



Onboard carbon capture

IMO meeting, 11th September 2025

Juliana Monteiro, TNO

Jetro Dam, HMC



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Agenda

- EverLoNG goals
- Demonstration results
- Full scale design
- Business Case
- Way forward



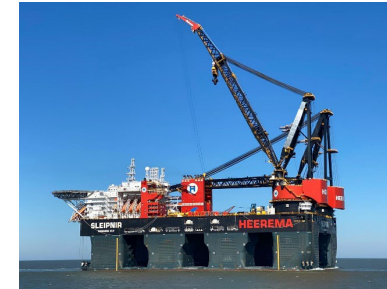
The EverLoNG project (2021 – 2025)

Goals: Demonstrating Onboard Carbon Capture (OCC) on LNG-fuelled ships.
Design full scale OCC system.

- ① 16 partners from NL, NO, GE, UK, USA
- ① Total budget: M€ 4.9 (funding: M€ 3.5)



Everlong's demonstrations



	LNG carrier	Crane vessel
Engine	Wartsila 12V50DF (4-stroke)	MAN 8L51/60DF (4-stroke)
Operation	Capture only	Capture + liquefaction
Fuel	LNG + pilot	LNG + pilot

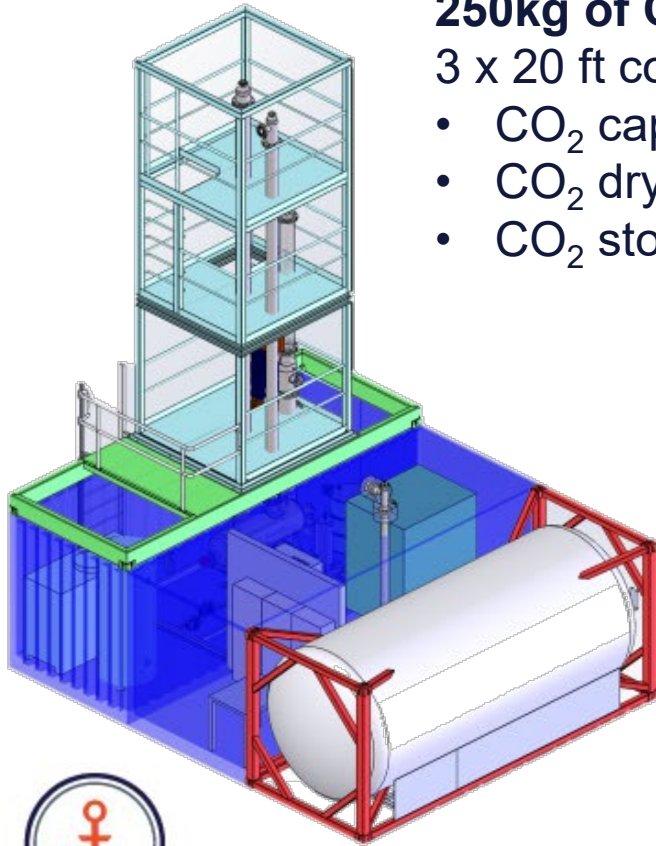


EverLoNG's OCC prototype

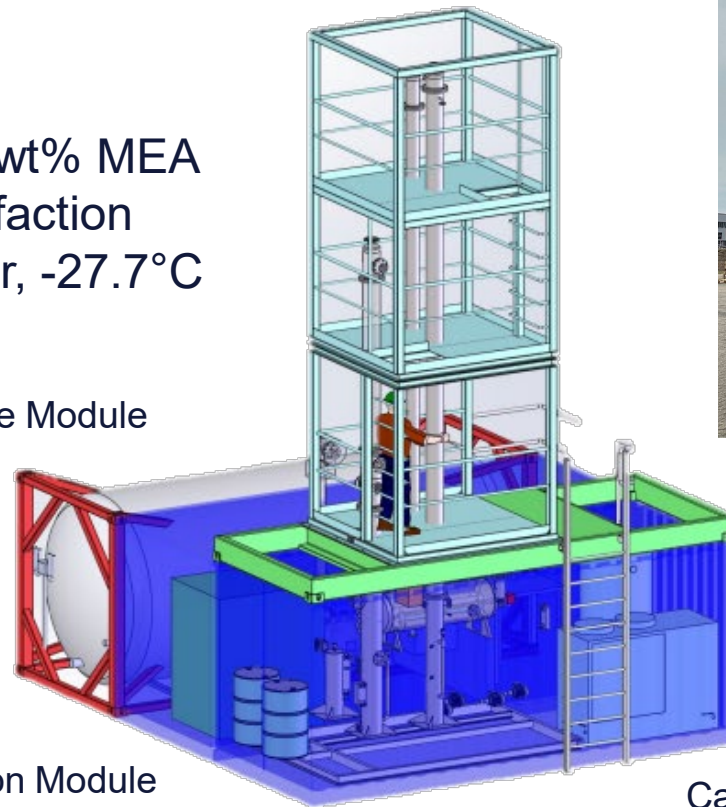
250kg of CO₂ per day

3 x 20 ft containers

- CO₂ capture with 30 wt% MEA
- CO₂ drying and liquefaction
- CO₂ storage at 15 bar, -27.7°C

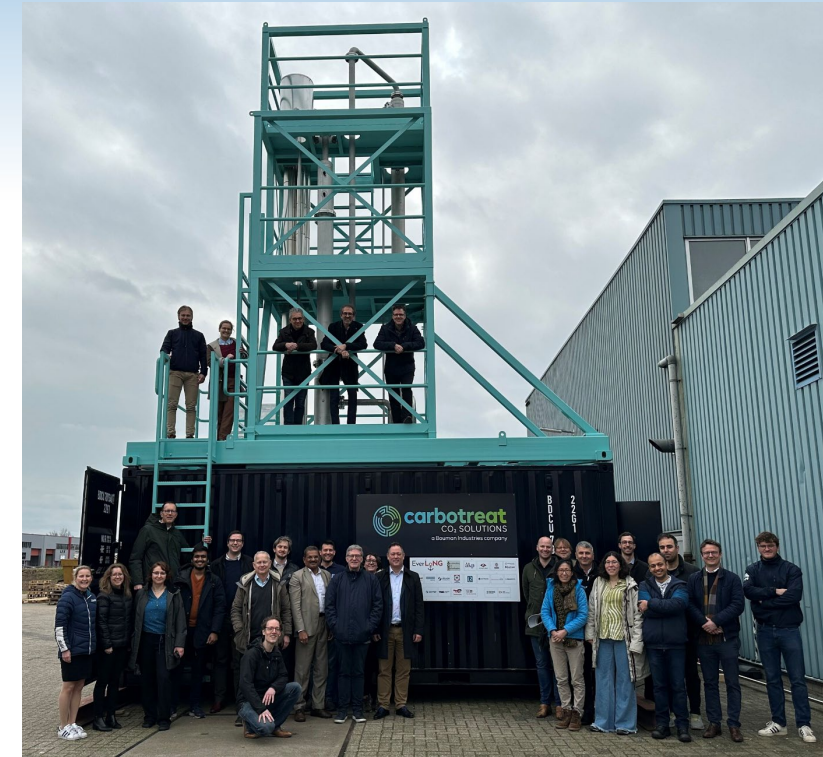


Storage Module



Liquefaction Module

Carbon Capture Module



Demonstration results



Seapeak Arwa Campaign

- ⚓ MEA solvent concentrations tested: 5–7% (low), 16–18% (medium), and 30% (target)
- ⚓ **Capture rate:**
 - ⚓ Low concentration: ~23%
 - ⚓ Intermediate: ~54%
 - ⚓ High concentration: ~79%
- ⚓ **1500+** operational hours



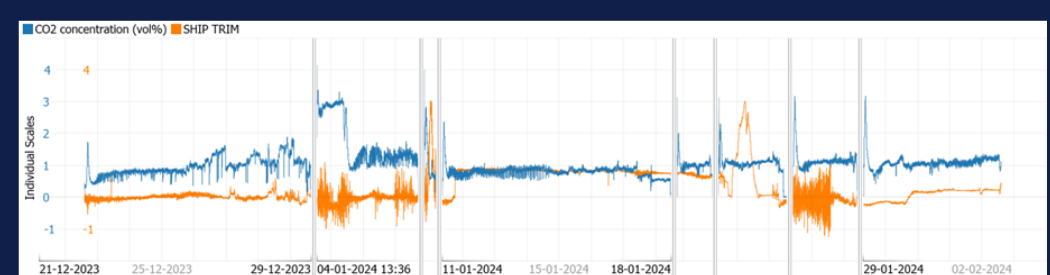
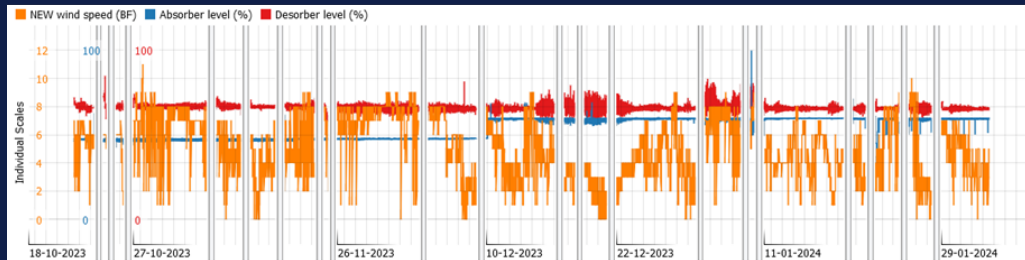
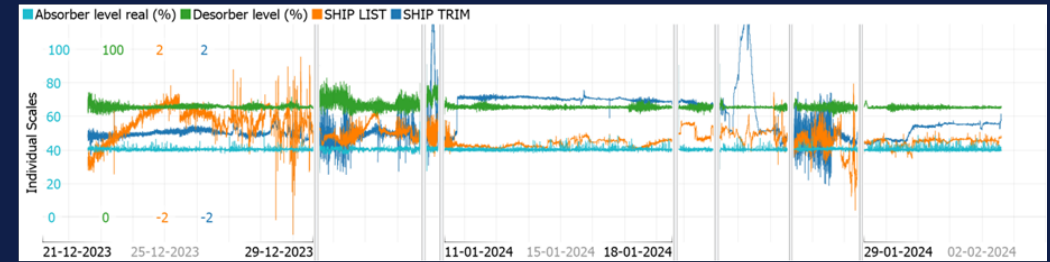
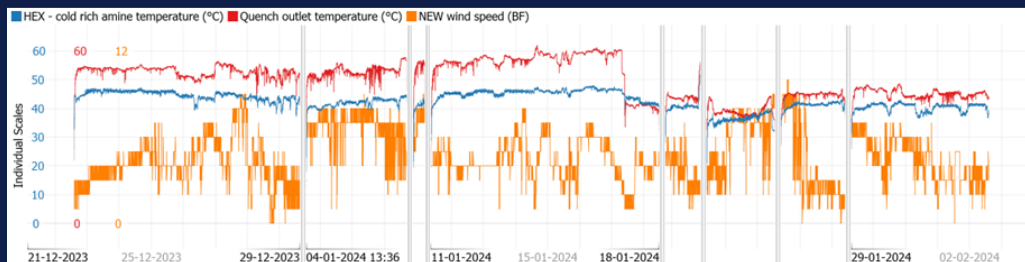
Sleipnir Campaign

- ⚓ **Capture rate:** ~98% (due to low exhaust flow)
- ⚓ **CO₂ captured:** ~4200 kg
- ⚓ **400+** operational hours

Demonstration lessons learned (1)

Ship motion doesn't seem to be a point of concern

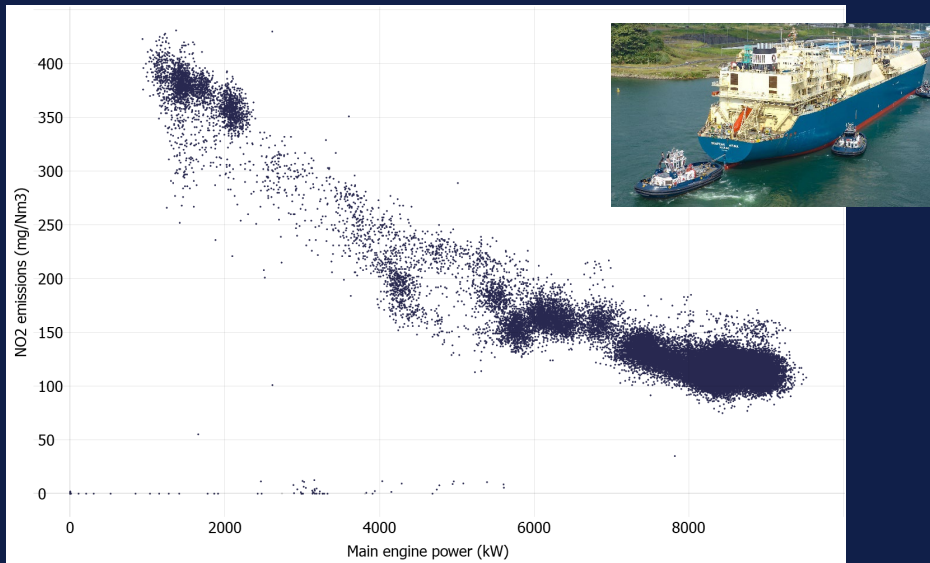
Ship sea movement or rolling evaluated throughout the campaign
Periods with strong wind speed (up to Beaufort 10, or above 24.5 m/s)



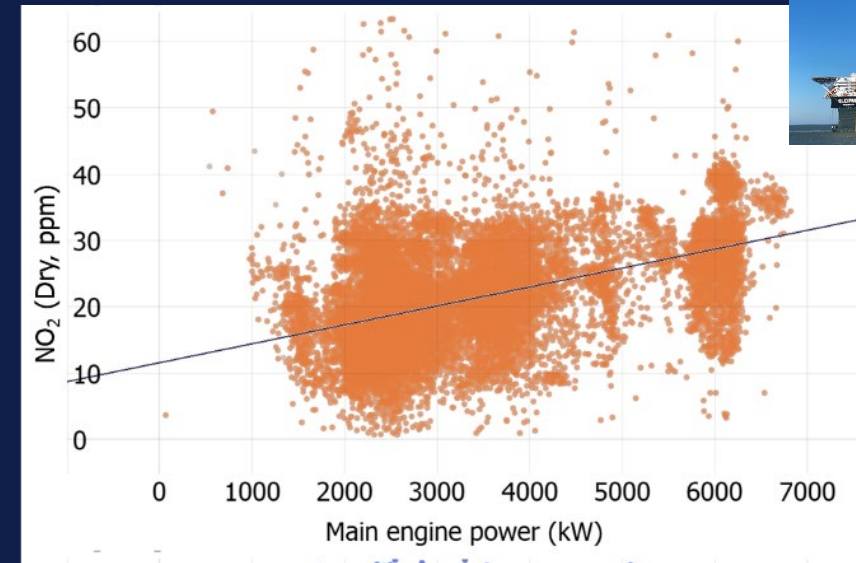
Ship motions had **no measurable effect** on CO₂ capture rate or other process parameters

Demonstration lessons learned (2)

High NO₂ content in exhaust gases



50-200 ppmv



10-30 ppmv

Onshore pilot references: below 5 ppmv



Demonstration lessons learned (2)

High NO₂ content in exhaust gases → high oxidative degradation rate

Component	Unit	TCM MEA	EverLoNG TotalEnergies
Formic acid	mg _L /Nm ³	2.0	6.2
Acetic acid	mg _L /Nm ³	0.3	2.9
Oxalic acid	mg _L /Nm ³	0.9	3.0

Onshore pilot
benchmark



Demonstration lessons learned (2)

High NO₂ content in exhaust gases → high oxidative degradation rate

Component	Unit	TCM MEA	EverLoNG TotalEnergies	EverLoNG Sleipnir
Formic acid	mg _L /Nm ³	2.0	6.2	1.8
Acetic acid	mg _L /Nm ³	0.3	2.9	0.4
Oxalic acid	mg _L /Nm ³	0.9	3.0	0.5

NO₂ 100% removed



Demonstration lessons learned (2)

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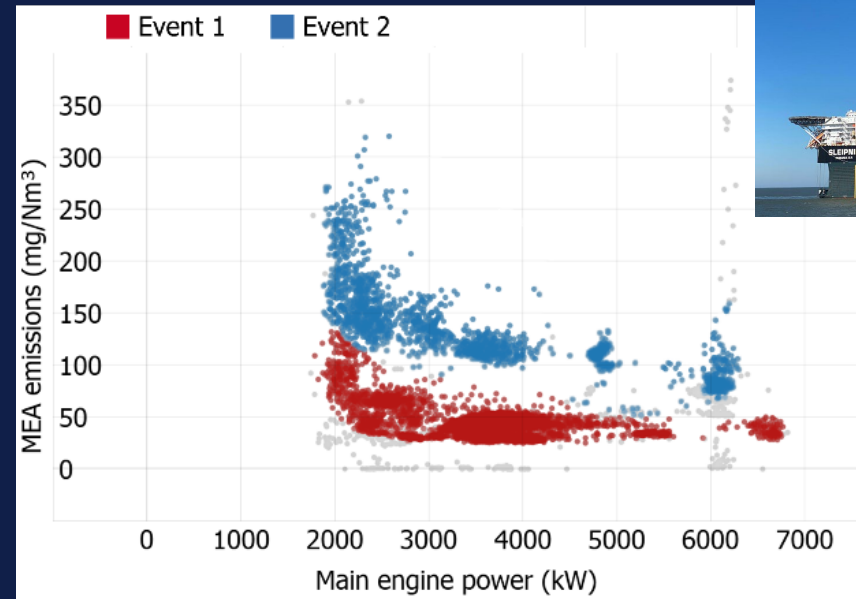
2 pathways: remove NO_x (e.g. SCR) or allow higher degradation rate

Demonstration lessons learned (3)

Potential for aerosol-based emissions



Volatile emissions dominate
Average: 2.1 mg/Nm³
Standard deviation: 14.8 mg/Nm³



Aerosol emissions
dominate

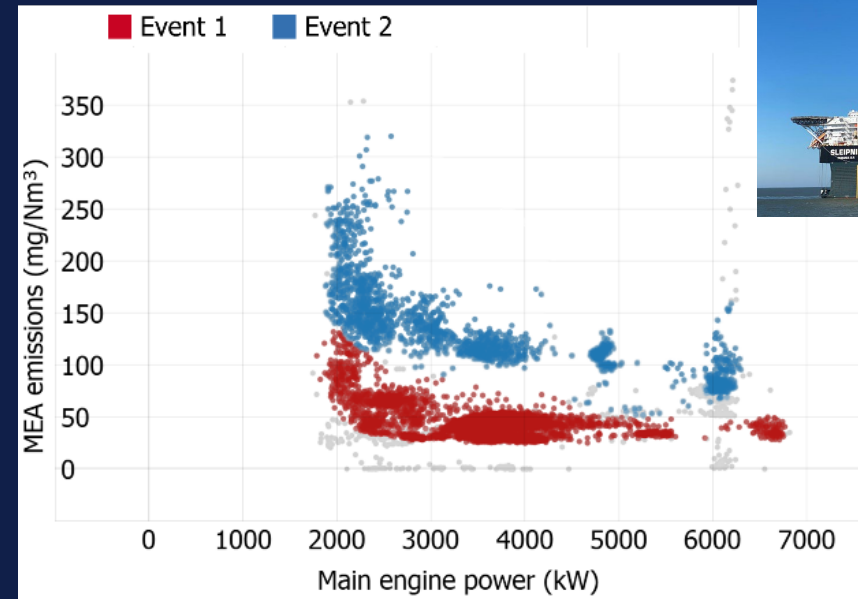


Demonstration lessons learned (3)

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Aerosol emissions
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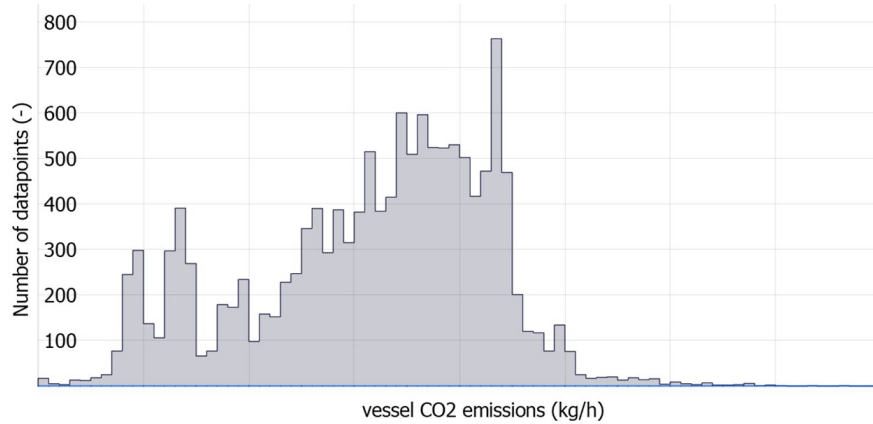
Particle measurements onboard &
integrate countermeasure in OCC design

Design of full-scale OCC systems

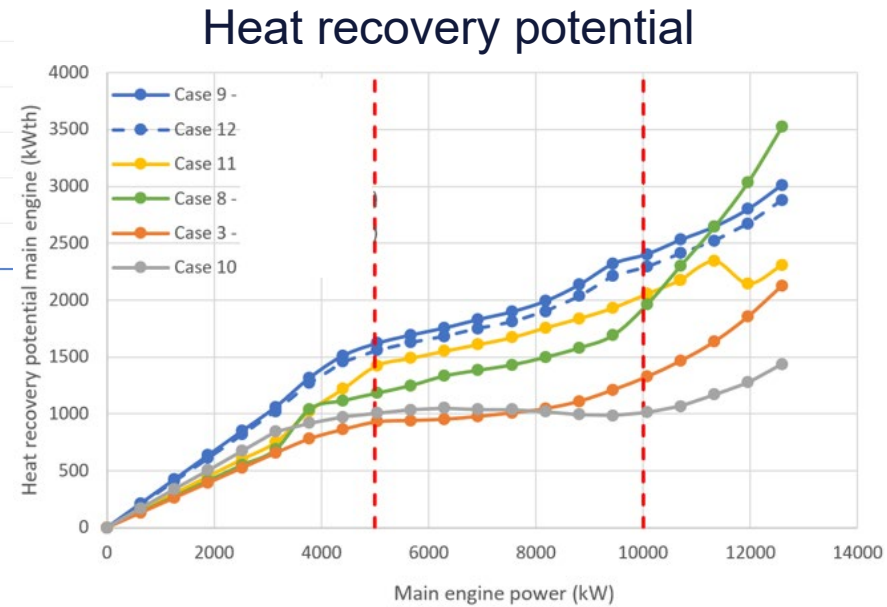
- Two cases:
 - Sleipnir (Heerema Marine Contractors)
 - LNG carrier (TotalEnergies chartered)
- Target: 70+% reduction of CO₂ emissions (tank to wake)



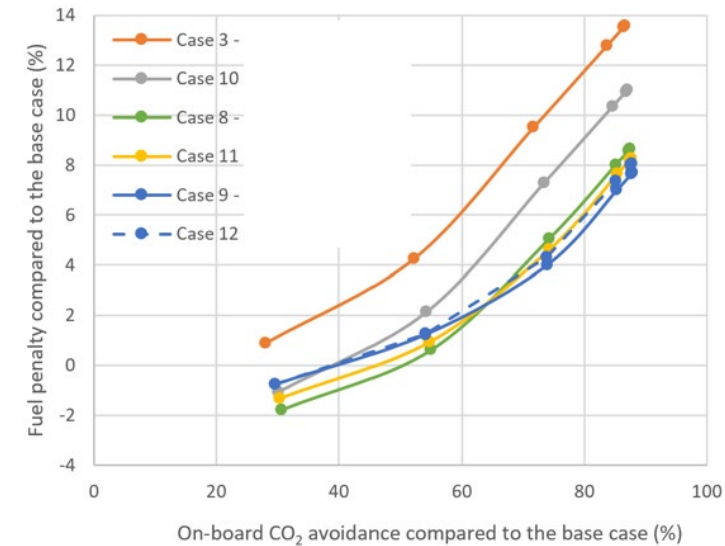
Capture system design: “digital cousin” approach



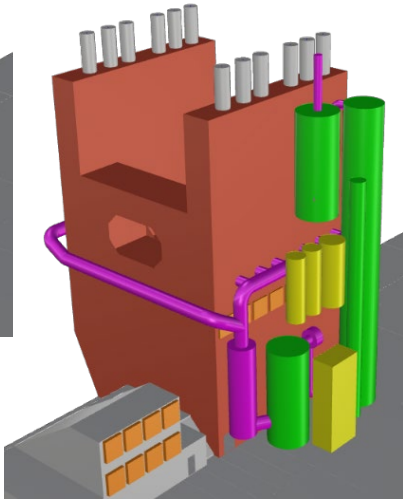
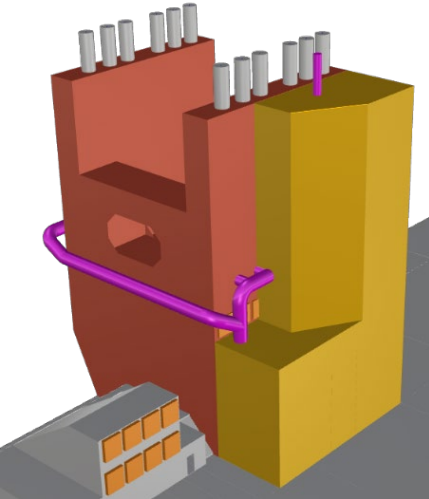
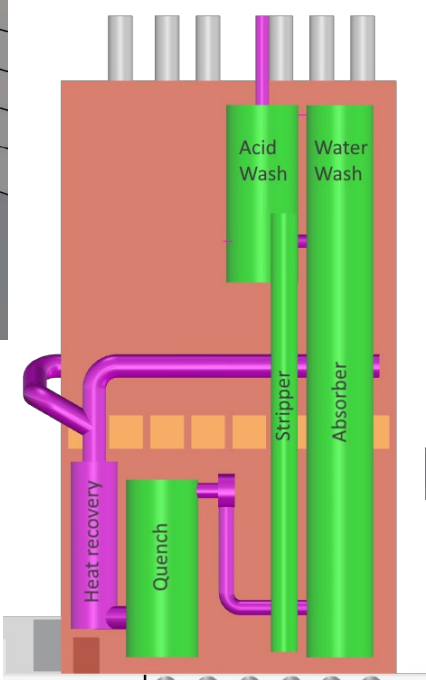
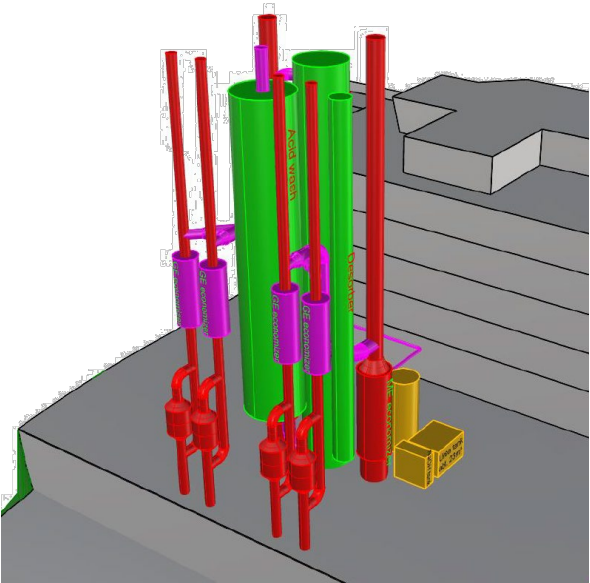
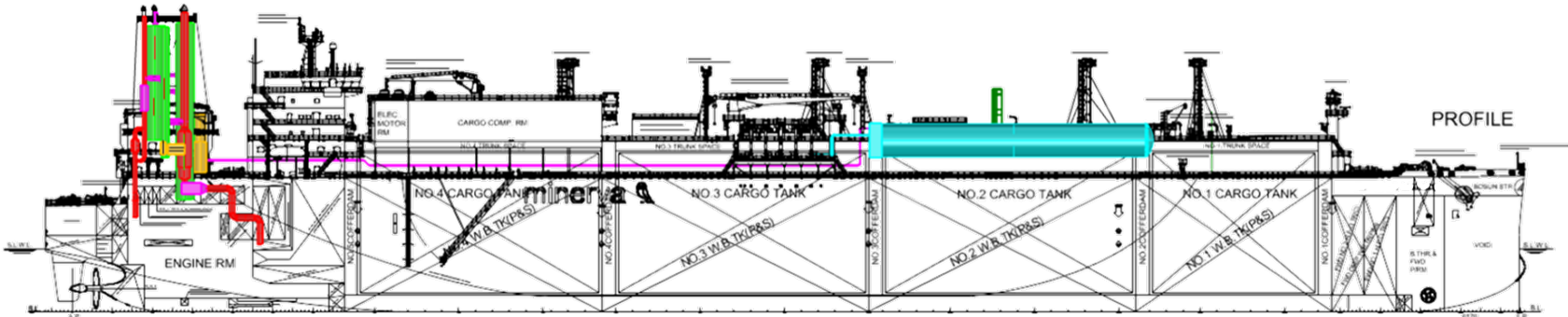
Real operational profiles



Fuel penalty



Design and integration



Design lessons learned: heat recovery

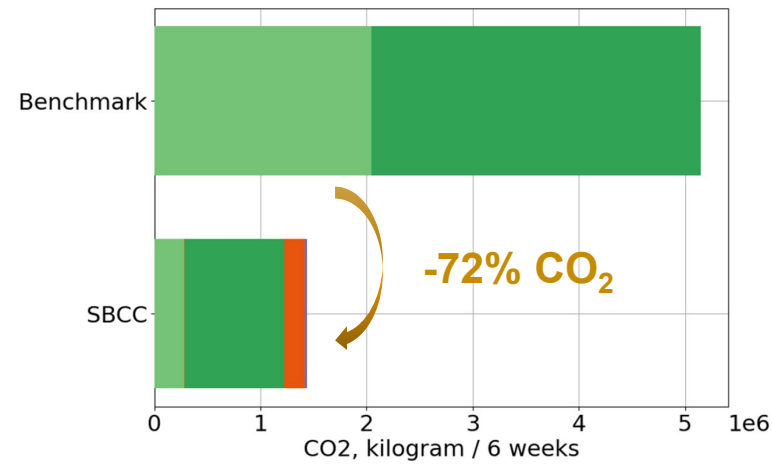
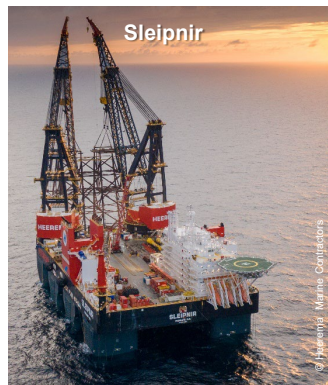
- Heat availability for **four-stroke engines** is typically sufficient for high capture rates (up to 95%)
- For **two-stroke engines**, additional heat is required to enable high capture rates
- HFO has a high heat demand, hence heat not available for carbon capture: if possible, avoid HFO

Design lessons learned: standardisation

- For **high capture rates**, a tailor-made design can provide significant benefits
- Standardisation becomes easier with a **lower design capture rate** (smaller fraction of treated exhaust gas)



On-ship (tank to wake) emissions



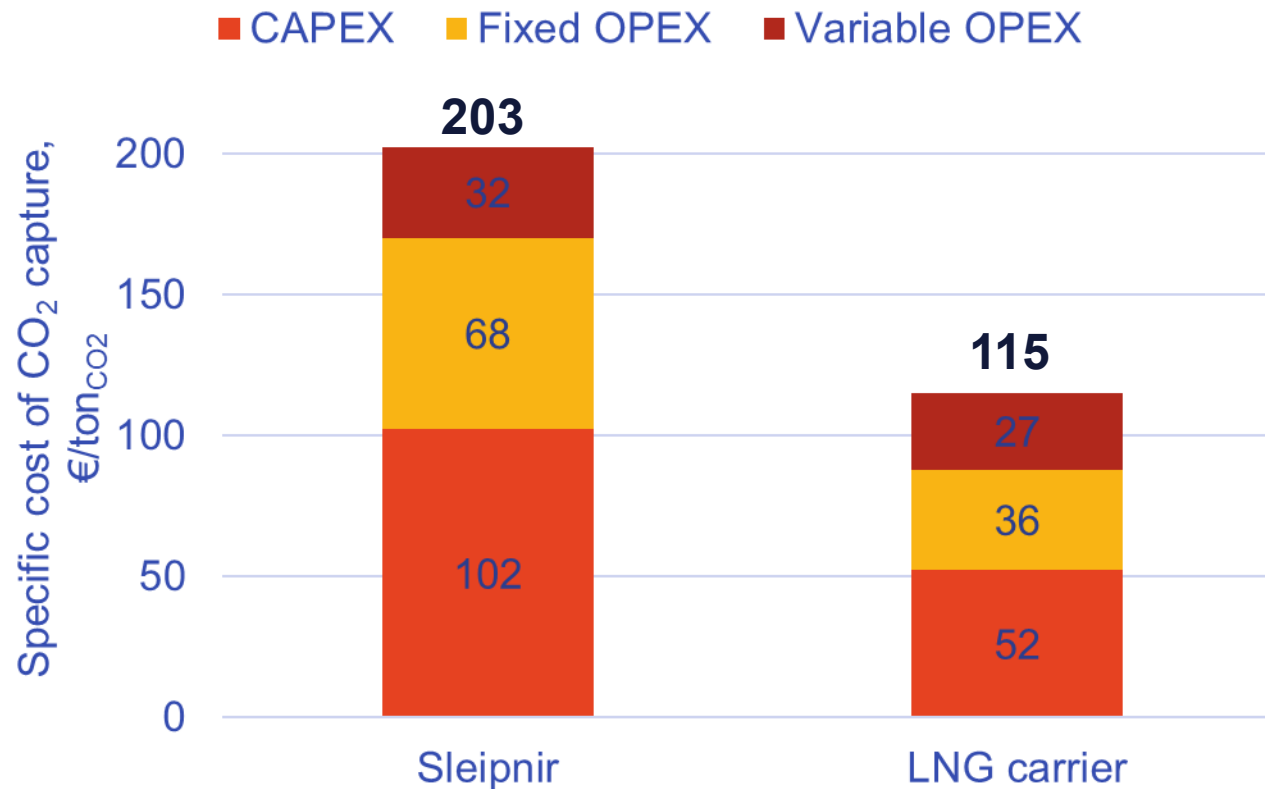
70% CO₂ reduction
target achieved



-84% CO₂



Cost of CO₂ capture

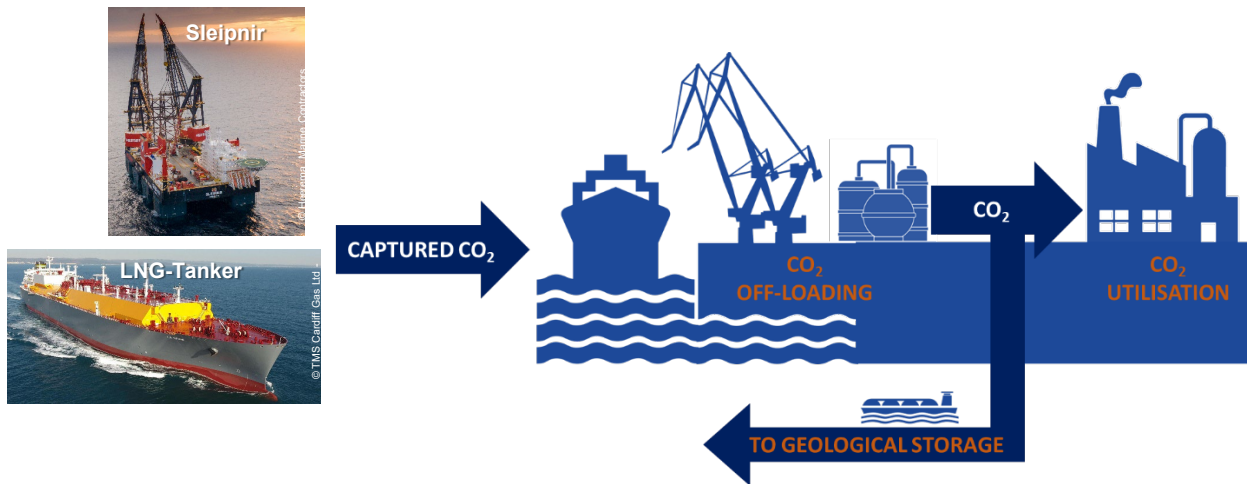


Main differences Sleipnir vs. LNG carrier

- 1) Retrofit vs. New-built
 - 2) CO₂ storage tanks (42 vs. 16 days)
 - 3) Capacity factor
- CAPEX doubles
→ variable OPEX is comparable (+20%)



Full-chain costs: capture, transport and storage



Cost element	€/t _{CO2} captured
On-board carbon capture	115 - 200
Receival facility	20
Cost of transport, pipeline	20
Cost of storage	40
Total	195 - 280



TEA lessons learned

- **Methane slip** hinders further emissions reduction → improvements potential on engine and gas-treatment level.
- Increased **heat recovery** efficiency can attenuate fuel effects.
- Onboard **CO₂ storage** effects ship design in more than just cost.
- **Value of carbon** is potential for business case success.



Way Forward “LNG Zero”

Continue development of full design.

Full supply chain development.
including ship to ship logistics.



Partners



Acknowledgement

- ACT funding partners



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U.S. DEPARTMENT OF
ENERGY





Thank you for listening

For questions, please contact:

Erik Vroegrijk, erik.vroegrijk@lr.org



info@everlongccus.eu

[@everlongccus](https://twitter.com/everlongccus)

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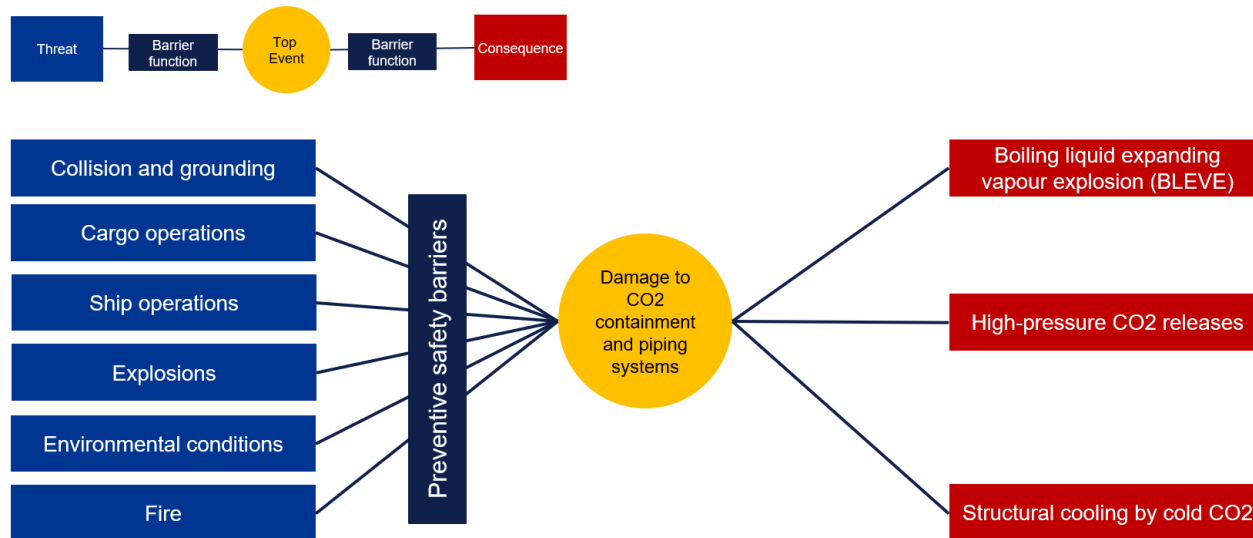
Additional slides



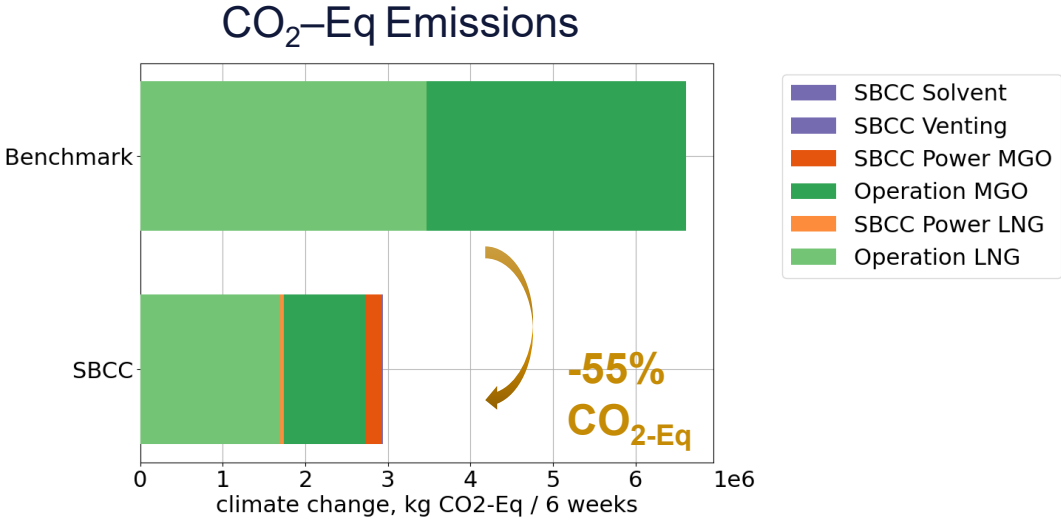
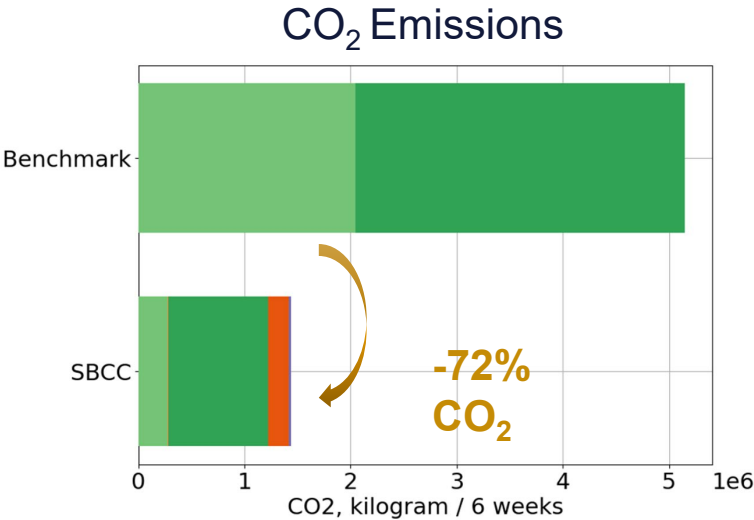
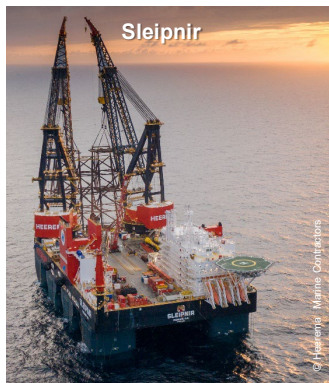
Lessons learned on safety aspects

Generic safeguards:

- Derived from the full scale HAZID workshops
- Organised by SBCC safety risks and comprehensively explained
- Report on the generic safeguards is available to the public and be downloaded here: <https://everlongccus.eu/about-the-project/results>



On-ship (tank to wake) emissions



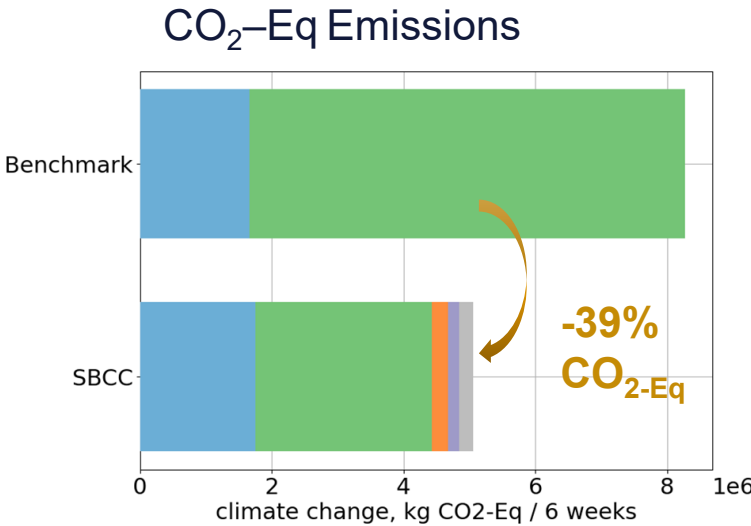
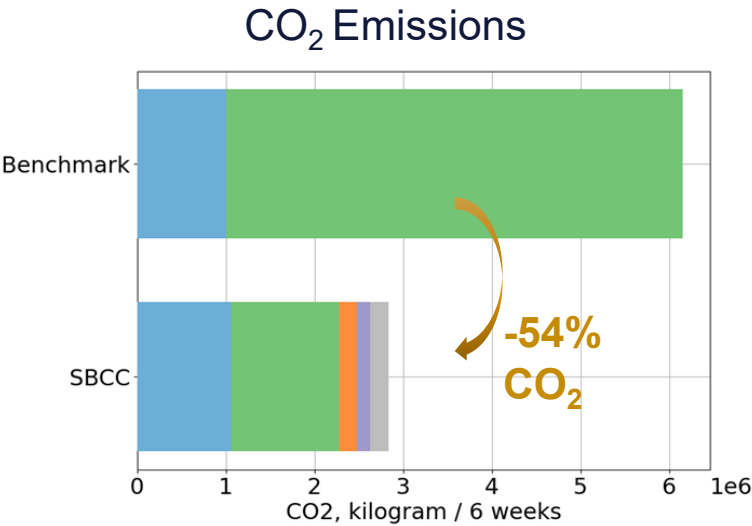
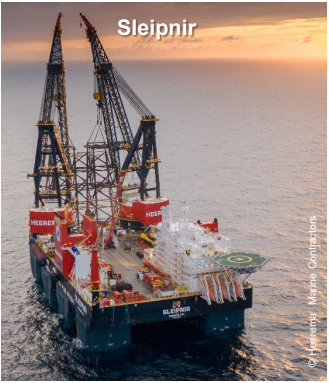
-84%
CO₂

-75%
CO₂-Eq

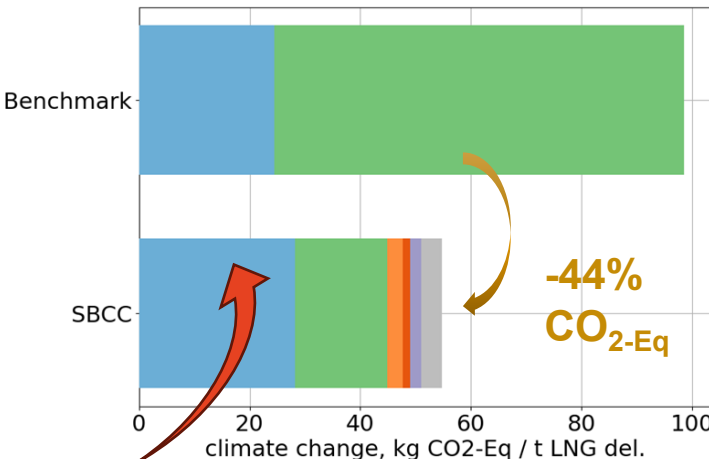
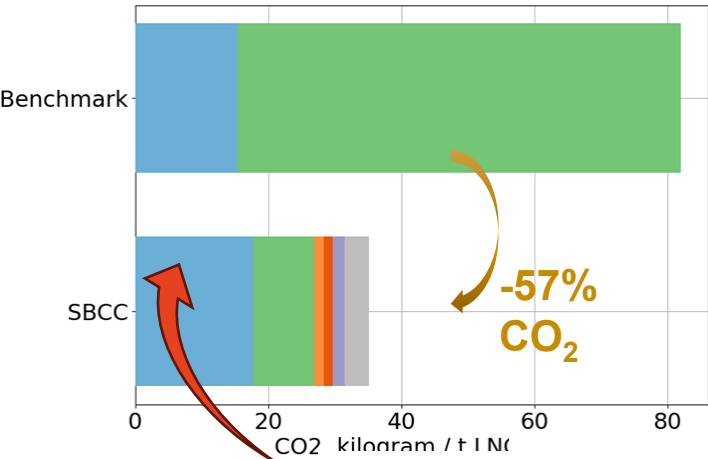
Methane slip adds to the emissions
and are not abated by OCC



Full Life Cycle incl. CO₂ Pathway

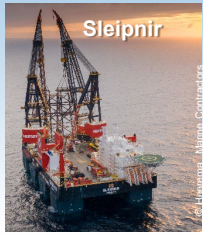


- CO₂ Pathway
- SBCC System
- SBCC Power
- Benchmark
- Upstream Fuel

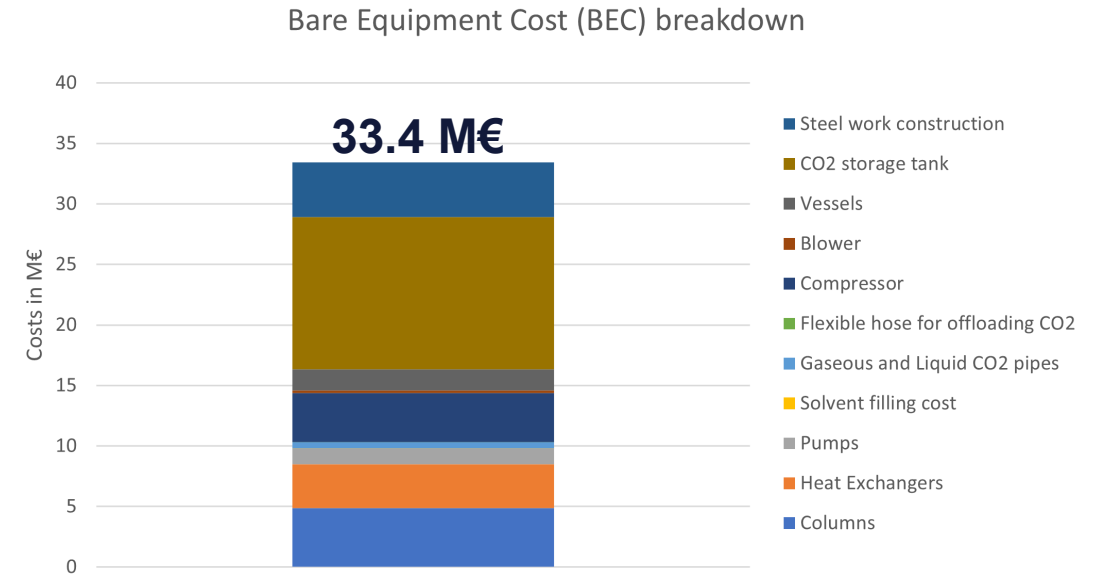
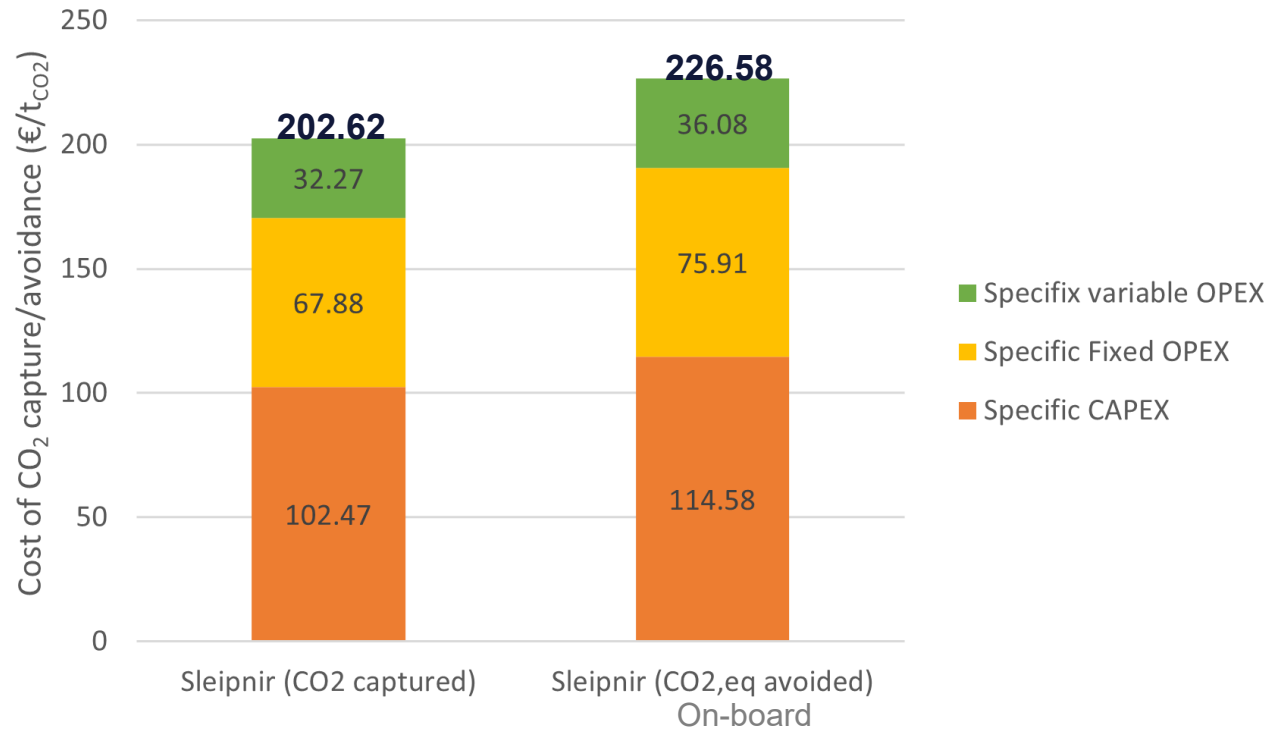


- CO₂ Pathway
- SBCC System
- SBCC Heat
- SBCC Power
- Benchmark
- Upstream Fuel

GHG emissions of fuel production



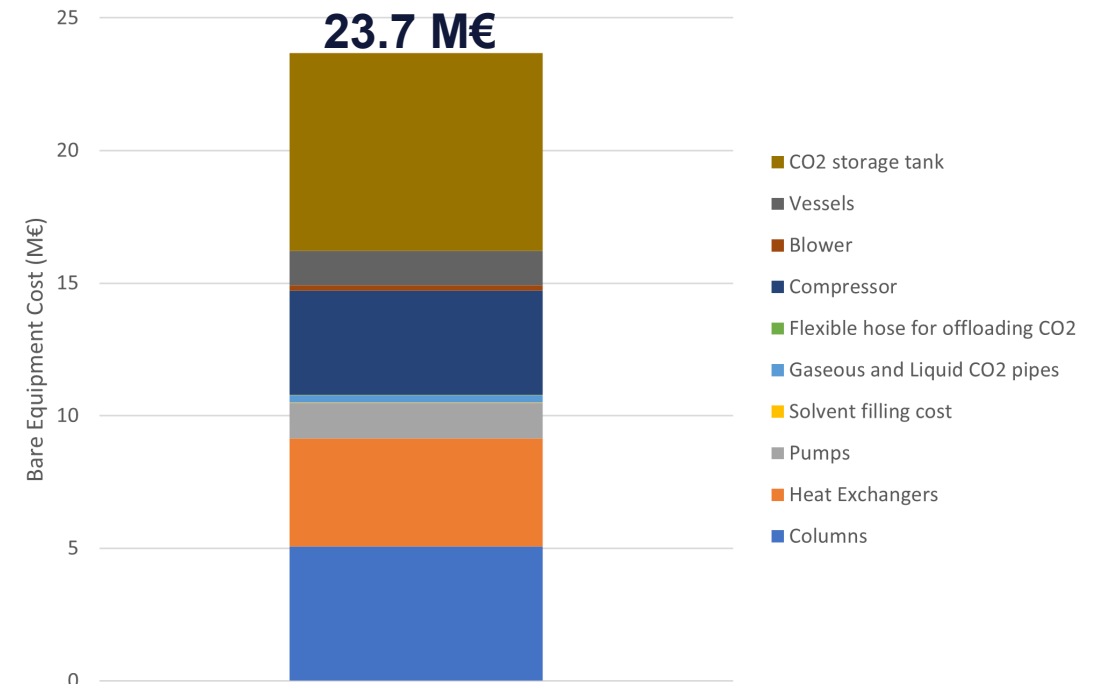
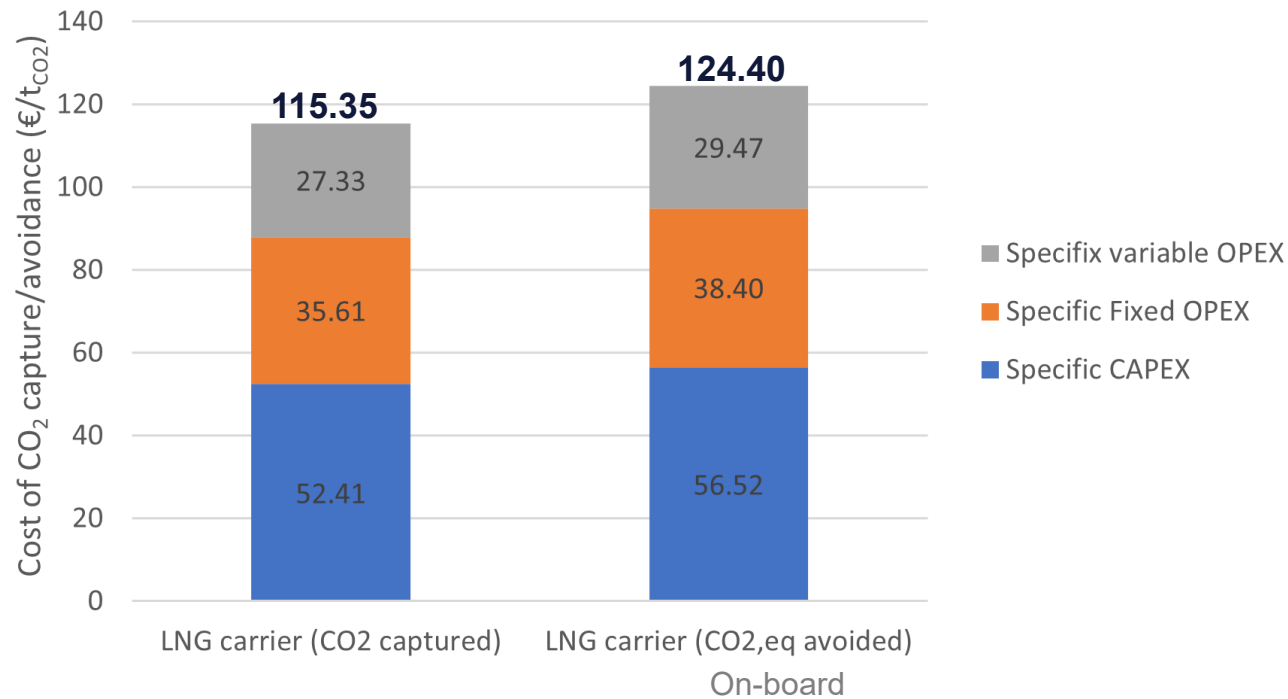
TEA - Sleipnir Case



- **CO₂ storage tank cost** is the major equipment cost driver.
- Since this is a retrofit case, steel work construction costs are considered.



TEA - Tanker Case



- CO₂ storage tank cost is the major equipment cost driver but lower than Sleipnir.
- Since this is a **new-built case**, **steel work construction costs are NOT considered**.
- **The capacity factor of the capture system is higher** here thereby giving **lower specific total costs**.

Roadmap for OCC implementation in Europe

OCC contributes to net zero emissions in 2050

2050

OCC on all C-containing fuels
(including carbon-neutral)
700 ships with OCC
35 Mt CO₂

2045

75% alternative fuels
No fossil fuel without OCC

2040

OCC in all major ports
New ships on alternative fuels

2030

Implementation in Ports of
Rotterdam and Antwerp

2035

Implementation in several ports
50 ships with OCC