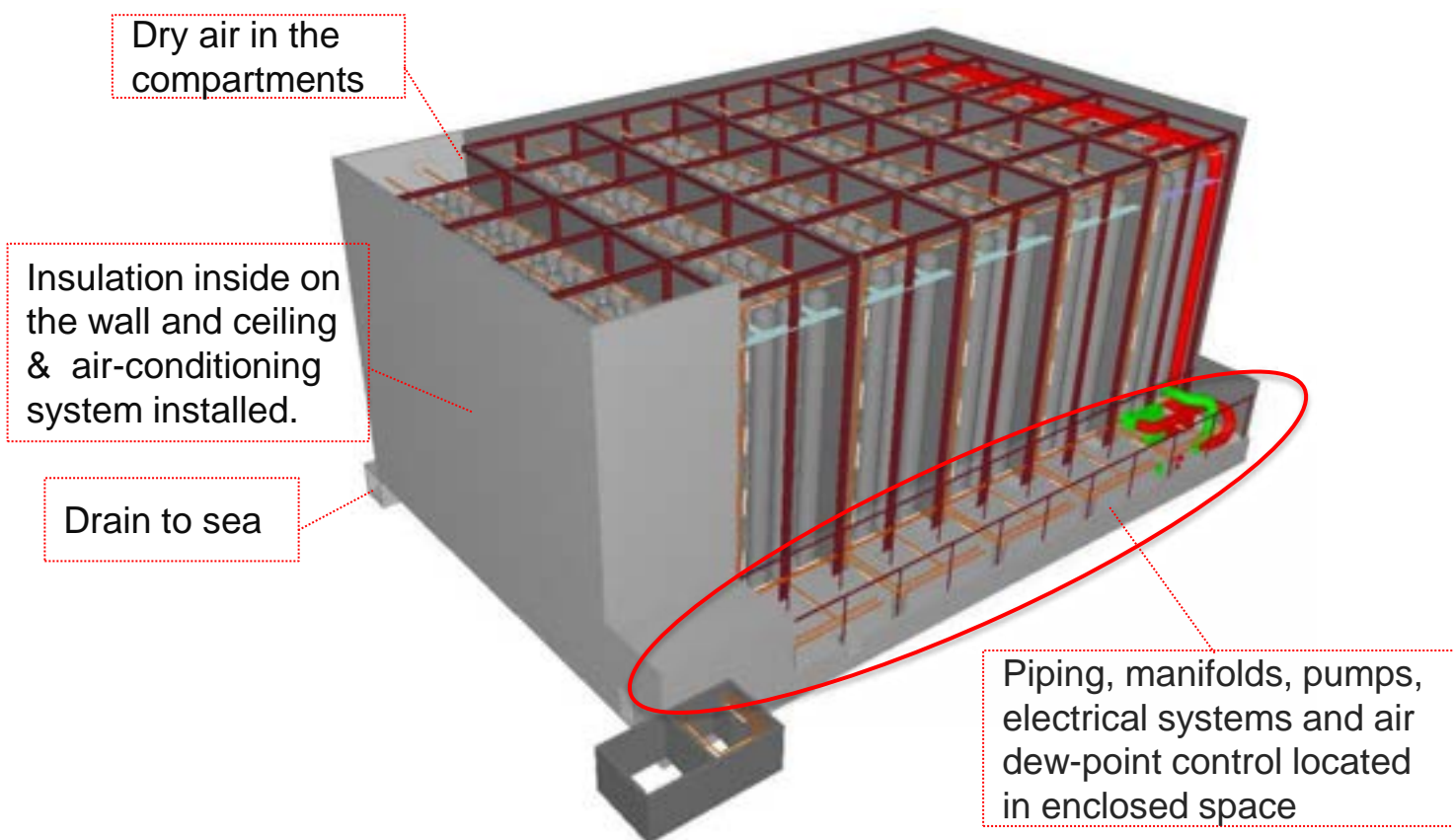
3816 m²

Onshore storage possible lay-out

Flexible design



Module concept applied for efficient and low-cost design, production and fabrication.



Schematic Image of EP onshore storage with six compartments
= 360CTCs = abt 13200cbm

Design Philosophy & key features

- One valve and two pressure relief on each tank
- Level measurements per two tanks
- Dew-point air less than tank operating temperature
- Low operating cost
- Limited downtime for tank inspection
- Isolation by tank possible in case of emergency case(i.e. leakage)

- Main purpose of the test is to:
 - Test and verify thermodynamics effects and calculations, especially in relation to the monitoring the CTC system
 - Test and develop operational procedures
 - Stress-testing of amongst others, leakages
 - Possible to test effect of impurities and optimal pressure temperature to allow future flexibility
 - Condition from -25 to +10 °C possible to test



Unique tool to improve our knowledge about CO2



Thank You

<https://www.kn-cc.com/>