Pittsburgh, Pennsylvania
FECM/NETL Carbon Management
International Carbon Management
Heidelberg Materials' Projects

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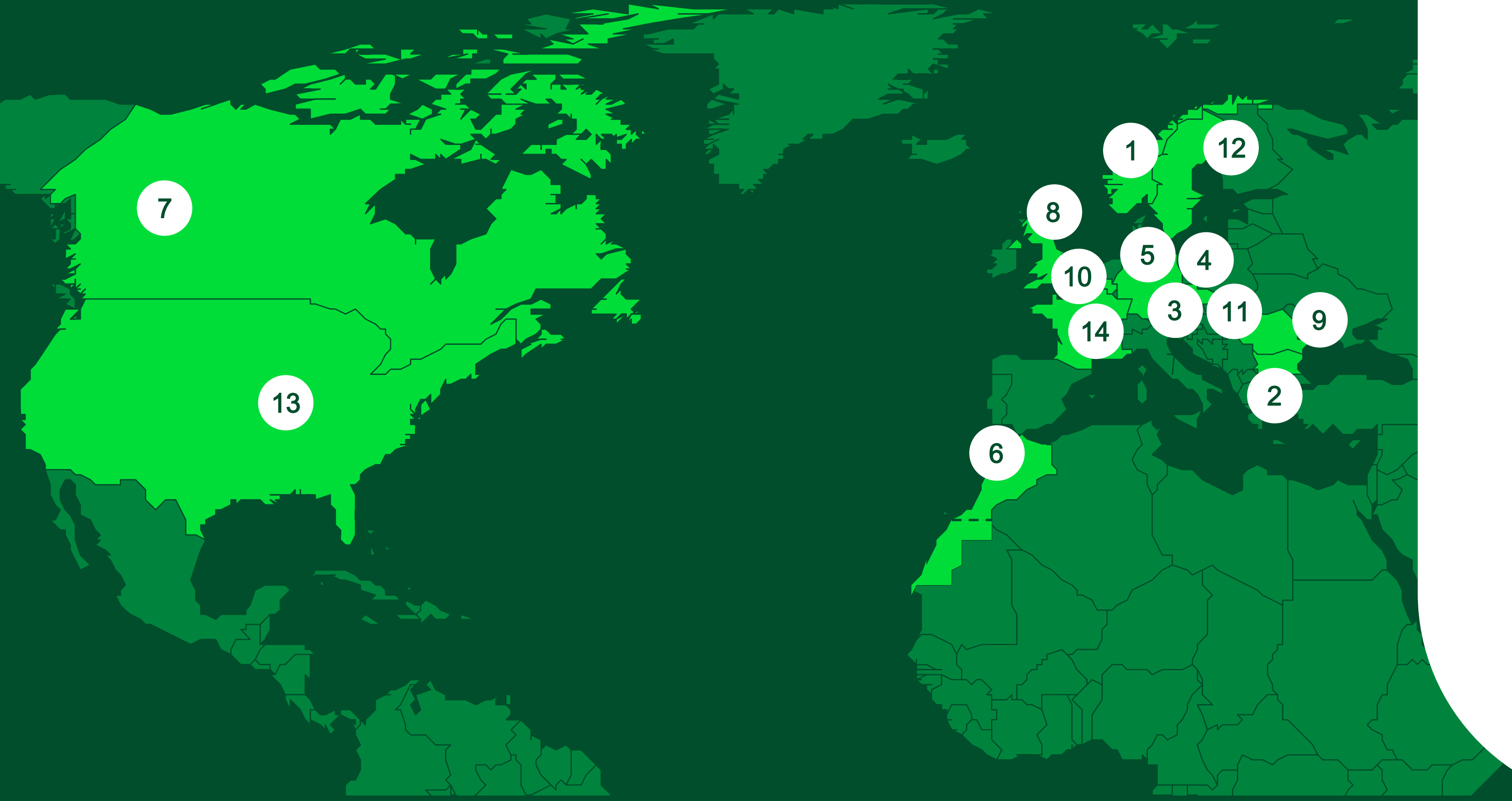
Driving CCUS with the most advanced project portfolio in the sector



1 | CCS 2024
Brevik, Norway
400 kt CO_2 p.a.

2 | CC 2024*
Devnya, Bulgaria
OxyCal pilot site

3 | CC 2025
Mergelstetten, Germany
Oxyfuel pilot

4 | CCU 2025
Lengfurt, Germany
70 kt CO_2 p.a.

5 | CC 2026
Ennigerloh, Germany
LEILAC1+2, 100 kt CO_2

6 | CCU 2026
Safi, Morocco
Upscaling capacity

7 | CCUS 2027
Edmonton, Canada
> 1,000 kt CO_2 p.a.

8 | CCS 2028
Padeswood, UK
800 kt CO_2 p.a.

9 | CCUS 2028*
Devnya, Bulgaria
800 kt CO_2 p.a.

10 | CCUS 2029
Antoing, Belgium
800 kt CO_2 p.a.

11 | CCS 2029*
Geseke, Germany
700 kt CO_2 p.a.

12 | CCS 2030
Slite, Sweden
1,800 kt CO_2 p.a.

13 | CCUS 2030
Mitchell, USA
2,000 kt CO_2 p.a.

14 | CCS 2030
Airvault, France
1,000 kt CO_2 p.a.

*EU funded projects
All dates estimated start of operations, timing dependent on various factors, incl. funding decision

Overview of the project

The world's first in the cement industry

400,000 tonnes
of CO_2 per year

55 tonnes
of CO_2 per hour

Capturing **50% of the plant's CO_2 emissions** – limited by **available waste heat**

46 MW waste heat recovery – **ca 30 MW** from cement kiln, **16 MW** from **CO_2 compressor**

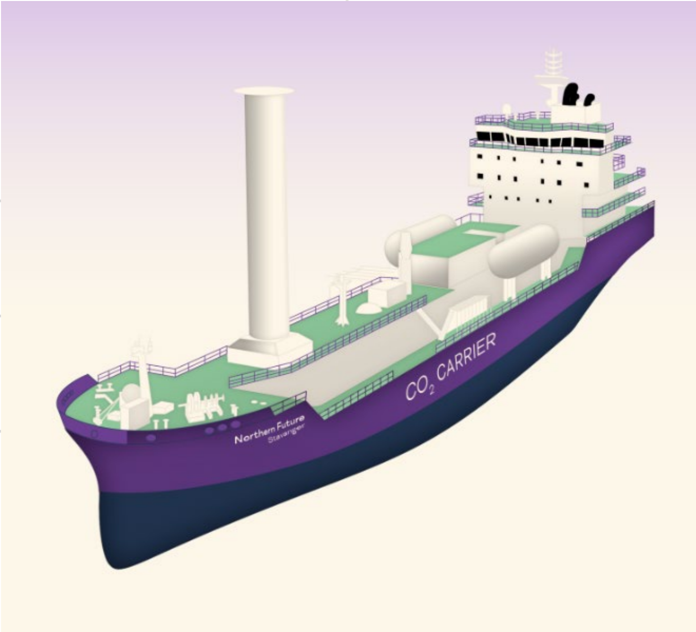
The Longship Project

01 | Carbon capture from **industrial sources incl.** Brevik cement plant

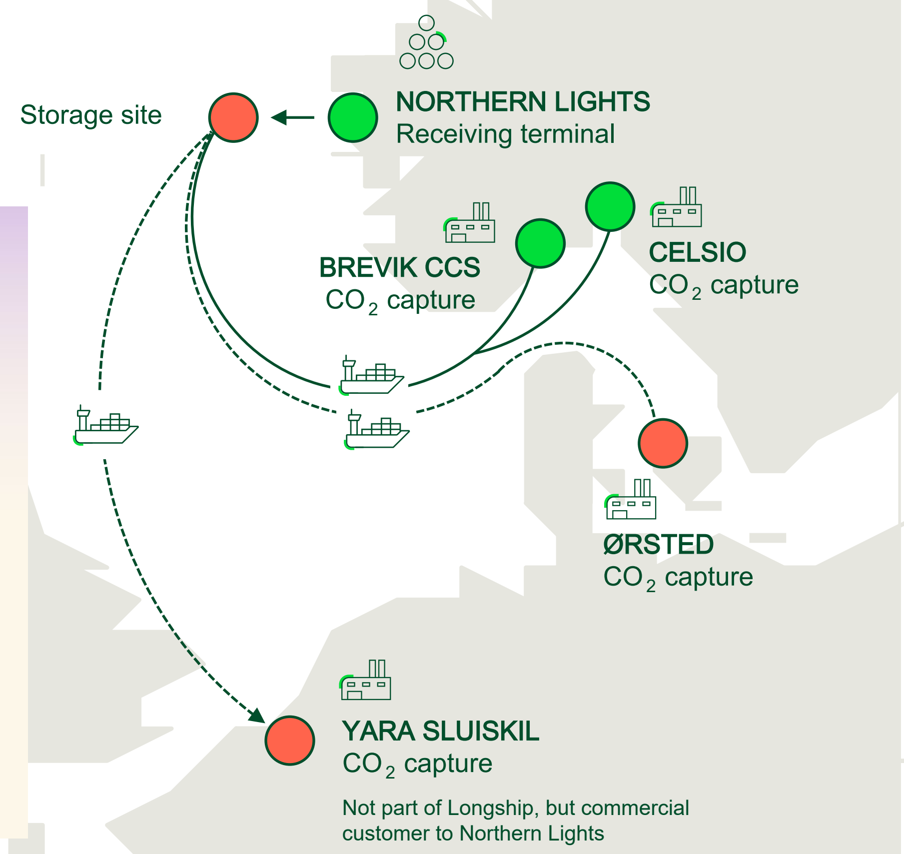
02 | Transport to Øygarden

03 | Pipeline to storage in North Sea

Supported by state funding for installation and 10 years operation



- Transport by 2 ships
- 700 km distance
- Liquefied state (16 bar, -26°C)



Temporary storage and ship loading

Storage capacity: 5,000 m³

6 storage tanks with a total capacity of 5,000 m³ – enough to store the CO_2 from 4 days of production

Preparing the CO_2 for transport

CO_2 is compressed to 16 bar pressure and cooled to -26º C – liquid state, suitable for transport and interim storage. Insulated tanks. No active cooling

People & project

More than **900,000 working hours**, very good performance on health & safety records

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15 "Carbon Catchers" (operators + process engineers) have been hired, are being trained on a simulator and will be involved in commissioning

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In total, plant will have **195 full-time employees** once the CCS facility is operational, of which 29 will be working for the CCS project

Lessons Learned

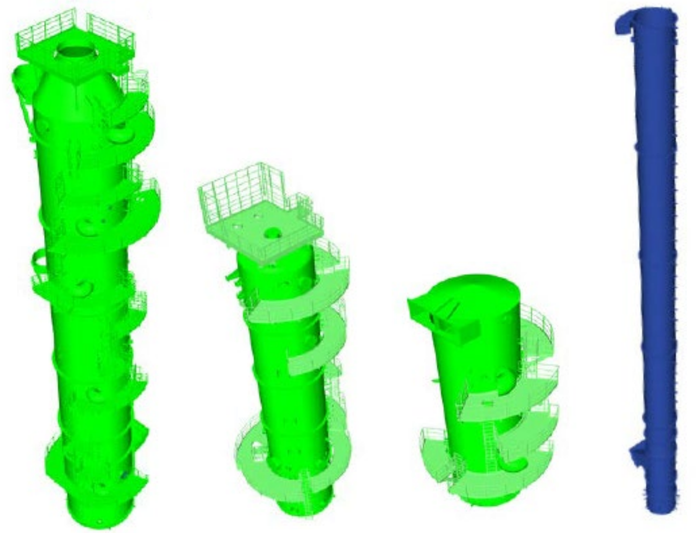
- A clear recommendation for future CCS projects is to have **sufficient piping expertise** on the project team in areas like:
  - pipe suppliers and pipe supply markets
  - prefabrication methods and companies
  - logistics tracking of pipe components
  - productivity assessments in pipe fabrication and installation
- Include an **Operating Training Simulator** as part of the project to prepare dedicated process operators for the CCS plant for commissioning, startup and operation. The simulator also helped optimize and tune the PLC logic, controllers and timers for a smoother startup.
- Risks can be reduced by separating the CCS facility as much as possible from the operating plant. Challenges of having the CCS system closely integrated with the cement plant:
  - Civil engineering difficulties working with existing structures
  - Communicating and documenting interfaces to the existing plant - is this owner or supplier responsibility?
  - Limited room for construction activities adding pressure to the schedule
- Pipelines for liquid CO_2 need to be designed to be drained
- Identify safe locations of CO_2 venting (operational as well as emergency)
- Plate and frame heat exchangers to have flow control between units and able to be isolated for maintenance

Mounting the CCS plant: 4 heavy -lift campaigns in 2023 and 2024

The challenge

Several components weighing **200 tonnes** or more had to be lifted into place…

… and assembled with **millimeter precision.**



Other Challenges

- The **offshore oil & gas (high cost/no-risk)** versus **cement (low cost/practical) cultural misunderstandings** have proven significant and challenging to overcome. It takes years to build a common understanding with suppliers even in the cement industry.
- **Reporting requirements for publicly funded projects** are much higher than for conventional projects within Heidelberg Materials. The project must be sufficiently staffed for these demands.
- Postponement of construction of maintenance building due to **space limitations**.
- The CO_2 loading point was **relocated twice** due to changes in base assumptions / space for docking.
- **Cost increase** to the forecasted budget and **project delays** of around 10 months.
  - The **scaffolding** for the support of construction works in the project has been far more than budgeted.
- Use of EN 13480 versus ASME B31 piping systems; availability of EN-piping has proven challenging
- Necessity of heat-tracing and insulating plant air (compressed air)
- Painting, equipment preservation (protection during installation)
- On-site installation of **insulation of liquid CO_2** storage tanks required careful climate control during the installation process and is challenging to do in the winter due to risk of condensation on the tank surface.

Thank You.

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