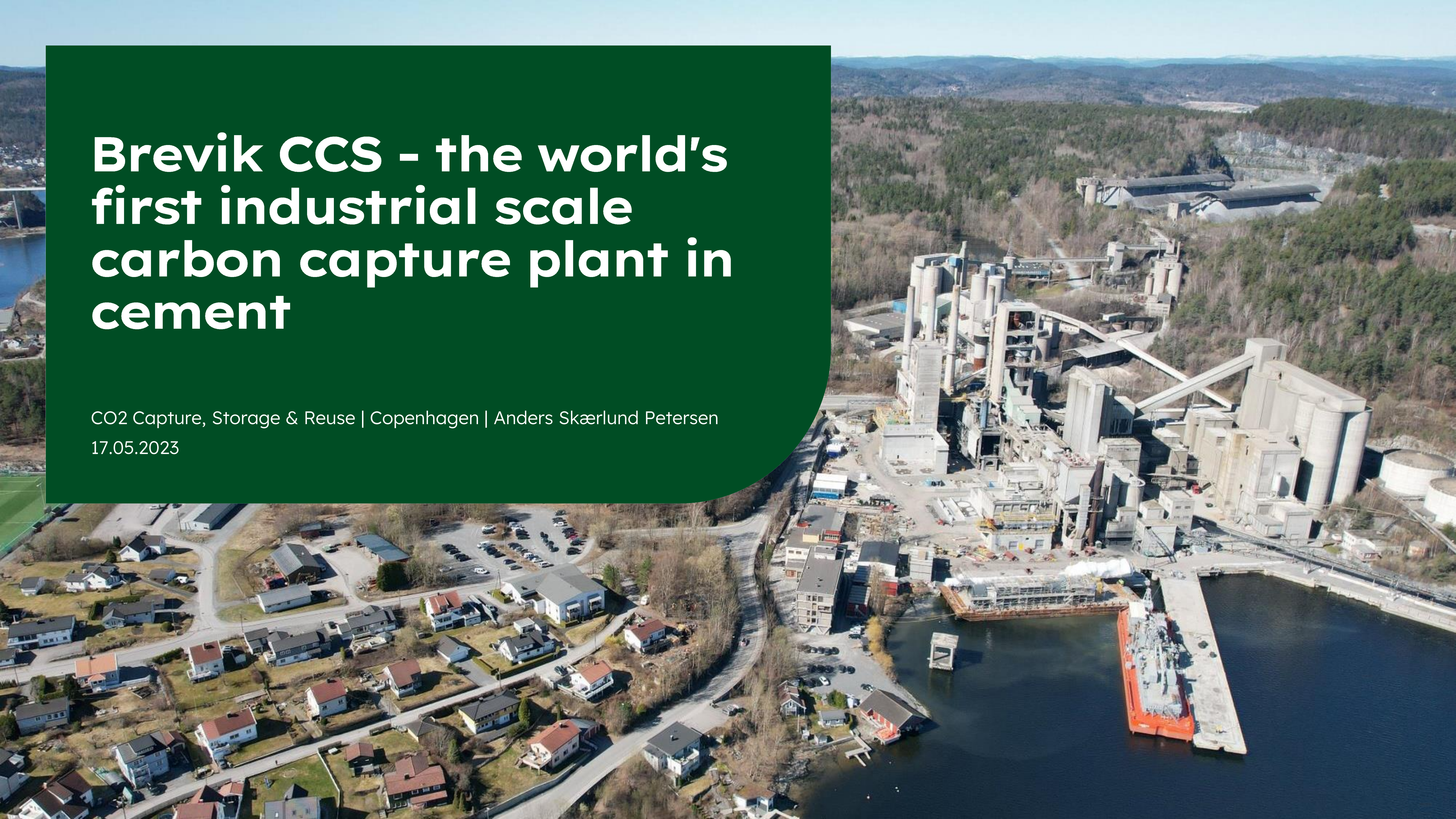
Brevik CCS - the world's first industrial scale carbon capture plant in cement

CO2 Capture, Storage & Reuse | Copenhagen | Anders Skærlund Petersen

17.05.2023



Agenda

1. **History and Status**
   From pilot testing to full throttle ahead
2. **Project Overview**
3. **FEED and Final Design**
4. **Project Development**
5. **Main Units**
6. **Take Away**

1 History and Status

From pilot testing to full throttle ahead

1. CCS Development in Norway
2. Longship Today

1. CCS Development in Norway & the Brevik CCS project

1996 – Statoil (now Equinor) established a capture and storage solution at the Sleipner field in the North Sea. From 1996 to 2023 - 16 mill. ton CO_2 injected and monitored.

2006/7 – Government decided that Norway should take the lead to develop CCS. Gassnova was established and plan for full scale CC at Mongstad with permanent storage in the North Sea.

2008 – Approval by government and ESA (European Surveillance Authority) announced by the Ministry of Oil and Energy (OED) in February 2010.

2013 – Full scale (3.400 tpd) Mongstad-project stopped. TCM opens in 2012.

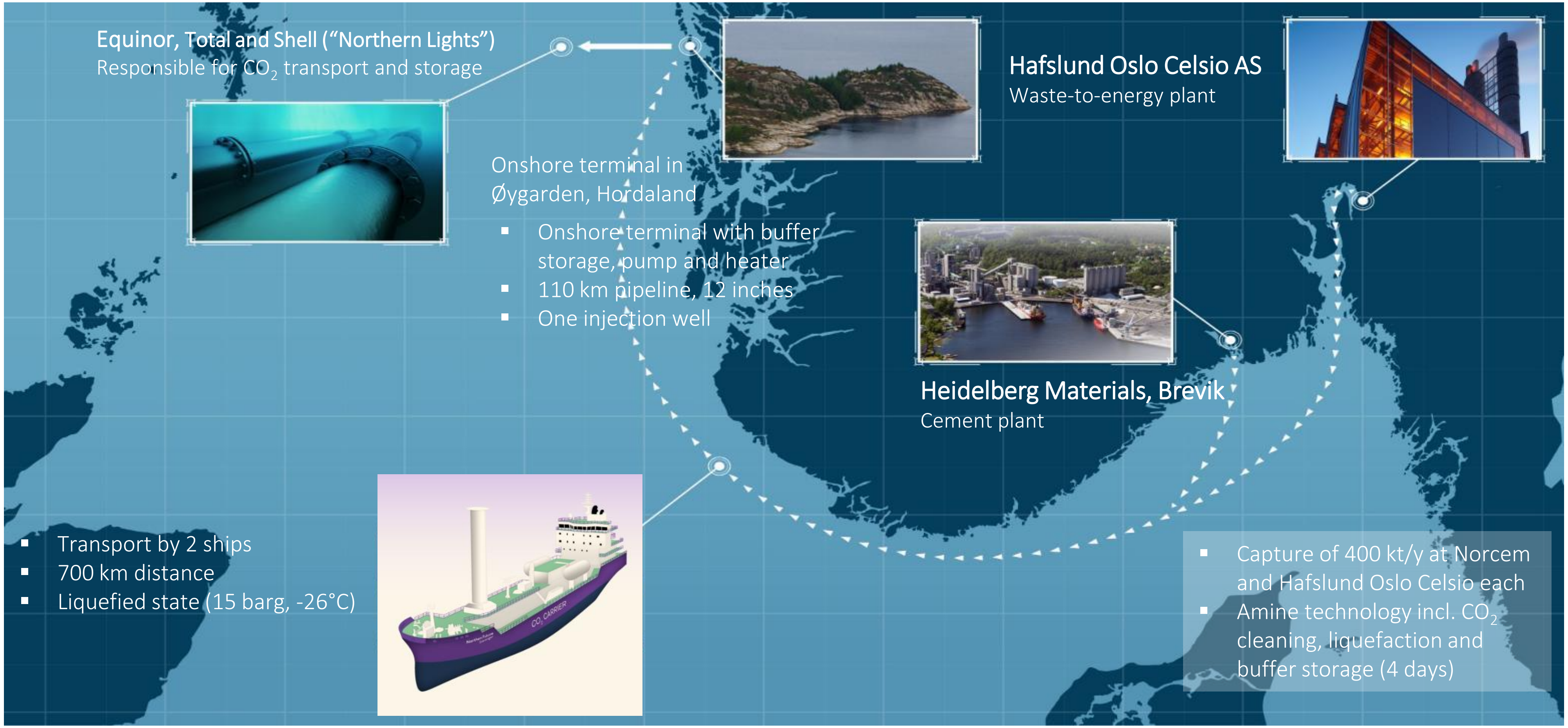
2015 – Scope changed based on input/proposal from Norsk Industri (federation) and Heidelberg Materials (Norcem). Norwegian Carbon Capture Demonstration project launched three capture projects, transport and storage.

2017 – Brevik Concept studies submitted.

2019 – Brevik FEED-studies submitted.

2020 – Longship launched 21 September 2020.

2. Longship Today



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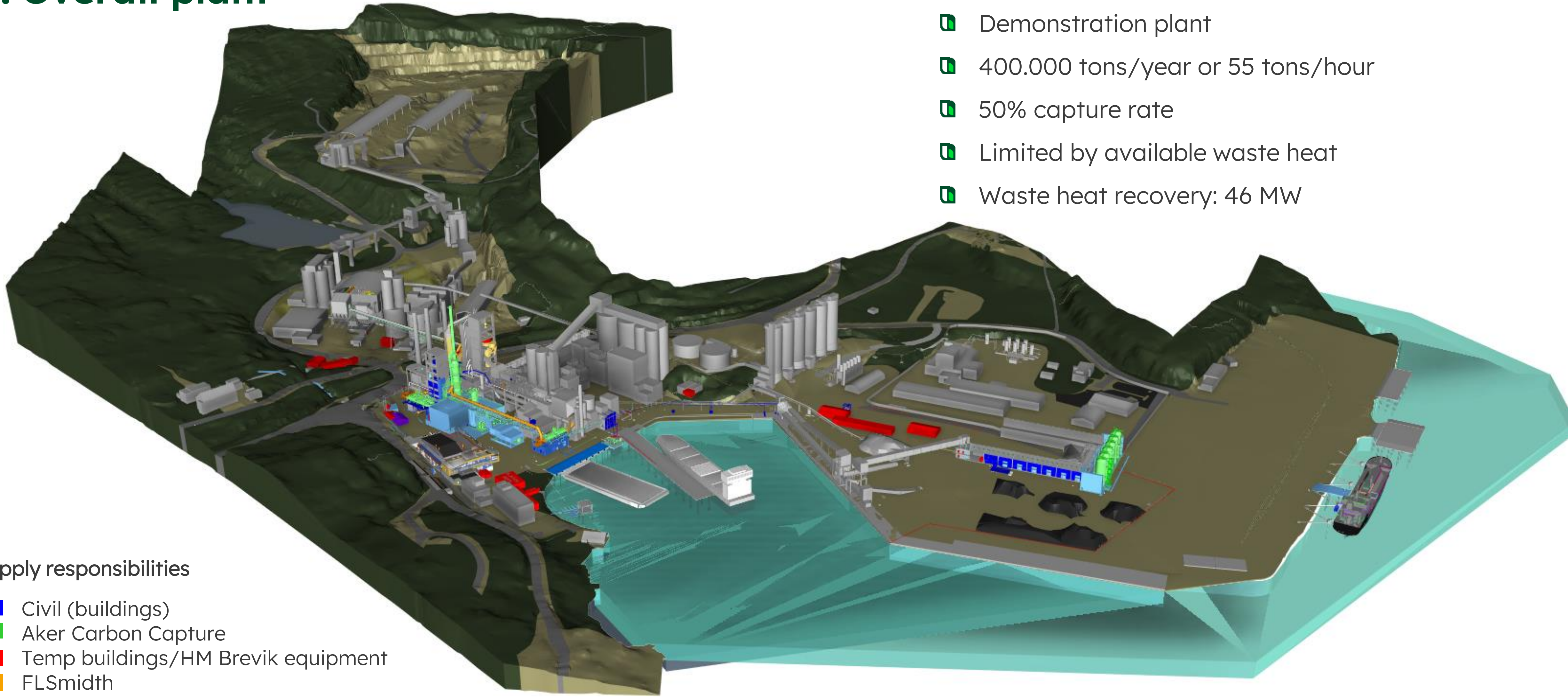
Project Overview

1. Overall plant
2. Carbon Capture Plant
3. Carbon Capture Units
4. CO_2 Storage

1. Overall plant

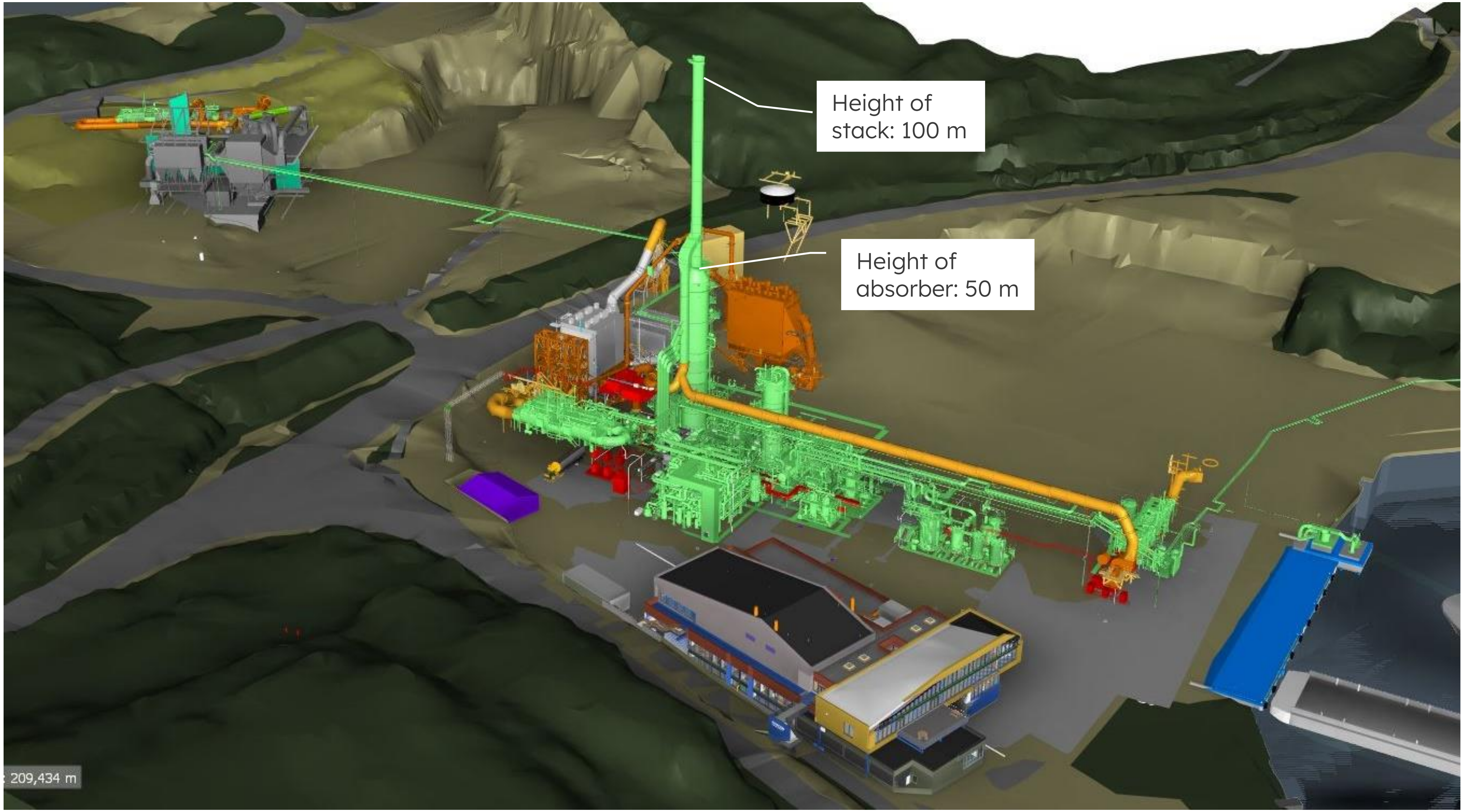


- Demonstration plant
- 400.000 tons/year or 55 tons/hour
- 50% capture rate
- Limited by available waste heat
- Waste heat recovery: 46 MW

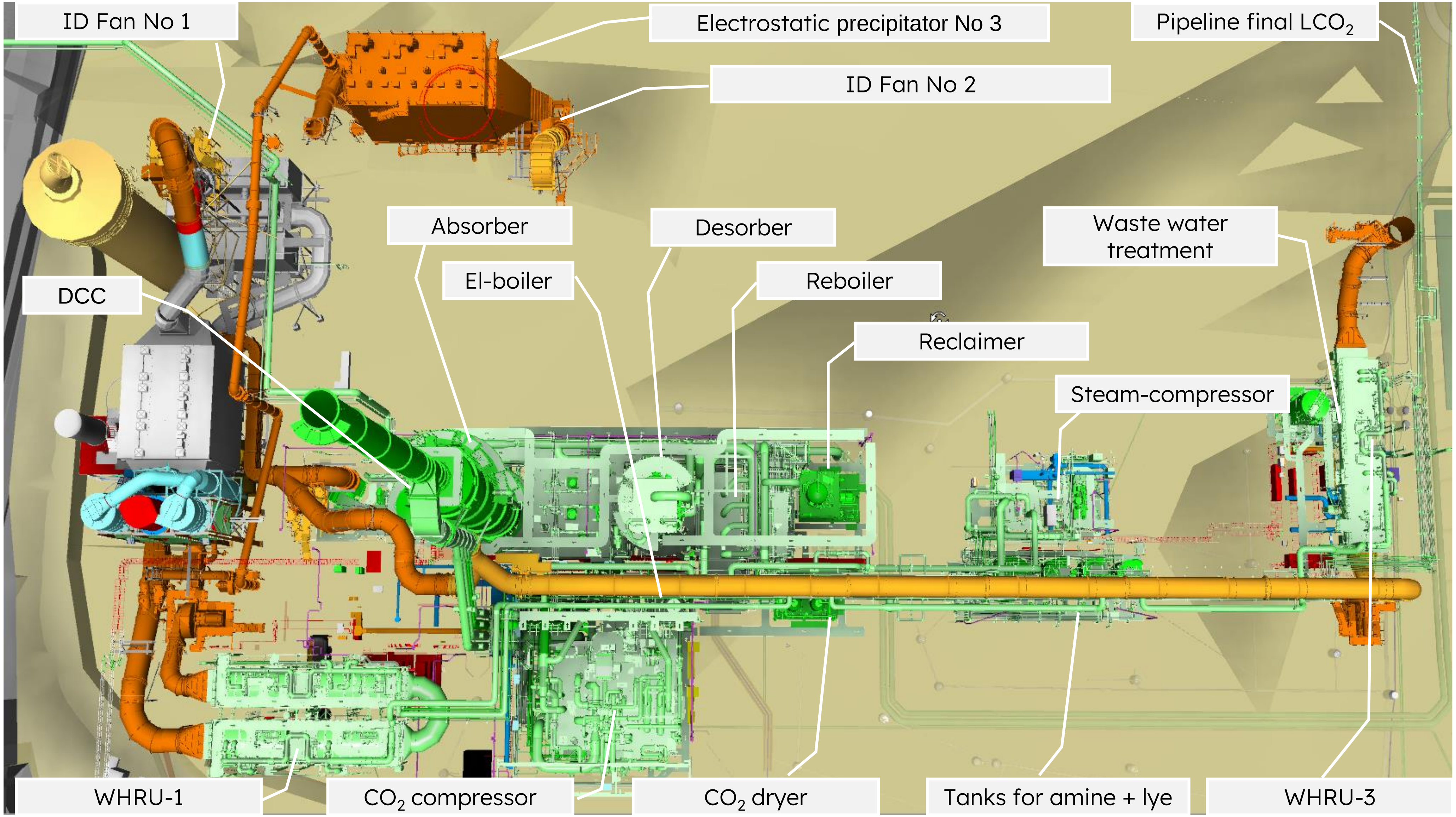
Supply responsibilities

- Civil (buildings)
- Aker Carbon Capture
- Temp buildings/HM Brevik equipment
- FLSmidth
- Existing cement plant

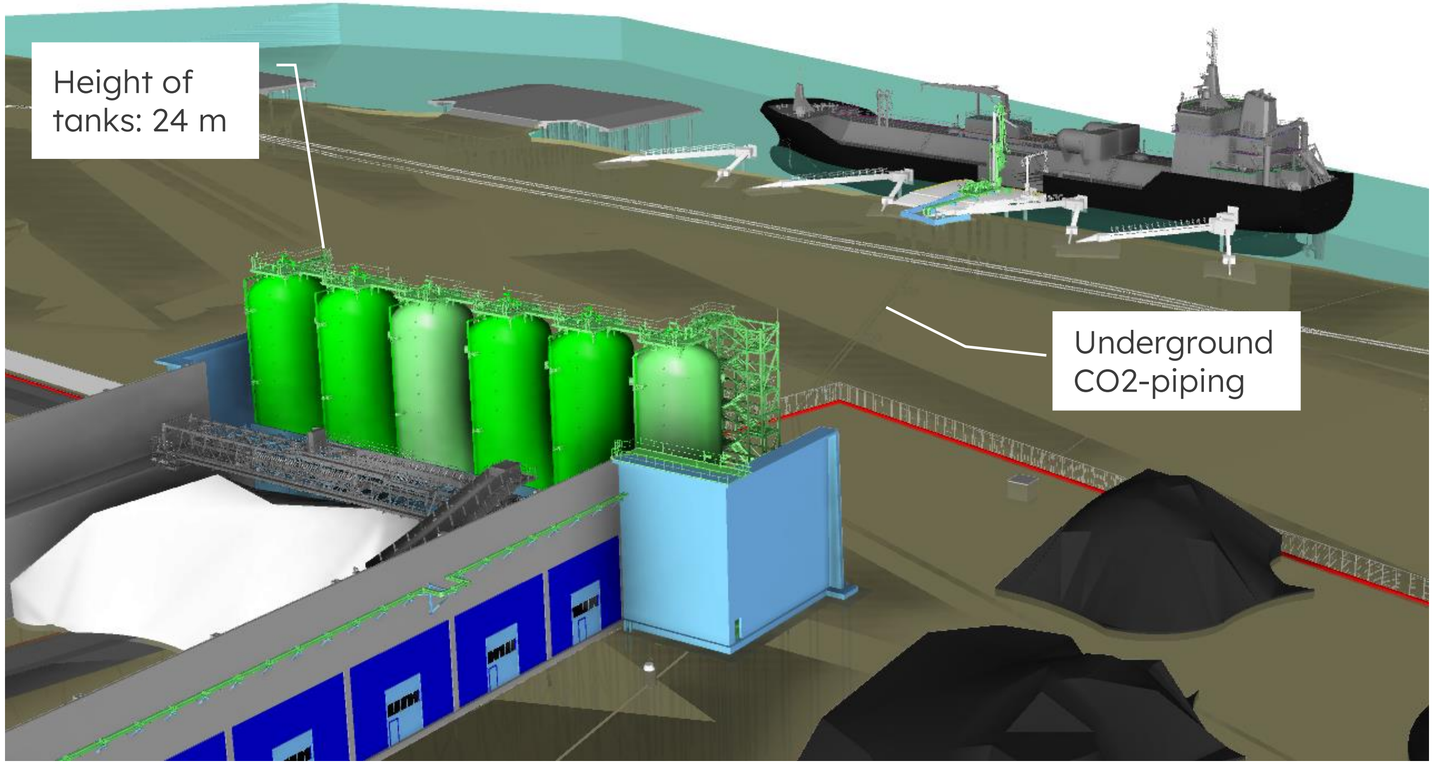
2. Carbon Capture Plant



3. Carbon Capture Units



4. CO_2 Storage



- **Storage capacity:** 5.000 m^3
  - 4 days of production
  - Ship load capacity: 800 tph, 7.500 m^3
- **State of CO_2**
  - Liquid
  - -26°C, 16 bar
- **Insulated tanks**
  - No active cooling
  - Natural evaporation (returned to capture plant)

3

FEED and Final Design

1. FEED Design of CO_2 Capture System
2. Final Design of CO_2 Capture System
3. FEED Design of CO_2 Compressor System
4. Final Design of CO_2 Compressor System

1. FEED Design of CO_2 Capture System

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2. Final Design of CO_2 Capture System

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3. FEED Design of CO_2 Compressor System

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4. Final Design of CO_2 Compressor System

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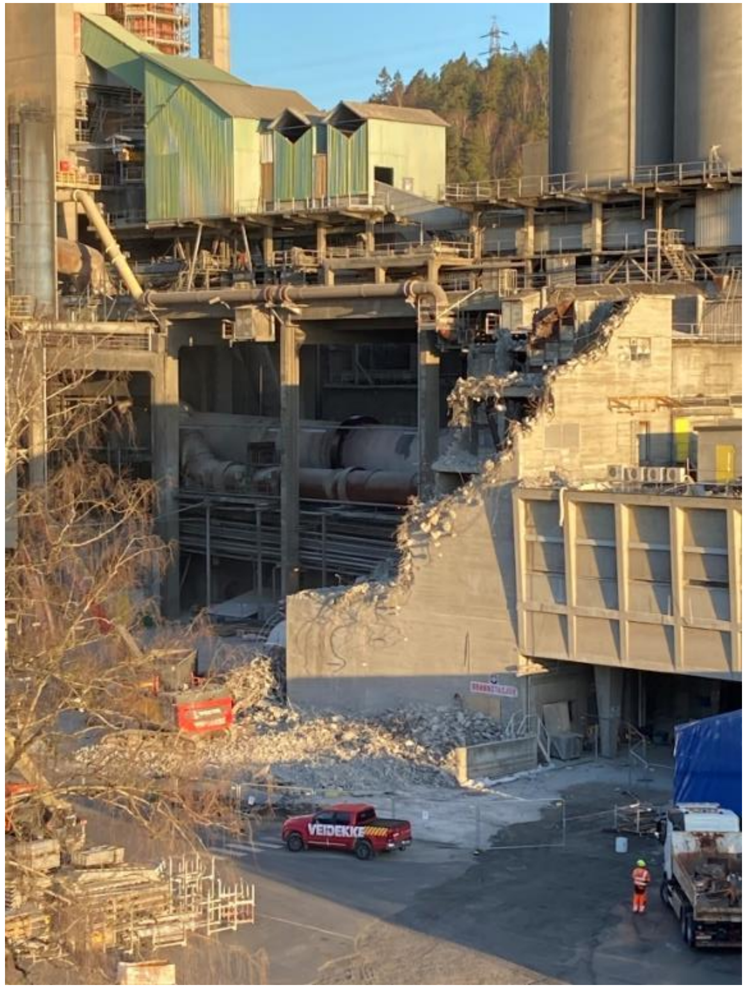
4 Project Development

First capture next year: Past and current status at the construction site

1. March/April 2021: Site Preparation Ongoing



2. March 2022: Jetty construction under way

April/May 2022: Equipment being fabricated/installed at sub-suppliers

WRHU's being welded

Drying and reclaimer package

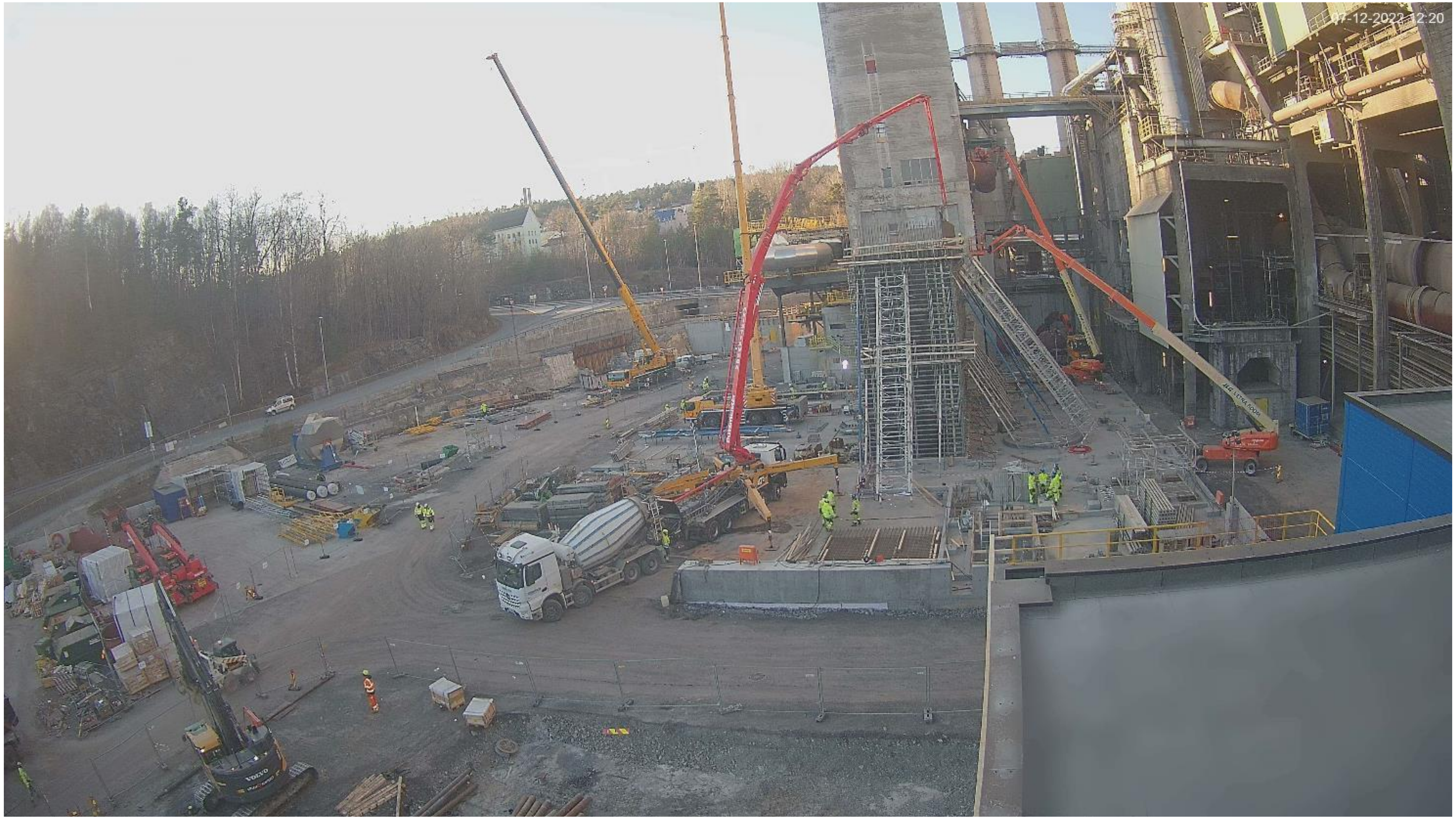
3. June 2022: Effluent water treatment building being erected

August 2022: Piling completed

5. October 2022: WHRU's set in place

6. November 2022: All WHRU's have been installed, WHRU3 fan installed

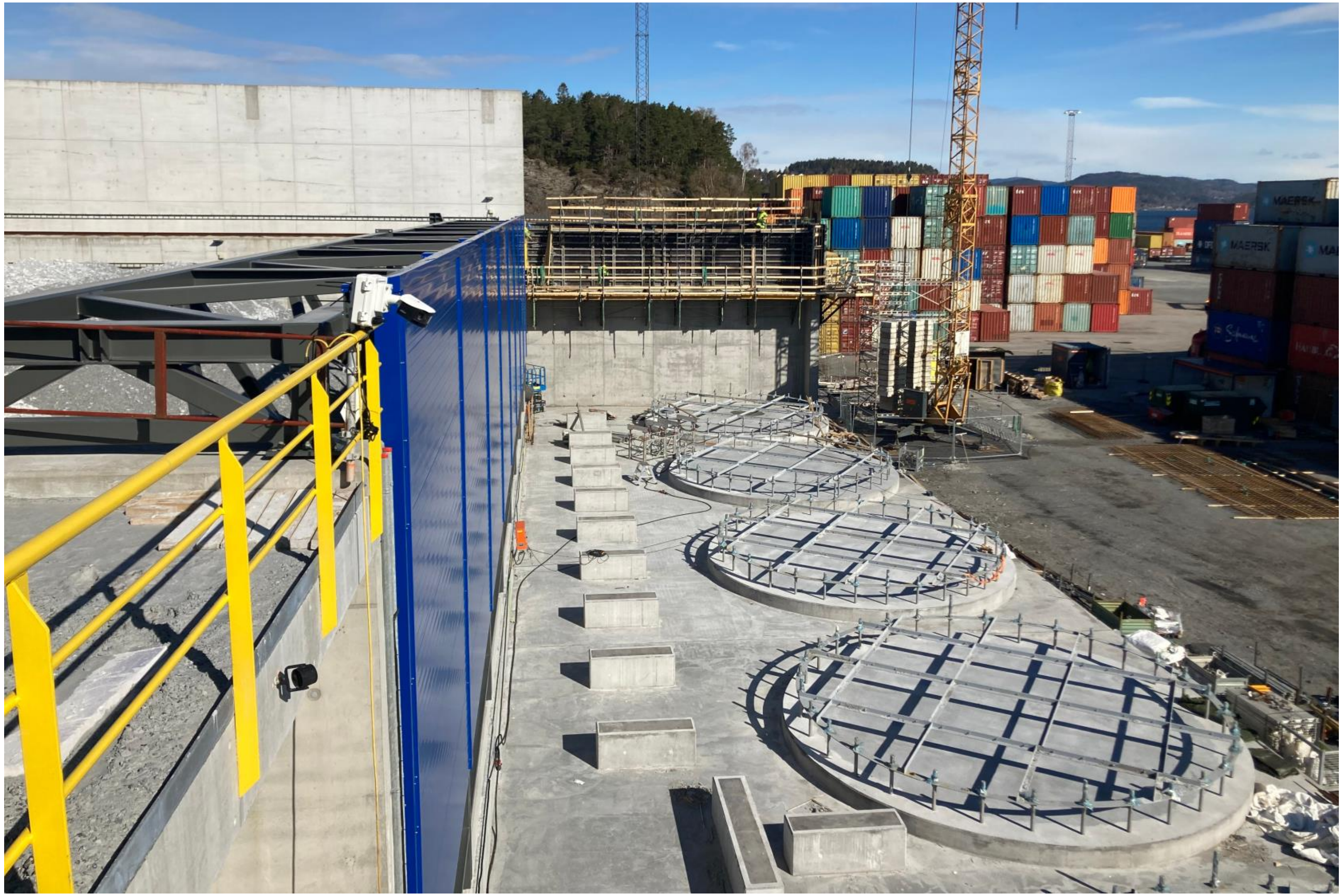
7. December 2022: Compressor walls being cast, flue gas fan on site



March 2023: Internals installation, pipes for high-voltage cables being installed

End April 2023: Overview of the construction site

End April 2023: Overview of CO_2-tank farm foundations

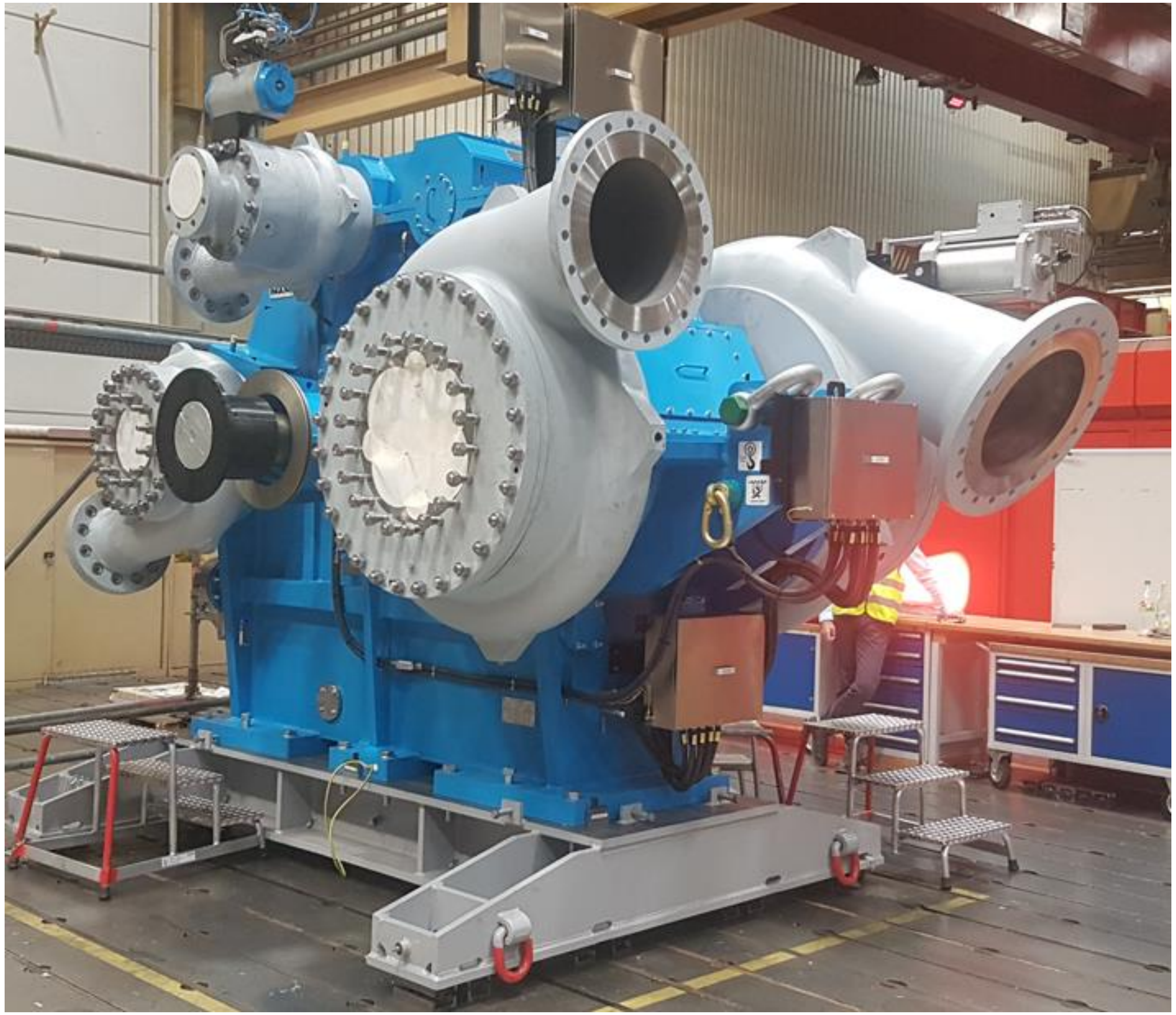


5 Main Units

1. Absorber column in fabrication
2. CO_2 compressor in MAN ES fabrication facility

1. Absorber column at fabrication facility

2. CO_2 Compressor in MAN ES fabrication facility



6 Take Away

The cement industry meets the petrochemical industry

1. Project Challenges
2. Lesson Learned
3. Lesson Learned – potential for cost/time savings

1. Project Challenges

- **COVID** with repeated lockdowns, mandatory home office and travel restrictions.
- Postponement of construction of maintenance building due to **space limitations**.
- **The entire Electrostatic Precipitator** filter need to be replaced rather than only a portion.
- **Gas conditioning towers** had to be replaced due to the higher operating temperatures.
- **Gas suspension absorber** had to be replaced due to corrosion.
- **Relocation** of CO_2 loading point due to changes in base assumptions.
- A second change in the proposed CO_2 **loading point** to Ro-Ro south due to insufficient space for docking.
- Agreement that piping should be supported by Contractor structures, and not by civil structures; this turned out to be unrealistic.
- Increase in **civil costs** due to challenges of close integration into existing cement plant.
- **Delay** due to difficulty in sourcing materials due to war in Ukraine.
- Notification of **cost increase** to the forecasted budget and **project delays** of around 6 months.

The cement industry meets the petrochemical industry (example)

Carbon steel, crude supports etc (cost-effective focus)

Stainless steel, fully welded supports

2. Lesson Learned

- The speed of development of CCS projects within HM have been greatly enhanced by the experience gained by the Brevik CCS project and knowledge gained is **being used actively on other CCS projects.**

- Single sourcing of FEED study reduces the competitive pressure on the contractor. To maintain competition throughout the development phase of a CCS project, it is **recommended to conduct two simultaneous FEED studies with different suppliers.**

- **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.

2. Lesson Learned

- The **offshore oil & gas vs 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.

- Due to the complexity of CCS projects, standard project management principles must be followed.

- Risks can be reduced by separating the CCS facility as much as possible from the operating plant. Some of the challenges of having the CCS system closely integrated with the cement plant operation:
  - 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

3. Lesson Learned – potential for cost/time savings

There is **room for cost reduction** by reducing the design requirements based off offshore project experiences. Recommend relaxing of specifications to be more in line with land-based projects:

- painting, equipment preservation (protection prior to installation)
- using supplier's standard specifications
  (one supplier added ~30 % extra cost due to non-standard spec)
- pipe supports (stainless steel versus less costly carbon steel supports)
- use of EN 13480 versus ASME B31 piping systems;
  availability of EN-piping has proven challenging
- use land-based requirements to documentation
  (~20 docs versus 120+ docs on a single process fan)

3. Lesson Learned – potential for cost/time savings

Additional focus during the pre-FEED & FEED periods can improve the overall project design and reduce the cost.

Examples:

- Pipelines for liquid CO_2 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 multiple units and a possibility to be isolated on an individual basis for maintenance
- CO_2 compressor emergency blow-off scenarios
- During the FEED the contractor should develop their subcontractor / installation strategy

Changing the future starts today!

Heidelberg Materials

Thank You