KNOWLEDGE SHARING 2026

CCS & CDR Summit

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AN INITIATIVE OF THE CLEAN ENERGY MINISTERIAL

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Thomas Skadal

CEO

GASSNOVA

Thomas Skadal joined Gassnova as CEO on May 1, 2025. He previously served as CEO of Biozin Holding, where he led the company through an extensive development phase. Before this, he spent many years at ExxonMobil in various management roles in Norway and internationally, covering refining operations, international trading and business development. He holds an MSc in Economics with a specialization in financial management and corporate finance from the Norwegian School of Economics.

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08:40-10:45	**Longship Experience Sharing: Insights Across the Full Project Lifecycle** Moderator: Eve Tamme, ZEP		
10:45-11:15	Break		
11.45-12:45	Workshop #1 **CO_2 transport technologies, contractual frameworks and systems** Moderator: Stijn Santen, EBN	Workshop #2 **Insuring CCUS and CDR projects** Moderator: Lesley Harding, Liberty Mutual	Workshop #3 **Driving large scale carbon dioxide removals** Moderator: Juho Lipponen, CEM CCUS &MI CDR
12:45-14:00	Lunch		
14:00-15:30	Workshop #4 **Integrating technologies and processes for cost effective CO_2 specifications over the CCS value chain** Moderator: Stijn Santen, EBN	Workshop #5 **CCUS/CDR MRV in Action: Challenges, Opportunities, and Implementation Strategies** Moderator: Jasmin Kemper, IEAGHG	Workshop #6 **Pushing projects forward: How government policy can help develop sound business models for carbon management** Moderator: Eadbhard Pernot, ZEP
15:30:16:00	Break		
16:00:17:30	Workshop #7 **Scaling up storage: Insights on developing operational storage capacity in Europe** Moderator: Sarah Gasda, NORCE	Workshop #8 **Reducing Cost and Risk in CO_2 Capture Through Real-Plant Operation and Knowledge Sharing** Moderator: Svein Ingar Semb, Gassnova	Workshop #9 **Financing carbon management: challenges and solutions** Moderator: Stijn Santen, EBN
17:30-17:40	Walk to conference hall «Parksalen»		
17:40-18:00	**Key Learnings from the workshops** Moderator: Ingvild Ombudstvedt, IOM Law		

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MODERATOR

Eve Tamme is a distinguished climate policy leader with over two decades of experience across government, intergovernmental organisations, non-profits, consultancy and advisory roles. She holds several non-executive positions in carbon markets and carbon management organisations, including serving as Chair of the Zero Emissions Platform.

Eve Tamme

CHAIR

ZERO EMISSIONS PLATFORM

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LONGSHIP EXPERIENCE SHARING: INSIGHTS ACROSS THE FULL PROJECT LIFECYCLE

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Aslak Viumdal

HEAD OF MARKET DEVELOPMENT INSIGHT

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Aslak Viumdal is an economist working in the intersection between technology development, market creation, and the development of regulatory frameworks for CCS. Aslak has developed and is coordinating the benefits realisation program of "Longship". This program focuses e.g. on knowledge sharing activities. He has previously held different positions as consultant and public servant in the energy sector.

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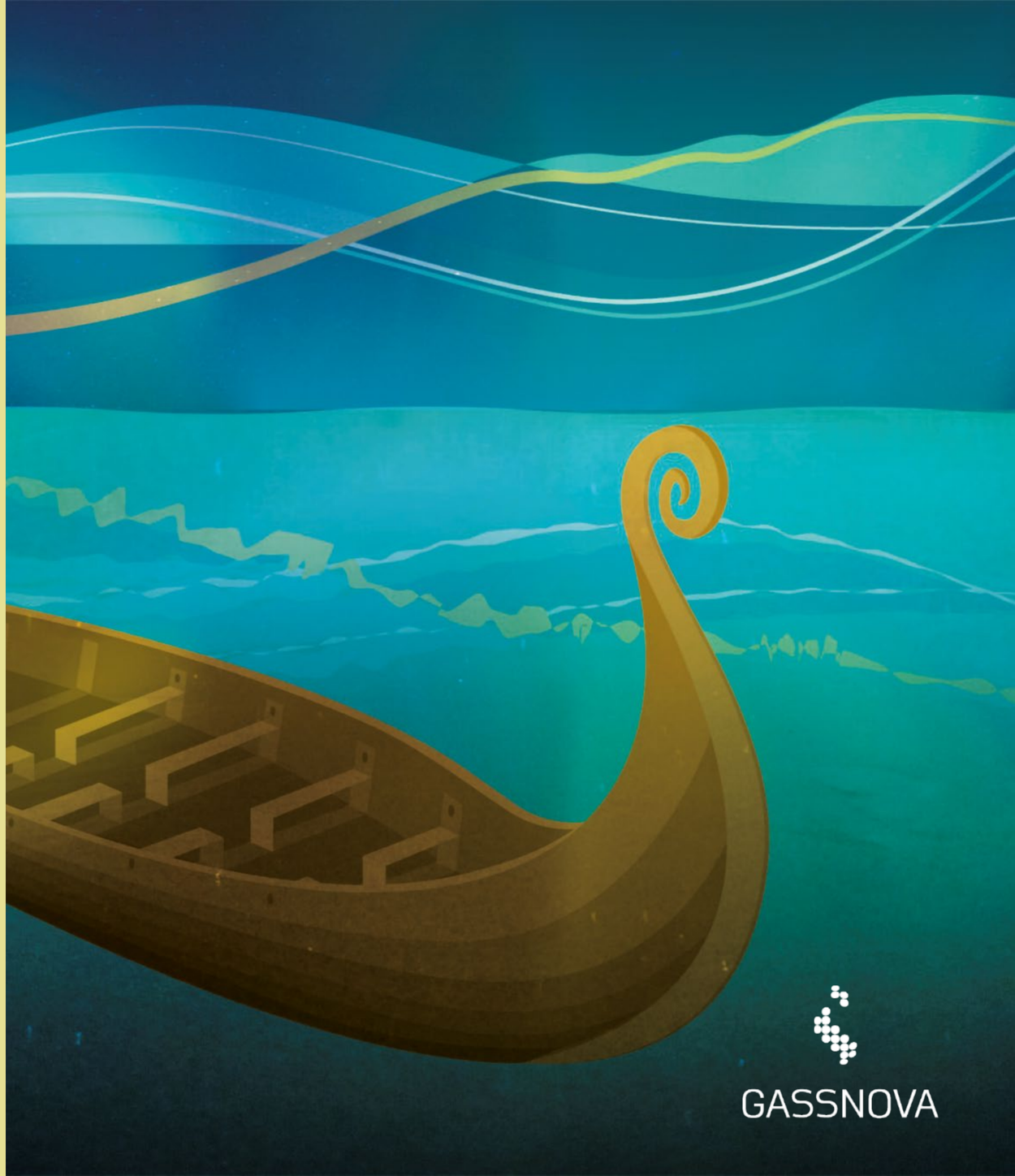
Introduction of Longship, and some lessons learned

Knowledge Sharing 2026, CCS & CDR Summit

15.04.2026
Workshop: Longship Experience Sharing: Insights Across the Full Project Lifecycle

Aslak Viumdal, Head of Market Development Insight in Gassnova and benefits realization Longship

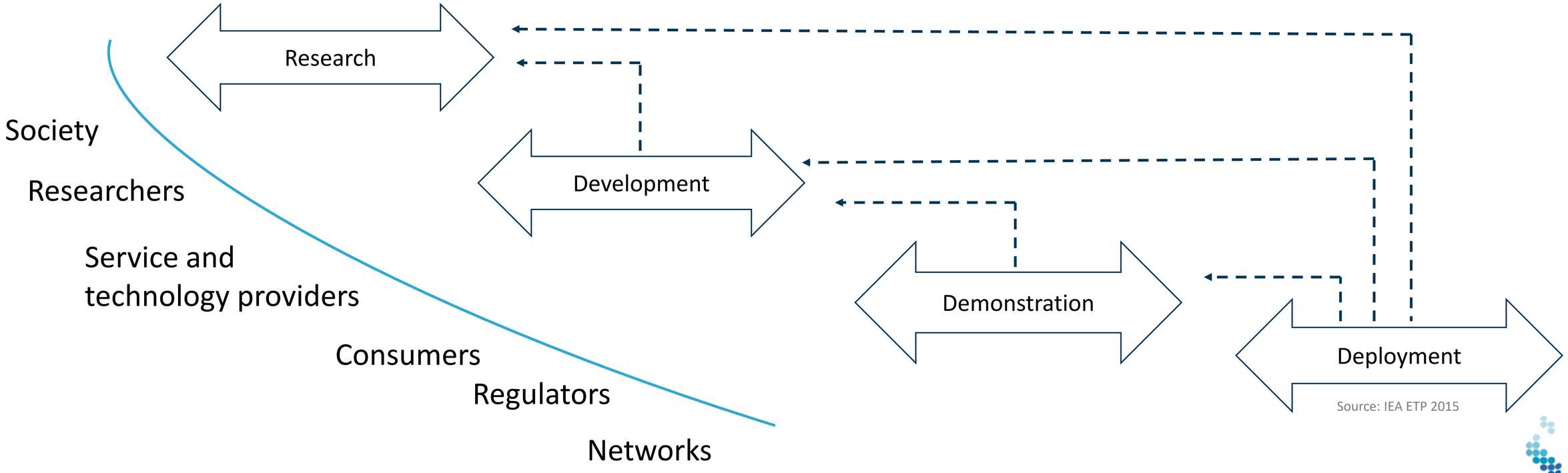


Gassnova's purpose: "promote technology development and competence building for cost-effective and future-oriented solutions for CO_2 management"

Gassnova roles and responsibilities

CLIMIT **TCM** **Longship**

Advisor to the Ministry of Energy on CO_2 management



Source: IEA ETP 2015

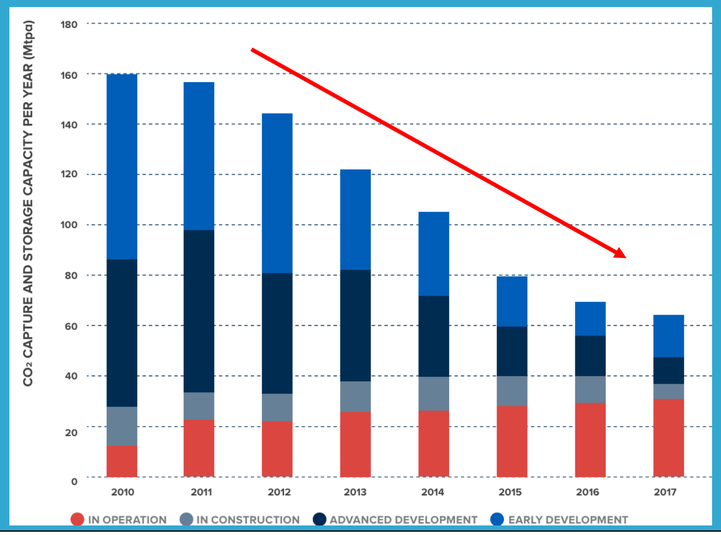
Gassnova was mandated to lead a pre-feasibility study in 2015. What did the CCS landscape look like at that time?

Flagship reports highlighted the great significance of CCS:

Year	Report	Overall «CCS communication»
2014	IPCC AR5	CCS widely needed in 2°C pathways. Absence greatly increases costs of achieving climate ambitions (+138 %)
2015	IEA ETP	CCS is vital technology. industry cannot decarbonise without it, or far more costly

The global CCS project portfolio was shrinking

GCCSI' Global status report. Years 2010-2017



No business model, no support mechanisms:

- EU ETS allowance price: ~€6/tCO_2 (2014–2017) and no incentives for bioCCS/CDR
- No dedicated EU support mechanisms for industrial CCS projects at the time
- Limited political and public acceptance

There was a need an industrial full scale, full chain CCS demonstration project

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Norway’s objectives: “Demonstrate CCS. By that, contribute to the development of CCS, so that EU and Norway can reach long term climate goals cost efficiently.”

Key expected benefits:

- Demonstration and knowledge-sharing effect
  - Show that CCS is feasible and safe
  - Give technical, regulatory and commercial learnings
- Contribute to cost-reduction for following projects
- Lay a foundation for new industrial opportunities and value creation

“Whole-chain risiks” were identified as a major barrier. Gassnova took the role as a “project integrator” in the development of Longship

Gassnova’s tasks as a project integrator, some examples:

- Cooperation design and common project delivery plan
- Support scheme for the project development phase
- Common design basis across the CCS chain
- Integrated schedule, incl. coordination of decision gates (DGs)
- Assessment of industrial projects at decision gates

Gassnovas integrator role did not replace the industrial ownership and responsibility of their own projects

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Longship


Storage site
NORTHERN LIGHTS
Receiving terminal
CELSIO
CO_2 capture
BREVIK CCS
CO_2 capture
ØRSTED
CO_2 capture
YARA SLUISKIL
CO_2 capture
Ministry of Energy
Gassnova
State aid agreement
State aid agreement
State aid agreement
Northern Lights JV (Phase 1)
Brevik CCS Heidelberg-Materials
Oslo CCS Hafslund Celsio
GASSNOVA

Some important learnings

- Longship demonstrates that a full-scale value chain for CO_2 management is technically feasible.
- Regulations exists for CCS projects, even if there still are regulatory challenges

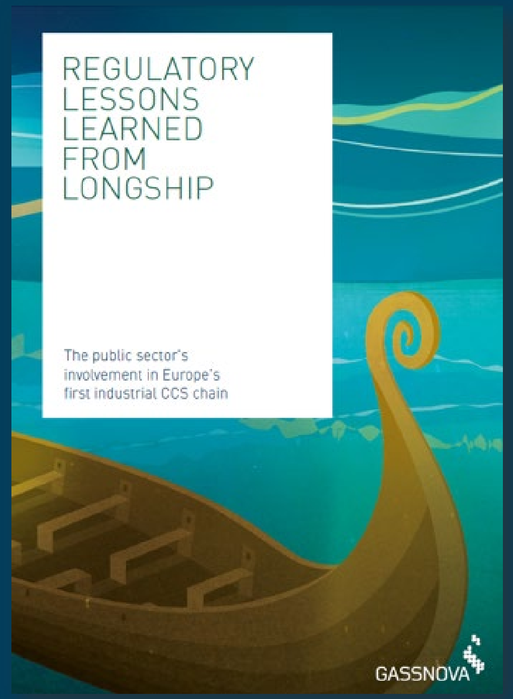
!

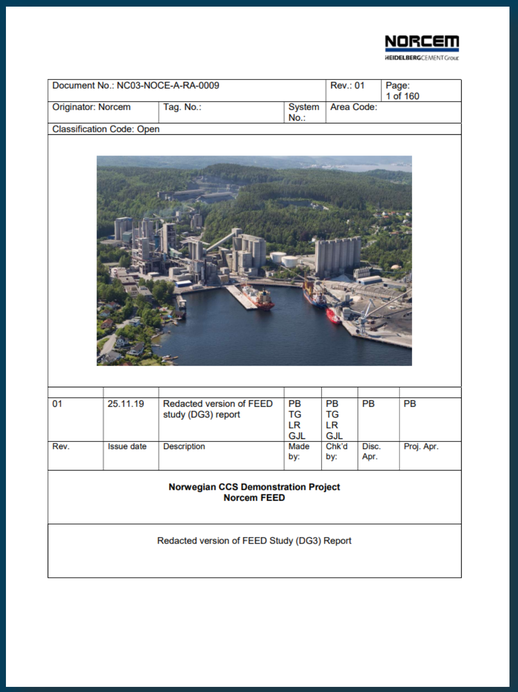
- CO_2-capture projects demands industrial capability and expertise to deliver large-scale projects
- Many public stakeholders. Competence to handle CCS relevant regulations is important to develop in the public sector

€

- Need for continued cost reduction efforts
- Technologies, standards, and regulations should be tailored for CO_2
- Innovation in business models is needed
- Predictability in energy, industry and climate policies are crucial

www.ccsnorway.com
- Knowledge sharing from Longship





Thank you for your attention!

avi@gassnova.no

We share our CCS knowledge

gassnova.no/en

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Tor Gautestad

CCS MANAGER

HEIDELBERG MATERIALS

As M.Sc. graduate from Faculty of machinery at NTH in Trondheim I joined Norcem Brevik in 1992. Since then, I have had a variety of positions and challenges within what has become Heidelberg Materials, and since 2018 I have been full time engaged in Brevik CCS project as Project Manager, Operational Manager and currently as CCS Manager.

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Lessons Learned Brevik CCS April 2026

Tor Gautestad, CCS Manager, HM Brevik

19/04/2026

Maturing the project

>7500 hours of testing with Aker's MTU

3000 hours of testing with pilot boiler

2005 Full scale desk study

2011 Pre-engineering

2013 Kick off TCB (2013-17)

2014-15 Technology testing

2016 Feasibility study

2016-17 Concept study

2018-19 FEED Study 29/8-18 – 31/10-19

- ✓ 450 reports
- ✓ 500 drawings
- ✓ 3D-model

2019-20 Decision process Government

- ✓ Press conference by government 21/9-20
- ✓ State budget release 7/10-20
- ✓ Decision in Parliament 20/12-20
- ✓ Development- and negotiation of contracts

2021-2025 Realization

100% 07.11.2025

- ✓ Start execution: 2/1-2021
- ✓ MC: 1/12-2024

Attention

FEED study
(Front End Engineering and Design)

Maturity assessment according to AACE 18R-97

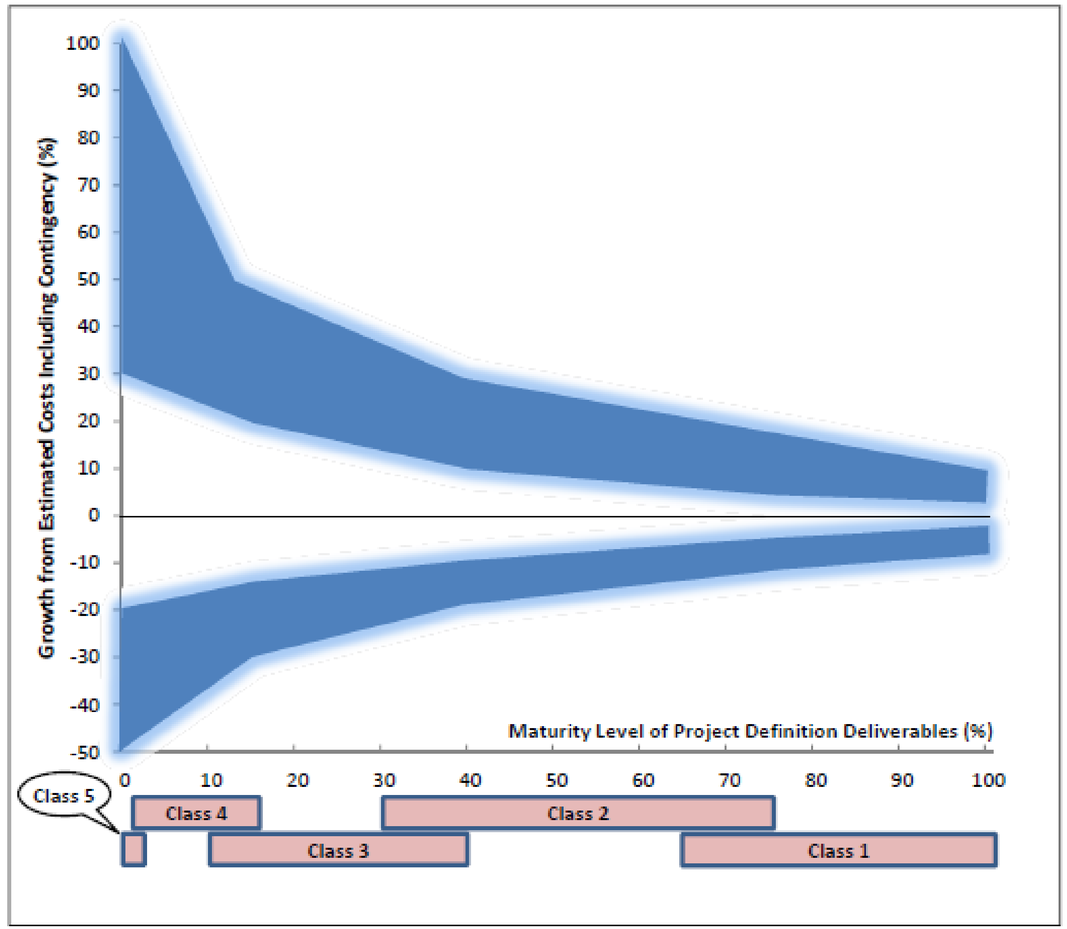


Figure 1 – Example of the Variability in Accuracy Ranges for a Process Industry Estimate

	ESTIMATE CLASSIFICATION				
	CLASS 5	CLASS 4	CLASS 3	CLASS 2	CLASS 1
MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES	0% to 2%	1% to 15%	10% to 40%	30% to 75%	65% to 100%
General Project Data:					
Project Scope Description	Preliminary	Preliminary	Defined	Defined	Defined
Plant Production/Facility Capacity	Preliminary	Preliminary	Defined	Defined	Defined
Plant Location	Preliminary	Preliminary	Defined	Defined	Defined
Soils & Hydrology	Not Required	Preliminary	Defined	Defined	Defined
Integrated Project Plan	Not Required	Preliminary	Defined	Defined	Defined
Project Master Schedule	Not Required	Preliminary	Defined	Defined	Defined
Escalation Strategy	Not Required	Preliminary	Defined	Defined	Defined
Work Breakdown Structure	Not Required	Preliminary	Defined	Defined	Defined
Project Code of Accounts	Not Required	Preliminary	Defined	Defined	Defined
Contracting Strategy	Not Required	Preliminary	Defined	Defined	Defined
Engineering Deliverables:					
Block Flow Diagrams	S/P	P/C	C	C	C
Plot Plans	NR	S/P	C	C	C
Process Flow Diagrams (PFDs)	NR	P/C	C	C	C
Utility Flow Diagrams (UFDs)	NR	S/P	C	C	C
Piping & Instrument Diagrams (P&IDs)	NR	S/P	C	C	C
Heat & Material Balances	NR	P/C	C	C	C
Process Equipment List	NR	S/P	C	C	C
Utility Equipment List	NR	S/P	C	C	C
Electrical One-Line Drawings	NR	S/P	C	C	C
Design Specifications & Datasheets	NR	S/P	C	C	C
General Equipment Arrangement Drawings	NR	S	C	C	C
Spare Parts Listings	NR	NR	P	P	C
Mechanical Discipline Drawings	NR	NR	S/P	P/C	C
Electrical Discipline Drawings	NR	NR	S/P	P/C	C
Instrumentation/Control System Discipline Drawings	NR	NR	S/P	P/C	C
Civil/Structural/Site Discipline Drawings	NR	NR	S/P	P/C	C

«Show me»

Table 3 – Estimate Input Checklist and Maturity Matrix (Primary Classification Determinate)

Scope Changes

Generally, changes tends to cause many <u>more</u> changes than first anticipated.
Typically:

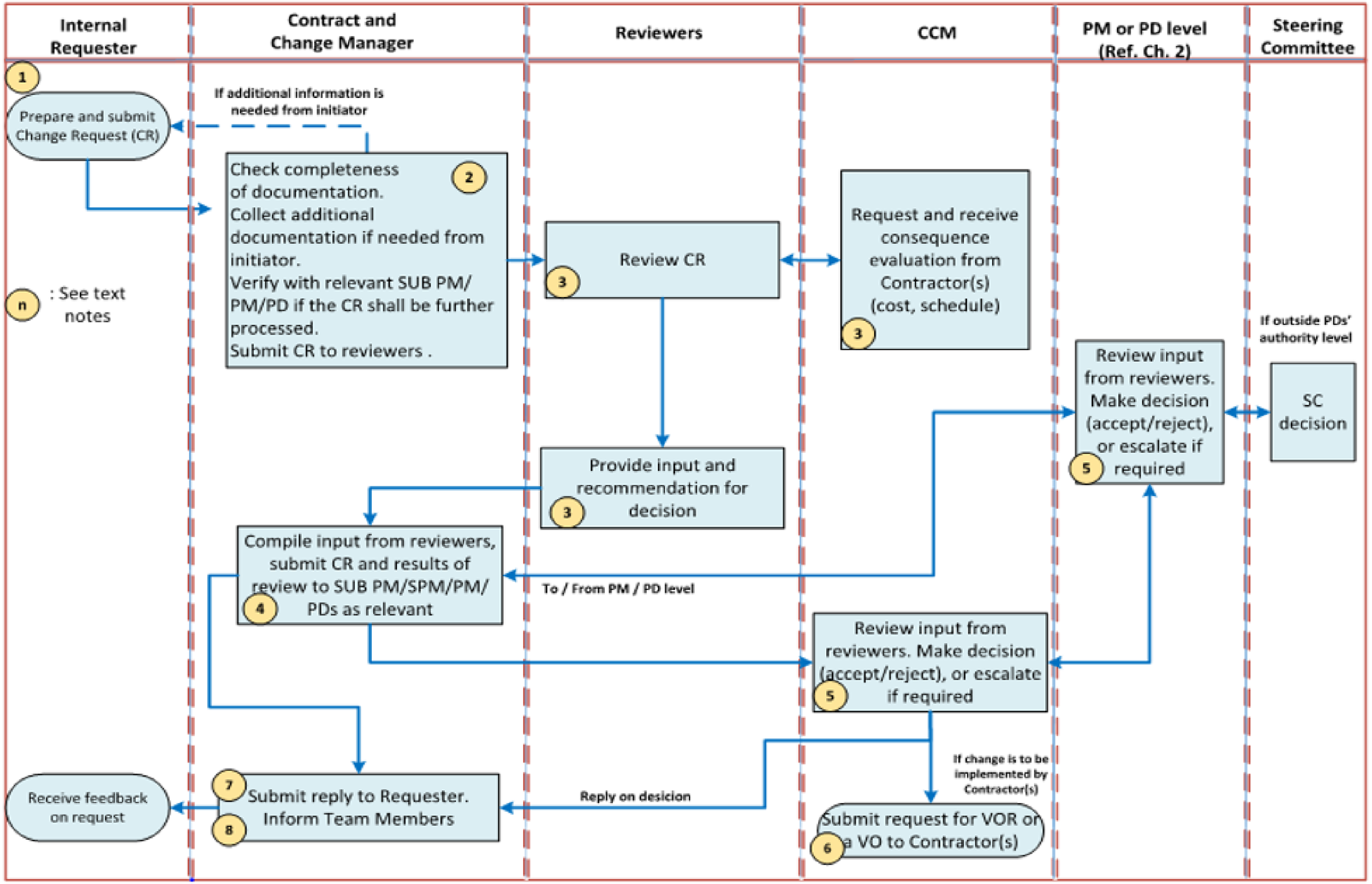
- **Increased project costs** (additional engineering, procurement, construction hours)
- **Schedule delays** affecting milestones, commissioning, and handover
- **Resource reallocation** leading to overload, conflicts, or skill shortages
- **Design rework** and re-approval cycles causing inefficiency
- **Procurement impacts** such as reordered materials, change orders, or vendor delays
- **New technical risks** introduced late in the process (unknown add-on effects)
- **Technical documentation** update
- **Spare part specification** changes
- **Quality challenges** due to rushed implementation or parallel changes
- **Reduced predictability** for stakeholders and partners
- **Contractual complications** including claims, disputes, or renegotiations
- **Team disruption** and loss of focus due to shifting priorities

Make sure that FEED- decisions are on solid ground

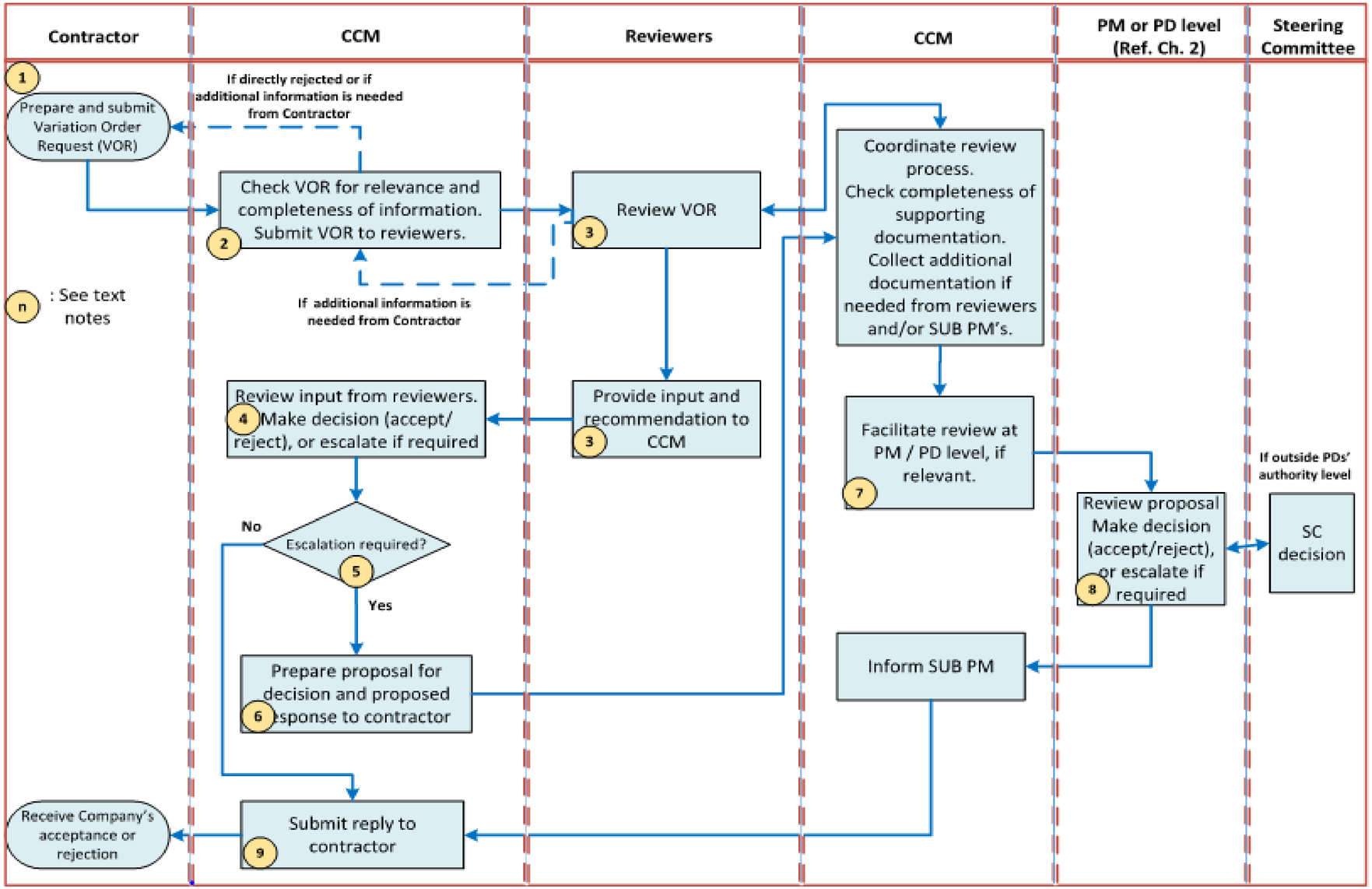
Make sure you implement suitable change management system

You don’t want scope changes!!!

Changes initiated by Company



Changes initiated by Contractor (VOR)



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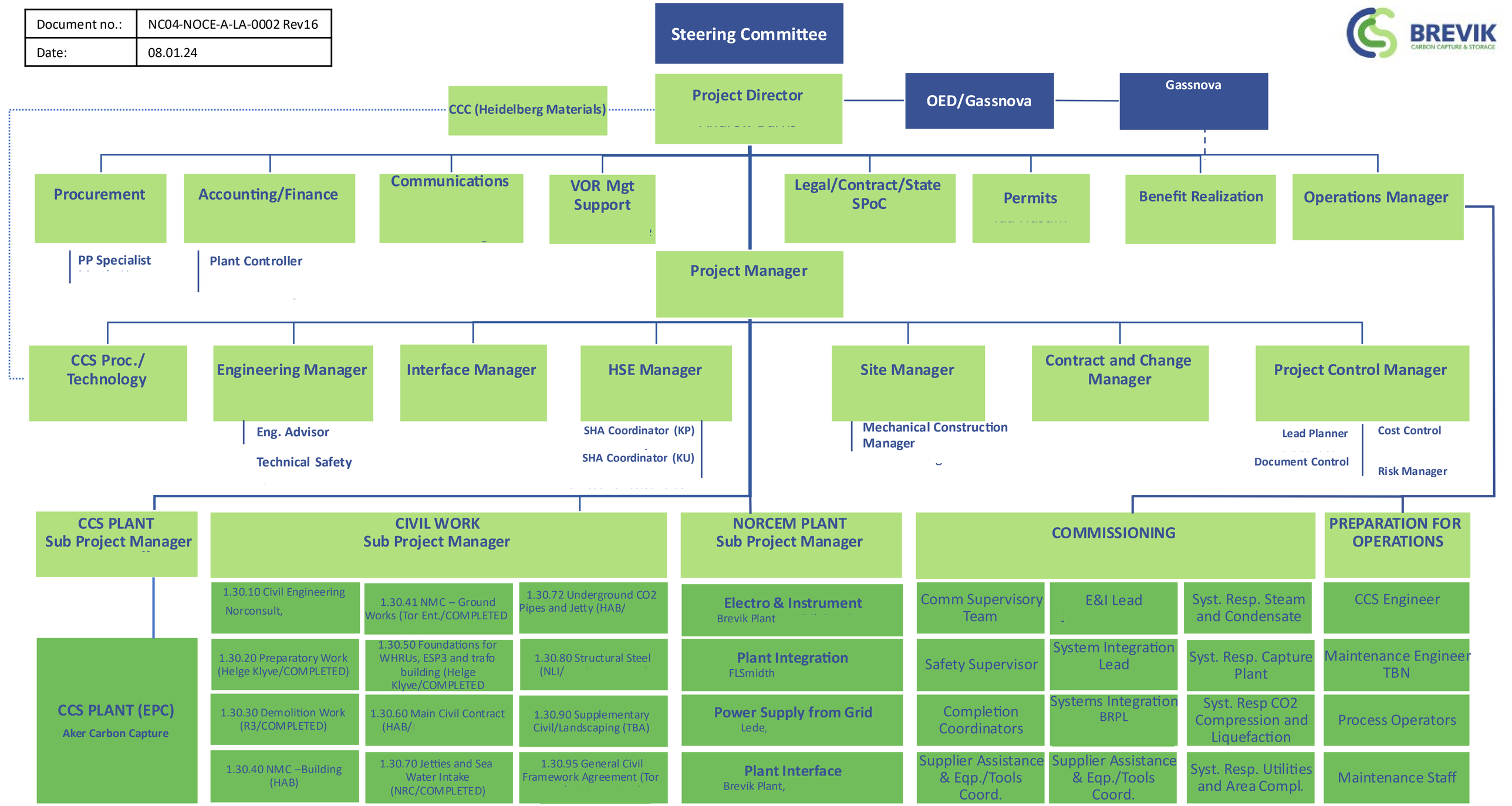


Oil&Gas meets Cement

Design: Pressure relief valve on instrument air receiver

Existing cement plant, Brevik

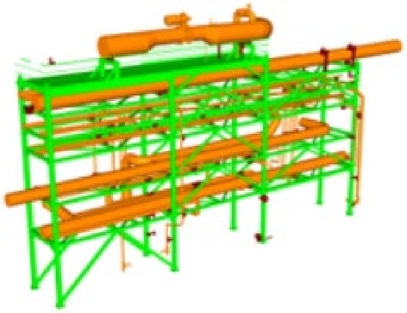
- Carbon steel vessel (from 1979)
- No support

Brevik CCS

- Stainless steel vessel
- Complex and massive support on concrete plinth
- Stainless steel pipe and pipe support
- Costs: 10 times more

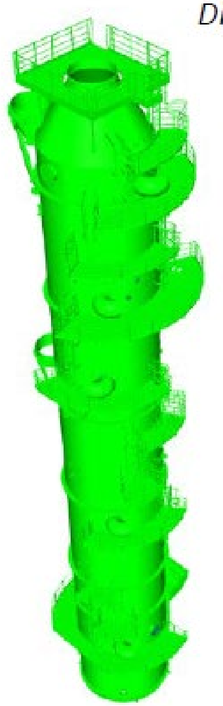
Heavy lift campaigns

- HL1-1: 14/8 – 20/8
  - Absorber (14/8)
  - Absorber duct from DCC (18/8)
  - Absorber stack (21/8)
- HL1-2: 4/9 - 19/9
  - Install 6 CO_2 tanks
- HL1-3: 3/10 – 12/10
  - Piperack M01 and M02
  - Stairtower
- HL2: March 2024
  - Blow off pipes
  - Desorber
  - Reclaimer module
  - Module M03, M04 and M05
  - Bridge over B60

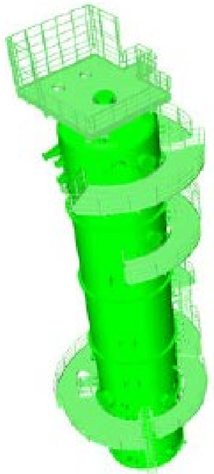


M01: Piperack 01
Lifting weight = 83T

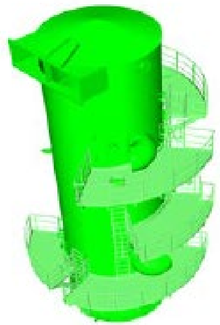
Dimensjoner:
Absorber: Ø=6,8m H=50,8m Weight=228t
Absorber stack: Ø=2,6m H=48,8 Weight=53t
Desorber Ø=5,0m H=27,6m Weight=126t
DCC: Ø=4,9m H=15,3m Weight=34t



Absorber



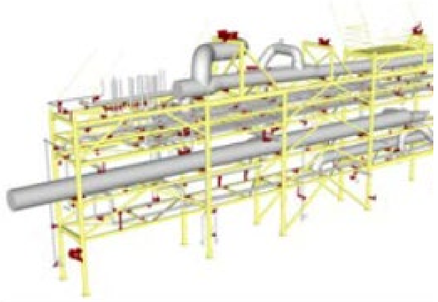
Desorber



DCC

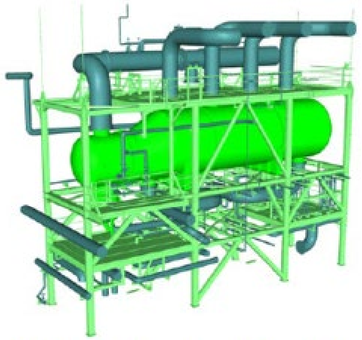
Aborber Stack

LCO2 tanks x 6
250 tons each

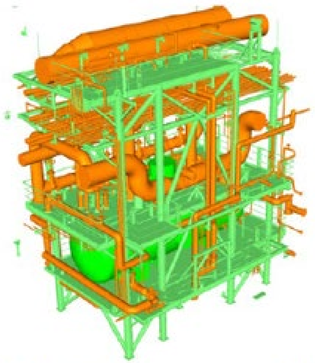


M02: Piperack 02
Lifting weight = 111T

M03: Liquefaction Module
Lifting weight = 212T



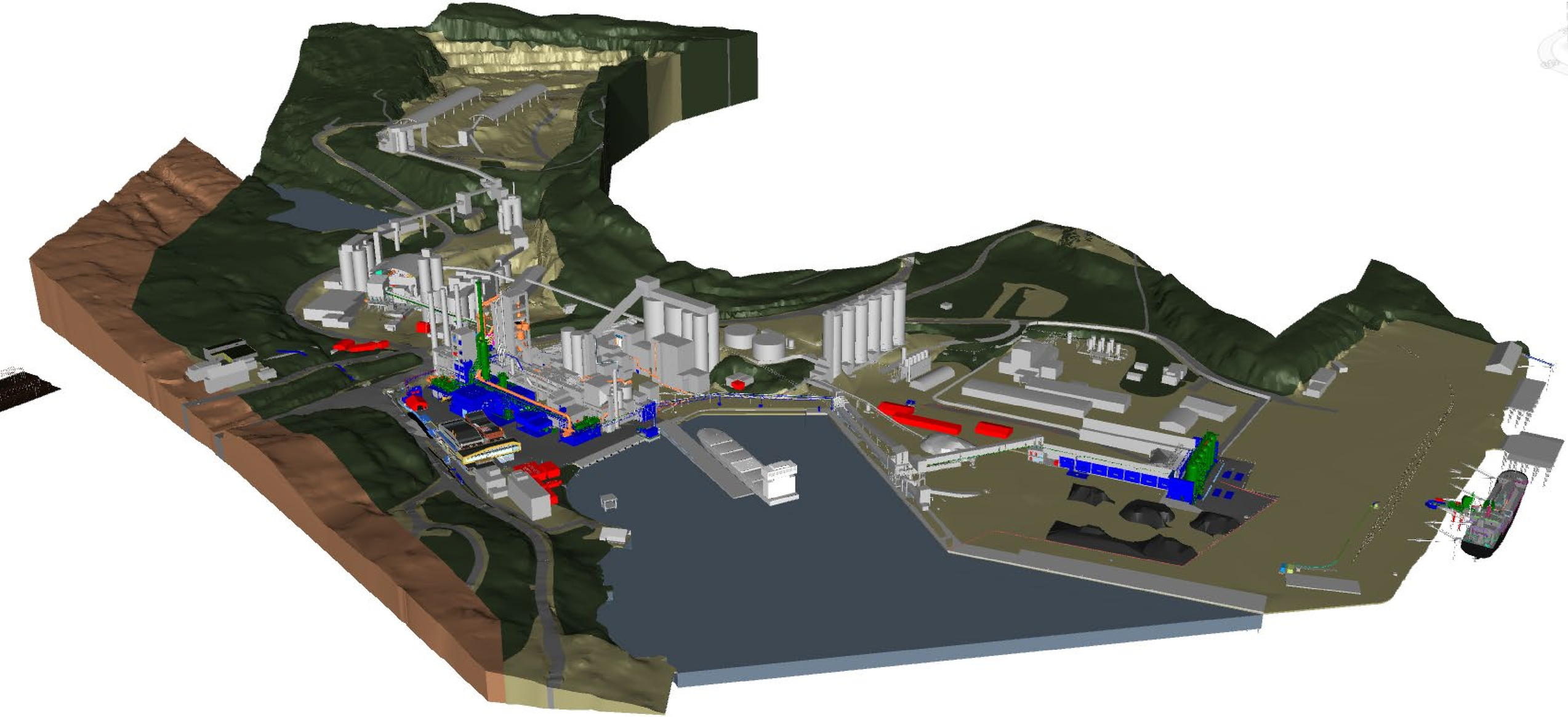
M04: Reboiler Module
Lifting weight = 168T



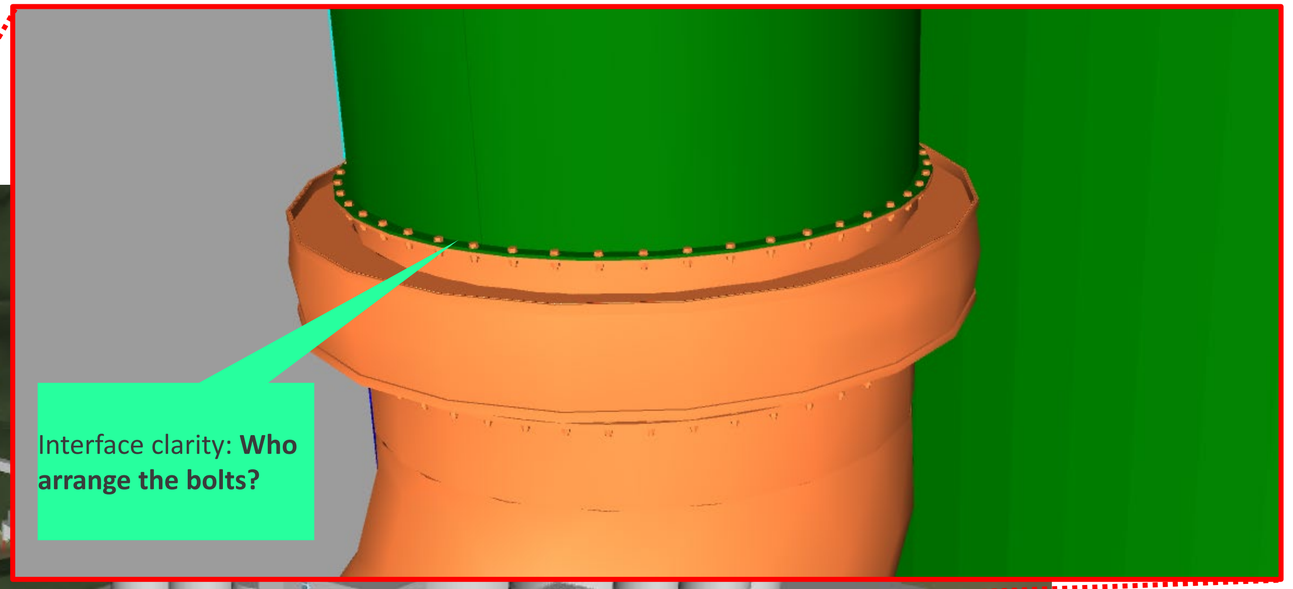
M05: Condensate Platform
Lifting weight = 104T


MAM MOET
MAM MOET
Crane Runway

3D model – Color coding



3D model – Color coding

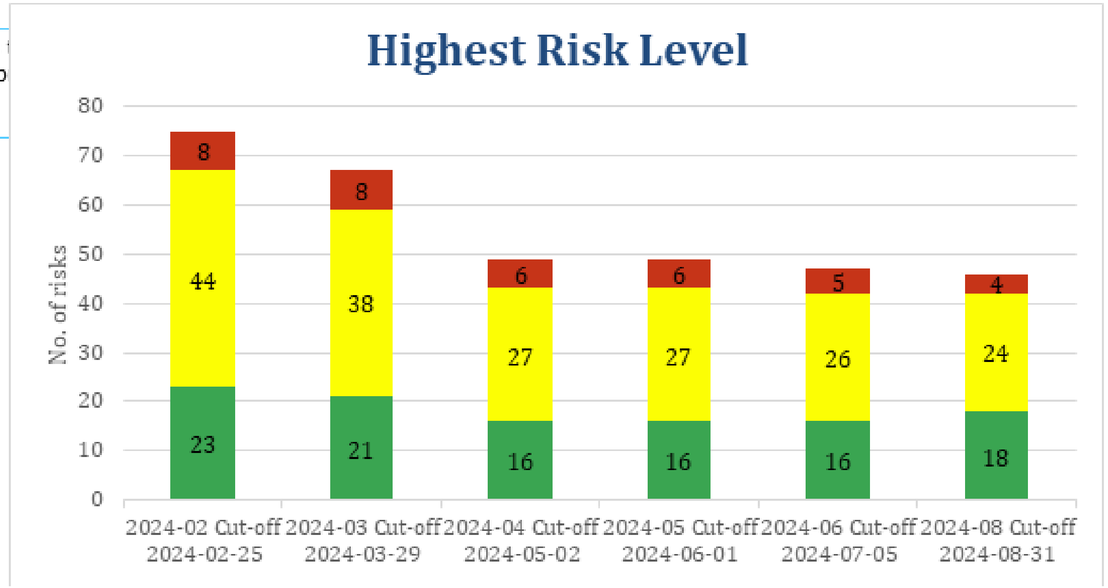


Different object maturity status shall be shown for the following object maturities[1]:

- S1 - Preliminary
- S3 - Frozen Interface
- S4 - Detail Design Completed/ IFC

Risk management

No.	Description	Present
295	U-3 ACC delivery capability productivity, incl. planning)	Schedule
117	Congested site causes delays for ACC (79481)	Schedule
296	Too strict limits set by authorities for emissions to sea due to errors in calculations	Reputation
311	HM scaffolding cost increases	Cost
153	Late access … delays the p…	

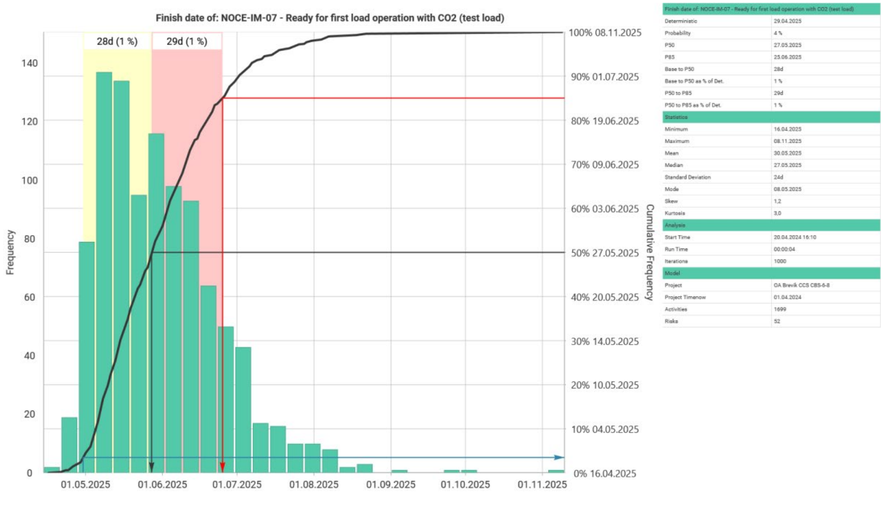


- Brevik CCS used RAMRISK from Danish Ramböl. Worked well and according to our expectations and needs
- Simple and low cost

- **Active Risk Management change mindset to being more proactive**
  - **You really want risks to disappear**

350 risks handled

Enables integrated cost- and schedule risk analysis:



Operator Training Simulator

- Operator Training Simulator (OTS) provides a real time, full scale, simulation of the CCS-plant and ship loading
- Process plant operators can train on operating the plant in normal and in upset conditions
- The HMI (Human Machine Interface) and PLC logic is identical for both real control system and OTS, the OTS will therefore provide authentic training environment
- Important for optimization of startup procedures and preparations for commissioning
- Not very costly

Installation of the OTS mitigated a long list of risks

Pressurized equipment – laws and regulations

PED is the European Pressure Equipment Directive 2014/68/EU. Pressure equipment with an operating pressure greater than 0.5 bar falls under the scope of the Directive and therefore CE marking is required by law

- Pressurized equipment
  - Steam systems
  - CO_2 compression
  - LCO_2 systems
- PSV's
- Gaskets
- Flanges
- Torques
- Bolt specifications
- Lubrication of bolts
- CE-certification
  - Declaration of confirmity
- Inspection routines of pressurized equipment
- Permit for operation from national authorities

- Operation of steam systems have very specific legal requirements with comprehensive control scheme an daily, weekly, monthly and annual basis
- All PSV's (75-80 in Brevik CCS) must be recalibrated before startup and then annually (possible to extend after few years of experience)
  - Comprehensive process. Some are small, some are large (1-300 kg)
  - Specialized job (dismantling, handling, calibration, re-certification, re-installation)
- «Gaskets» is a surprisingly complicated and critical matter
  - Many types, dimensions, standards and pressure classes
  - Type of gasket must match type of flange
  - Bolt specification must match torque, flange type, pressure class and gasket type
  - Type of bolt lubrication is crucial for correct torque
  - Gaskets must be handled as spare parts with BOM, not as a consumable
- Declaration of confirmity required from system suppliers
- Interpretation of laws and regulations is not straight forward and must be formally verified from relevant national authorities
- Very strong requirements on Safety Instrumented Function (SIF) and Safety Integrity Level (SIL) requires comprehensive testing. Tests must be whitnessed by third party

SIF and SIL – Requirement for Permit to operate

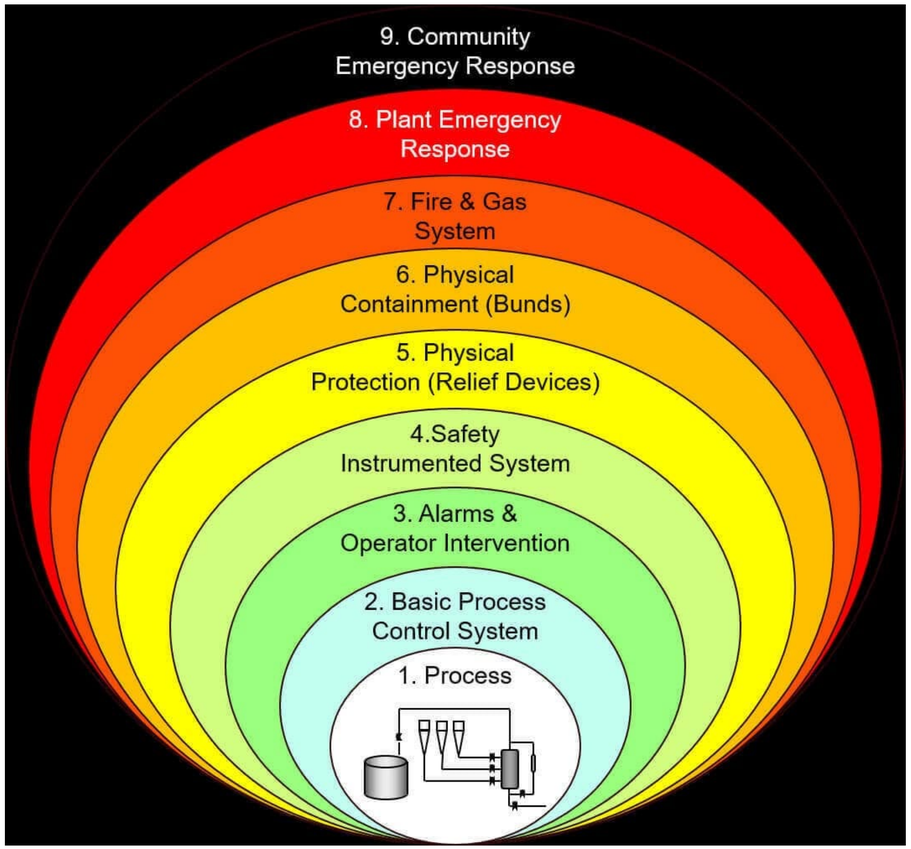
The terms **SIF** and **SIL** are central within functional safety in the process industry and follow international standards such as IEC 61511

SIF (Safety Instrumented Function):

- This is the actual safety function that must perform a specific task to bring a process to a safe state when a hazardous situation occurs. A SIF typically consists of a sensor, a logic unit (e.g., a PLC), and a final element (e.g., a valve).

SIL (Safety Integrity Level):

- This is a measure of the reliability or performance level of the safety function (SIF). It indicates how much risk reduction the function must provide.



Health and Safety

CO_2 exposure

- New safety hazards following from the CCS plant
  - Exposure for CO_2 in dangerous concentrations
  - Hot and pressurized steam in very large qantities
  - CO_2 under very high pressure (up to >70 bar)
  - LCO_2 under high pressure
  - Potentially dry ice (frozen CO_2) at -80°C
  - Chemicals
    - Amine products
    - Caustic Soda
    - (Flue gas condensate)
    - Others

Very steep curve from harmless to lethal

CO_2 is heavy – Low points are dangerous

Concentration can by anything up to 100%
Representative measurement is very difficult

Relationship Between CO_2 Concentration and Mortality

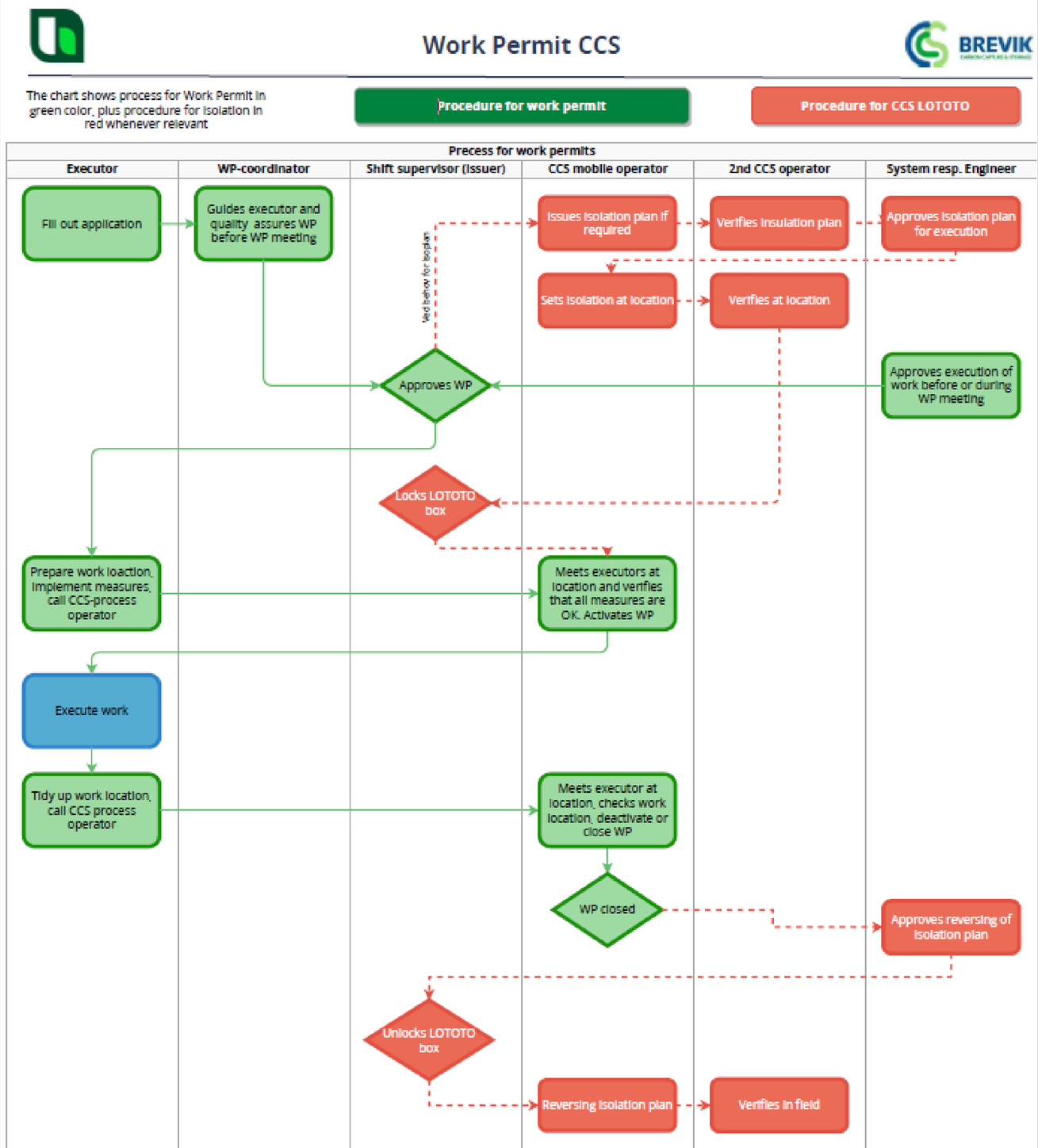
CO_2 Level	Concentration	Exposure Time	Health Effect
0.04 %	400 ppm	—	Normal outdoor air
0.1–0.2 %	1,000–2,000 ppm	Prolonged	Drowsiness, reduced concentration
0.2–0.5 %	2,000–5,000 ppm	Hours	Headaches, fatigue, nausea
0.5 %	5,000 ppm	8-hour TWA	OSHA/NIOSH permissible exposure limit
4 %	40,000 ppm	Minutes	IDLH – Immediately dangerous to life or health
4–5 %	40,000–50,000 ppm	Minutes	Headache, dizziness, elevated blood pressure, dyspnea
6 %	60,000 ppm	1–2 min	Visual/hearing disturbances, tremors
7–10 %	70,000–100,000 ppm	< 3 min	Rapid unconsciousness, severe neurological symptoms
10–15 %	100,000–150,000 ppm	1–3 min	Convulsions, unconsciousness
>17–30 %	170,000–300,000 ppm	< 1 min	Death due to asphyxiation (displacement of oxygen)

Digital Work Permit System - Enablon

- Implementation of Enablon work permit system has been successful
- Digital WP-systems significantly improves safety for maintenance operations
- Enablon has fully met our expectations

Wolters Kluwer

enablon

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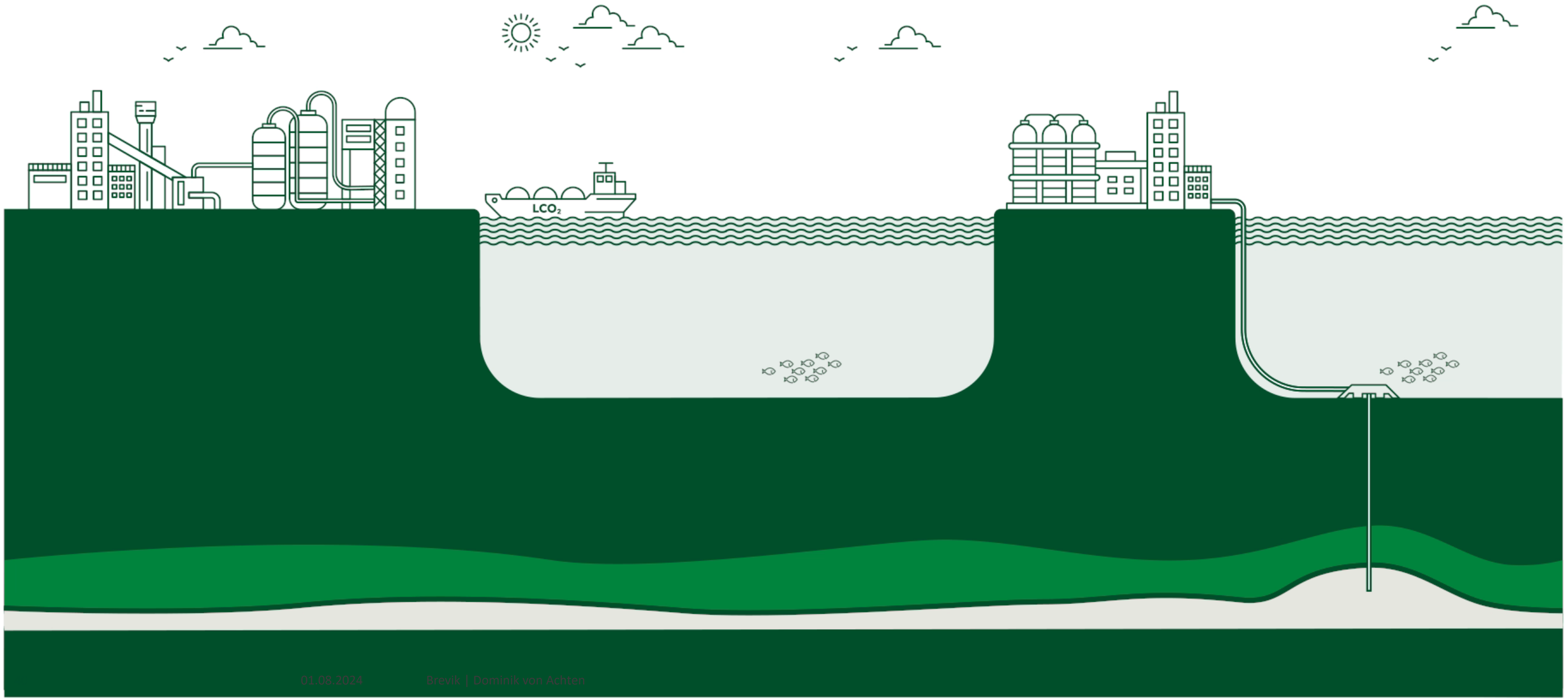
LNG
CO2 CARRIER
NORTHERN PATHFINDER
EVERGREEN
ENERGIZER

The CO_2 journey from capture to storage



SAP and Technical Documentation

SAP

- Don’t underestimate the workload of implementing the entire plant in SAP (or similar)
    - Assume 5 man-years for a Brevik CCS-sized project
- Decide technical structure
    - Sub Equipment
    - Sub-sub-equipment
    - Spare parts
    - Bill Of Materials (spare parts linked to equipment)
- All data must be 100% correct before import from Excel (otherwise import fails)
- Brevik CCS: 7000 lines x 170 columns = 1,2M cells
- Preventive Maintenance sceme on all equipment

Technical documentation

- Huge amount of documents
- Must be structured
- We have decided to keep Interaxo for technical documentation
- Importance of isometric drawings underestimated
    - Crucial information about pipes, flanges, bolts, gaskets, torques
    - 4000 drawings
- Routines for keeping P&ID’s updated at all times after handover to operations
    - Correct P&ID’s at all times is an absolute requirement for safe operation

Various technical LL's

- Trunnion ball valves exposed for pressurized CO_2 must be specialized. Brevik CCS experienced a lot of problems related to high friction in CO_2-exposed valves. All valves modified to:
  - PFTE-seals
  - Tungsten carbide surfaced balls
- Make sure pressure drops are properly calculated
- Tag-system
  - Make sure you don't end up with double tag-system (like Brevik CCS did)
  - Tags, P&ID's, procedures, programs and Process Control System are tied together and must harmonize perfectly
- Don't underestimate operational issues on the mother-plant's side of the interface. Changed running conditions are never problem free.
- Remote monitoring system on key equipment like for instance:

  DALOG®
- Ensure access to a LCO_2 evaporator if you are making LCO_2
- Optimization of PLC, controllers, alarm limits, interlock-limits, timers, etc takes months and even years. Make sure competent resources are secured for Opex period
- Dont forget first fill costs (chemicals & lubricants)

Thank you!

Tor Gautestad, CCS Manager, HM Brevik

19/04/2026

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Jannicke Gerner Bjerkås

DIRECTOR CCS AND CARBON MARKETS

HAFSLUND CELSIO

Director CCS and Carbon Markets in Hafslund Celsio, in charge of developing Celsio's full-scale CCS project on waste-to-energy in Oslo from 2018 until construction start. She is now head of commercial development of CCS and during 2025 succeeded in securing two large CDR agreements. She is also Director of the Board in Carbon Circle AS as well as Chair of the Board in CCUS Norway.

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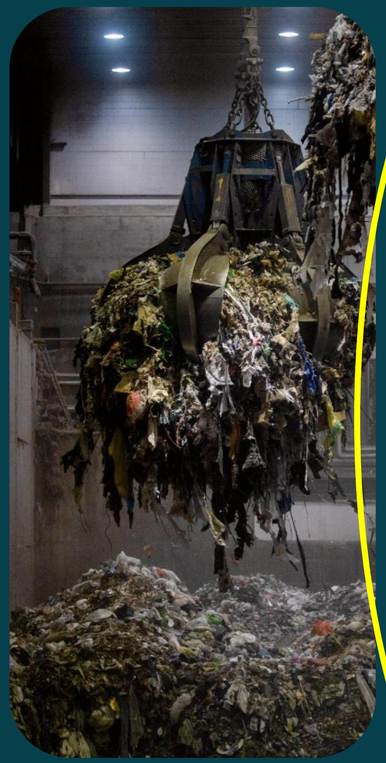
Carbon capture and removal from Waste-to-Energy in Oslo; learnings and experiences

Jannicke Gerner Bjerkås,
Director CCS and Carbon Markets
Hafslund Celsio
jannicke.bjerkas@celsio.no

This is Hafslund Celsio

Waste incineration

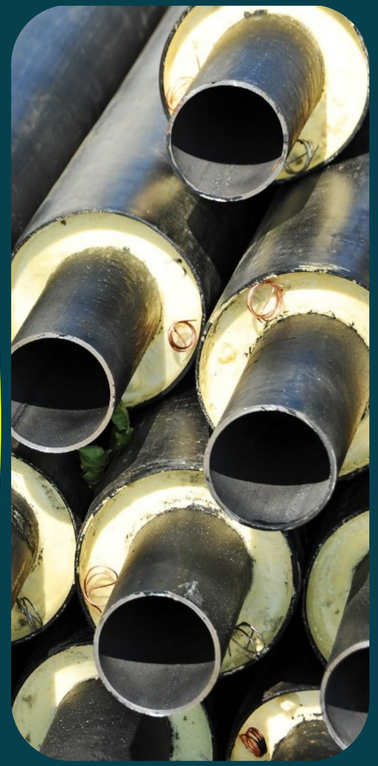


Norway's largest waste incineration plant (350 000 t/Y)

CCS

Construction started
CDR contracts secured

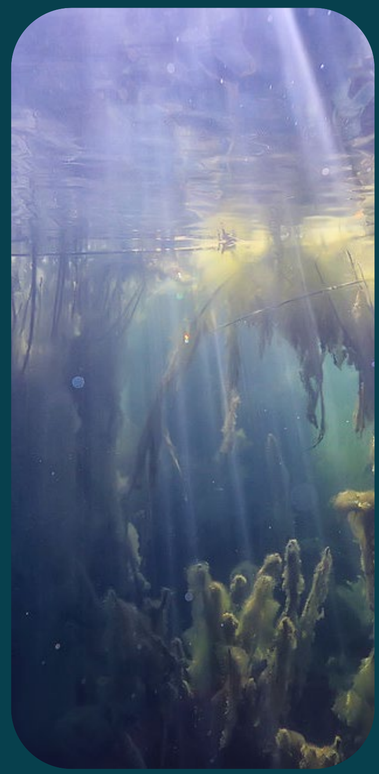
District heating



Norway's largest supplier of district heating

(1,8 TWh i 2025)

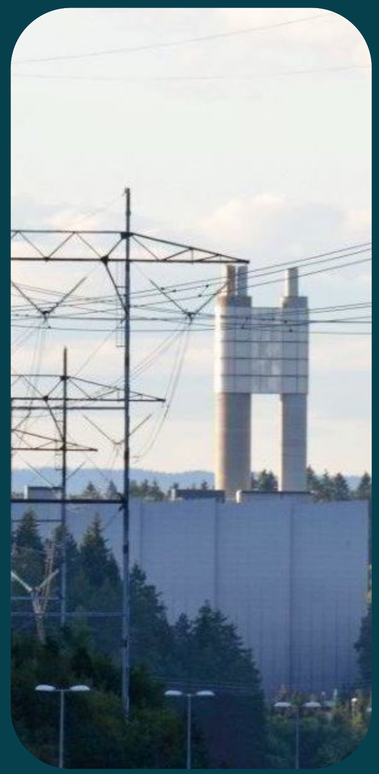
Cooling



Building up as supplier of district cooling

(150 GWh in 2035)

Electricity



Largest producer of electricity in Oslo

(150 GWh in 2025)

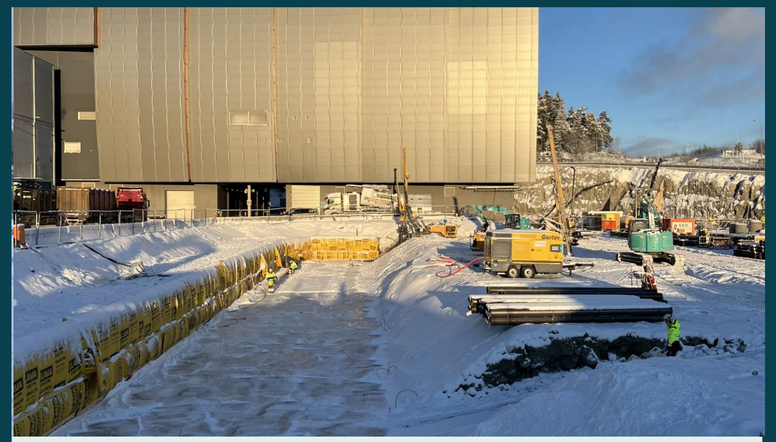
Hafslund

Full-scale CCS on waste-to-energy

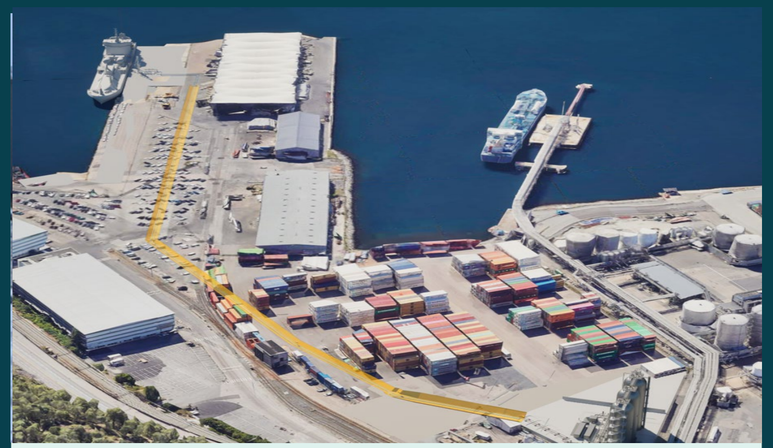
- Part of the Norwegian Longship
- Studies and pilot tests completed 2015-2024
- 350 000 t CO2 capture with 90% capture (50 % biogenic)
- Joint Venture; Aker Solutions and SLB Capturi
- Establishes a CO_2 hub for South-East Norway
- Public Private Partnership with State, City and private investors working togheter

Hafslund

Construction ongoing, start of operations mid-2029



- Civil works completed with new entrance to process plant
- Detailed engineering complete Q2 2026
- Long lead items ordered



- Detailed engineering at port complete Q1 2027
- Transport contract signed (Litra AS)
- CO2-hub for Southern Norway

- In 2029 the capture plant will send 350 000 tonnes of CO2 for permanent storage anually, with 50 % carbon removal

Oslo CCS project development from 2015 to 2025

Bertona-leder Frederic Hauge, byråd for miljø- og samferdsel Guri Melby (V) og byrådsleder Stian Berger Røsland (H) håper at Klemetsrud-anlegget kan bli et unikt prosjekt for CO2-fangst. – Det vil i så fall bli verdens første karbonnegative anlegg, sier Frederic Hauge.

Publiseringsdato: 3. juni, 2015

2015 - 2020

1 of 3 capture projects in Longship (late start)

Feasibility study and pilot testing x 2

Lighthouse project in Oslo's climate strategy

Ingen EU-støtte til CO2-fangst på avfall i Oslo

Syv selskaper får støtte – Fortum Oslo Varme i det norske Langskip-prosjek er ikke blant dem.

2021

Partial state funding granted

Applied to EU Innovation Fund 1. call

Lost to larger European emission points

2022

New owners

City of Oslo investment in the project

Investment decision June 2022

Oslos største klimasatsing kan ende på dynga

2023

Russian invasion of Ukraine

Increased cost estimations

Project halt entering cost reducing phase

2025

Secured world's first CDR contracts on WtE

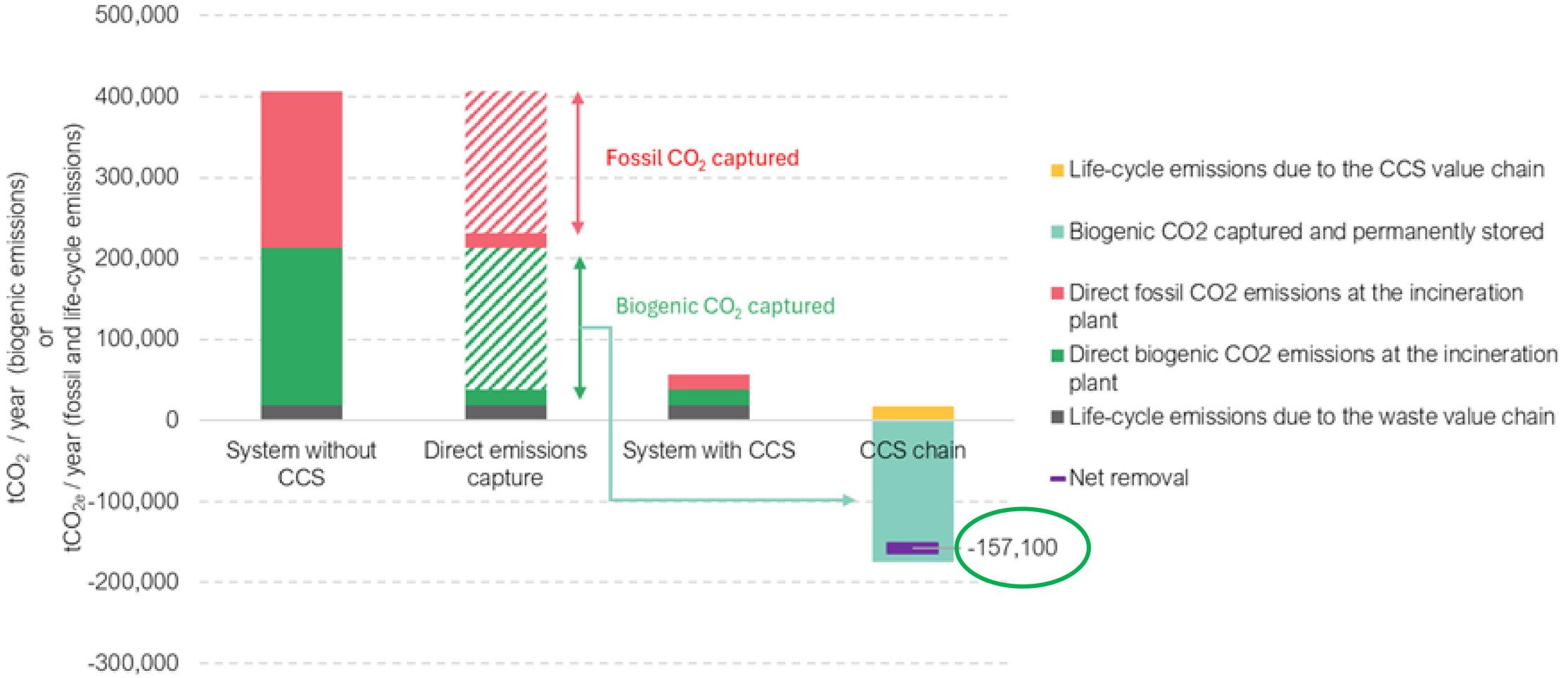
State funding continued

New investment decision

Construction start

Hafslund

From Oslo's largest point source of emissions (19 % of city emissions) to Norway's largest **carbon sink**



Carbon removal deals have played a vital role in enabling Oslo CCS

- **Frontier**: First-ever CDR deal from WtE
- **Microsoft**: Long-term offtake deal securing business case

- Demonstrating waste-to-energy as a credible and sustainable source of high-quality carbon removals

- Validating a model to be replicated across Europe and globally, to remove millions of tons of CO2

April 2025 → **June 2025**

Frontier

100 000 tons
Delivery 2029 and 2030

stripe, H&M, McKinsey Sustainability, salesforce, Meta, shopify, workday., AUTODESK, J.P.Morgan

Microsoft

1 100 000 tons
Delivery 2029 to 2039


EXCLUSIVE SUSTAINABLE BUSINESS

The Next Big Thing in Carbon Capture? Trash.

A group of tech companies is investing in a new method of removing CO2 from the atmosphere by capturing gas emitted when household waste is incinerated

By Yusuf Khan

April 1, 2025 5:30 am ET | WSJ PRO

Share Resize


Hafslund Celsio announces a 10-year carbon removal agreement with Microsoft

30.6.2025 09:00:00 CEST | Hafslund | Press release

Share

Oslo, June 30, 2025: Today, Hafslund Celsio announces the sale of 1.1 million tonnes of permanent carbon removals to Microsoft over a 10-year period. The agreement is a significant contribution to the commercial success of Hafslund Celsio's full-scale CCS project in Oslo and is a recognition of the waste-to-energy sector as a credible provider of permanent carbon removals.

Hafslund

Learnings during the project development

Project development

Separate project organization
Power access in area
Footprint increase
Signed agreements important

Technical aspects

Tech choice in 2016;
still valid
Pilot testing essential
(for first movers)
Complex integration with process plant
(water, energy, old infrastructure etc.)

Financing and value chain

Detailed FEED essential
Value chain risk reduction
Stacking of funds
Sale of CDR crucial

Surroundings

Active neighbor dialogue
Time consuming regulatory processes
Logistics during construction
Transport and solution at port

Hafslund

Experiences from the CDR market

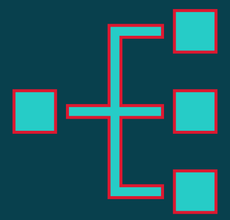
Digital MRV value chain

Suppliers of negative emissions/carbon removals

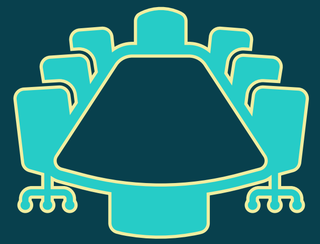
Framework/standards for carbon removal

Control organ/ registry

Brokers or traders



Market/Customers – companies with high margins and clear goals for net zero



- **Permanence**
- **Sustainability**
- **Additionality**
- **Single counting**

Hafslund

The CDR market; what we know

- Target; EU ETS to 0 in 2040, EU Net zero in 2050
- CDR gaining increased attention
- Longship is filling up with CDR projects
- Bilateral deals, no «market price»
- More customers in 25’, but small volumes
- Paris Agreement Art. 6 regulates agreements between countries and companies
  - ITMO vs VCM and C.A.
- EU Commission publishes proposal for revision of EU ETS i June 26’

The CDR market; we don’t know

- What will happen with the 2030 targets?
- Will the EU extend/change 2040/-50 targets?
- **Will Microsoft continue to drive the VCM?**
- (When) will we see a transiton towards a compliance market on CDR? ETS or other tool?
- What will happen to the CDR price in a compliance market?
- National funding/support mechanisms?
- Waste-to-Energy integrated in EU ETS?

*ITMO = Internationally Transferred Mitigation Outcomes
**VCM = Voluntary Carbon Market
***CA = Corresponding Adjustments

Hafslund

Hafslund

Jannicke.bjerkas@celsio.no

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Ove Dalland

TECHNICAL DIRECTOR

NORTHERN LIGHTS

Naval architect by background, worked in shipping, at the Norwegian yards before joining TotalEnergies. Have had several different positions in TotalEnergies, both in Stavanger and internationally. Last position before joining Northern Lights was at the regional management in Paris, with focus on the Danish affiliate and integration of Maersk Oil into TotalEnergies.

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CO_2 transport and storage as a service

Co-funded by the European Union

Phase 1 – part of Norwegian authorities' Longship project

Phase 2 – co-funded by the EU

equinor

TotalEnergies

Shell

Northern Lights

Northern Lights

Receiving terminal Øygarden: Equinor TSP

- Phase 1 & 2
- Operations

Ships: STASCO TSP

- NLJV owner ship 1, 2 & 3
- "K"LINE operates ship 1, 2 &3
- Berhard Schulte owner and operator ship 4
- Charter agreement with “K” LINE & MISC Berhad and Mitsui O.S.K. Lines for 4 new vessels

Co-funded by the European Union

Phase 1 – part of Norwegian authorities’ Longship project

Phase 2 – co-funded by the EU

Northern Lights value chain

Northern Lights

NORTHERN LIGHTS SCOPE

CO_2 capture

Capture from industrial plants.

Liquefaction and temporary storage.

Transport

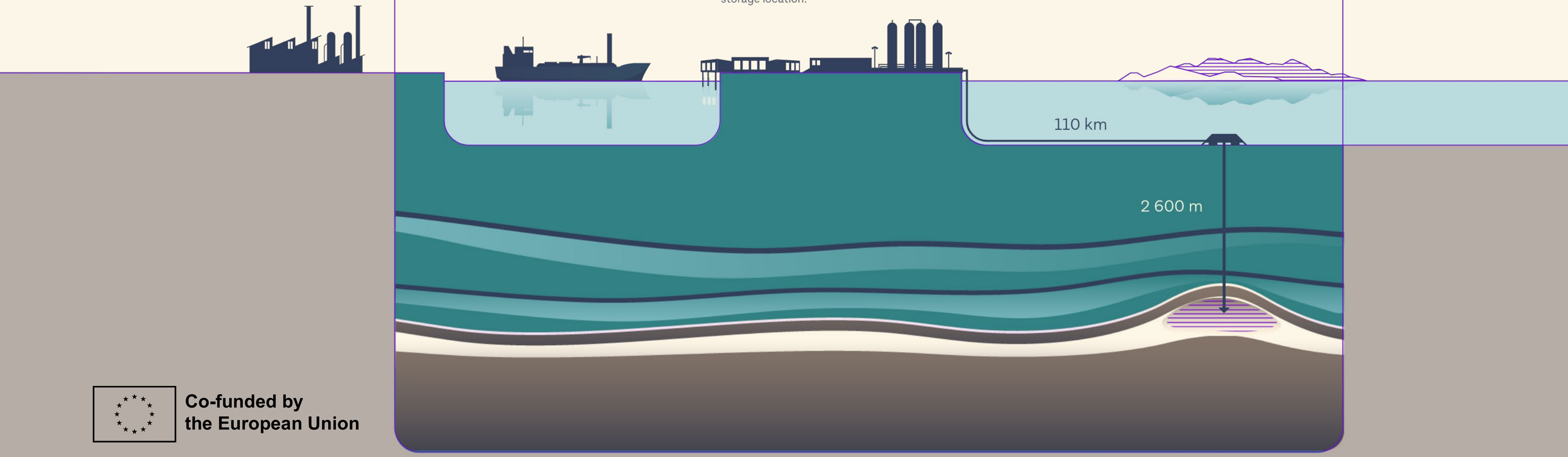
Liquid CO_2 transported by ship.

Receiving terminal

Intermediate onshore storage. Pipeline transport to offshore storage location.

Permanent storage

CO_2 is injected into a saline aquifer.



Co-funded by the European Union

Phase 1 – part of Norwegian authorities' Longship project

Phase 2 – co-funded by the EU

The complete value chain

7 Specialised CO_2 ships ordered or delivered:

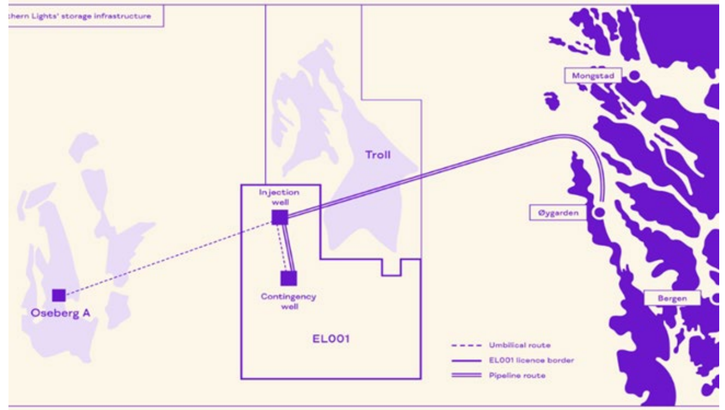
- 4x7.500 m^3 from DSOC yard
- 1x12.000 m^3 from DSOC yard
- 2x12.000 m^3 from Hyundai yard

At Øygarden, CO_2 is offloaded and stored temporarily in onshore tanks before injection into the reservoir.

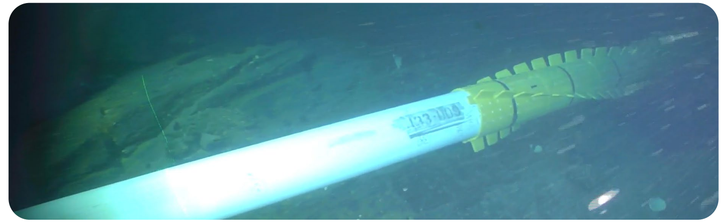
CO_2 from:

- Heidelberg Materials
- Yara
- Ørsted
- Stockholm Exergi
- Celsio

CO_2 is transported through a 100-kilometre pipeline and injected 2,600 metres below the seabed into the Aurora reservoir – for safe and permanent storage.



Captured CO_2 is liquefied, cooled, and loaded onto **purpose-built CO_2 carriers**.



Storage of CO_2 as a service

Northern Lights

The business:

Transport and store CO_2 for emitters, enabling our customers to avoid cost of emissions and/or selling negative emission certificates

The key challenges:

- Ensure safe storage of CO_2 in a geological formation
- Ensure affordability of the service through focus on improvements and cost reductions
- Optimize along the full CCS value chain to limit economic inefficiencies
- Ensure that system is protected from corrosion

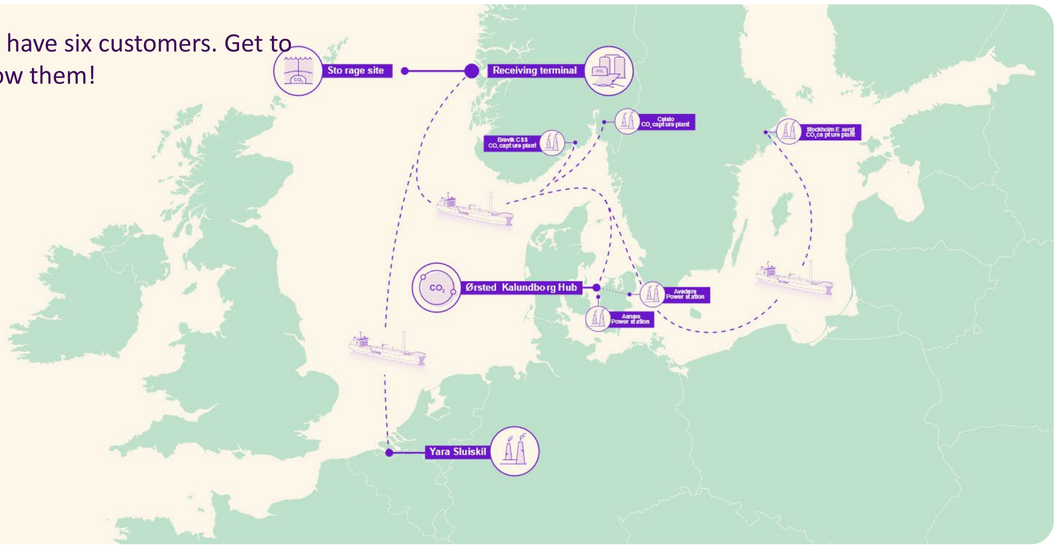
Co-funded by the European Union

Phase 1 – part of Norwegian authorities' Longship project

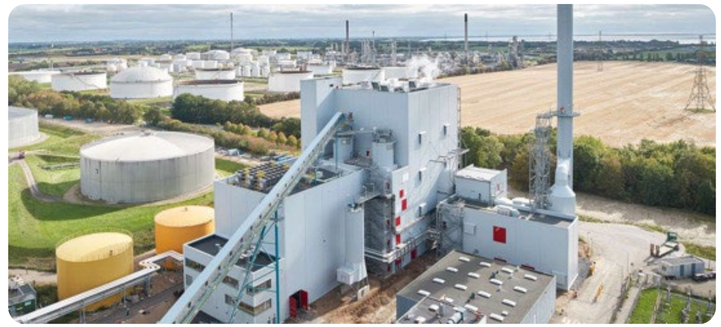
Phase 2 – co-funded by the EU

Northern Lights' **mission** is to enable the reduction and removal of **industrial emissions.**

We have six customers. Get to know them!



Ørsted
Location: Åsnæs & Avedøre
Volume: 430 000 tonnes of biogenic CO_2 per year



Hafslund Oslo Celsio
Location: Klemetsrud, Oslo
Volume: 400 000 tonnes of CO_2 per year

Heidelberg Materials
Location: Brevik
Volume: 400 000 tonnes of CO_2 per year

Stockholm Exergi
Location: Stockholm
Volume: up to 900 000 tonnes of biogenic CO_2 per year

Yara
Location: Sluiskil, Netherlands
Volume: ambition of 800 000 tonnes of CO_2 per year

Inherit
Location: Slemmestad, near Oslo
Volumes: up to 7 000 tonnes biogenic CO_2 per year

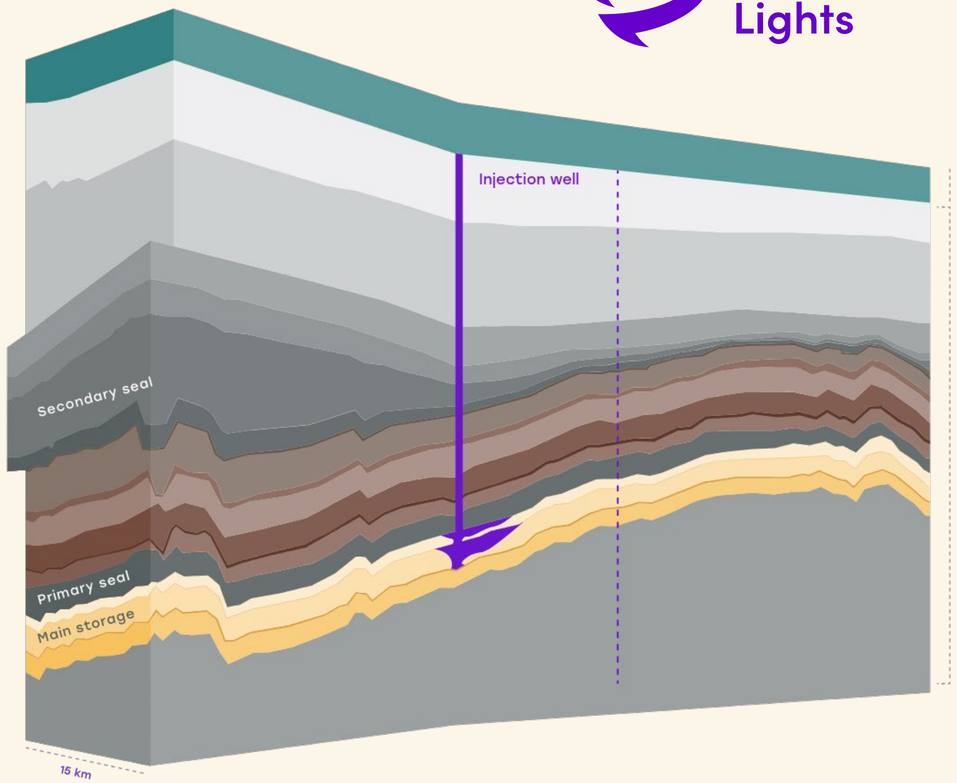
Value captured so far

→ **Ships & shipping**
- New designs
- Competition amongst yards evolving
- Strong interest from shipowners

→ **Onshore terminal and subsea installation**
- Covered in detail by Equinor TSP

→ **Drilling & wells**
- Further optimized desing
- Capacity above expectation in Phase 1

→ **Reservoir**
- Storage capacity
- Injection capacity
- Optimized monitoring



IN-WELL MONITORING

ACTIVE / 4D SEISMIC MONITORING

PASSIVE / NATURAL SEISMIC MONITORING

Co-funded by the European Union

Phase 1 – part of Norwegian authorities' Longship project

Phase 2 – co-funded by the EU

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Knut Bakke

PROJECT DIRECTOR - Northern Lights project

EQUINOR

Knut Bakke has been with the Northern Lights project since 2017 (front-end and execution) in different roles, ended up as Project Director responsible for start-up, completion of work and handover to Operations. Knut holds a Ph.D from the Norwegian University of Science and Technology and has worked in the oil and gas industry for some 30 years – in conventional oil and gas, deepwater and Brownfield projects, in R&D and in CCS projects.

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Timeline

- 2016 — Feasibility study
- 2017 — Shell and TTE joins study phase
- 2018 — Concept and FEED study
- 2019
- 2020 — Drilled confirmation well; Phase 1 FID
- 2021 — Northern Lights JV established; State FID
- 2022 — Project execution
- 2023
- 2024 — First fill of CO_2
- 2025 — First injection of CO_2 into reservoir; Phase 2 FID
- 2028 — Phase 2 ready

Concept:
- Onshore terminal
- Pipeline
- Offshore storage

Site selection:
Energiparken in Øygarden

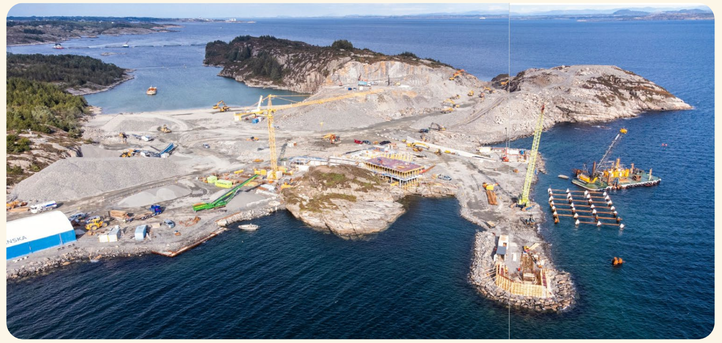
Site preparation
Construction of terminal, pipeline, storage wells
Ships
Regulatory & commercial ecosystem
Signed 2 commercial customers
14k visitors from 50+ countries

Phase 1 operational

Phase 2
- Expand to >5 Mtpa
- EU CEF funding
- Additional customers
- More ships

From start of execution to start-up

Northern Lights



CO_2 is not hydrocarbons, but our culture is

- CCS is "*the most regulated, non-existing business*"
- NL conforms to multiple national regulations, London Protocol and EU law
- Key Norwegian regulatory bodies (*e.g.* ME, NEA, NOIA, NOD) all developing "regulatory business"
- High expectations for documentation and evidence, driving demand for resources, time and cost
- Great focus on all possible and unlikely scenarios - while accepting 100% leak (*i.e.* the status quo or the do-nothing option)
- The owner teams and contractors "converge" to standard and familiar solutions
- Risk-based doesn't work unless you understand the risk

Source: www.daytoncvb.com

Key learnings timeline (2021–2025)

Northern Lights

2021
First-of-a-kind foundations

- CCS needs tailored standards and deliberate risk management (O&G not fit-for-purpose)
- Early authority alignment critical
- Governance & change control bottlenecks

2022
Design to execution

- FEED maturity is a major value lever
- Clear system/interface ownership required
- Contractor CCS experience matters

2023
Physical reality

- Late-maturing interfaces drive rework
- Execution reveals "hidden" constructability risks – 3D review is not really 3D
- Cross-scope start up planning workshops deliver strong alignment benefits

2024
Completion and Pipeline

- Access constraints cascade across seasons
- Pipeline cleanliness harder than expected

2025
Start-up

- Strong governance needed for parallel execution
- Pipeline integrity and cleanliness
- Early ops involvement improves handover

- CCS requires bespoke technical, contractual, and regulatory frameworks—oil & gas analogies only go so far.
- Interfaces (technical, organizational, regulatory) are the dominant risk drivers.
- Experience transfer is most valuable when it is structured, selective, and acted upon—not just documented.


Northern
Lights
NORTHERN PIONEER
STAVANGER
CO2 CARRIER
LNG

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CCS & CDR Summit

LONGSHIP EXPERIENCE SHARING: INSIGHTS ACROSS THE FULL PROJECT LIFECYCLE

Eve Tamme,
Moderator

Aslak Viumdal,
Gassnova

Jannicke Gerner Bjerkås,
Oslo CCS

Knut Bakke,
Northern Lights

Ove Dalland,
Northern Lights

Tor Gautestad,
Brevik CCS