



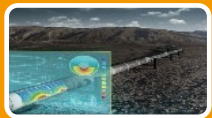
# CO2 SHIP TRANSPORT

2020.11.12

## CO2 : Déchet ou Matière Première d'Avenir ?

Clément Mérat  
CO2 transport R&D Manager  
Total E&P Norge

# HOW TO TRANSPORT CO2



By pipeline



By ship



By train



By truck

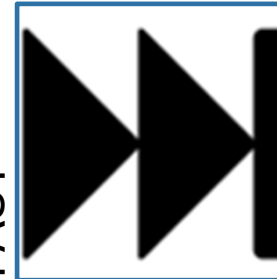
SAFE



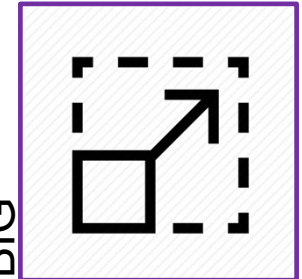
CHEAP



FAST



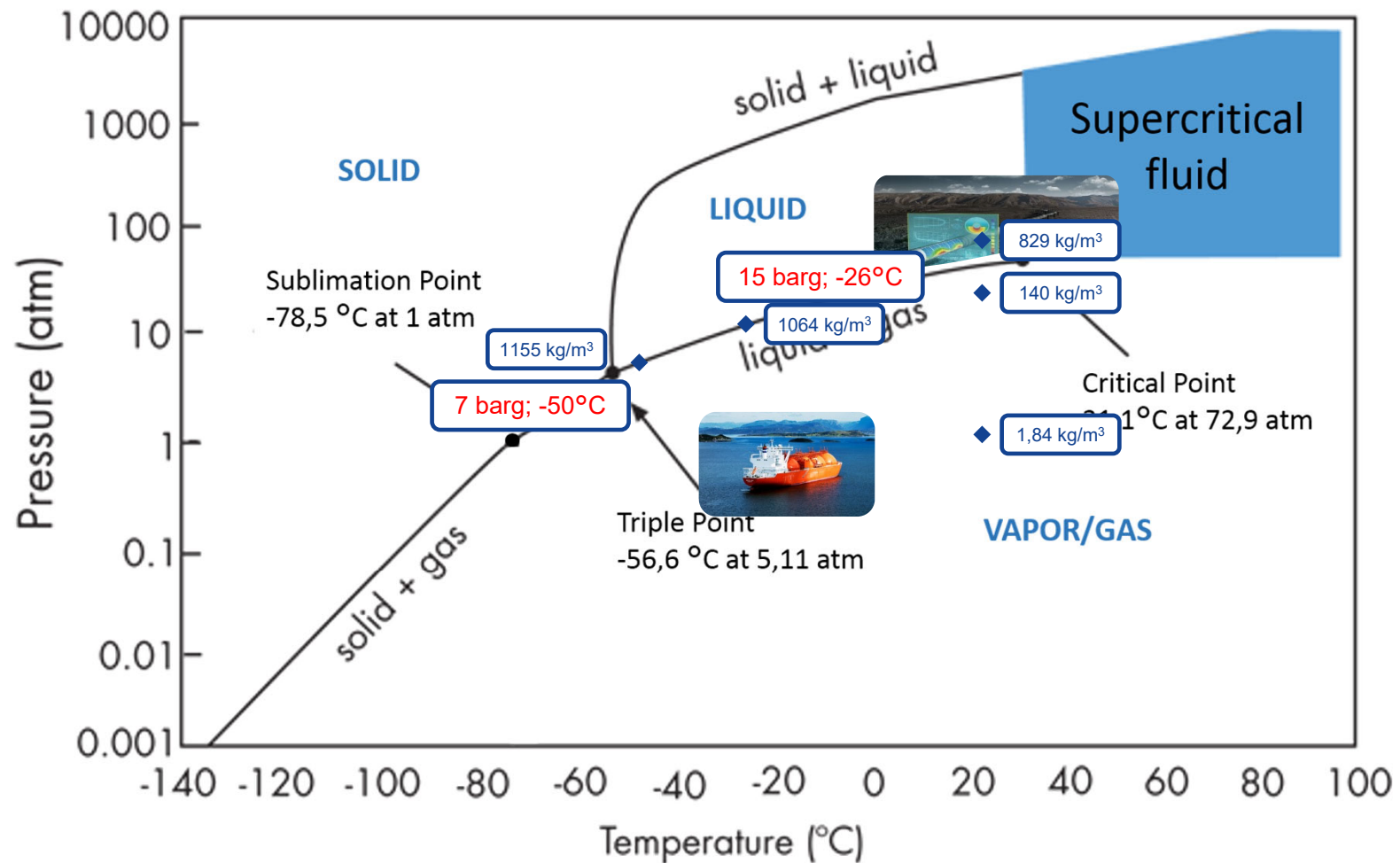
BIG



GREEN



# CO2 THERMODYNAMICS



# TRANSPORTING GAS BY SHIP – EXAMPLE OF LPG

## • 3 alternatives:

### Fully pressurized (max 18barg; min -10°C)

- Ambient temperature
- Two or three cylindrical or spherical cargo tanks
- Max capacity up to 10 000 m<sup>3</sup>



<https://citadelshipping.wordpress.com/2014/06/16/for-sale-cs00059-5000-cbm-lpg-tanker-fully-pressurized/>

### Semi-pressurized

- Semi-pressurized/semi-refrigerated state
- Control of both pressure and temperature
- High flexibility



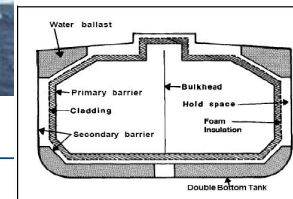
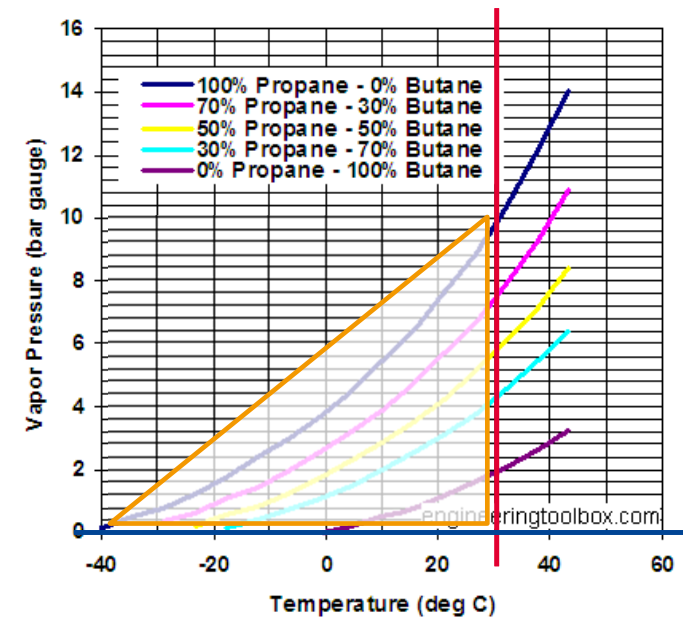
<http://www.gaschem.de/ships.html>

### Fully refrigerated (0barg; -42°C)

- Low temperature and atmospheric pressure
- Capacity up to 100 000 m<sup>3</sup>
- Prismatic tanks



<http://www.liquefiedgascarrier.com/Fully-Refrigerated-Ships.html>



# WHAT ABOUT CO2

- 3 alternatives?

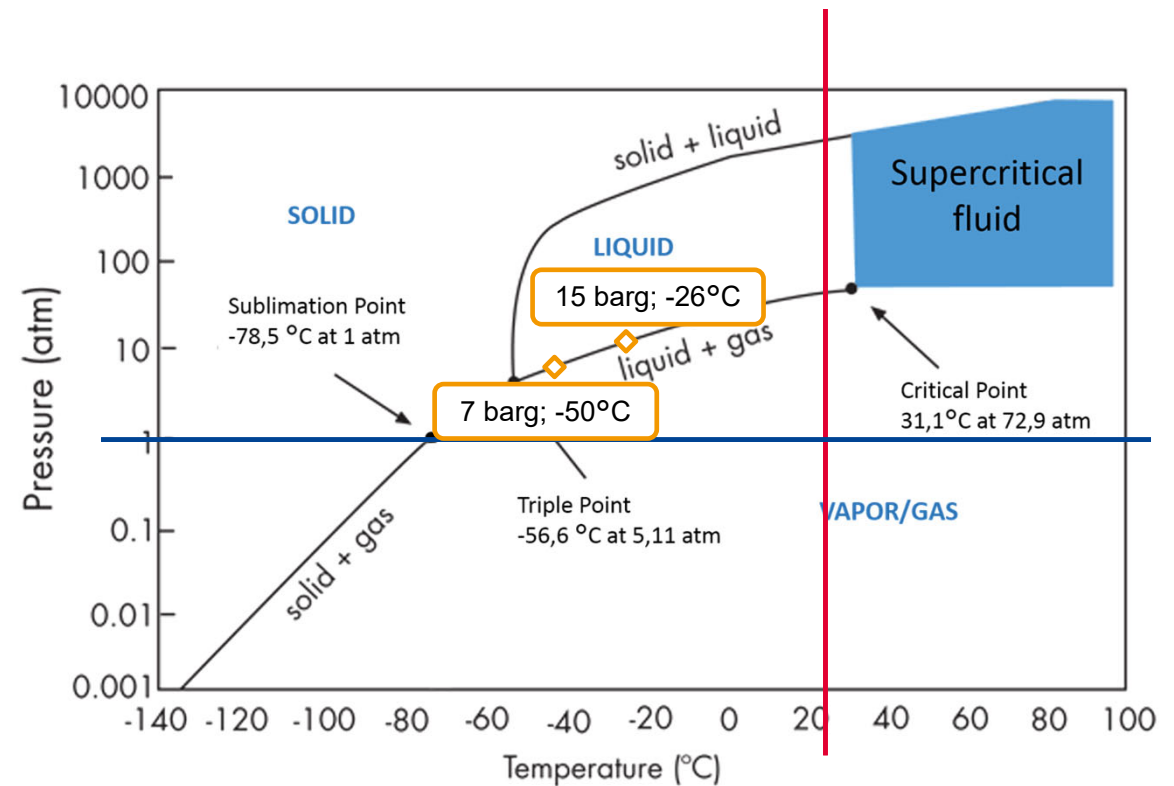
Fully pressurized ~~temperature~~

Semi-pressurized

- Semi-pressurized/semi-refrigerated state
- Control of both pressure and temperature

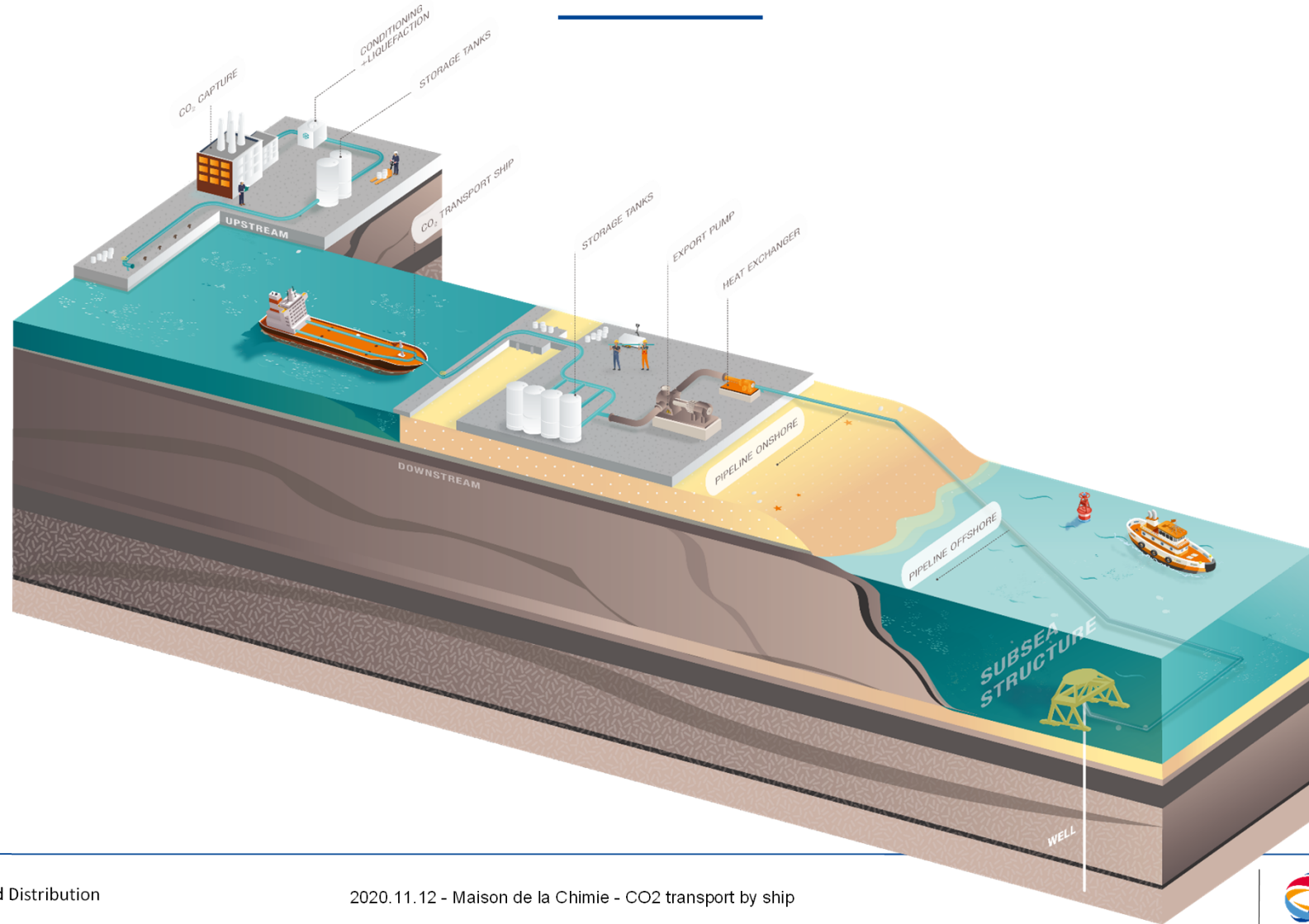
Fully refrigerated ~~pressure~~

- Low temperature and atmospheric pressure





# EXISTING CO2 TRANSPORT VALUE CHAIN



# EVOLUTION IN SHIP CAPACITY

## Current maritime transportation

Transportation of CO<sub>2</sub> is exclusively for food and beverage industry

5 ships built



Medium pressure condition  
(15-18 barg, -22 to -30°C)

Limited volumes (900-1850 m<sup>3</sup>)

## Northern Lights project

Part of the Norwegian CCS demonstration project, including capture, shipping and pipeline transport to reservoir



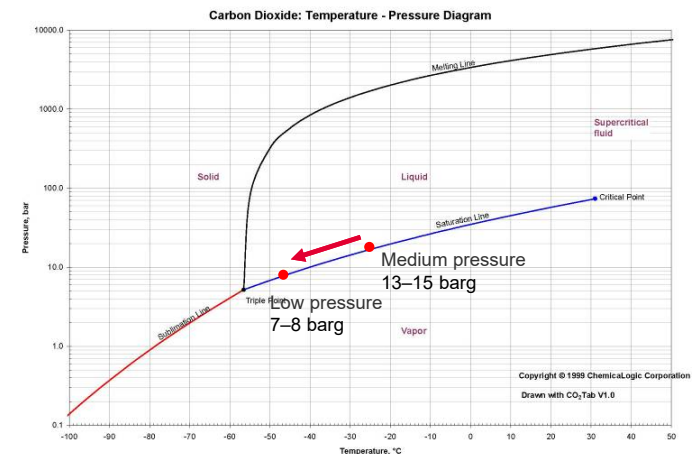
Source: Equinor/Northern Lights

Medium pressure condition  
(15-18 barg, -22-30°C)

Volume 7500 m<sup>3</sup>

## Future solutions

Larger CO<sub>2</sub> volume to be transported by ship



Low pressure solution  
(7 bar, -50°C)

Volume > 10 000 m<sup>3</sup>

↳ 30-40 000 m<sup>3</sup>

# LOW PRESSURE: CHALLENGES AND STAKES

## Interest and stakes

Advantages of Low Pressure transport conditions (compared to Medium Pressure):

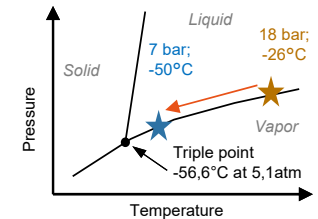
- Enabler for bigger ships (larger cargo tanks)
- Lighter and more efficient ships
- Increased liquid density
- Overall cost saving up to 15%

## Challenges

Ships carrying Low pressure CO<sub>2</sub> are non-existent.

The identified challenges are:

- Increased risk of dry ice formation
- Cargo tank design and arrangement
- Control of liquefaction and conditioning processes



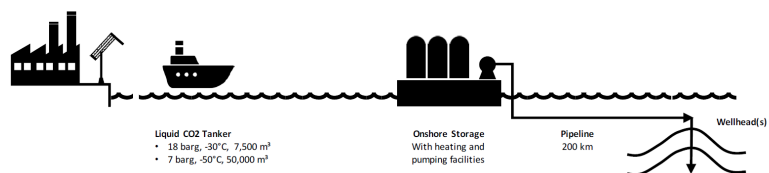
**Goal : identify, mitigate and remove technical show stopper to prove that low pressure CO<sub>2</sub>-transport is a viable solution.**



# ARCHITECTURE

1

## Conventional

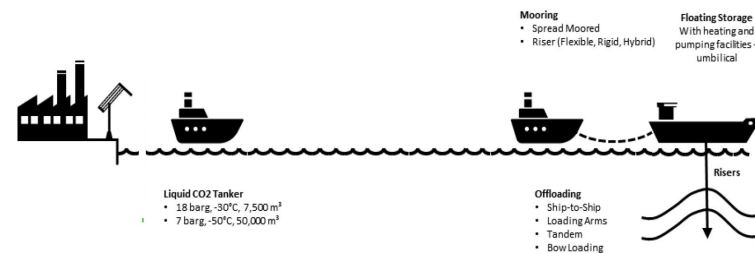


Ex: Northern Lights



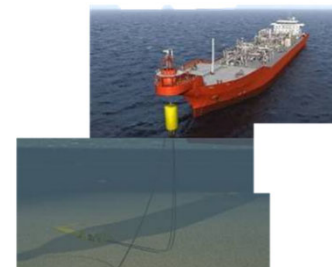
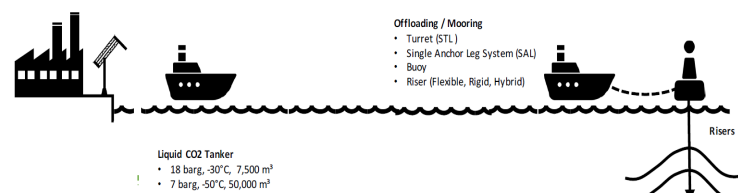
2

## Offshore intermediate storage



3

## Direct Offloading



# PIPELINE VS SHIP TRANSPORT



## Advantage of ship transport

Scalability  
Less CAPEX intensive



## Drawback of ship transport

More GHG emission

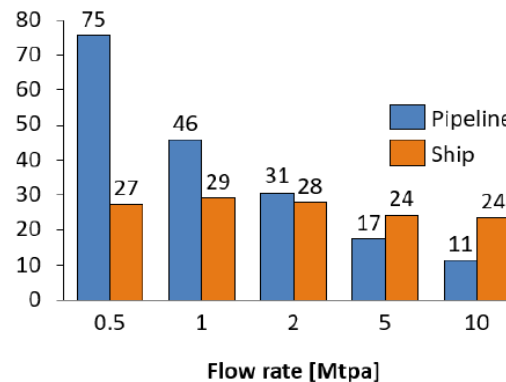
## Cost of transport is in favor of ship for

Longer distance  
Lower flowrate

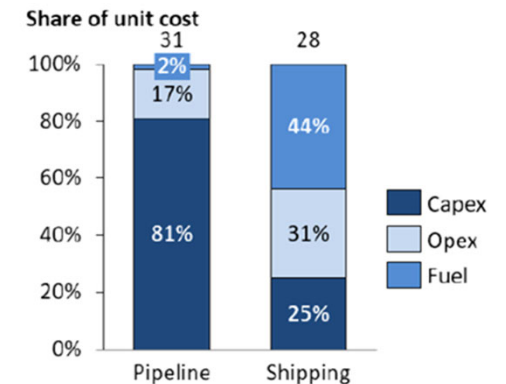


Unit cost of pipeline and ship transport (with onshore unloading) for different flow rate 1,000 km distance

Unit cost [€/tCO<sub>2</sub>]



Share of unit cost by of shipping and pipeline transport for 1,000 km distance and a 2 Mtpa flow rate



Source: IEAGHG The status and challenges of CO<sub>2</sub> shipping infrastructure – 2020 report



# LANGSKIP - NORTHERN LIGHTS

## A phased development

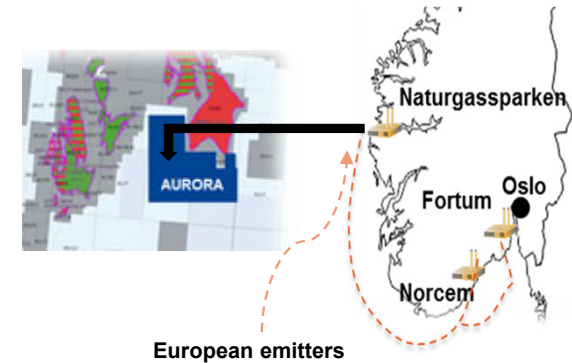
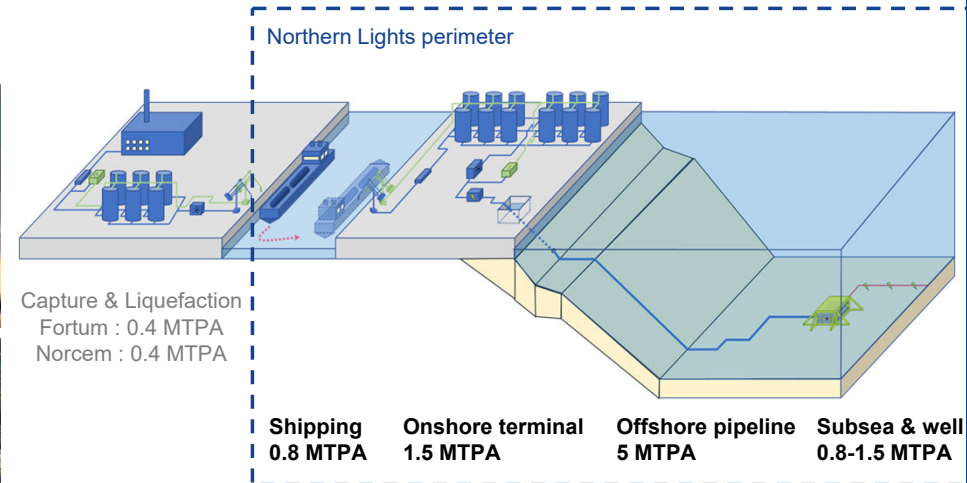
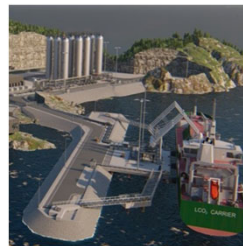
- Phase 1 includes capacity to transport, inject and store up to 1.5 MTPA
- Phase 2 will increase capacity up to 5 MTPA

## A flexible shipping solution

- Accommodating volumes from multiple emitters

## An incentive to launch a European CCS market

- Norwegian State subsidies during 13 years in exchange for 0.8 MTPA capacity reservation at zero tariff - conditioned to the funding of Fortum and Norcem capture plants
- Future revenues to be sourced from marketing of available capacity





# CO2 SHIP TRANSPORT

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ATTENTION

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