

CO₂ Transport and Storage as a Service



Mission:

Enable reduction and removal of European industrial CO₂ emissions

Carbon Capture & Storage



Context

→ COP21 in 2015 resulted in Paris agreement

- Pursue limit global temperature increase to 1.5°C
- Countries to submit plans

→ European Green Deal

- 2030 goal 55% reduction compared to 1990
- Net-zero greenhouse gas emissions by 2050

→ Norway's Climate Action plan

- 2030 goal 55% reduction compared to 1990
- Transportation, CCS, Renewable Energy

Carbon Capture & Storage

→ Net zero Industry act

- 50 mtpa injection capacity by 2030

→ To achieve climate target in Europe

- 280 mtpa by 2040
- 450 mtpa by 2050

→ Norway has great geology that can enable carbon storage

→ In 2020 the Norwegian government decided to support a full scale demonstration project for CCS: *The Longship Project*

The Longship project



- **A demonstration of large-scale, end-to-end CCS value chain** consisting of:
 - Cement manufacturing plant
 - Waste-to-energy facility
 - Northern Lights CO2 transportation and storage
 - Longship has co-financed Northern Lights Phase 1 with a capacity of **1.5 million tons** of CO2 per year (80% state)
 - State participation critical to de-risk initial investment and operation period

CO₂ transport & storage at scale - Longship



NORTHERN LIGHTS SCOPE

CO₂ capture

Capture from industrial plants.
Liquefaction and temporary storage.



Transport

Liquid CO₂
transported by ship.



Receiving terminal

Intermediate onshore storage.
Pipeline transport to offshore
storage location.



Permanent storage

CO₂ is injected into a saline aquifer.

100 km



Phase 1: 1.5 MTPA, 80% state funded

2 600m



CCS heritage

- Joint Venture between Equinor, Shell, and TotalEnergies
- Partnership established in 2017 – JV established in 2021
- 28 years of operational CO₂ storage experience on the Norwegian Continental Shelf (NCS)



Phased development

→ Northern Lights Phase 1

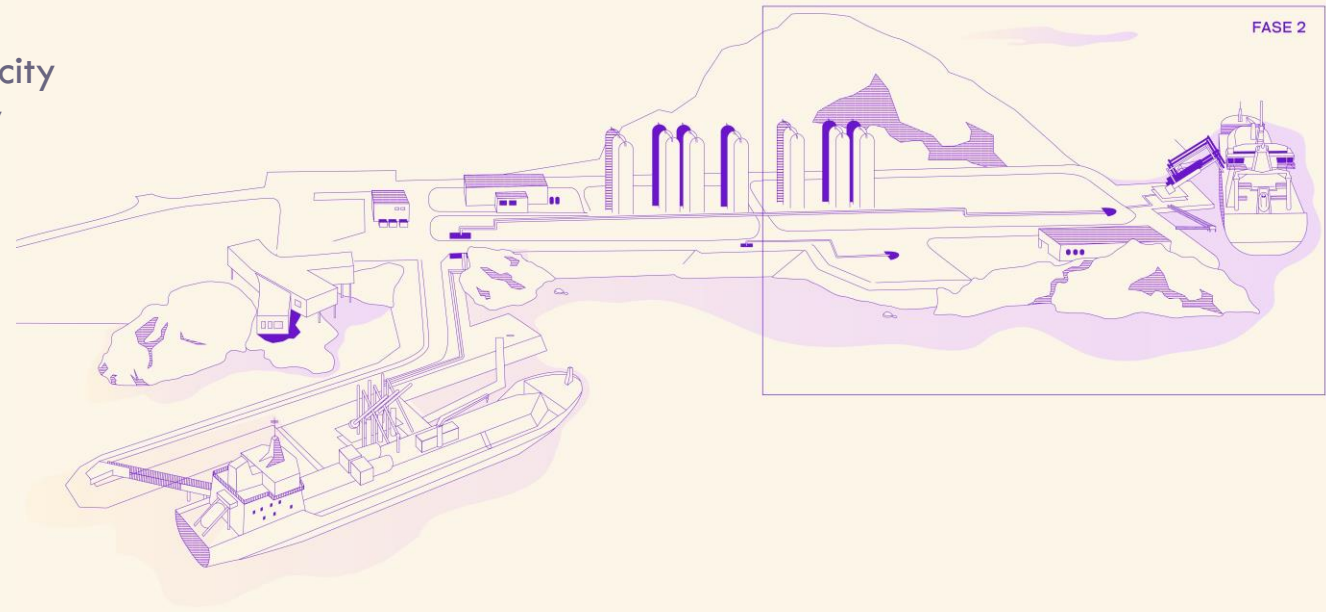
- 1.5 MTPA capacity, ready for start-up 2024
- 3 ships á 7,500m³ and 2 wells (one back-up)
- Phase 2 pre-investment in civil works and oversized pipeline
- Combination of commercial volumes and Longship volumes

→ Northern Lights expansion (Phase 2): commercial development

- “Filling the pipeline”: 5-7 MTPA
- Additional ships, storage tanks, increased pump capacity and associated utilities, more offshore wells, new jetty

→ Growth

- Additional pore space
- Concept not yet determined
- Storage licenses actively pursued by several players



Phase 2 development



- “Filling the pipeline”: 5-7 MTPA
- Additional ships, storage tanks, increased pump capacity and associated utilities, more offshore wells, new jetty

Commercial Customers



Yara

- Ammonia and fertiliser plant in Sluiskil Netherlands
- Transport and Services Agreement signed Oct 2023
- 800,000 tonnes CO₂ annually



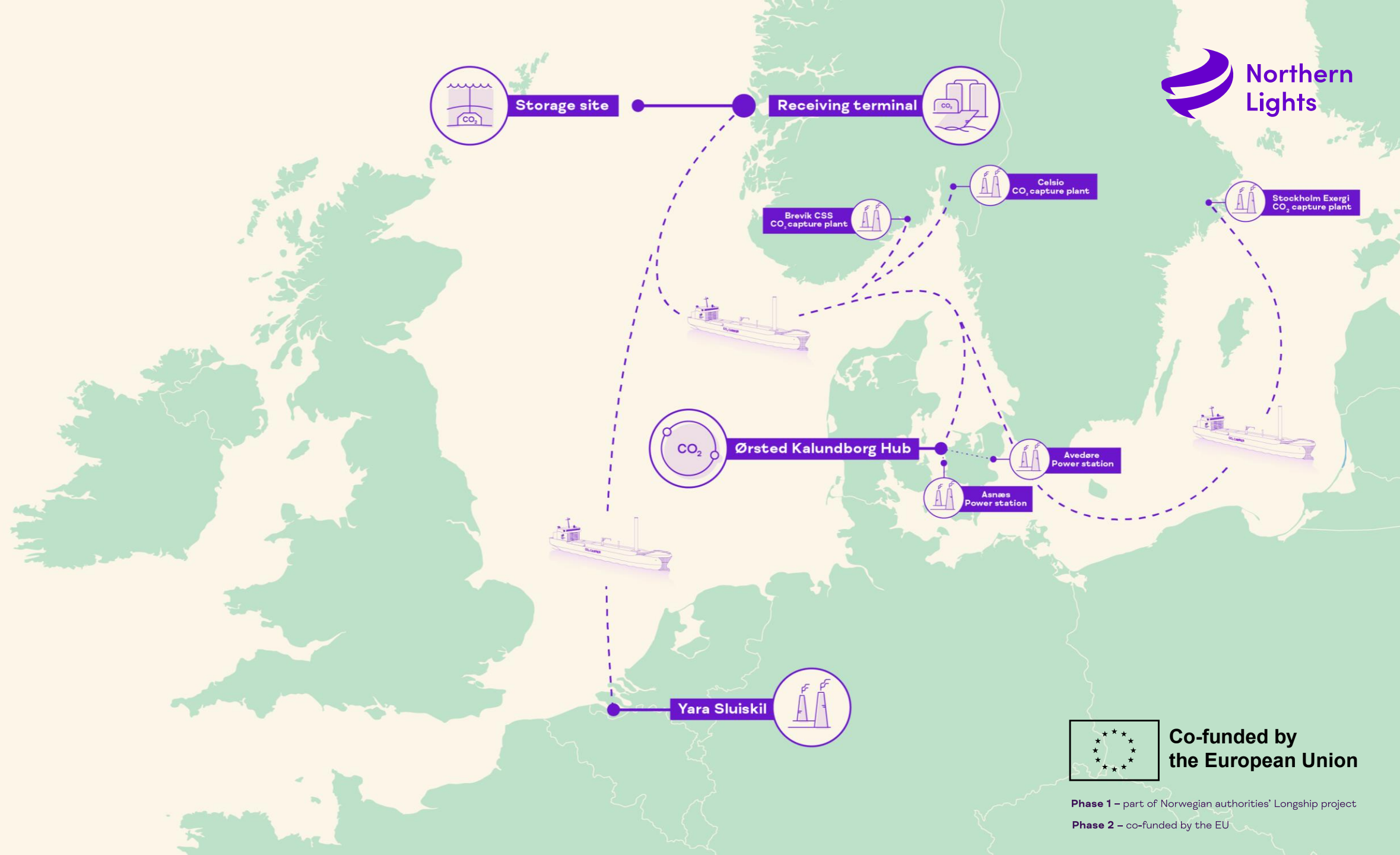
Ørsted

- Bioenergy plants in Denmark
- Transport and Services Agreement signed May 2023
- 430,000 tonnes CO₂ annually



Stockholm Exergi

- BECCS project in Stockholm, Sweden
- Transport and Services Agreement signed March 2025
- 900.000 tonnes CO₂ annually



**Co-funded by
the European Union**

Phase 1 – part of Norwegian authorities' Longship project

Phase 2 – co-funded by the EU



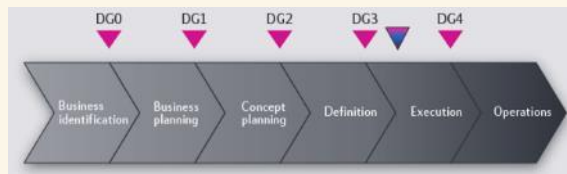
Project Development

Normal oil & gas

Regulatory framework exists

Business case

Resource is known,
permanent, validated



Markets existing
and predictable

Develop project to harvest business case

- Technical maturation with DGs
- Risks identified
- Concept freeze early
- Not schedule driven

CCS / Northern Lights

Tested Regulatory framework not in place

No business case

Resource is NOT
known, validated:

- Not reservoir
- Not CO2



No normal
markets

Develop project to build future markets

- Technical maturation with DGs
- Identified risks, *and many*
- Concept *partly* frozen early
- *Schedule driven*

Establishing a CCS market

- Northern Lights is the first to commercialise CO₂ transport and storage as a service
- Significant interest and demand for our services from industrial emitters
- Strong faith in the commercial viability of a CCS market

Challenges

- De-risking investments in infrastructure development on capture and storage side
- Establishing first of its kind contracts for transport and storage
- Streamlining and adapting regulatory framework
- Establishing bilateral agreements for cross-border CO₂ transport
- Changing geopolitical situation: energy security vs. climate targets



CCS Market Potential in Europe: 320 mtpa

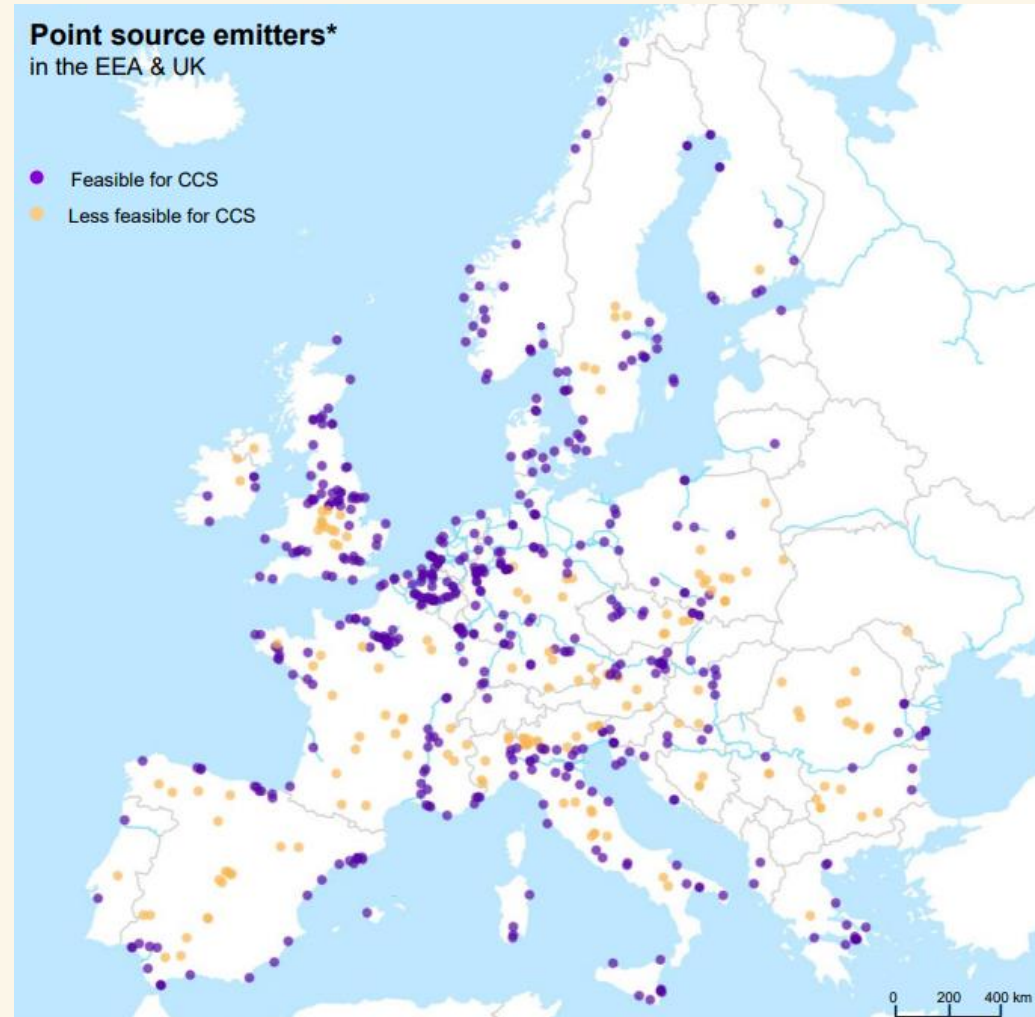
Hard-to-abate sectors:

- Waste Incineration
- Cement
- Steel and Aluminium
- Petrochemicals
- Ammonia and Fertilisers

Blue Hydrogen

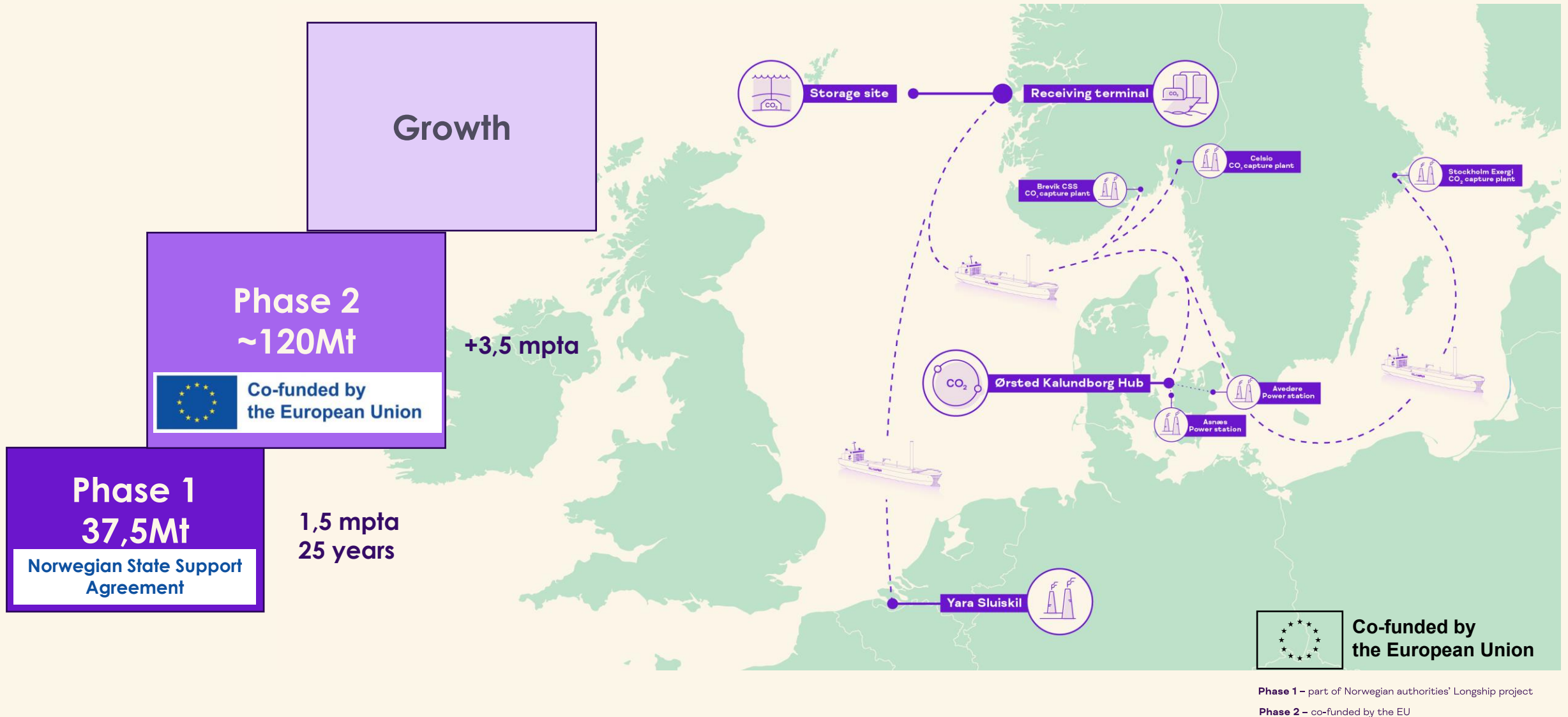
Negative-emission solutions:

- Bioenergy with CCS (BECCS)
- Direct Air Capture (DAC)



Source: Rystad Energy research and analysis

Cross border collaboration



CO2 is not HC – Some key points



CCS

Hydrocarbon Facilities

Characteristic

CO2 is heavy gas at atmospheric condition, **non flammable**, non-toxic, but can **cause suffocation**
NL transports CO2 at liquid phase: cryogenic and under pressure;
Very cold (T < -78 o C) **if released** from liquid to atmosphere;
Solvent to non-metallic materials

Gas or liquid at atmospheric condition, gas phase is lighter than air, **flammable** if mixed at air at certain flammable limit (namely LFL and UFL).
Toxic if contains H2S

Hazard

Suffocation at **high** concentration of **CO2**
Equipment **embrittlement** and **cryogenic burns**
Corrosion – **CO2** in combination **with free water** becomes **corrosive** (No water allowed – **equipment is not designed for it**)
Static electricity if released from dense conditions

Fires and explosions risk due to ignition and turbulence generated in the surroundings of gas cloud
Smoke resulting from fire can **create** hazard of **suffocation** and **hinder** evacuation.
Processed HC - not corrosive if free from contaminant
«Crude» HCs are **corrosive –equipment designed for it**

Fire & Gas Detection

CO2 Gas detection is placed **at low elevation**.
Alarm/confirmed at **0.5%-1.5% vol**
Personal gas detection in culvert, pump pit and confined space

Flame and **Flammable/ Toxic gas detection** are installed in **process area**. Alarm/confirmed detection at **10-20% LEL**.

Flare, Blowdown, and Drain

No flare/blowdown. Short Tail pipe **PSV at tanks** is **directed to atmosphere safe location**.
No specific closed / open drain required. Terrain is designed to lead CO2 towards sea.

Blowdown and flare are used to discharge gas safely **in case of an accidental leak**.
Closed drain system for **HC contaminated drains**. **Open drain** is used to **discharge liquid safely** and each fire area

Ignition Source Control

No electrical isolation nor ATEX required **during CO2 leak**.
Static electricity if **CO2 released from dense conditions** might create ignition source in CO2 plant with HC processing presence.

Electrical isolation is important during gas leak. **ATEX certification** is required **for ignition source control** on the process area.

Escape, Evacuation, Rescue

Wind sock is critical during emergency response
Use of **luminescence/ reflective paint** is important in escape route marking

Escape routes yellow markings + safety signs
Wind sock is critical during emergency response

Northern Lights onshore facilities



Admin/visitor centre

Workshop

Substation

Storage tanks

Injection pumps

Pipeline landfall tunnel

Future expansion / import jetty

Import jetty

Simplified sketch of the systems

1

Marine loading arms

Purpose: interface between ship manifold and onshore facility. Transfer of liquid CO₂ from ship and return vapour back to ship.

- Liquid: Flow rate up to 800 m³/hr
- Vapour return: Flow rate up to 800 m³/hr

2

Online analyzers

Purpose: online analyzer of H₂S, H₂O, O₂

- Both liquid inlet and gas return

3

Intermediate storage tanks

Purpose: Intermediate storage of CO₂.

- Storage capacity 8 250 m³ (1 ship load + 10%)
- 12 tanks (act as one unit)

4

Booster pumps

Purpose: Provide sufficient Net Positive Suction Head (NPSH) to the export pump.

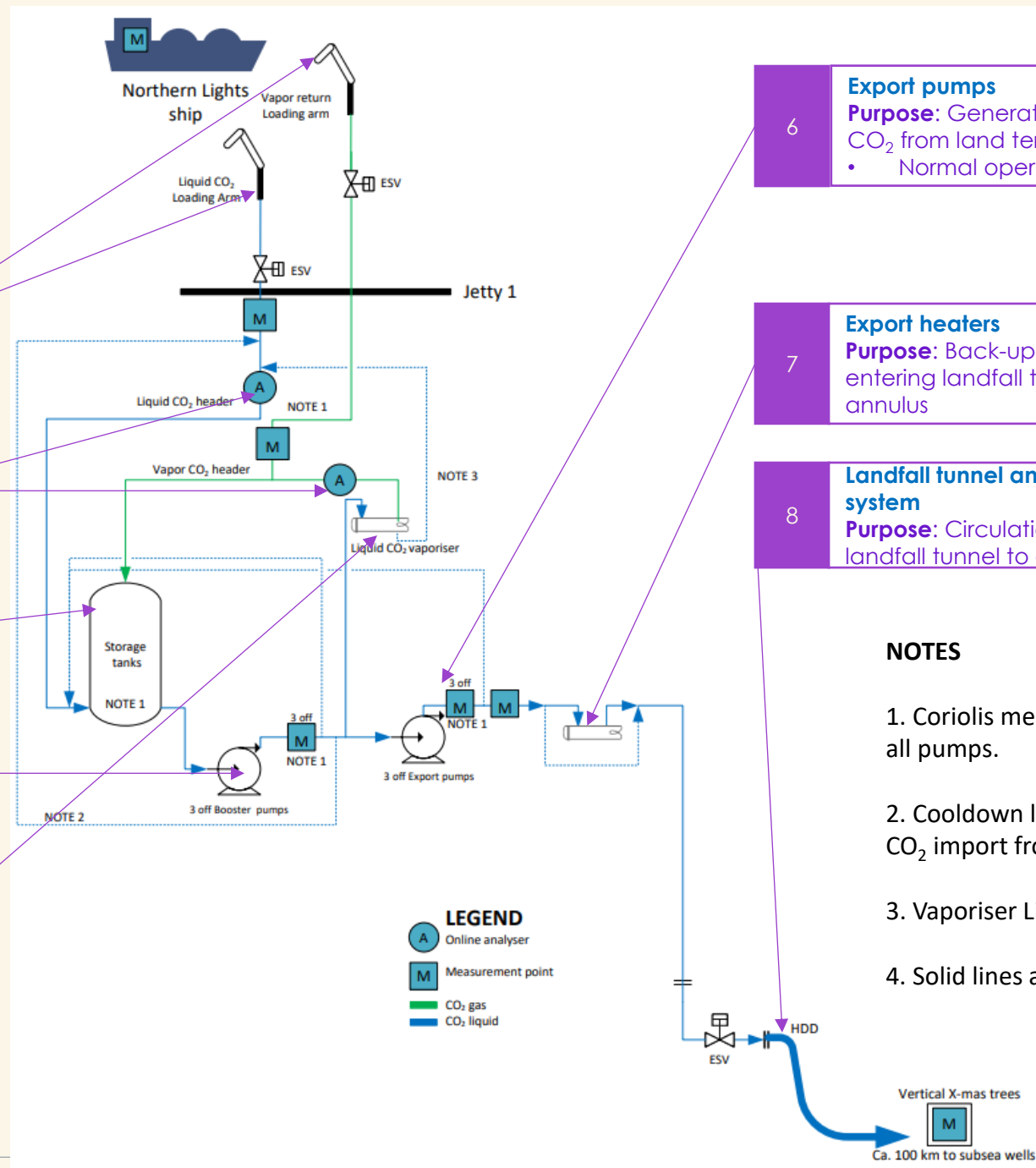
- 3 x 50%
- Fixed speed centrifugal pump

5

Liquid CO₂ vaporizer

Purpose: Generate vapor CO₂ for maintaining the pressure in the CO₂ storage tanks and ship tanks during ship offloading and injection operations.

- Electrical heaters: 2 x 100% configuration



6

Export pumps

Purpose: Generates export pressure to export CO₂ from land terminal to permanent storage

- Normal operating pressure is 50-90 barg

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Export heaters

Purpose: Back-up system to heat CO₂ before entering landfall tunnel to avoid freezing in annulus

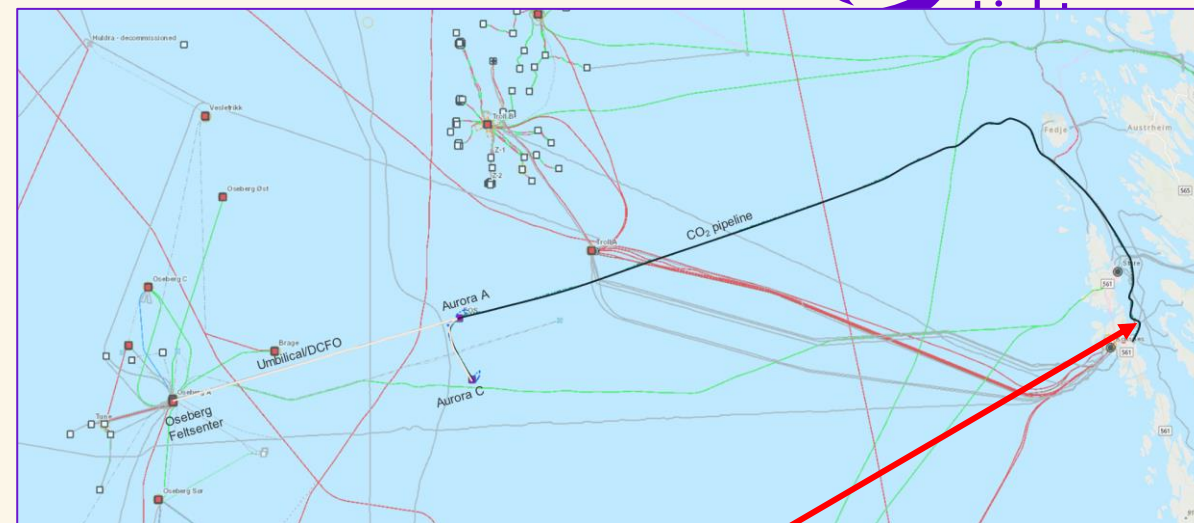
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Landfall tunnel and seawater circulation system

Purpose: Circulation of sea water through landfall tunnel to avoid freezing in annulus

NOTES

1. Coriolis measurement downstream all pumps.
2. Cooldown line (not in use during CO₂ import from ship)
3. Vaporiser Liquid drain
4. Solid lines are main lines in process



680 meter length, exit at -266 meter (-800 ft)

Pipeline

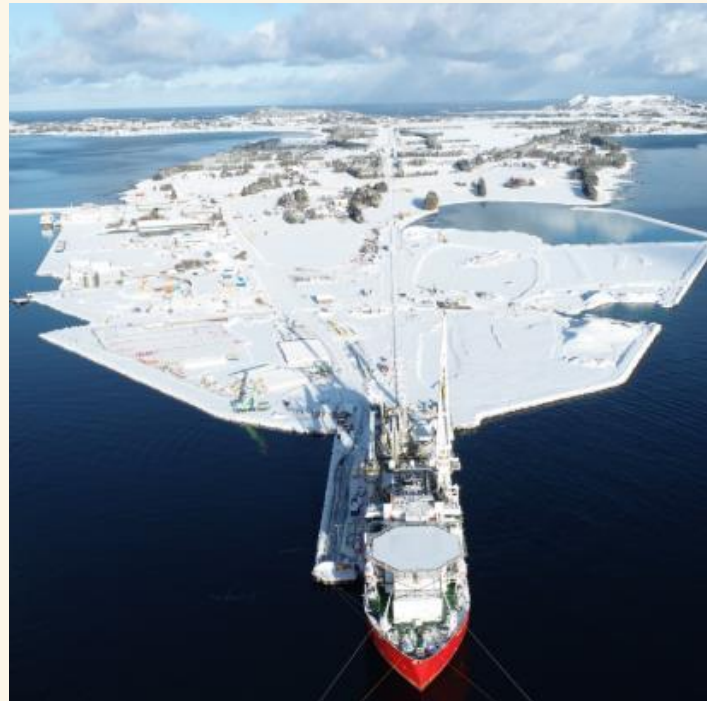
Linepipe & Coating

- About 100 km 12"
- 14 000 T / 9400 joints
- Manufactured in Italy (Tenaris)
- Coated in Norway (Shawcor)



Pipeline prefabrication

- Vigra - Norway

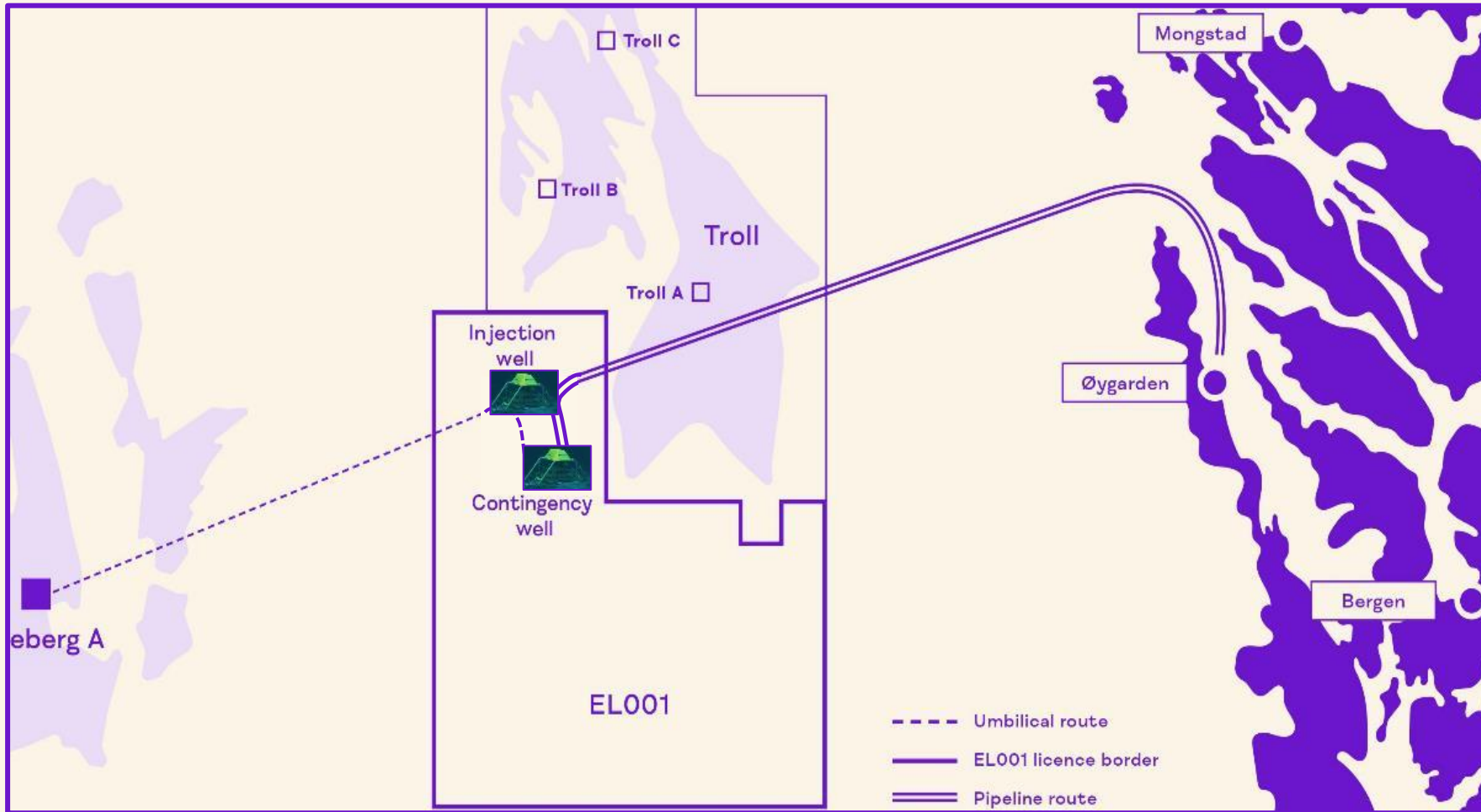


Pipeline Installation

- Reel-Lay
- Seven Oceanic



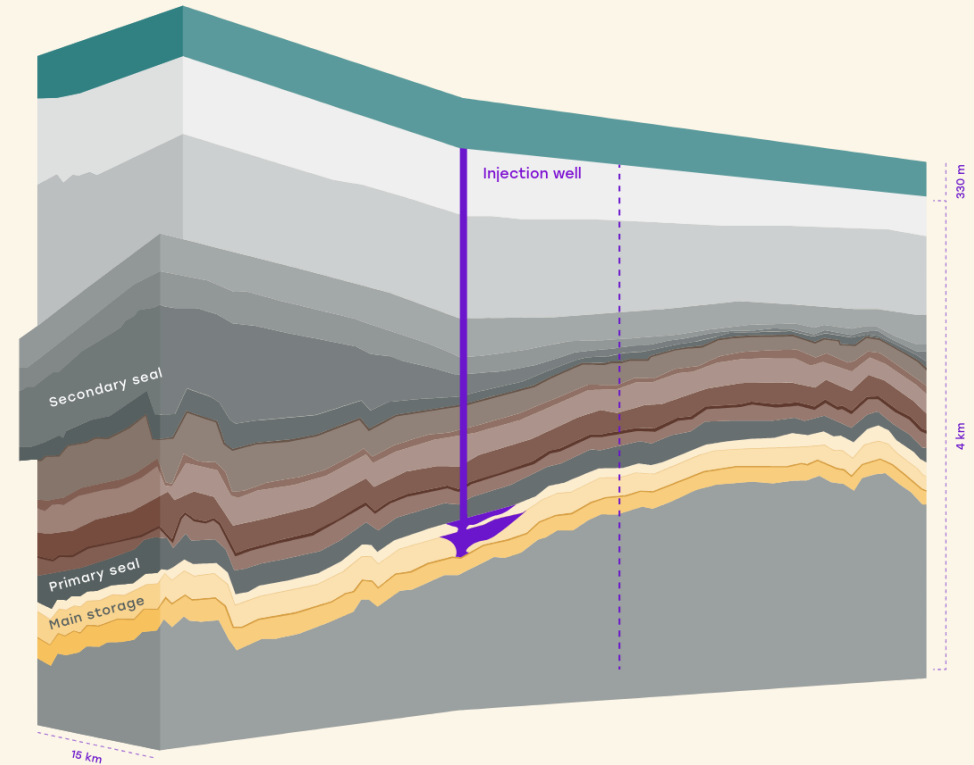
Subsea Facilities and Wells



World Class Geological Storage

Northern Lights Storage (“Aurora” License)

- Deep, offshore: Porous rock (sandstone) formation 2600 m below seabed, 100 km offshore
- High Quality: Confirmed (dynamically tested) as highly permeable
- Build on Experience: CO₂ has been stored offshore Norway for more than 25 years (Sleipner, Snøhvit)
- Safe and permanent
 - Two proven, independent dynamically tested seals (“cap rocks”)
 - Storage utilises the same trapping mechanisms that have kept oil and gas underground for millions of years
 - Tectonically quiet area
 - No legacy wells (leakage potential) within the license



Monitoring Strategy

IN-WELL MONITORING
for assessment of
Injection well performance
Storage pressure
development

**ACTIVE / 4D SEISMIC
MONITORING**
for assessment of
CO₂ plume migration
(dimension and speed)

**PASSIVE / NATURAL
SEISMIC MONITORING**
for assessment of
• **Natural seismicity**
• **Potential induced seismicity**

CO₂ Ships



- Norther Pioneer and Pathfinder have been delivered.
- Vessel 3 to be delivered 30th November 2025
- Vessel 4 to be delivered 30th May 2026

Ships specifications

New type of vessels for a new industry

Enabling access to industrial emitters all over Europe, the shipping solution is a flexible model that can be scaled to market demand

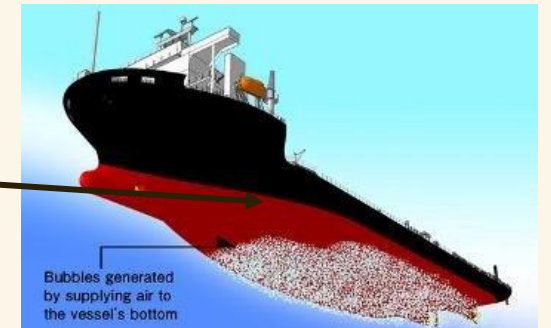
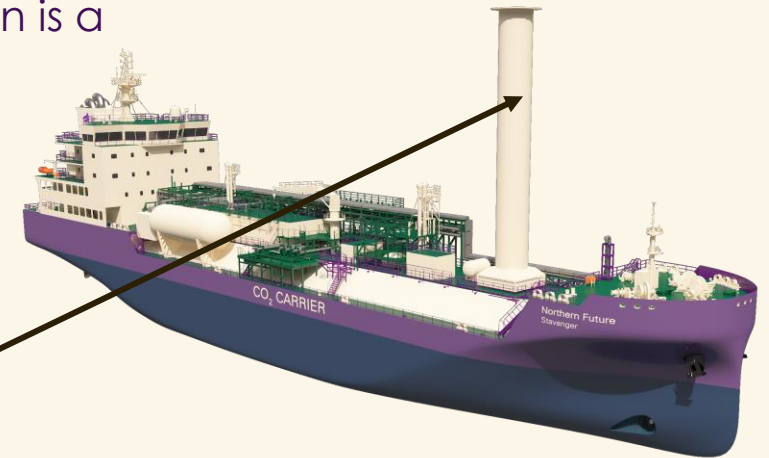
→ **Dimension:** Length: 130 m, width 21m and 8 m draft

→ **Cargo tanks capacity :**

- 7,500 m³ (2 X 3750 m³), 15 barg and -26°C,.
- Purpose-built pressurised cargo tanks (type C tanks)

→ **Low emission ships with low consumption**

- Wind assisted propulsion system (Rotor sail) and
- Air lubrication for the hull
- Electrical connection at quay side during operations
- The above will **reduce carbon intensity** by around 34% compared to conventional systems



Biggest LCO2 tanks ever built



Benefit realisation

- Knowledge and experience sharing important part of our mandate
- Welcomed more than **12 000 visitors** to site since construction start in 2021
- Representing **70 countries** across the world





Northern Lights

norlights.com