# Grønne Gasdage 2023

Biogas Danmark

GREEN GAS DENMARK

27. september

# CCUS regulering og fangst

09.45 Hvordan bygger man en speedbåd? – Status over dansk og europæisk regulering på CCUS området

Henrik Sulsbrück
Enhedschef CCS, Energistyrelsen

10.15 Amin-baseret $CO_2$-fangst teknologi i dag og perspektiverne for videreudvikling

Anders Rooma Nielsen
Sales Manager, Aker Carbon Capture

Biogas Danmark GREEN GAS DENMARK

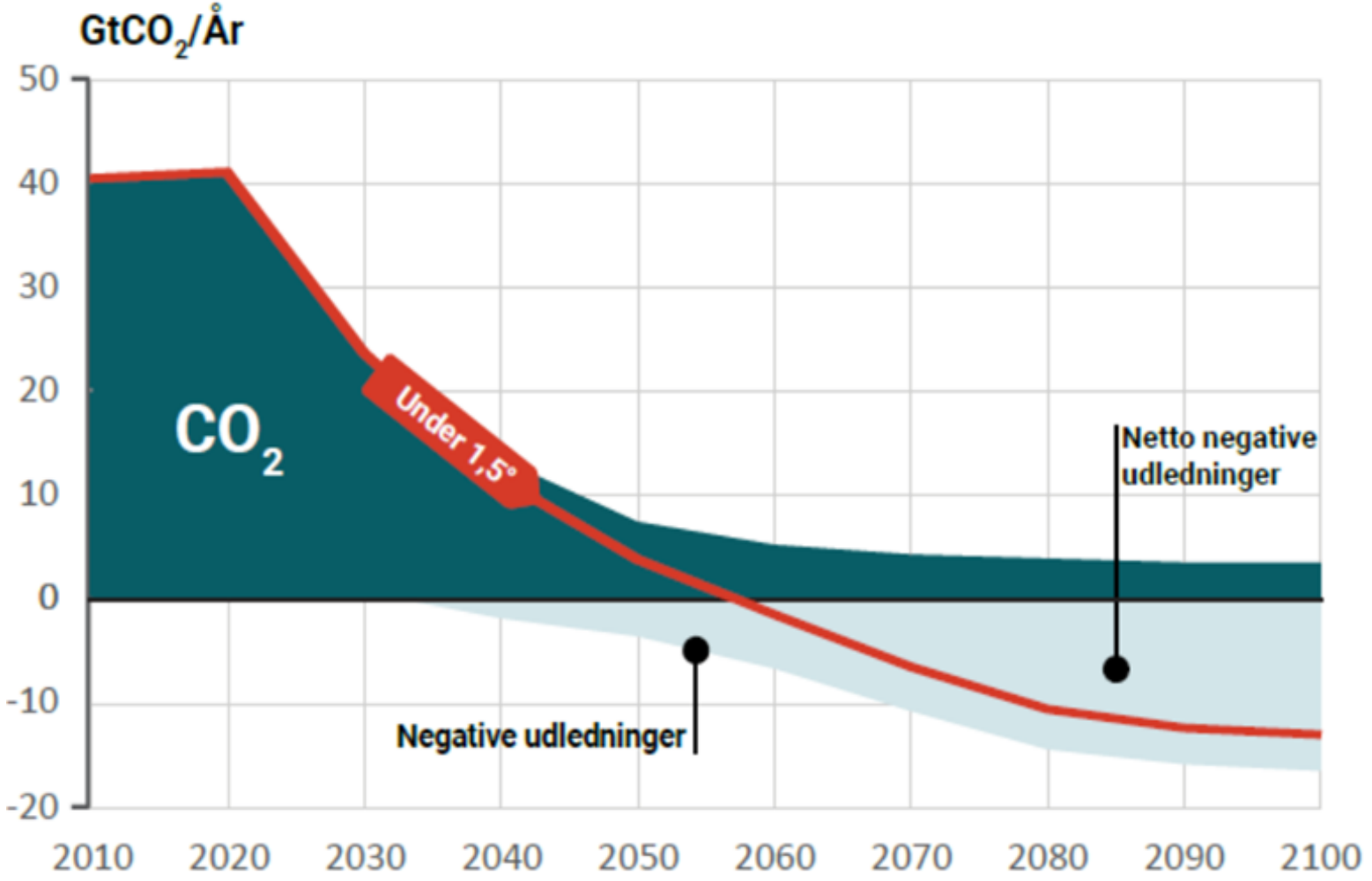
2023

Danish Energy Agency

# Hvordan bygger man en speedbåd?

Henrik Sulsbrück, Enhedschef CCS, Energistyrelsen

# HVORFOR?

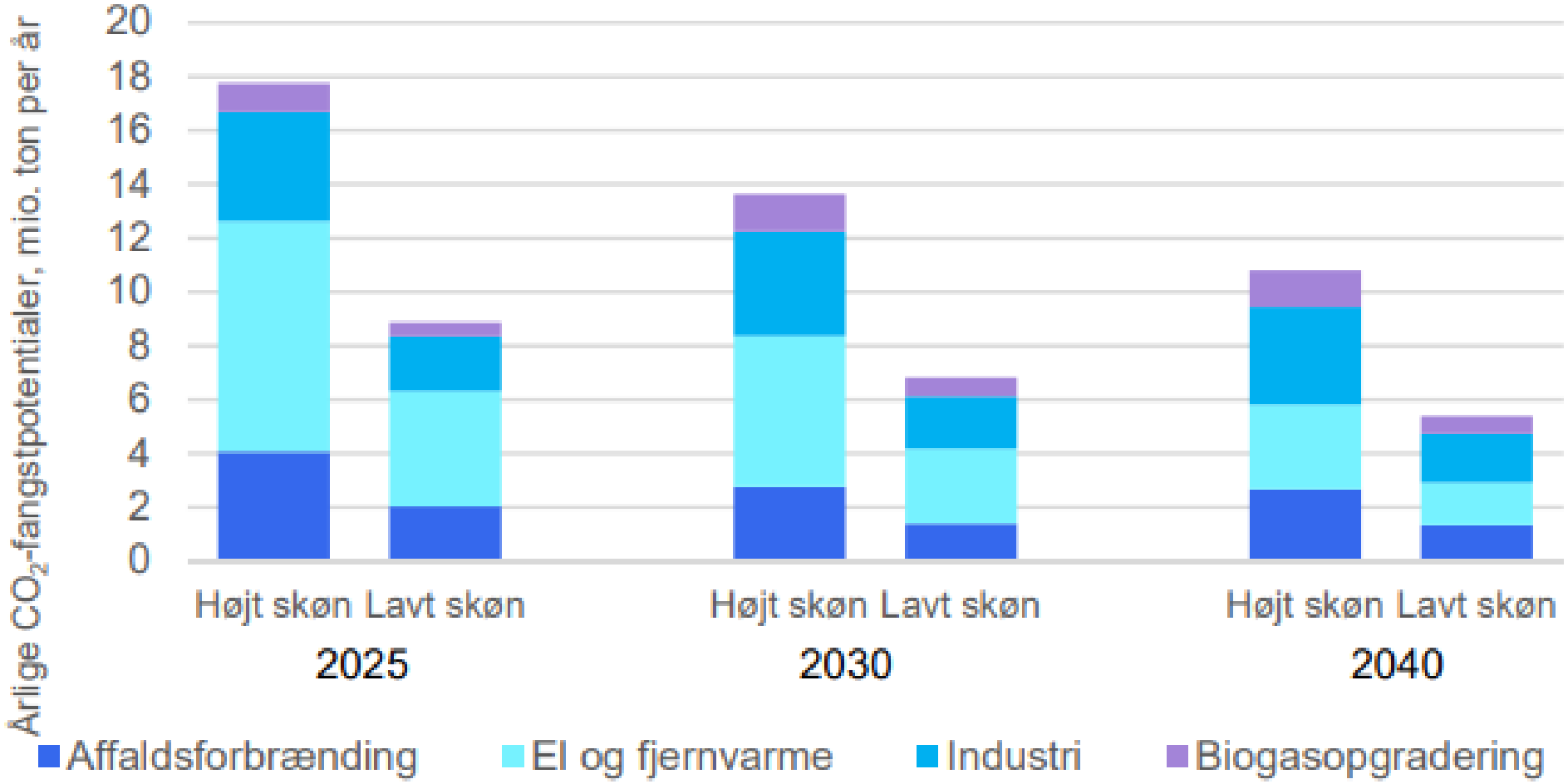




Figur baseret på IPCC's 1,5 graders rapport, 2018 og UNEP GAP rapport 2017.

# RETNING


# $CO_2$-FANGST POTENTIALE



# SIDEN STARTEN I 2020 ER DET GÅET STÆRKT

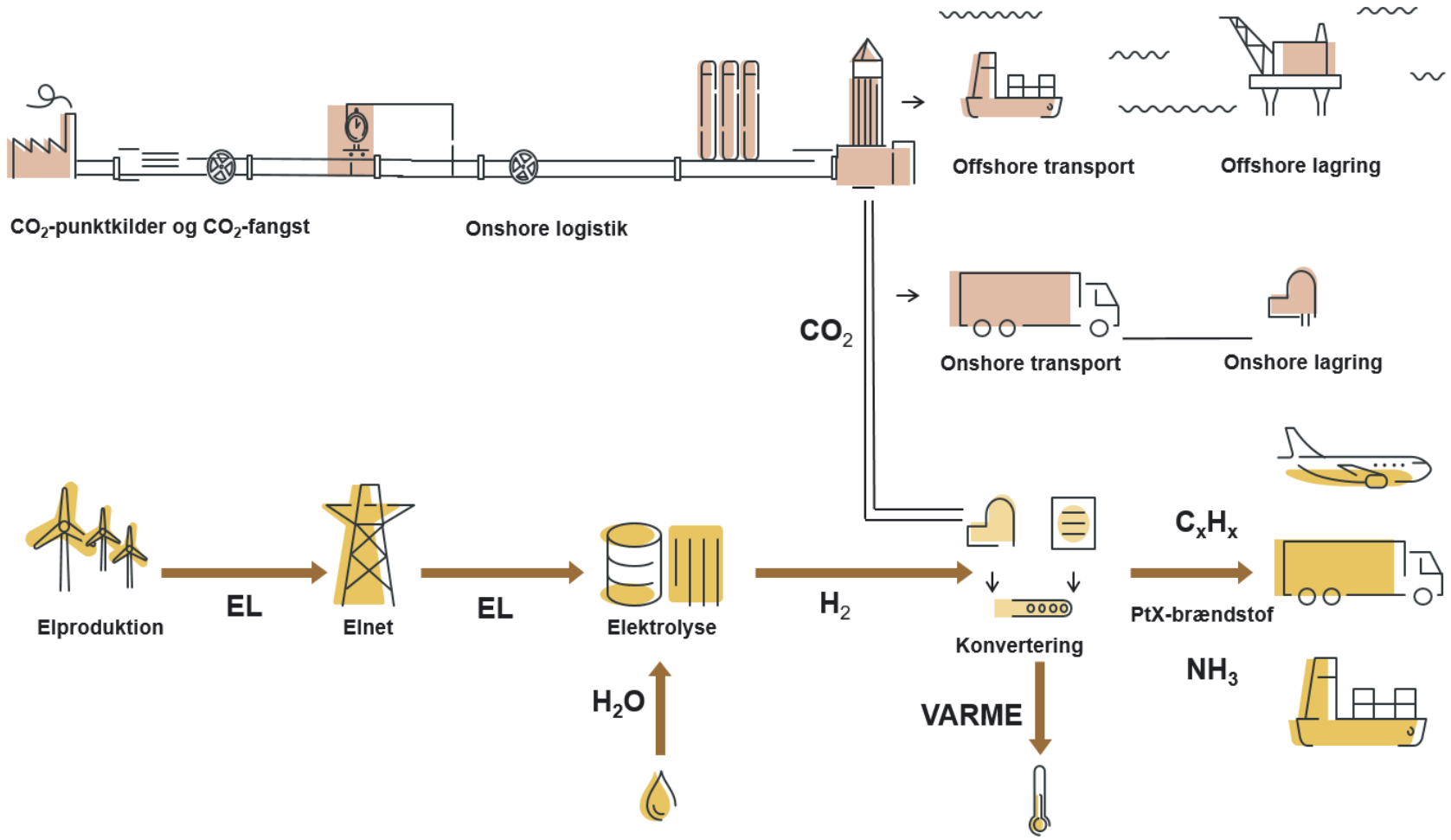
Politisk aftaler


CCUS puljer



Første lagrings-licenser

# VI ER IKKE FÆRDIGE…




$CO_2$ GASEOUS

# SENESTE POLITISKE AFTALE SEPT 2023

INFRASTRUKTUR

ÉN PULJE

LAGRING

EU FOKUS

# BORGERINDDRAGELSE - VIGTIGST AF ALT ?

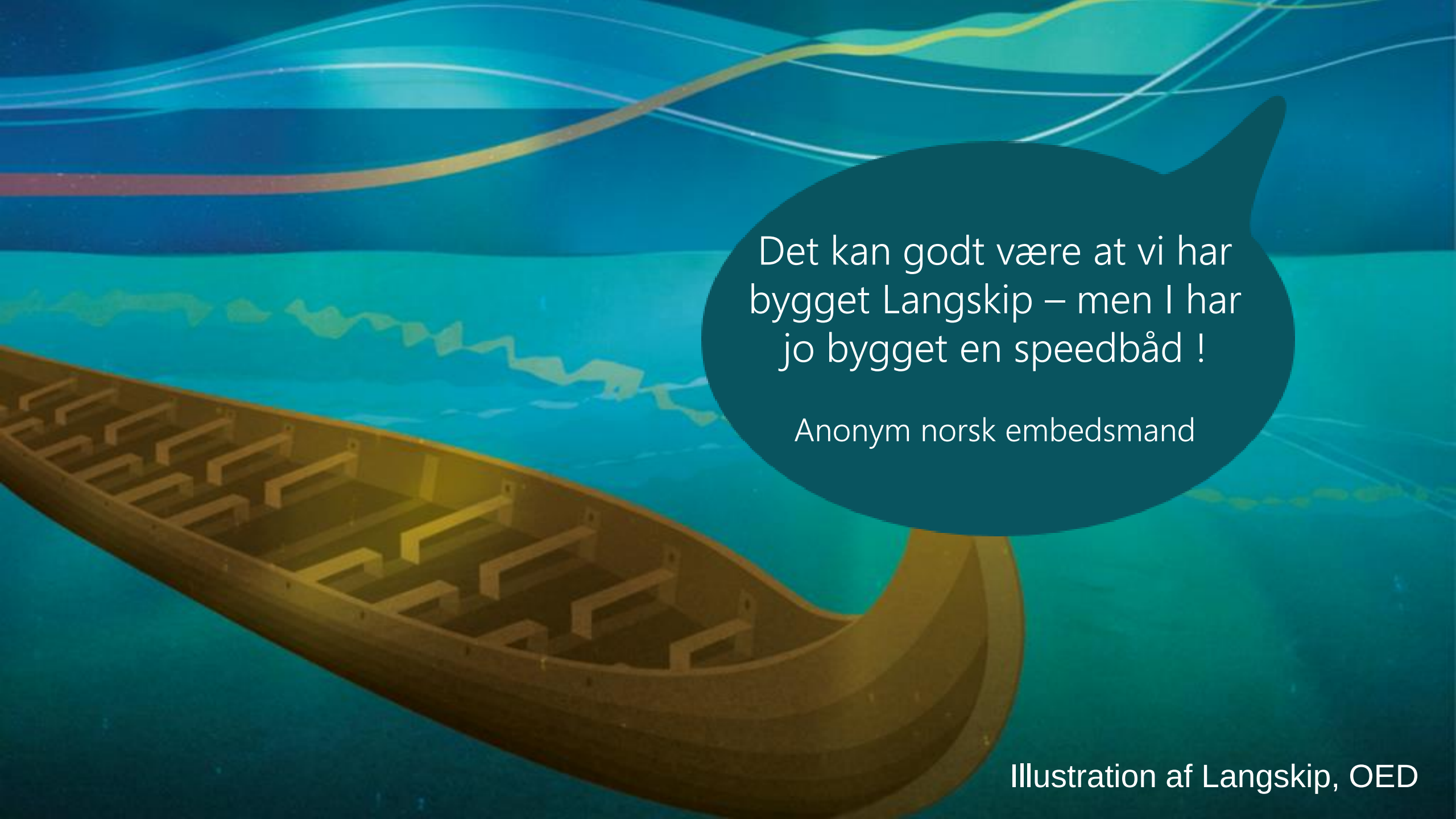
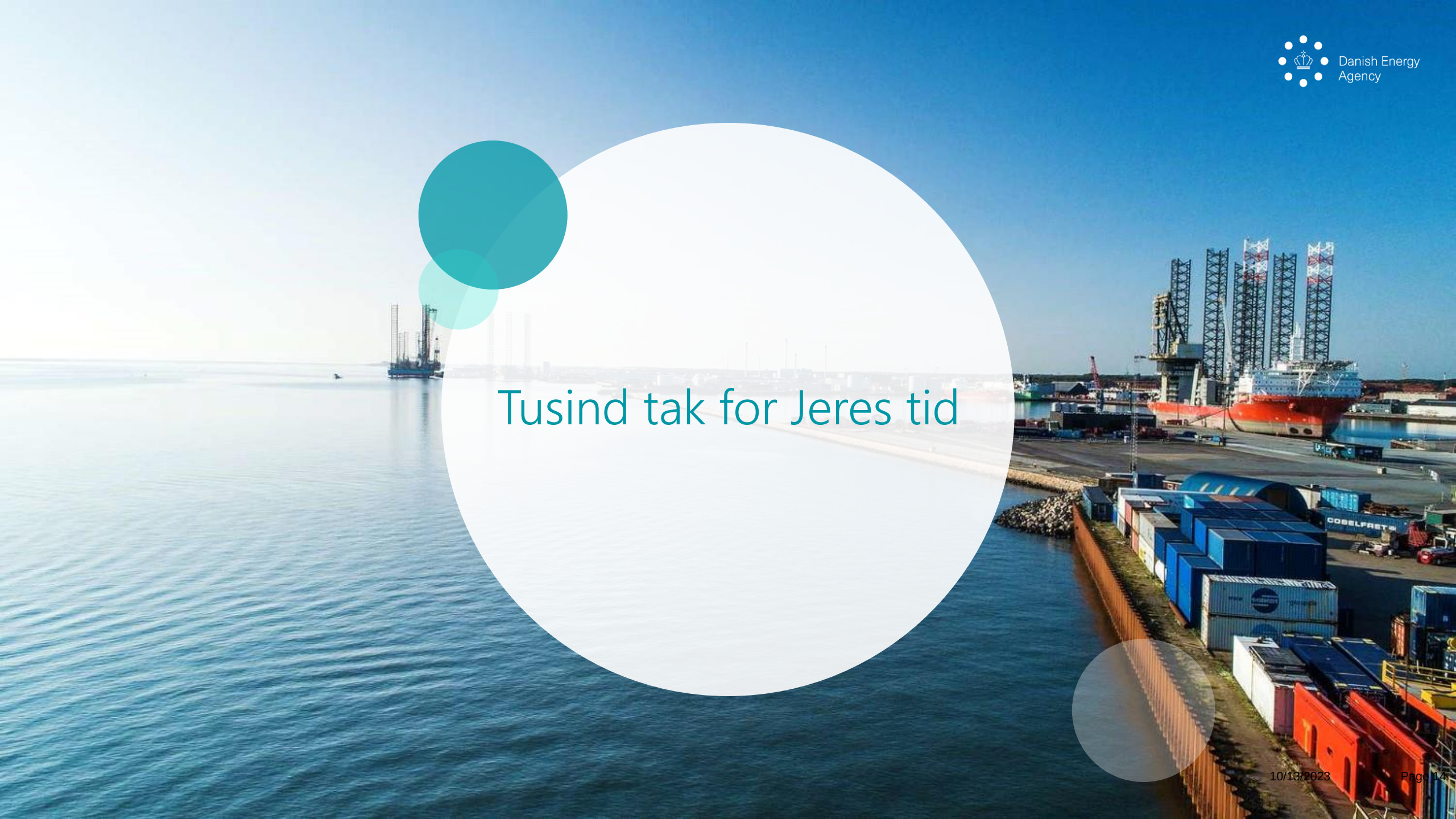



Illustration af Langskip, OED



Danish Energy Agency

# Tusind tak for Jeres tid

# Næste oplæg

Anders Rooma Nielsen,
Aker Carbon Capture

Biogas Danmark

GREEN GAS DENMARK

2023

# Amin-baseret $CO_2$-fangst teknologi i dag og perspektiverne for videreudvikling

September 2023

**Anders Nielsen**

**Advisory Services**

**Aker Carbon Capture Danmark A/S**

**Anders.Nielsen@akercarboncapture.com**

**+45 22754627**


## Introduction to Aker Carbon Capture

## Technologies to capture CO2

## Amine based CO2 capture process

## Perspectives for further development



AKER CARBON CAPTURE


# Aker Carbon Capture: Realizing Carbon Capture Now



AKER CARBON CAPTURE

# A long-term Aker Group technology initiative

**1996**
Start of Norwegian carbon capture initiative

World's first offshore $CO_2$ storage project

**2008 – 2020**
Extensive testing, development and validation

Mobile Testing Unit (MTU) – Flue gas testing

SOLVit CCS R&D Programme

Technology Center Mongstad

Full scale CCS value chain
*(Longship project 2014 – 2024)*

**Now**
Commercialisation

Start of operation of Twence, Norcem and Ørsted projects in 2023, 2024 and 2025

**$CO_2$ separation from natural gas production during processing**

**Leading one of the largest R&D programmes in Europe (SOLVit)**

**Operating MTU and TCM at industrial-scale**

**Established as a standalone carbon capture company**



1) Global Status Report 2019, Global CCS Institute; 2) Subject to project funding from government and final contract |Source: Global CCS Institute

# Unique track record from Mobile Test Unit (MTU) – advanced $CO_2$ capture pilot

**11** different flue gases tested (high process flexibility)

**30,000+** operating hours

Performance data is paramount for technology qualification

**50x** technology upscaling proven at TCM carbon capture plant

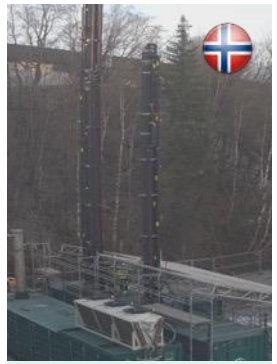
**Natural gas**
Risavika Gas Center

**Coal power**
National CCC

**Natural gas**
Dong CHP

**Waste to Energy**
Klemetsrud WtE

**Char**
Polchar



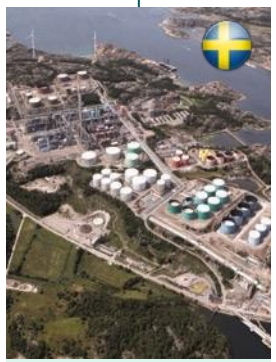
**Limestone calc.**
SMA Minerals

## Continuously upgraded and developed since 2008

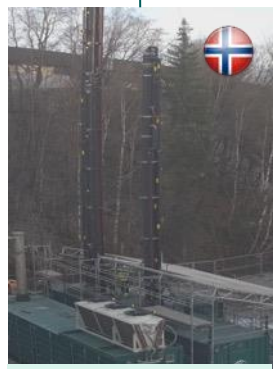
**Coal power**
Longannet Power

**Heavy oil cracker**
Equinor oil refinery

**Cement**
Heidelberg/ Norcem



**Hydrogen**
Preem refinery



**Ferrosilicon**
Elkem



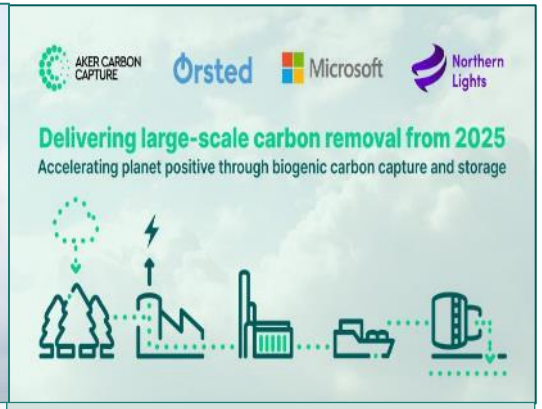
AKER CARBON CAPTURE

# Aker Carbon Capture today

## Ongoing full-scale installations

Norcem, Cement, storage

Twence, Waste-to-Energy, greenhouse




Ørsted, Biomass, storage

## Planned test campaigns in 2023-2024

Denmark / Norway / Belgium / Greece

## Other selected ongoing projects

BP Net Zero Teesside, UK. FEED study

SSE Thermal, Keadby 3, UK. FEED study

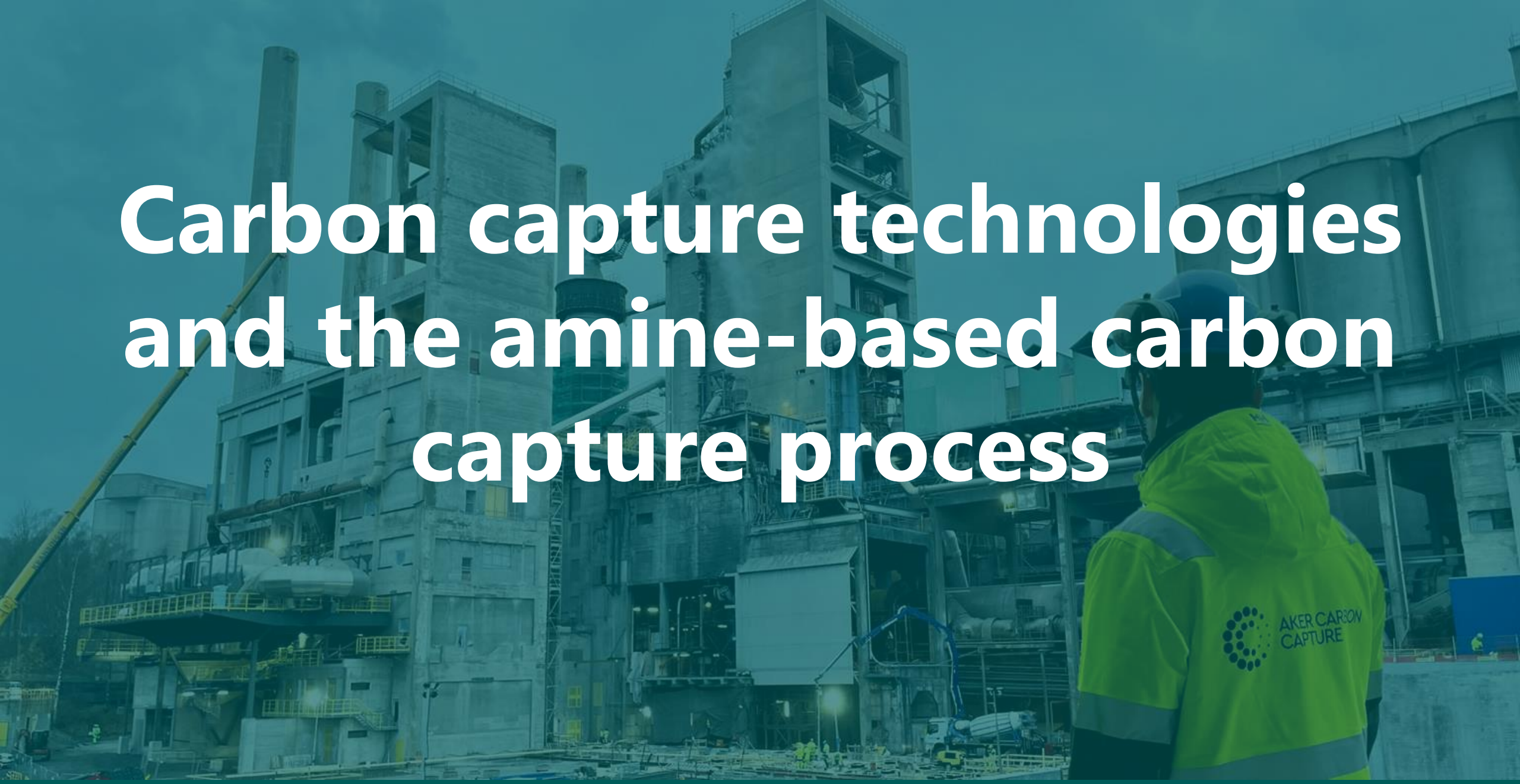
## Partnerships

Microsoft
Ørsted
Twence®
SIEMENS energy
Carbfix
Northern Lights
NORCEM HEIDELBERGCEMENT Group
MAN Energy Solutions
Future in the making



AKER CARBON CAPTURE

# Carbon capture technologies and the amine-based carbon capture process



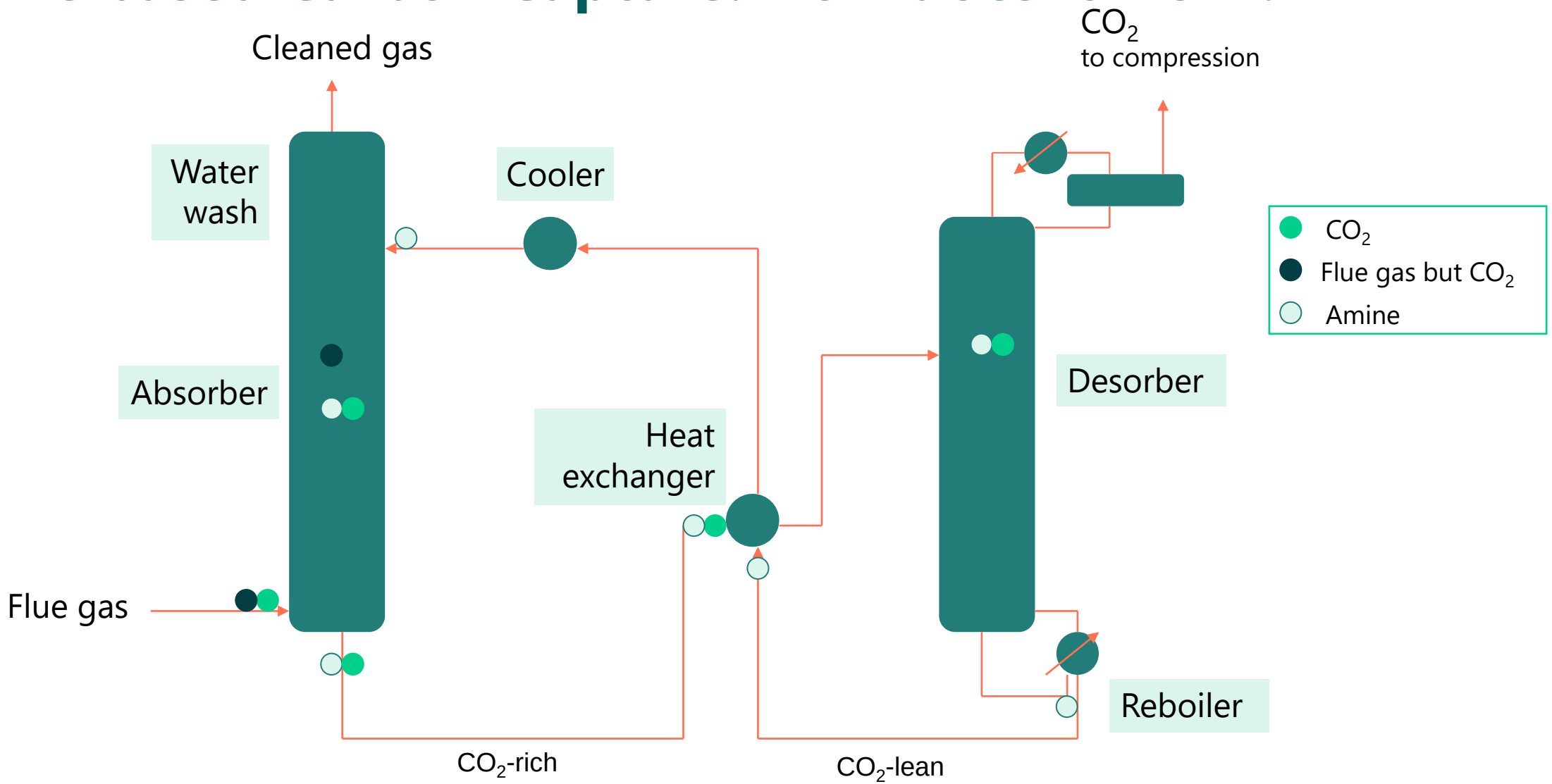

 

AKER CARBON CAPTURE

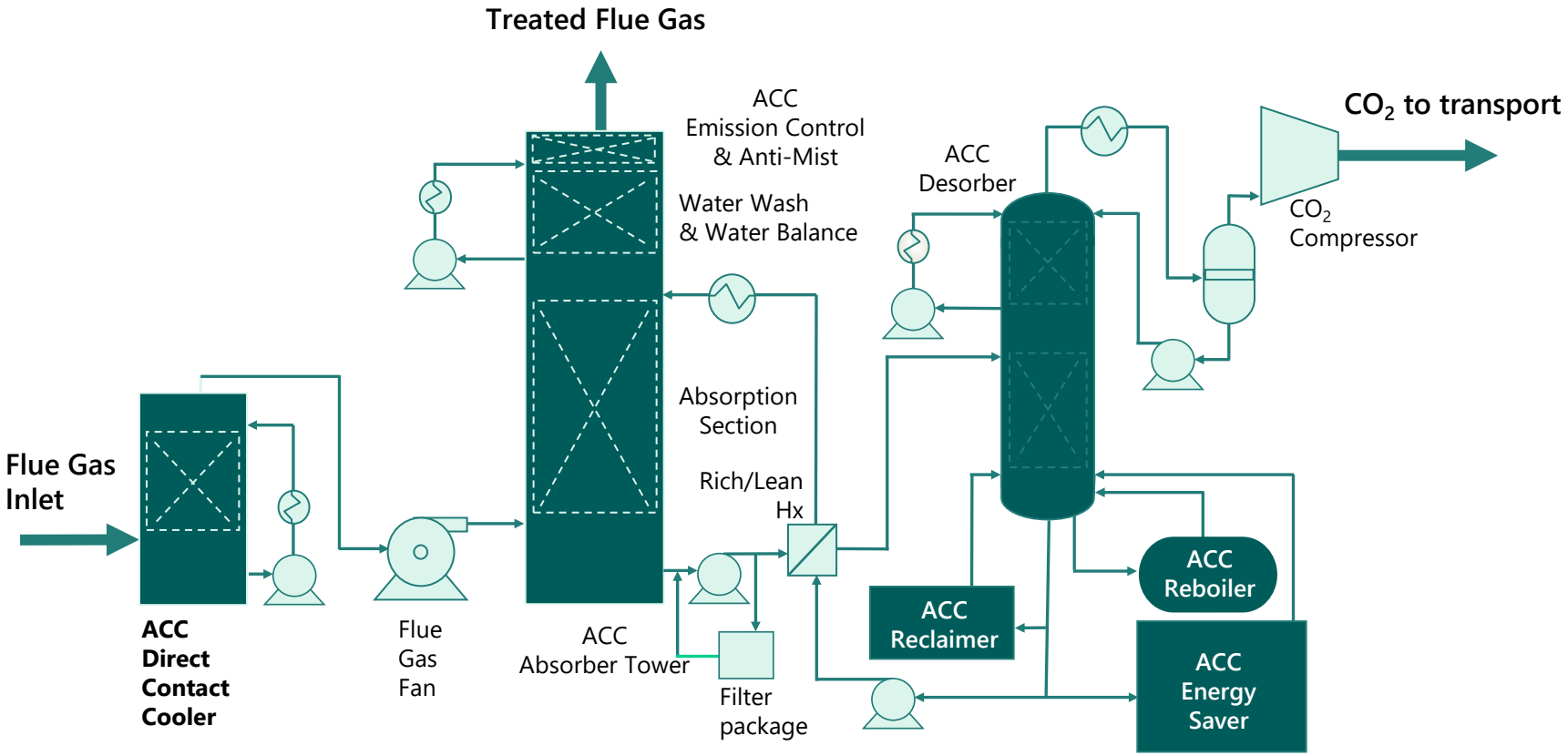
# Technologies to capture CO2

- Solvent based: Amines. Widely accepted as the most mature technology! Industrially proven.
- Solvent based: Carbonates
- Cryogenic
- Oxyfuel
- Adsorbents
- Enzymes
- Membranes
- Direct Air Capture (DAC)

# Amine based Carbon Capture: How does it work?



# Key equipment in a carbon capture plant




## Key considerations

### Solvent stability

- Performance
- Emissions
- Waste

### Energy efficiency

- Heat integration
- Electrification

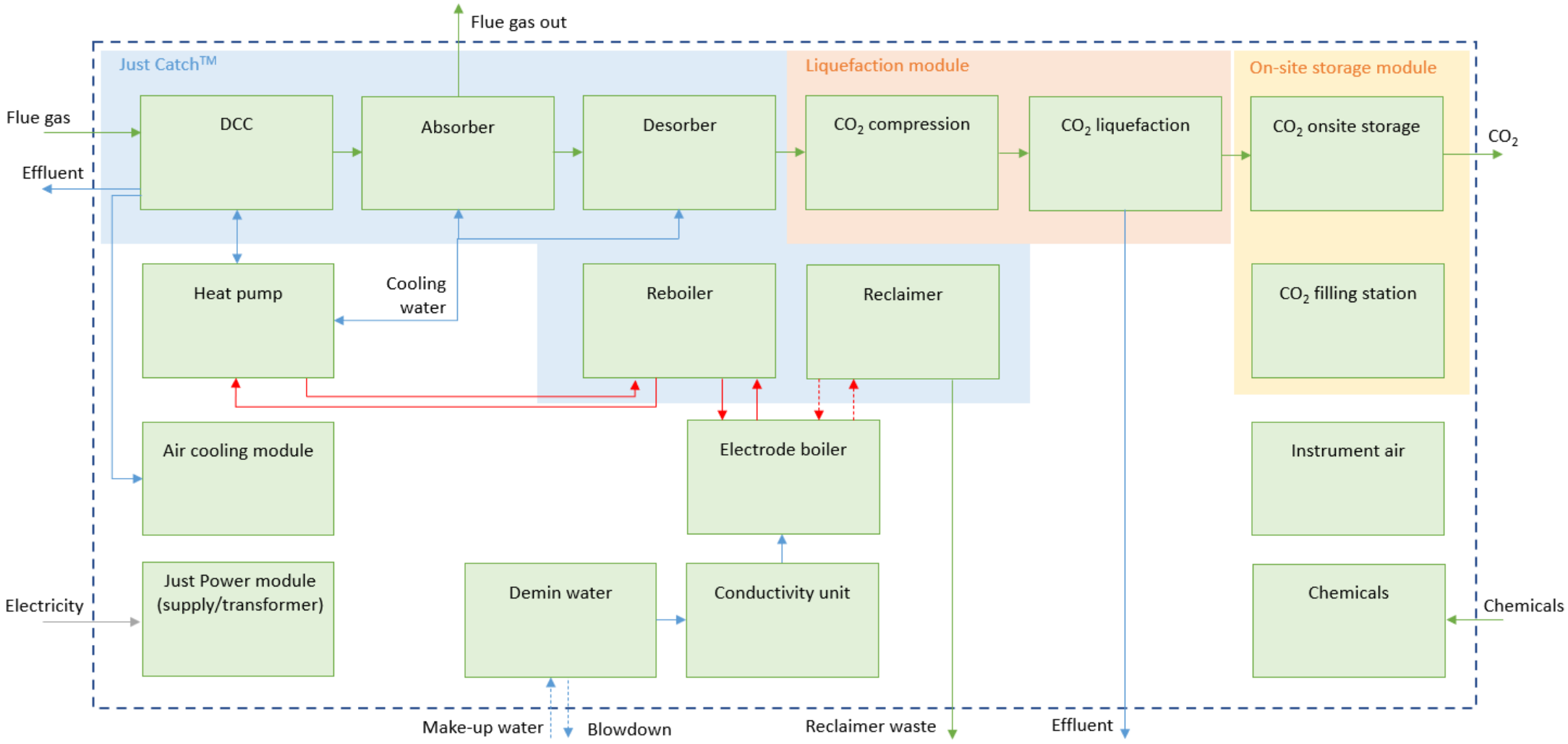
### Operational reliability

- Flue Gas variation
- Proven performance

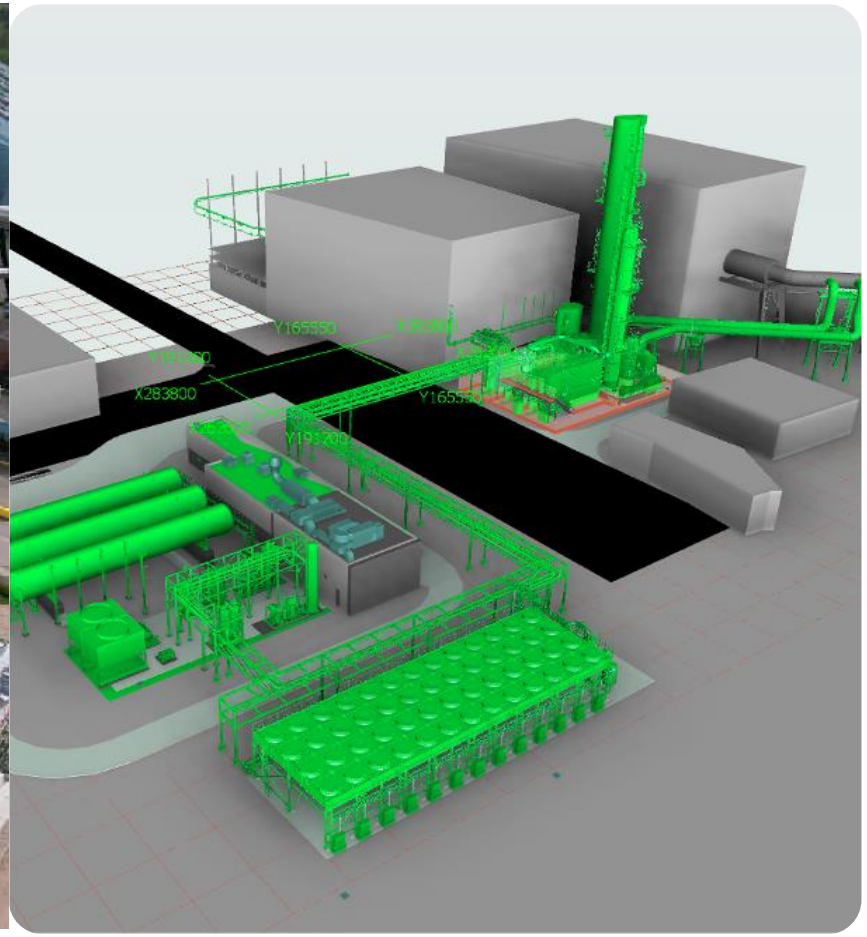


AKER CARBON CAPTURE

# Example of a complete carbon capture installation



# Example of layout from Twence CCU project


## WASTE TO ENERGY

- Hengelo, Netherlands

- Capture plant for 100,000 TPA
- Compression & liquefaction
- Storage tanks
- $CO_2$ loading stations
- Air coolers
- Piping
- BOP



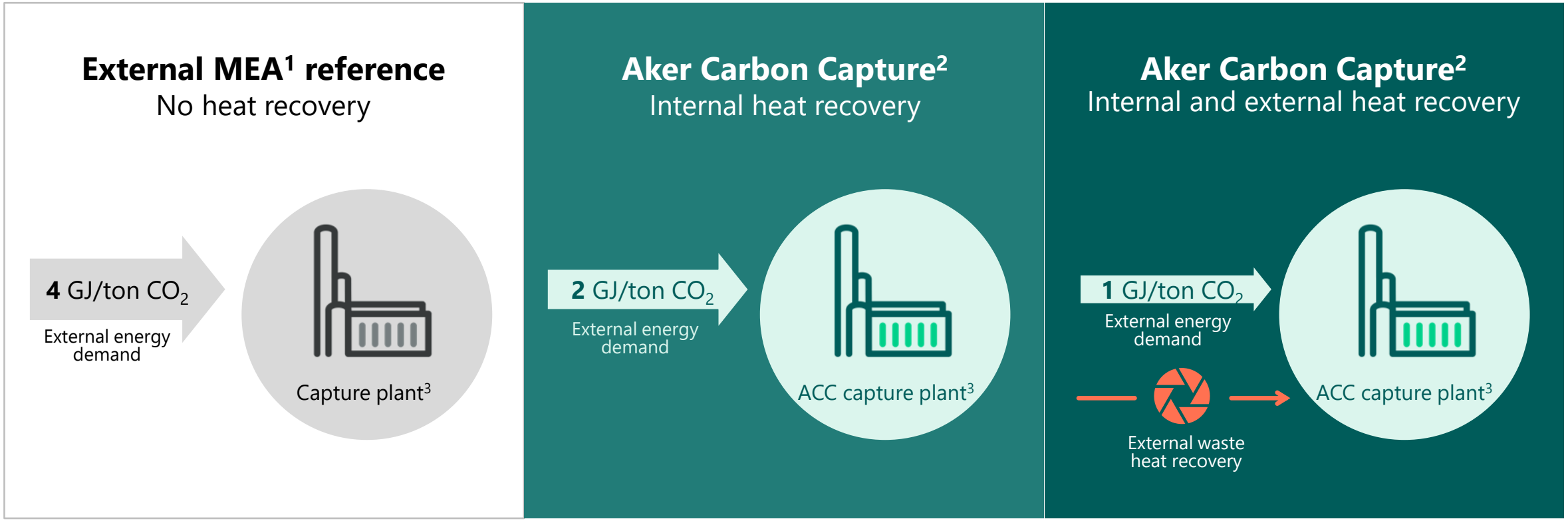
AKER CARBON CAPTURE

# Perspectives for further development




AKER CARBON CAPTURE

# Innovation driving energy optimization



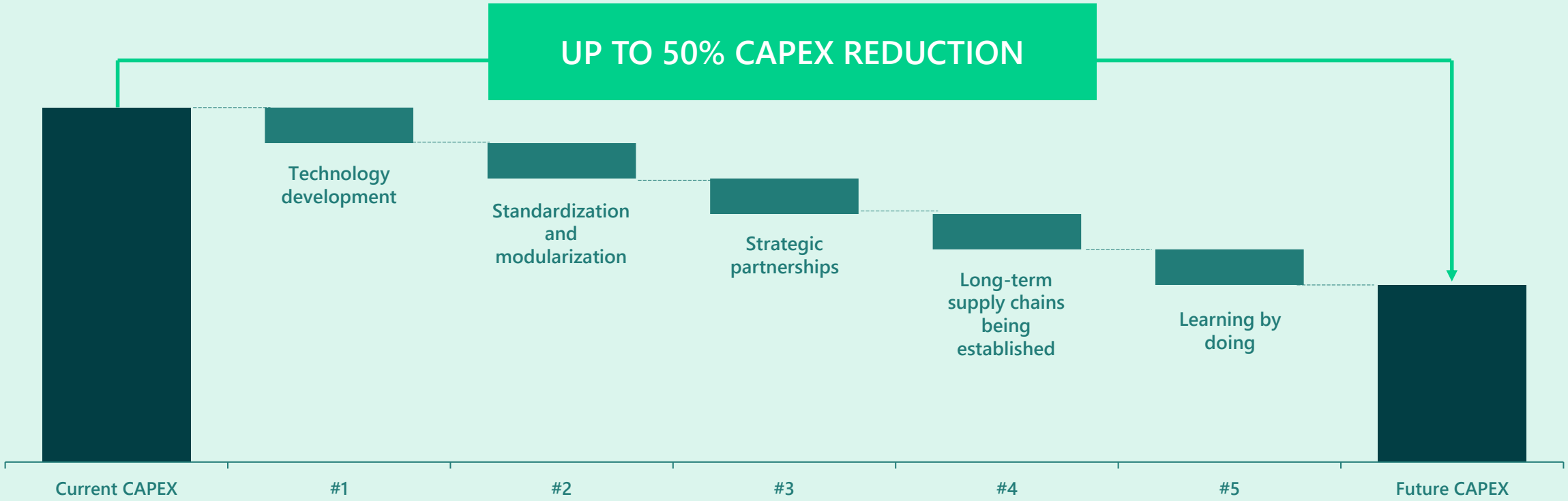

 

1) Monoethanolamine (MEA) is a standard solvent for amine-based carbon capture
2) Aker Carbon Capture proprietary solvent portfolio
3) Carbon capture plant with liquefaction

AKER CARBON CAPTURE

# Potential for significant capex reduction by 2030

Illustration purposes only




**Introduction of new technologies may also lead to cost reductions – but expected after 2030!!**

# Modularized solutions – Aker Carbon Capture's Just Catch™ products

## Key features

- Containerized core process modules - transportable on road
- Pre-fabricated
- Easy and fast to install
- Short lead time (~ 24 months for complete plant)
- Small footprint
- Designed to ISO/EN standards

Enabled **by mass production principles**


# Thanks for your attention!

# Questions?



AKER CARBON CAPTURE

# Copyright and disclaimer

## Copyright

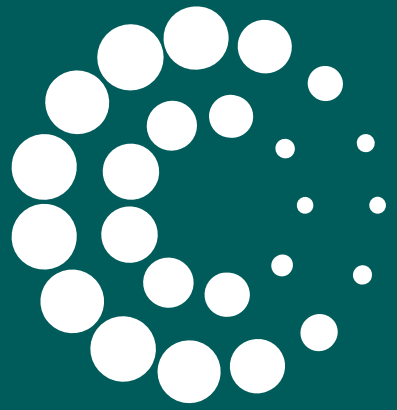


## Disclaimer

This presentation includes and is based, inter alia, on forward-looking information and statements that are subject to risks and uncertainties that could cause actual results to differ. These statements and this presentation are based on current expectations, estimates and projections about global economic conditions, the economic conditions of the regions and industries that are major markets for Aker Carbon Capture Norway AS and Aker Carbon Capture Norway AS's (including subsidiaries and affiliates) lines of business. These expectations, estimates and projections are generally identifiable by statements containing words such as "expects", "believes", "estimates" or similar expressions. Important factors that could cause actual results to differ materially from those expectations include, among others, economic and market conditions in the geographic areas and industries that are or will be major markets for Aker Carbon Capture Norway AS's businesses, market acceptance of new products and services, changes in governmental regulations, interest rates, fluctuations in currency exchange rates and such other factors as may be discussed from time to time in the presentation. Although Aker Carbon Capture Norway AS believes that its expectations and the presentation are based upon reasonable assumptions, it can give no assurance that those expectations will be achieved or that the actual results will be as set out in the presentation. Aker Carbon Capture Norway AS is making no representation or warranty, expressed or implied, as to the accuracy, reliability or completeness of the presentation, and neither Aker Carbon Capture Norway AS nor any of its directors, officers or employees will have any liability to you or any other persons resulting from your use.



AKER CARBON CAPTURE



AKER CARBON CAPTURE

# Pause til kl 11.00

Kaffe, netværk og udstillingsboder

Biogas Danmark

GREEN GAS DENMARK

2023

# Kilder og transport af $CO_2$

11.00 Biogen $CO_2$ fra kraftværker

Martin Schrøder
Chefkonsulent, Ørsted

11.30 Udvikling af en dansk CO2-infrastruktur for realisering af danske klimamålsætninger og et muligt europæisk eksporteventyr

Laura Agneessens
Business Developer, Evida

Biogas Danmark

GREEN GAS DENMARK

2023

Ørsted

# Ørsted Kalundborg Hub

**Martin Schrøder**
**Senior Lead Business Developer**

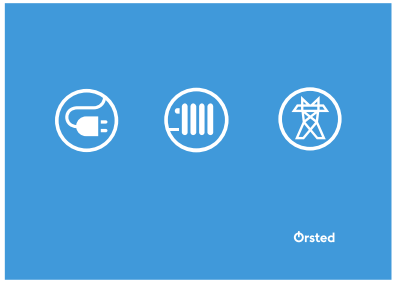
2023

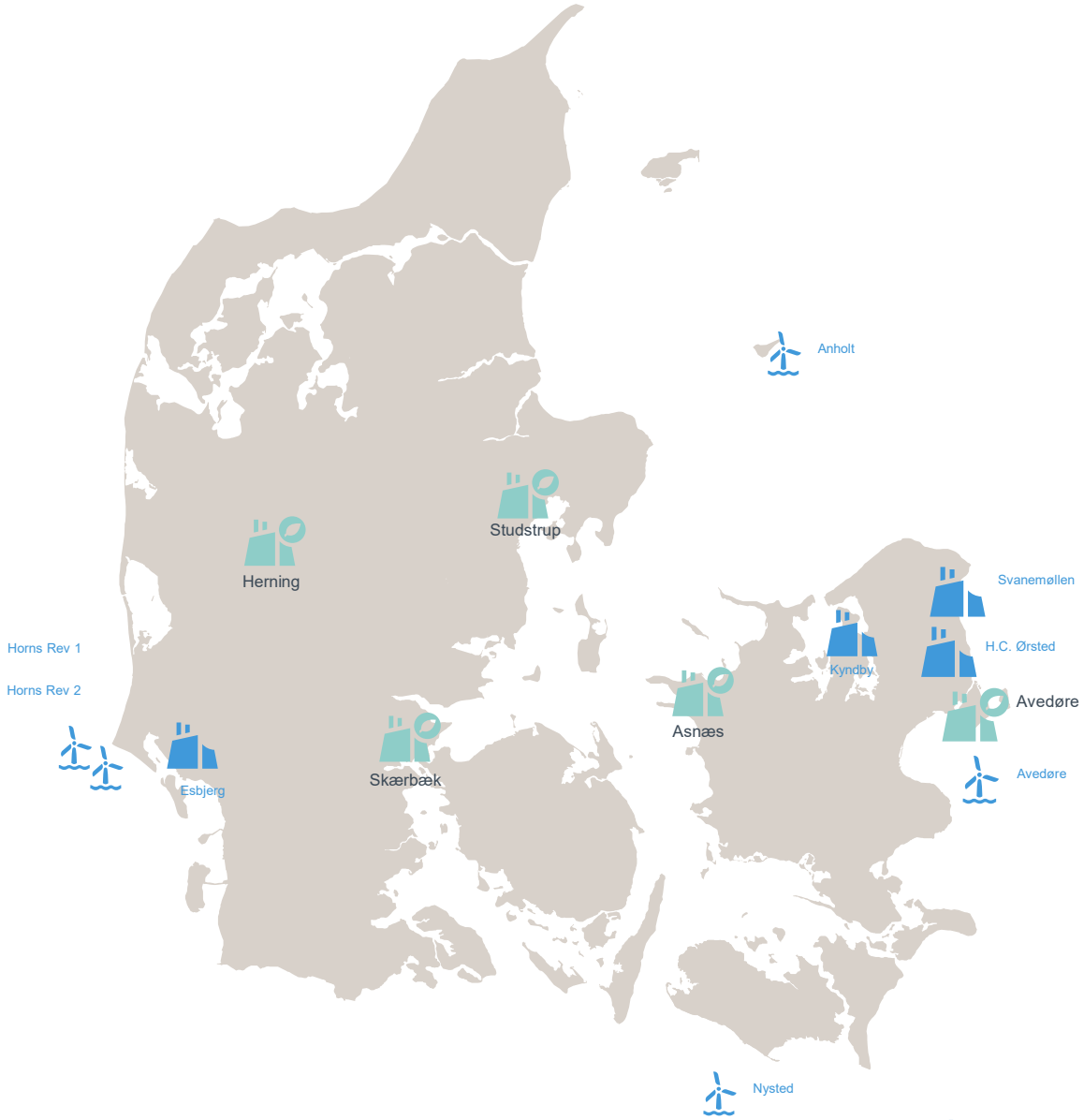
# Ørsted ambitions and opportunities

- Ørsted has five sites in Denmark with biomass fired Combined Heat & Power plants
- Ørsted uses 100% certified sustainable biomass
- In total, they emit approximately 3 mio. tons of biogenic CO2
- Ørsted expects to deploy carbon capture in a combination of retrofits and co-construction with new power plant builds.





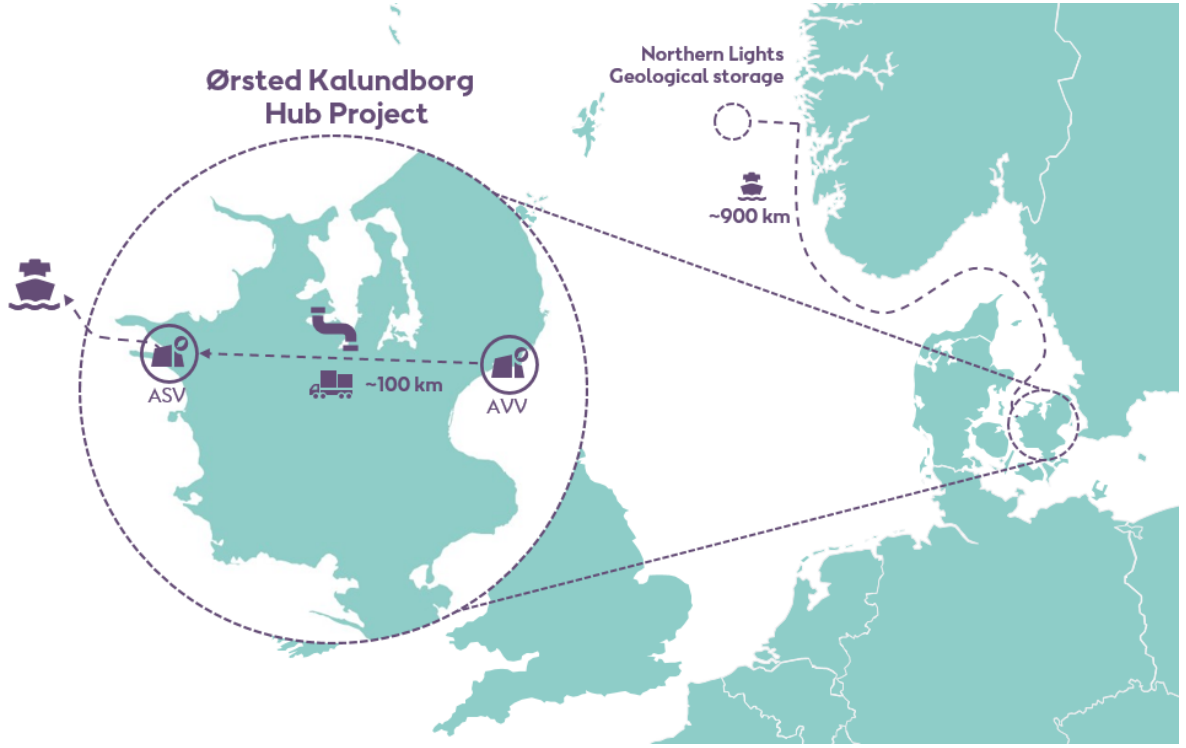



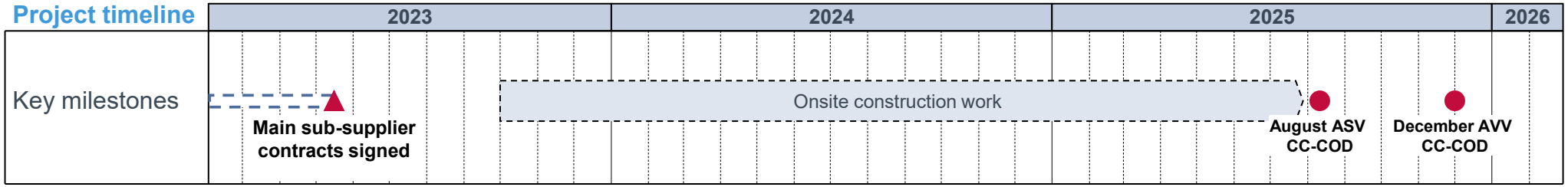



# Project Concept

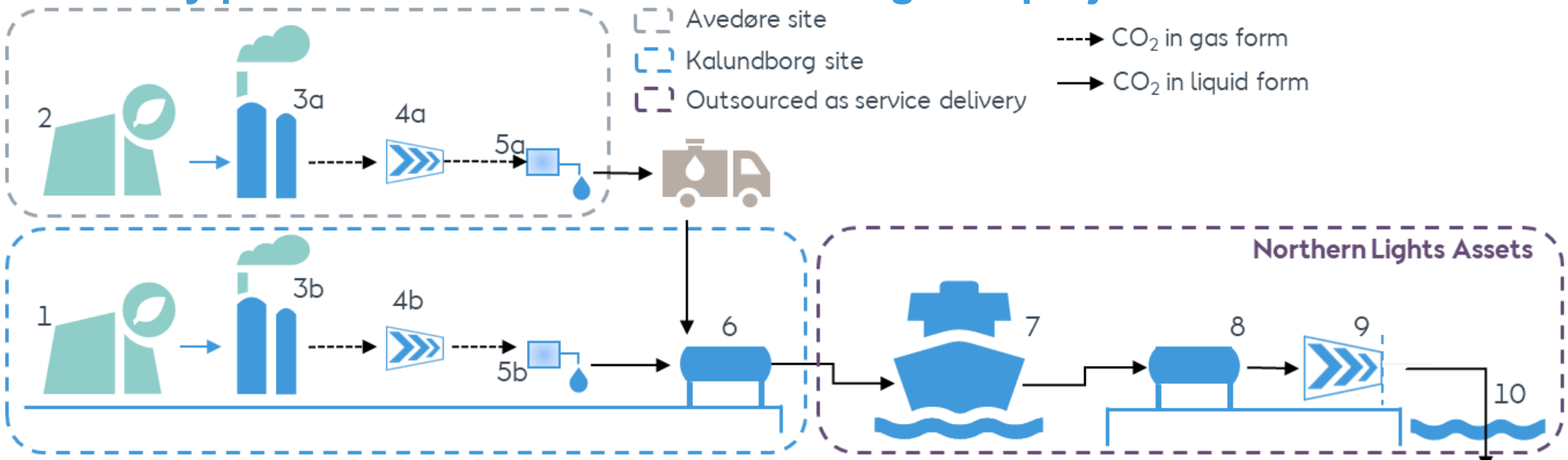
## Carbon capture on two sites and transport to permanent offshore storage

- From 2026, more than 430.000 tons of biogenic $CO_2$ is captured each year on two sites on the island of Zealand in Denmark:
  - Site 1: Avedøreværket in Copenhagen, AVV
  - Site 2: Asnæsværket in Kalundborg, ASV
- $CO_2$ from the AVV site is transported initially via truck and later via pipe to the ASV site where the combined $CO_2$ streams awaits transport to permanent storage
- From the ASV site all of the $CO_2$ is transported by ship to the Northern Lights geological storage terminal in Norway
- The Northern Lights terminal receives $CO_2$ from multiple sources in North-western Europe and injects it into a dedicated saline aquifer under the North Sea



# Ørsted's key partners in the Ørsted Kalundborg Hub project




Description

The solution is based on a concept with the two point sources:

(1) Asnæsværket unit 6 (ASV6)

(2) Avedøreværket, unit 55 Straw Boiler

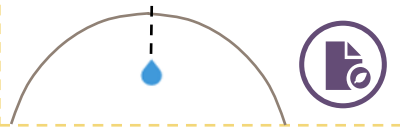
$CO_2$ is captured from five carbon capture modules (3) before it is liquefied by compression and cooling (4). The liquid $CO_2$ streams are joined in the shared intermediate storage and shipping terminal, awaiting transport (5)

Transportation of captured $CO_2$ from AVV to ASV via truck (6)

At ASV terminal the $CO_2$ is loaded to intermediate storage tanks (7)

Transport is performed by ship (8), at a rate consistent to the operation of the two CC units. Liquid $CO_2$ is delivered to onshore intermediate storage terminal (9) ahead of transfer and injection into offshore permanent geological reservoir (10) 2,600 m

Carbon removal certificates (11) from BECCS at ASV and AVV can be sold through bilateral offtake agreements and commodity trading platforms



Ørsted

AKER CARBON CAPTURE

Northern Lights

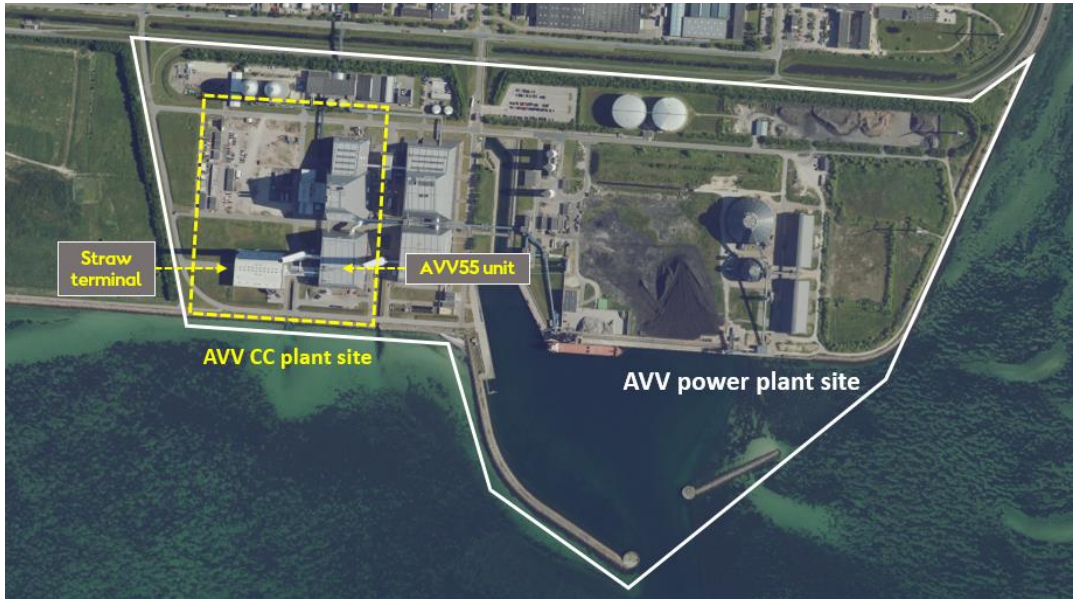
Microsoft

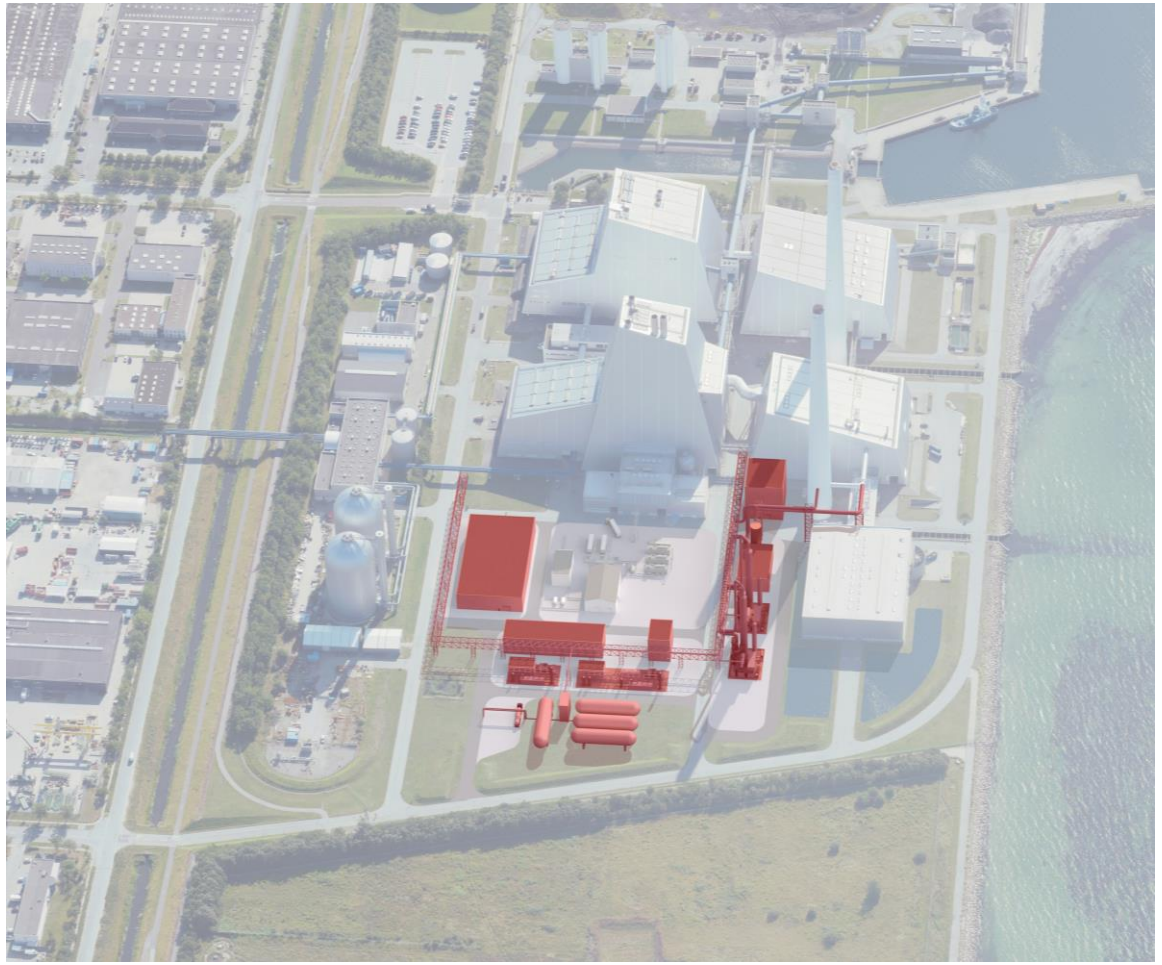
Ørsted

# Site Avedøreværket

## Scope on Avedøreværket

- 150.000 ton/year of $CO_2$ captured on the straw-fired boiler AVV55
- Boiler operation is determined by heat demand in Copenhagen
- Flue gas condensation, a steam turbine and a heat pump is part of the investment
- 1.800 ton intermediate storage for truck transport



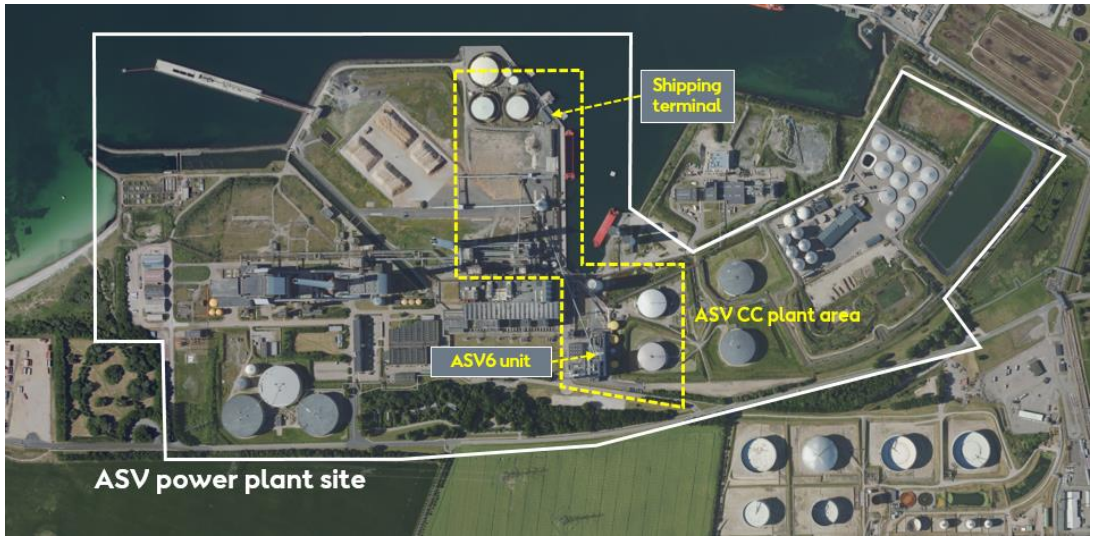


Ørsted

# Hub site on Asnæsværket

## Scope on Asnæsværket

- 280.000 tons/year of $CO_2$ captured on the woodchips fired boiler ASV6
- Boiler is operated mainly to supply steam to the Novo Nordisk insulin factory in Kalundborg
- 10.800 ton intermediate storage for ship transport
- Can work as both an import and export terminal for liquid $CO_2$ able to service third-party emitters who needs access to offshore geological storage.





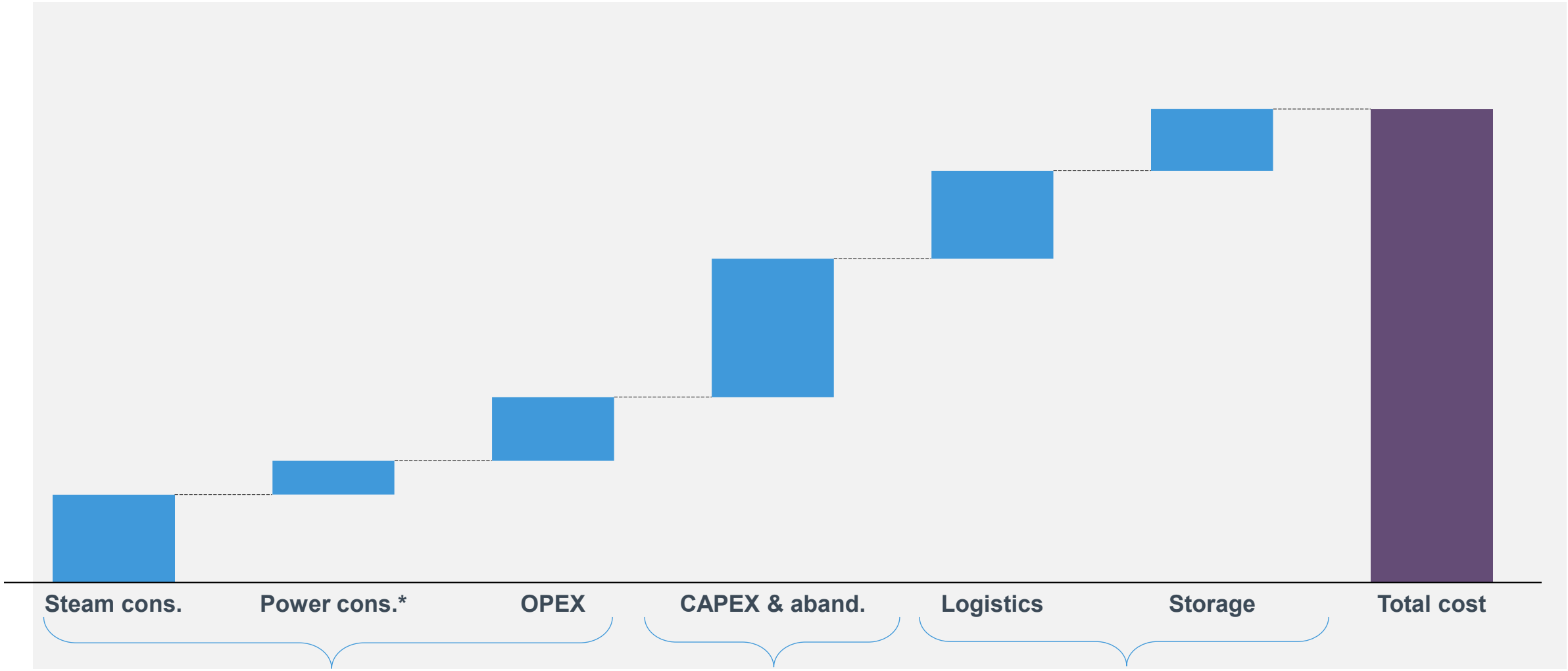

Ørsted

# Industry challenges highlight the need for scaling efficient value chains

**The market is in need of solutions that are cost efficient, flexible and easily scalable, because:**

| | |
|---|---|
| 1 | **CCS is a low cost game** driven by cost efficiency to scale up investment |
| 2 | **The CCS industry is growing**, though the exact capture timelines are difficult to predict |
| 3 | **Available storage uncertainties** in regards to capacity and timeline |
| 4 | **Scaling of transport solutions** needs to be aligned with above and at low cost |

# General BECCS cost structure




Cost structure based upon CC with liquifaction and non-pipe transport to geological storage.

*Power consumption primarily related to liquifaction.

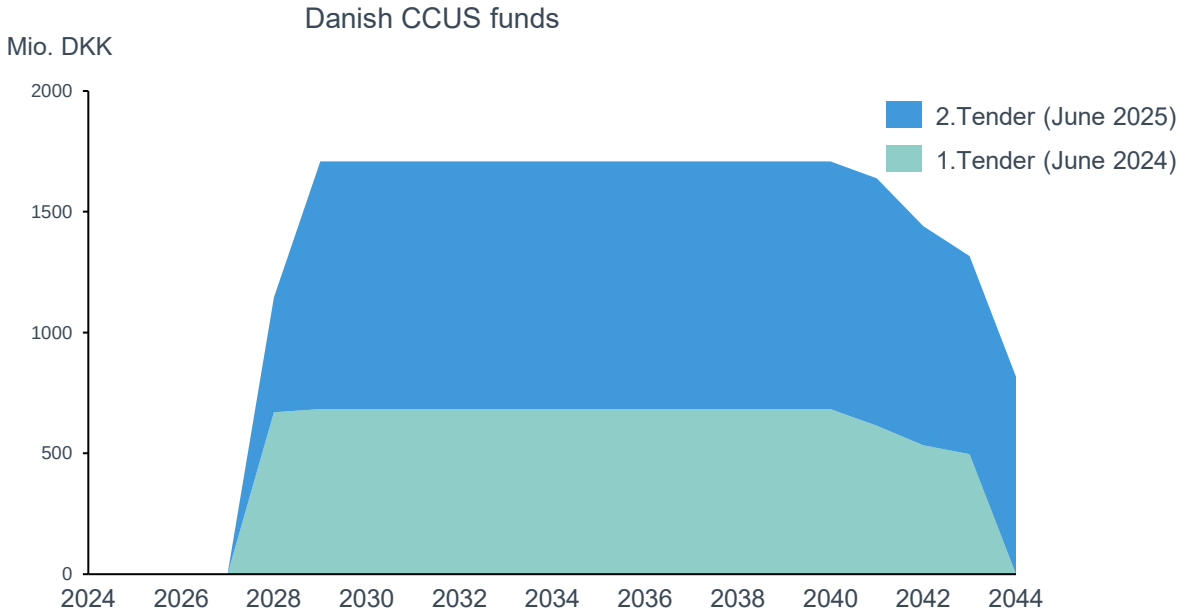
# Project financing is achieved from two sources

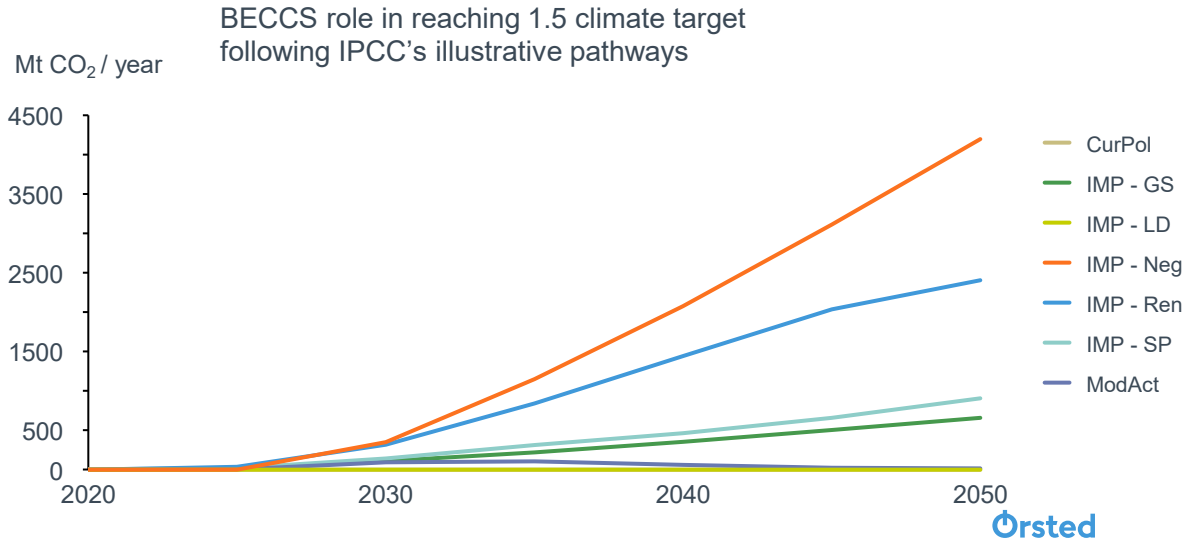
## Public funding

- Financing is achieved from the Danish CCUS funds
- The CCUS funds covers ~40% of the necessary revenue in the business case
- The CCUS funds are awarded under a contract with the Danish government lasting 20 years from project commissioning
- The CCUS funds are part of a portfolio of Danish climate mitigation funds currently ranging until 2049

## Voluntary Carbon Market

- Since governmental funds only cover part of the case, it is necessary to find additional financing from the private sector
- The Voluntary Carbon Market offers the opportunity to achieve further financing by selling Carbon Credits to purchasers who are looking to contribute to climate change mitigation and to offset own emissions
- A contract with Microsoft for more than 2.6 Mtons of Carbon Removals have been agreed as part of this project.



# Næste oplæg

Laura Agneesens,
Evida

Biogas Danmark

GREEN GAS DENMARK

2023

# Udvikling af dansk $CO_2$-infrastruktur – danske klimamålsætninger og et europæisk eksporteventyr

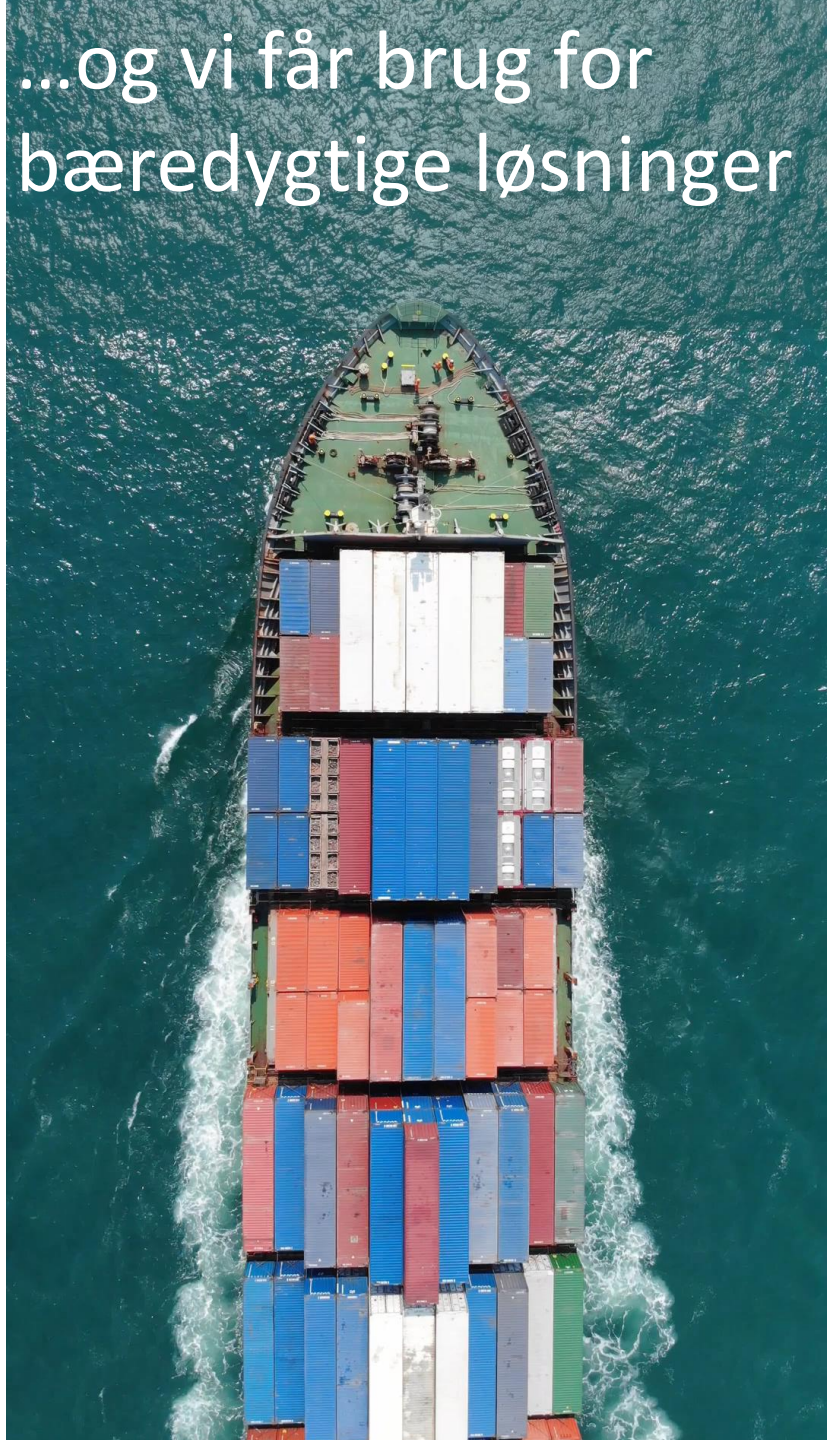
Grønne Gasdage 2023
26 – 27 september 2023, Billund

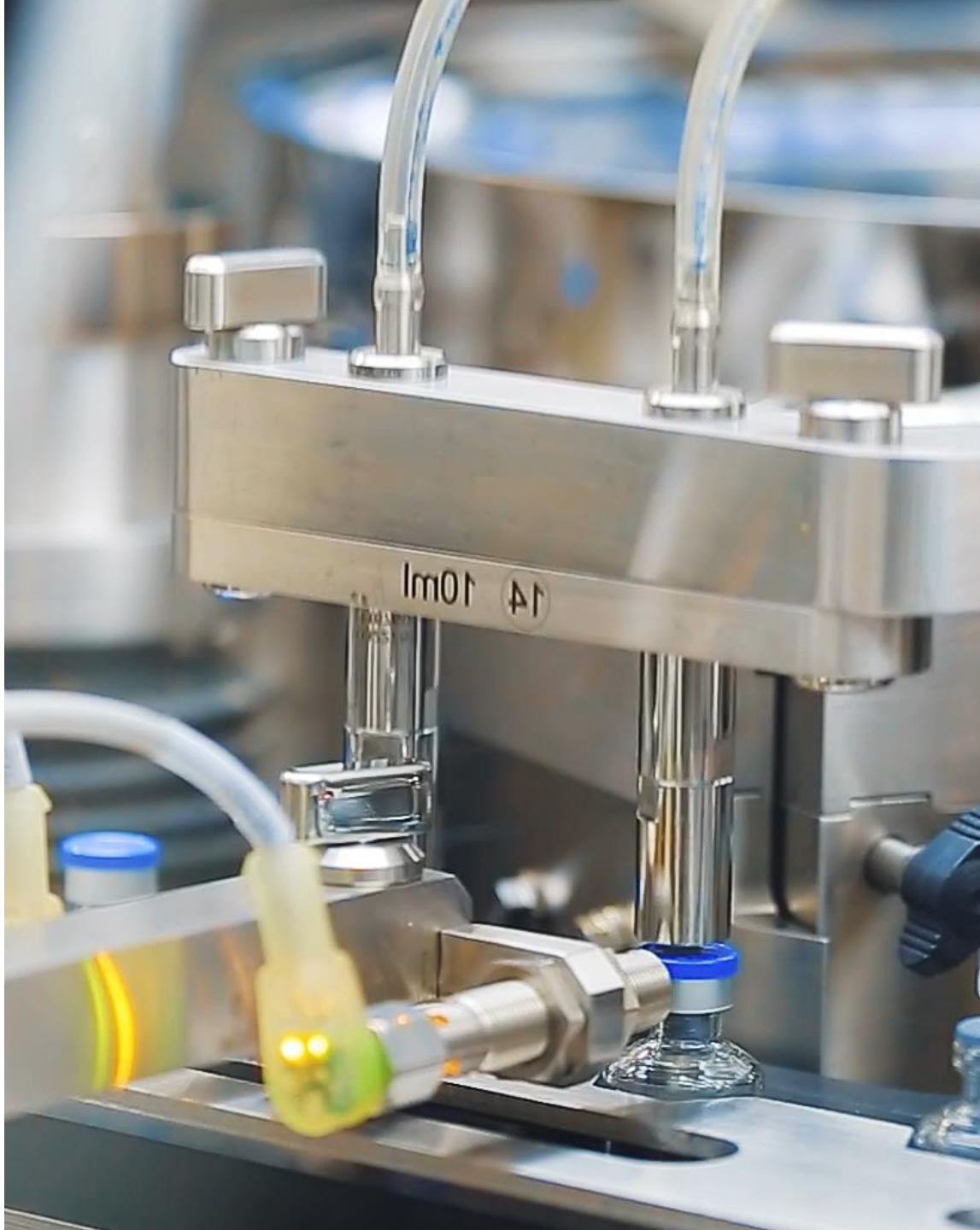
Laura Agneessens/ Forretningsudvikler
lauag@evida.dk / +45 30 78 91 12

evida


Vi har et problem…

…og vi får brug for bæredygtige løsninger





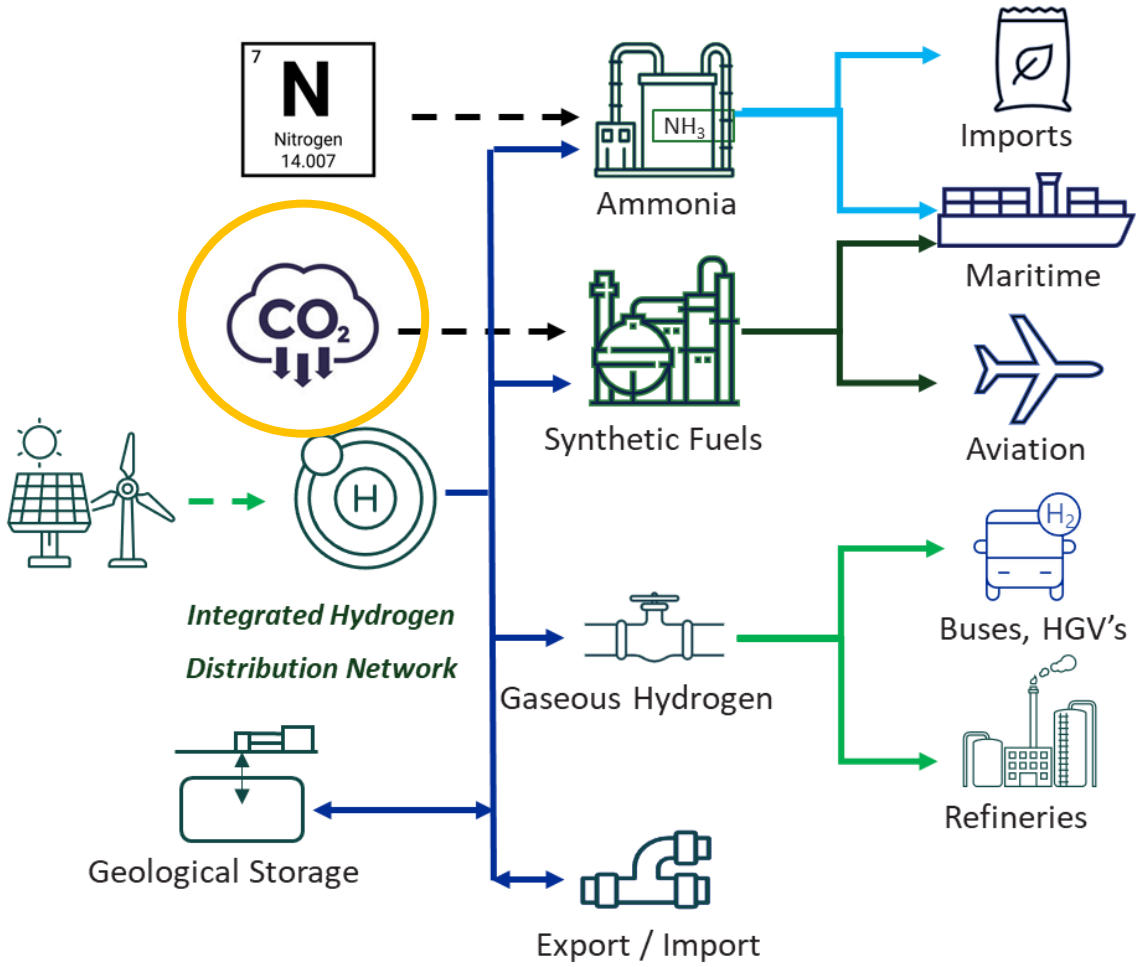
## Danske klimamålsætninger

- 70% $CO_2$-reduktion i 2030
- Netto nuludledning senest i 2050

## Politiske aftaler

- Power-to-X og CC(U)S som del af værktøjskassen

# $CO_2$ bliver et produkt

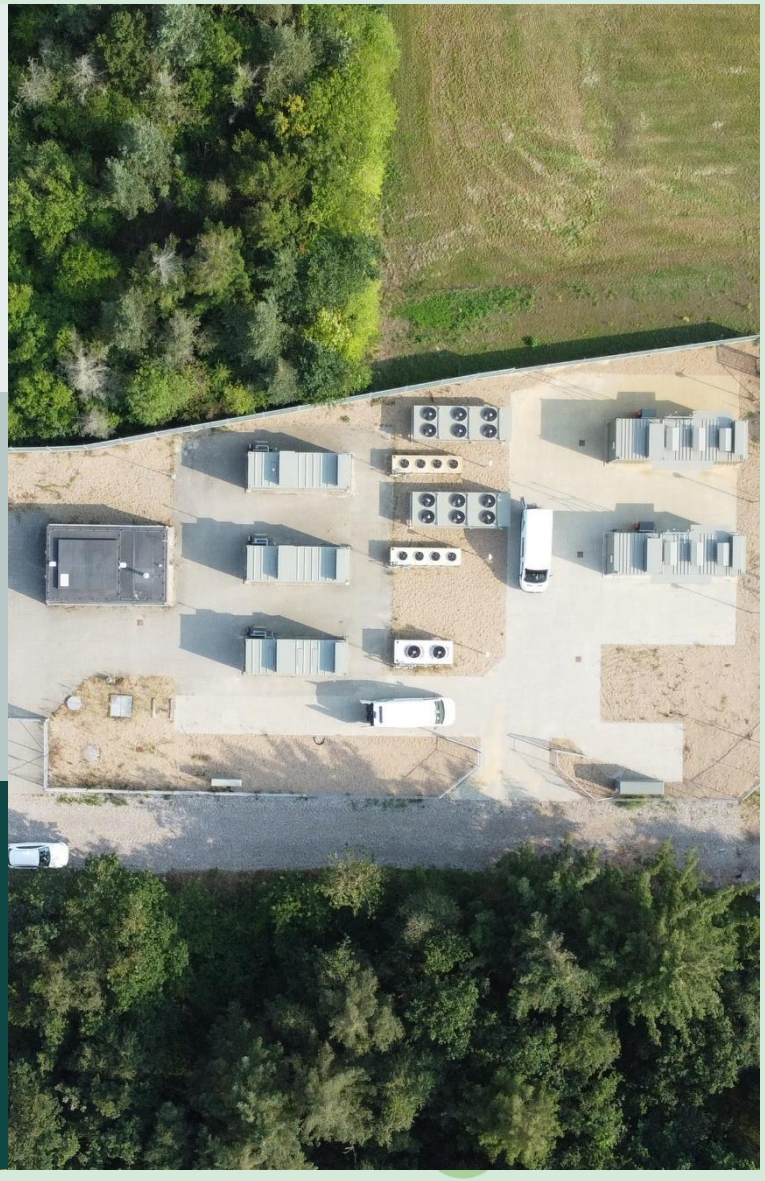


# $CO_2$-infrastruktur som nøgle til Danmarks grønne omstilling

Adgang for $CO_2$ til CCU og CCS

Sikker, omkostnings-effektiv transport

Kan positionere Danmark som Europæisk $CO_2$ hub



# Markedsdialog for $CO_2$ (2023): hovedresultater

**28**
aktører

**DELTAGERE**

**5,6**
mio. ton $CO_2$ årligt

**FANGSTPOTENTIALE**

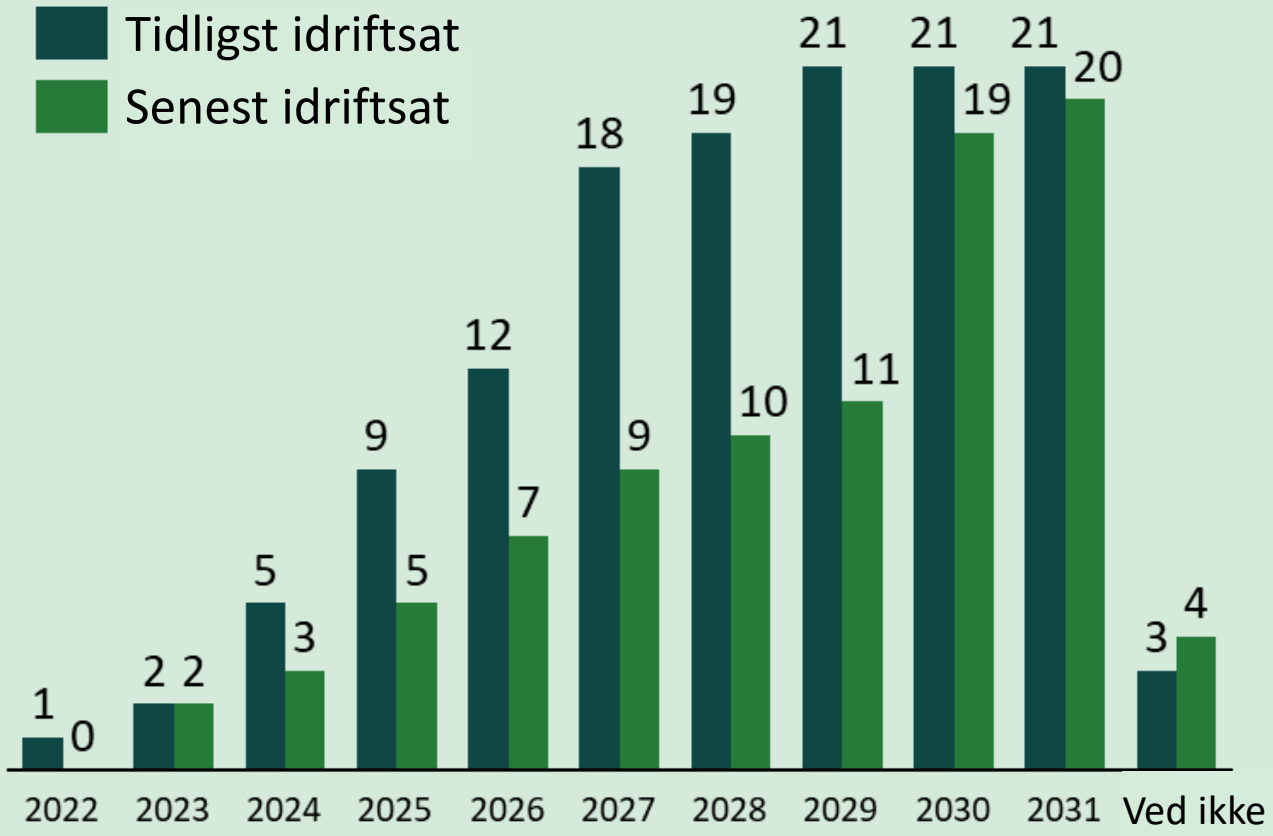
**46**
procent

**BEHOV FOR INFRASTRUKTUR**

**GEOGRAFISK DIFFERENTIERING I FANGST OG FORBRUG**

evida

# Projekteret idriftsættelse af danske projekter



# Danmark som Europæisk $CO_2$ lagringshub

DANMARK

FANGSTPOTENTIALE
**~10,8 MIO. TON PER ÅR I 2040***

LAGRINGSPOTENTIALE
**22 MIA. TON****

| | FINLAND | GERMANY | POLAND | SWEDEN |
|---|---|---|---|---|
| Industrial $CO_2$ emissions 2019 (2017 for Germany) ($MtCO_2$) | 49,73 | 420,78 | 174,31 | 49,18 |
| Political maturity | ◐ | ◐ | ◔ | ◕ |
| National CCS objectives | ✗ | ✗ | ✗ | ✓ |
| Total $CO_2$ capture potential ($MtCO_2$) 2022-2050 | ~286 | ~896 | ~596 | ~323 |
| National storage potential | ○ | ◔ | ◐ | ◔ |
| Possibility for storage in Denmark | ◕ | ◐ | ◐ | ◕ |

*Danish Energy Agency predictions, Feb. 2023
**Geological Survey of Denmark and Greenland, www.GEUS.dk

”Tekniske og økonomiske analyser til klyngesamarbejde om CO2 infrastruktur og transport, Rambøll 2022” available from www.c4cph.dk

# Hvordan understøtter Evida udvikling af en dansk CCUS sektor?


$H_2$

$CH_4$

$CO_2$

# Årtiers erfaring skal sikre effektiv fremtidig infrastruktur


- +30 års erfaring med anlæg og drift af rørinfrastruktur – ikke mindst overvågning og sikkerhed
- Decentral indfødning af biogas og balancering af gasnet
- Solid forståelse for myndigheder og tilladelser

evida

# Det første $CO_2$-testprojekt sættes i gang

# Evida etablerer et pilot $CO_2$-rør

- **The Cement cArbon Storage Pilot for Emission Reduction (CASPER) – et 3-årig INNO-CCUS project**
- **Demonstration af den fulde CCS-værdikæden**
- **Erfaringsindsamling om rørført $CO_2$-transport**

aalborgportland CEMENTIR HOLDING

evida

PENTAIR

TEKNOLOGISK INSTITUT

INNO-CCUS Carbon capture, utilisation and storage

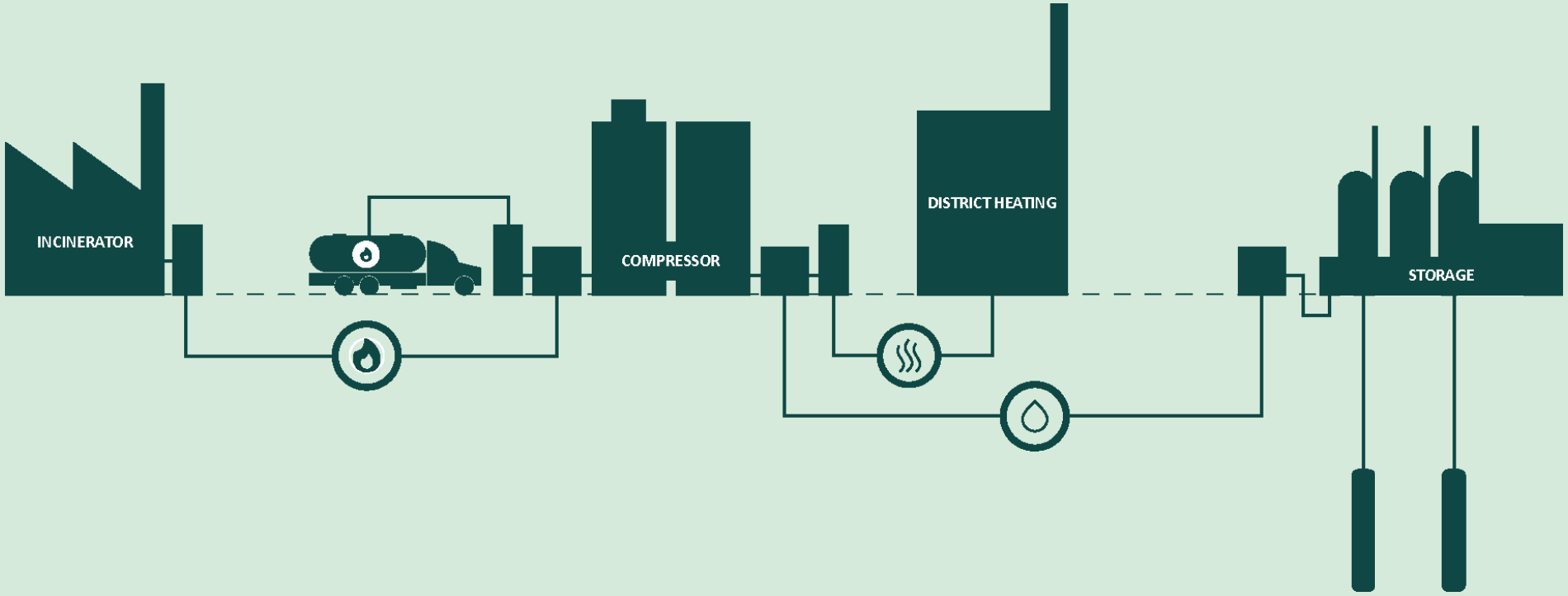
Innovation Fund Denmark

DGC

GAS STORAGE DENMARK

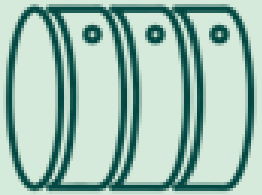
DTU Danmarks Tekniske Universitet

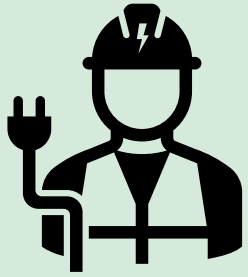
# Konceptuel model for storskala $CO_2$-transport

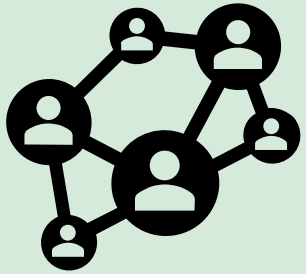


# Tempo og skala er afgørende

**… ligesom certifikater, standarder for gaskvalitet, risikoprofil og finansiering, EU CCUS strategi, …**







# Tak for opmærksomheden

Laura Agneessens| Forretningsudvikler
+45 3078 9112| lauag@evida.dk

# Frokostpause til kl. 12.35

Frokost i Multihuset

Mulighed for at besøge udstillingsboderne

Biogas Danmark

GREEN GAS DENMARK

2023

# $CO_2$-lagring

12.35 Sådan bliver Danmark europæisk centrum for lagring af $CO_2$

Martin Michelsen
Lead CCS Business Developer, TotalEnergies og Bifrost samarbejdet

13.05 Industriens $CO_2$-værdikæde og Danmarks rolle

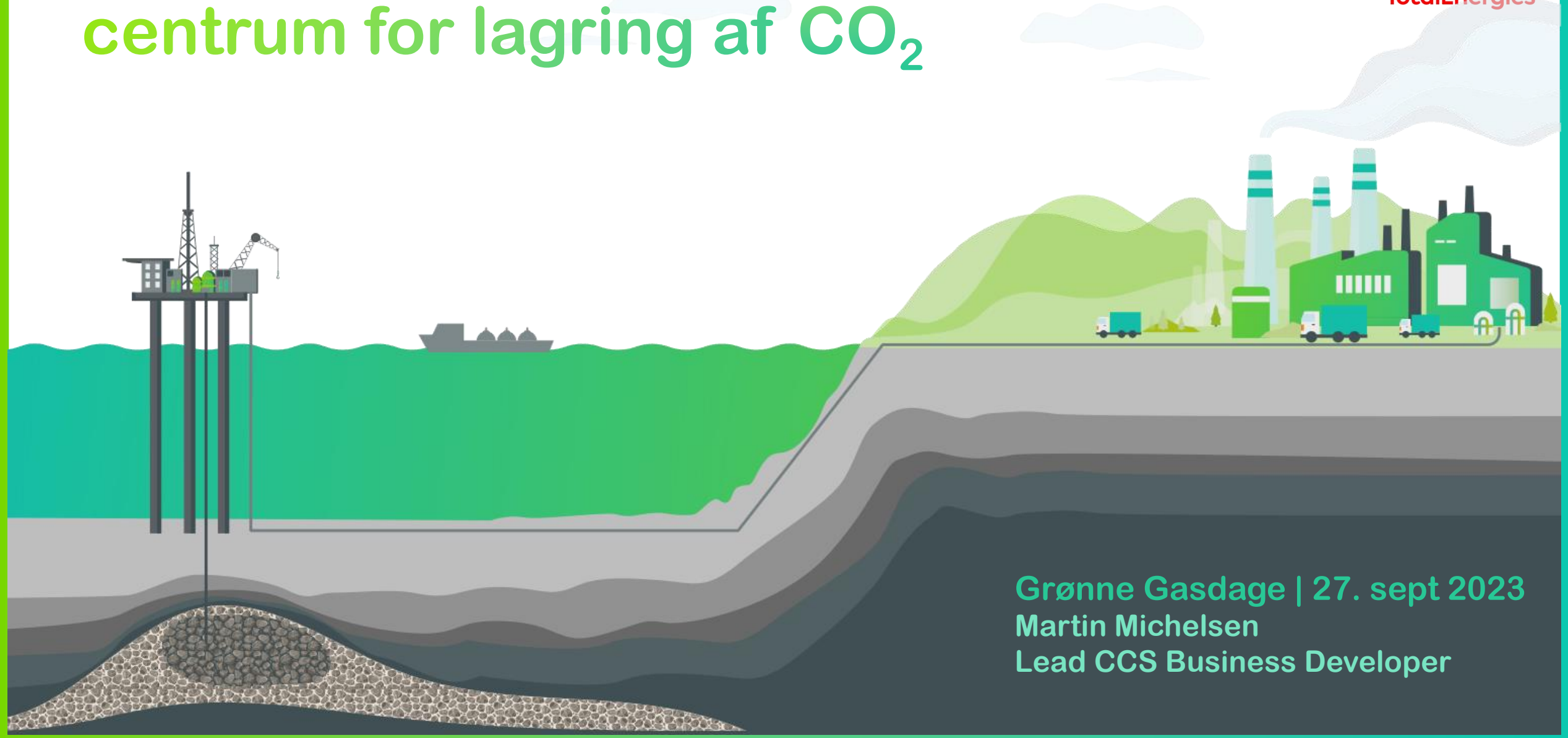
Lotte Kemplar
General Counsel, Fidelis New Energy Europe

Biogas Danmark

GREEN GAS DENMARK

2023

# Sådan bliver Danmark europæisk centrum for lagring af $CO_2$



Grønne Gasdage | 27. sept 2023

Martin Michelsen
Lead CCS Business Developer

# TotalEnergies er en global multienergivirksomhed

## Vores virksomhed

OIL GAS ELECTRICITY HYDROGEN BIOMASS WIND SOLAR CCS

TotalEnergies producerer og markedsfører følgende energiformer:

- Olie og biobrændstoffer
- Naturgas og grønne gasser
- Vedvarende energi og elektricitet

## Vores ambitioner og mål

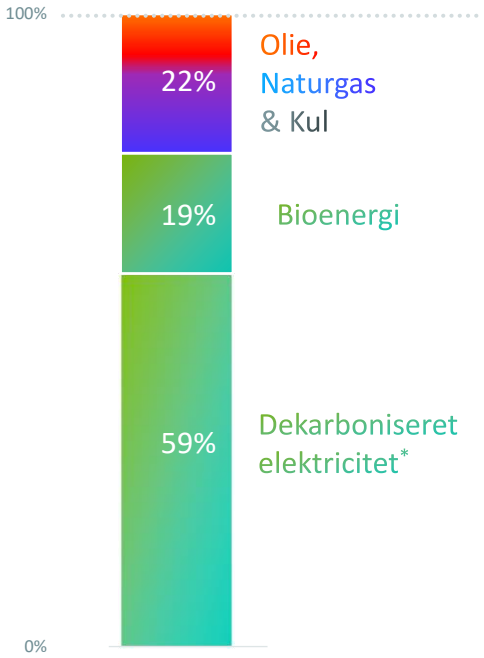
- At udvikle energi, der er stadig billigere, renere samt mere pålidelig og tilgængelig for så mange mennesker som muligt
- Net zero by 2050 – sammen med samfundet

## Nøgletal

- Flere end 100.000 ansatte, 1.200 af dem i Danmark
- Aktiv i mere end 130 lande med en omsætning på 263,3 mia. USD i 2022
- Ejes af 1.300.000 aktionærer, hvoraf medarbejdere ejer 7 % af aktierne

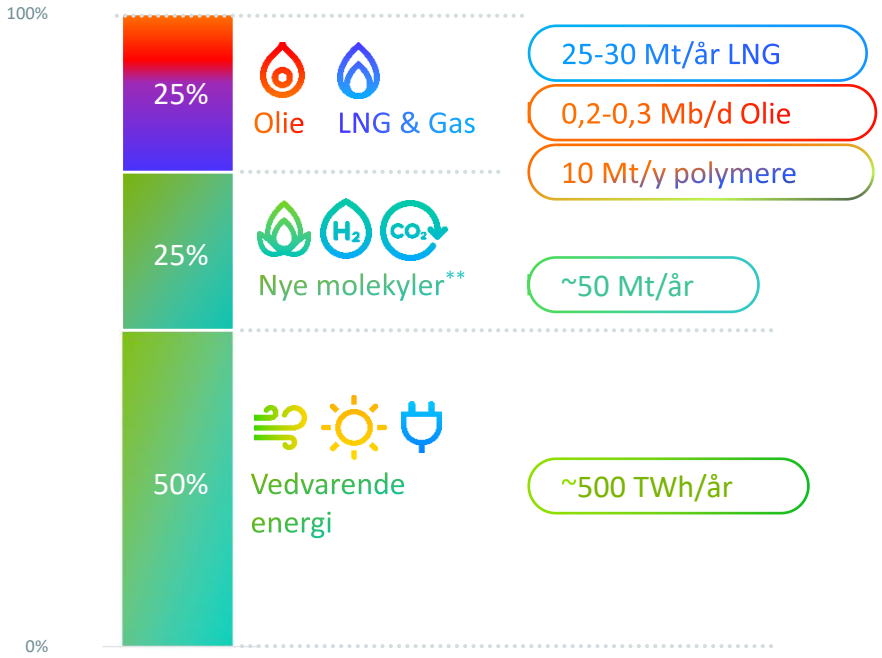
# Net-zero energimix i 2050

## IEA NZE Energimix i 2050




CCS: 7 $GtCO_2e$

## TotalEnergies' 2050 Energimix
(Produktion og salg)




CCS: 50-100 $MtCO_2e$

* Hydro, sol, vind and kernekraft
** Biofuels, biogas, brint og e-fuels/e-gas

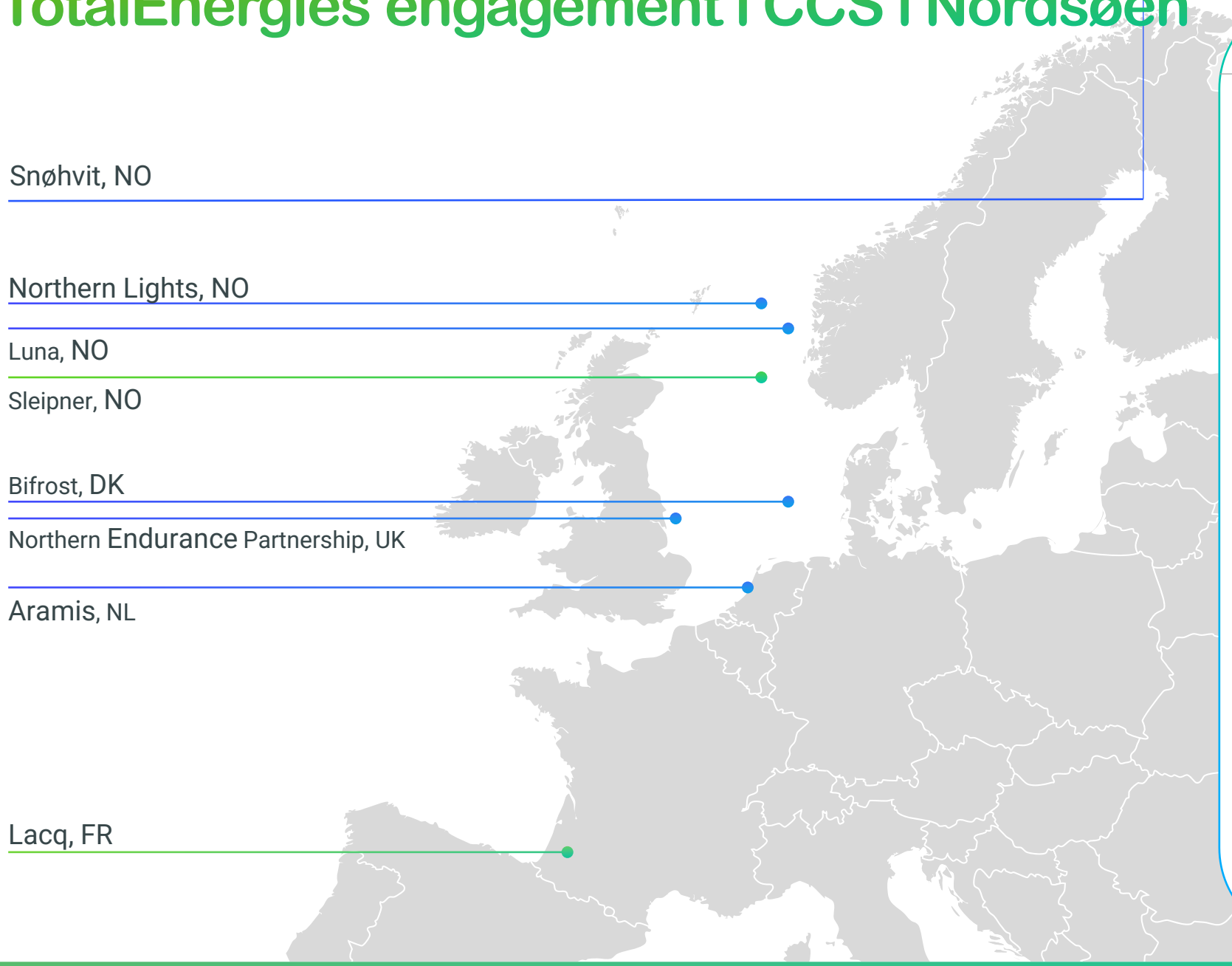
# Projekt Bifrost's første video er live

bifrost

www.bifrost-ccs.com

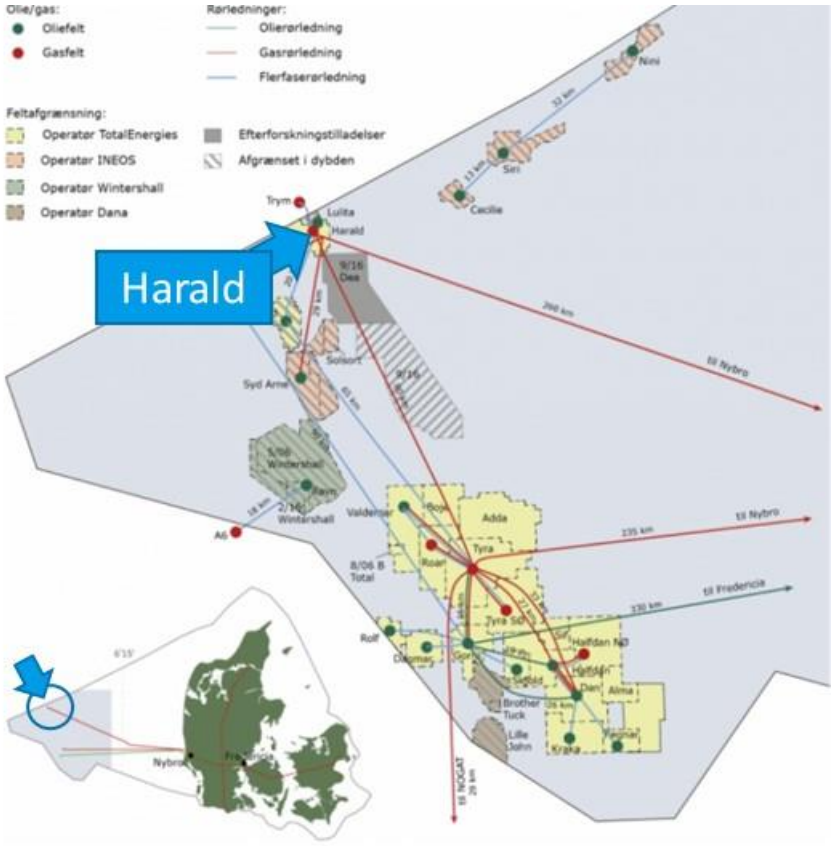
EUDP TotalEnergies DTU Ørsted nordsøfonden BlueNord

# TotalEnergies engagement i CCS i Nordsøen



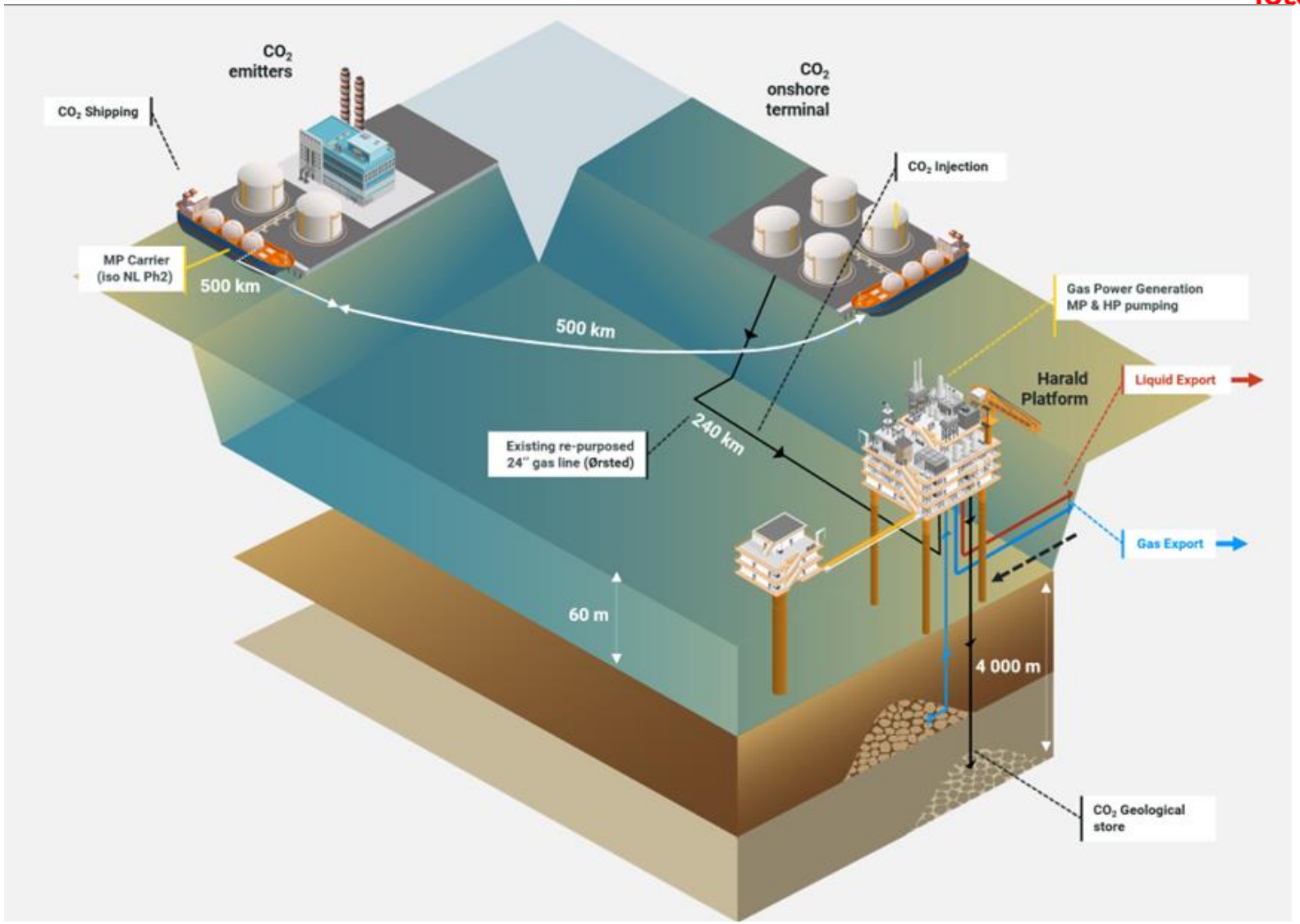

| | Første injektion | $CO_2$ (ton) |
|---|---|---|
| Snøhvit | 2008 | ≈1 mio./år |
| Northern Lights | 2024 | 5 mio./år (fase 2) |
| Luna | TBC | TBC |
| Sleipner | 1996 | ≈800k/år (1996-2016) |
| Bifrost | Ca. 2030 | 5 mio./år (2030) |
| Northern Endurance | 2027 | 10 mio./år (fase 2) |
| Aramis | 2028 | >5 mio./år (fase 1) |
| Lacq (Onshore) | 2007 | 51.000 (2010-2013) |

# Projekt Bifrost – første skridt mod storskala CO2-lagring




# Projekt Bifrost – første skridt mod storskala CO2-lagring

TotalEnergies



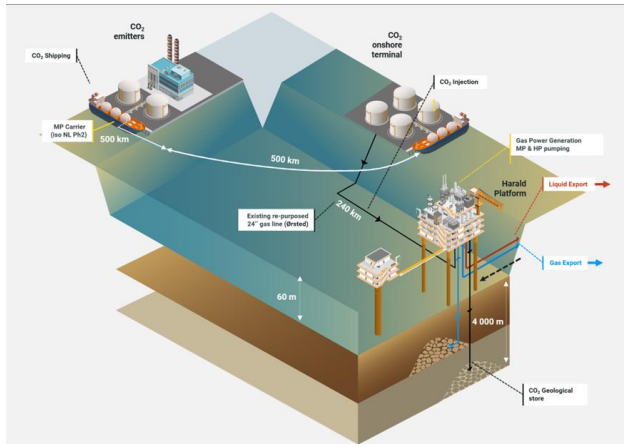

EUDP: 2022-2023

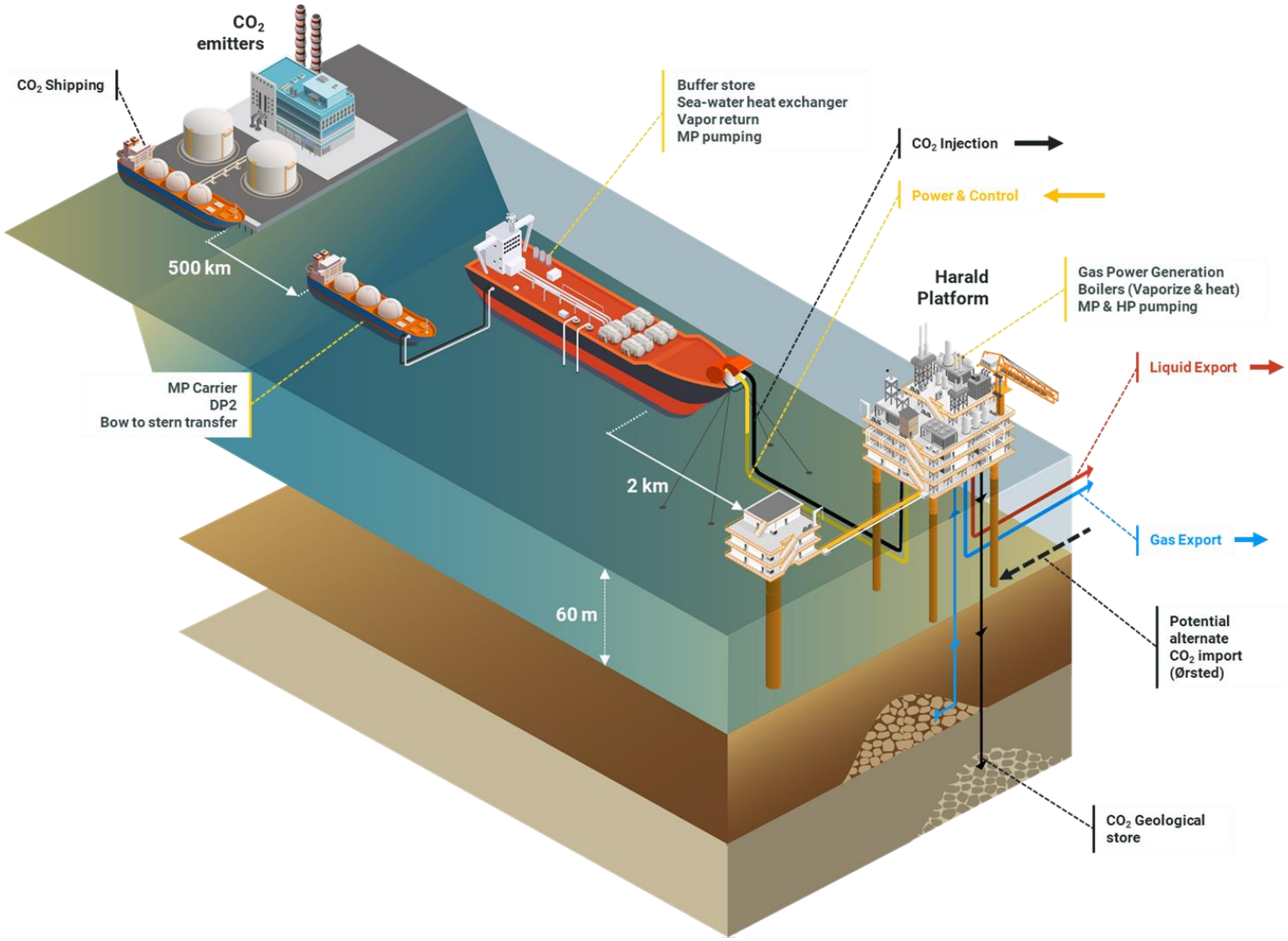
bifrost

TotalEnergies BlueNord DTU

nordsø fonden Ørsted

# Projekt Bifrost – første skridt mod storskala CO2-lagring (offshore offloading)



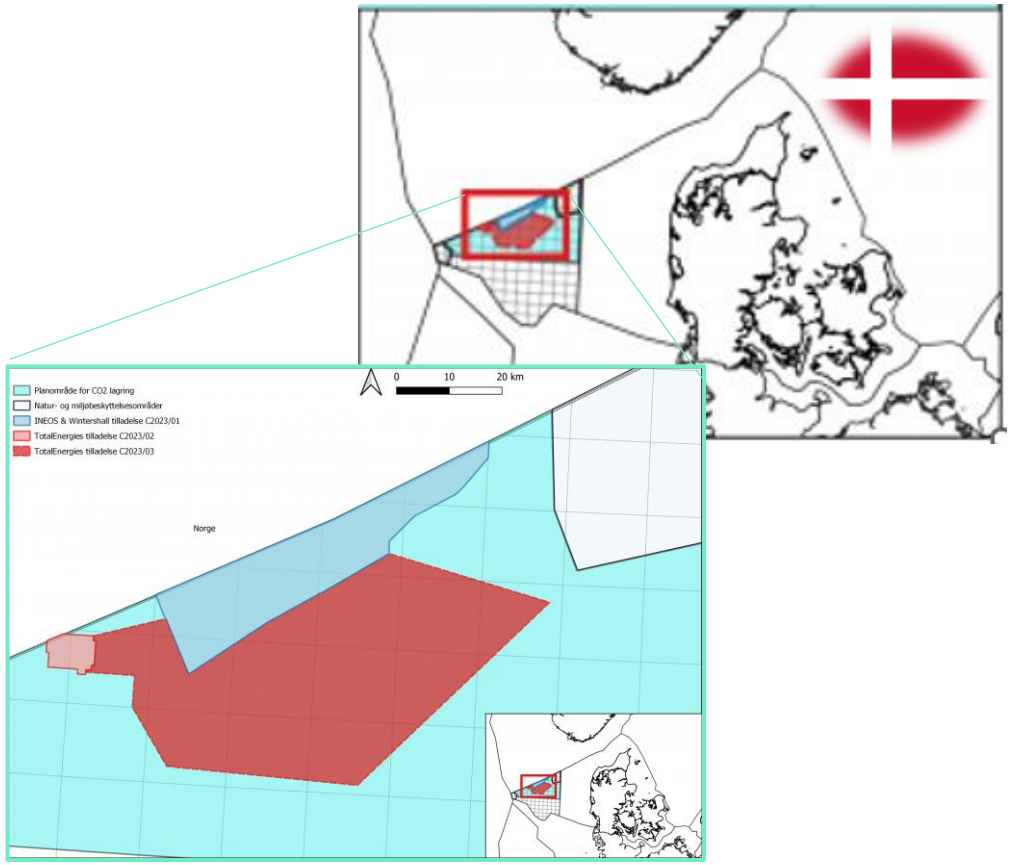

EUDP: 2022-2023

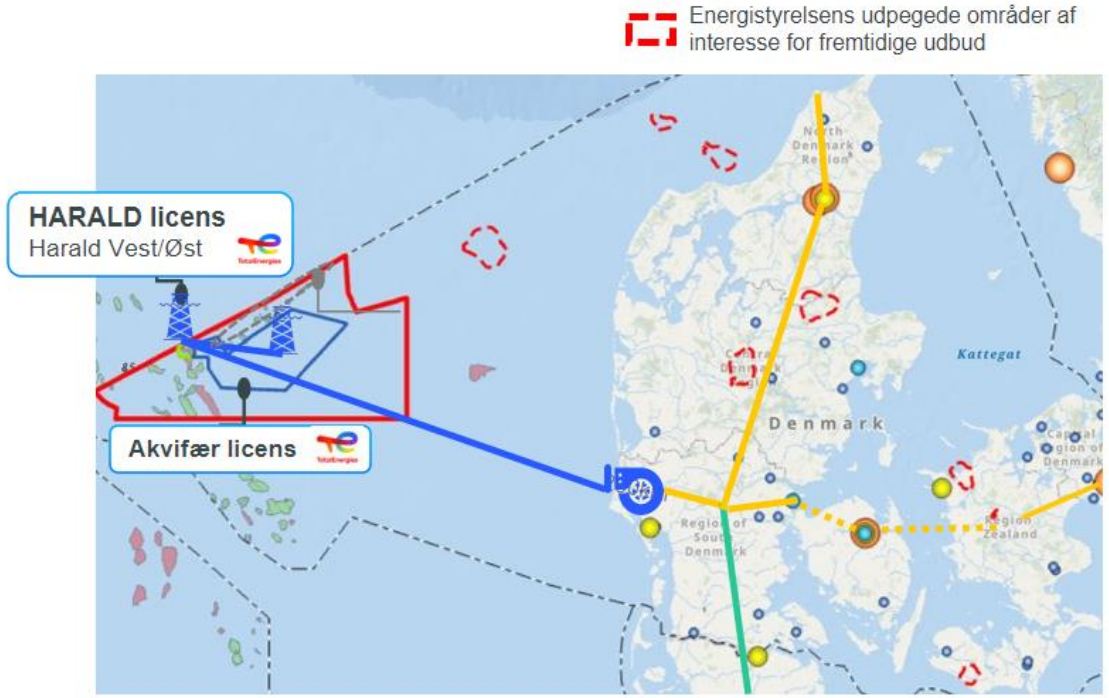
bifrost

TotalEnergies BlueNord DTU

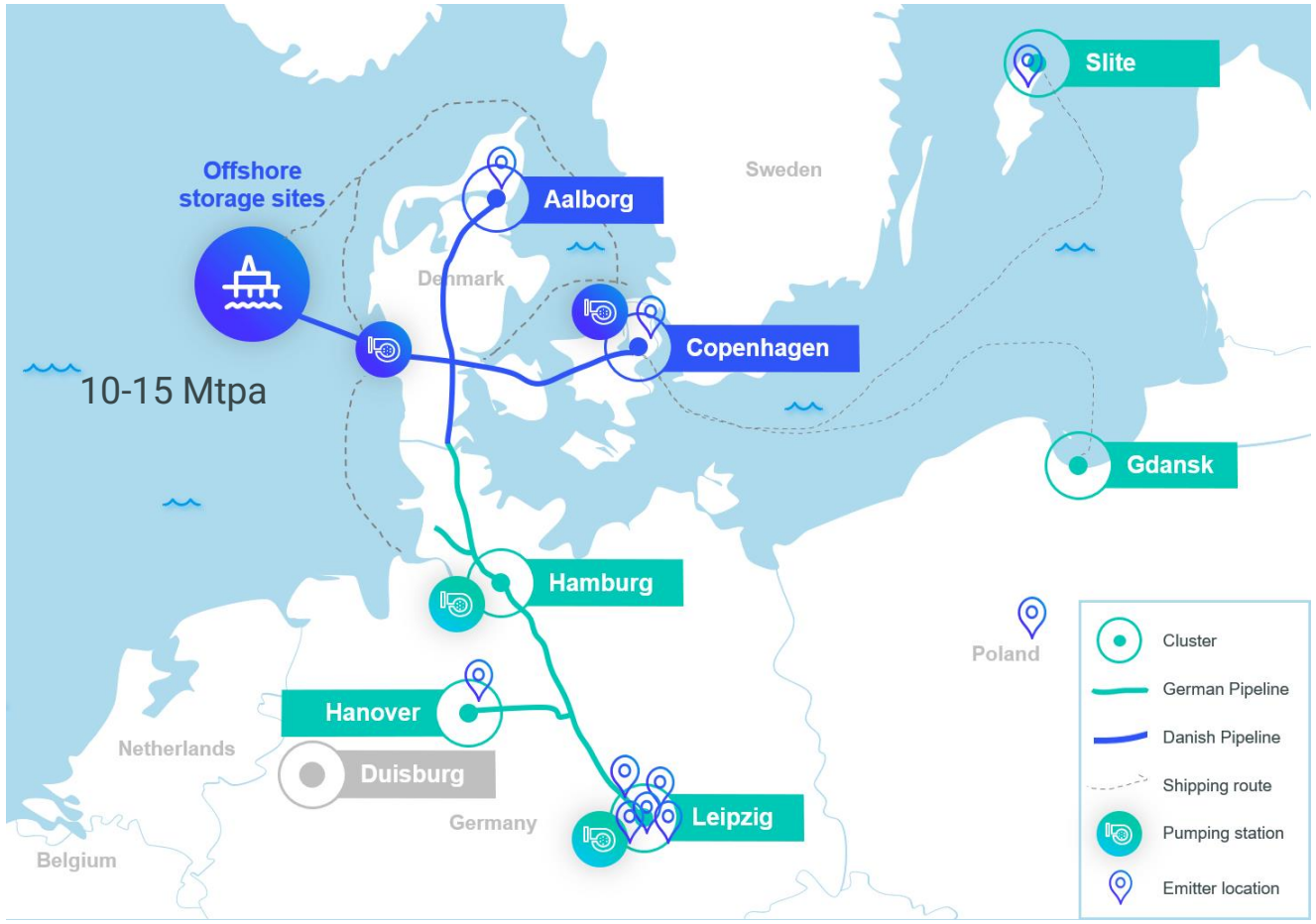
nordsø fonden Ørsted

# Projekt Bifrost – første skridt mod storskala $CO_2$ -lagring



# PCI - Vision for CO2-infrastruktur




Coordinator:

TotalEnergies

Infrastrukturpartnere:

ONTRAS

evida

gasunie

nordsø fonden

Ørsted

VNG

Industripartnere:

Dow

aalborgportland
CEMENTIR HOLDING

Carbon Capture Cluster Copenhagen

HEIDELBERGCEMENT

LAFARGE CEMENT

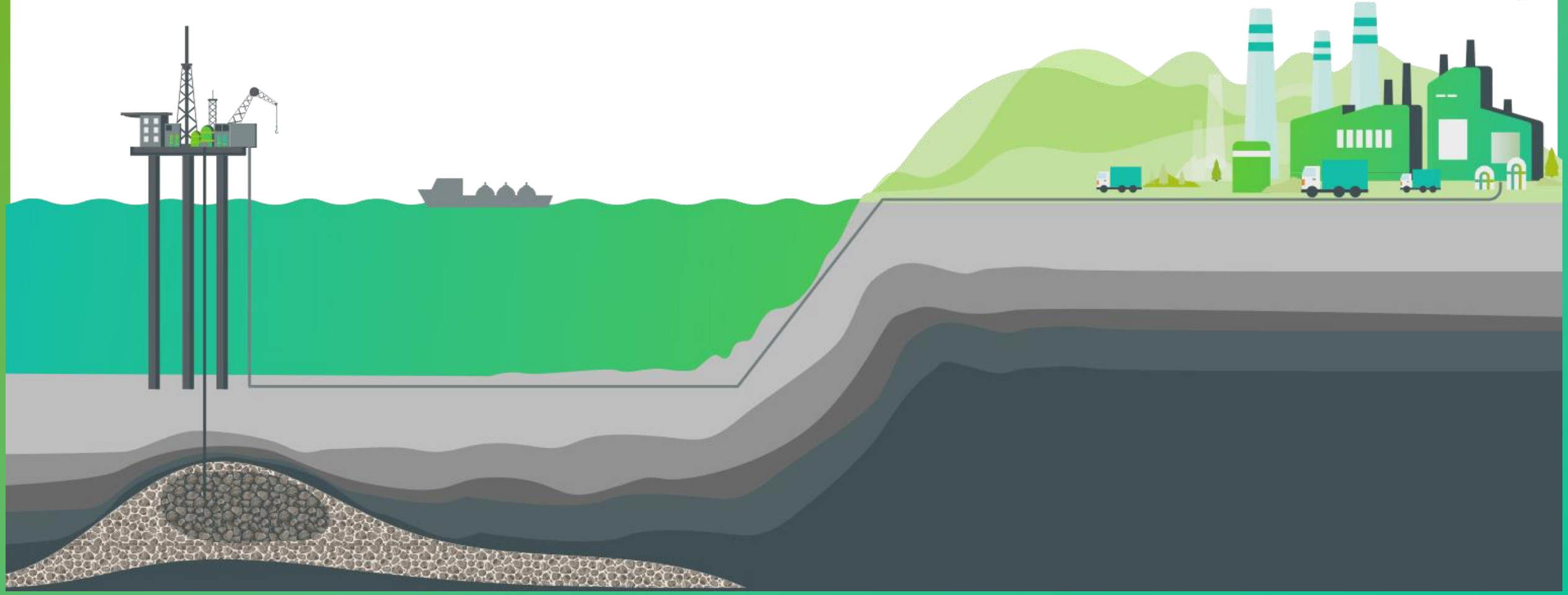
skw. PIESTERITZ

asc

# Centrale prioriteter på vej mod Danmark som europæisk $CO_2$-hub

- Ligestil værdien af negative og fossile emissioner - helst på EU-niveau
- Staten bidrager med risikovillig kapital til udbygningen af den centrale CCS-infrastruktur
- Udbyd flere licenser til lagring
- Sikre fri handel af $CO_2$ til offshore-lagring

# Q&A



# Næste oplæg

Lotte Kemplar,
Fidelis New Energy Europe

Biogas Danmark

GREEN GAS DENMARK

2023

# Industriens $CO_2$-værdikæde og Danmarks rolle

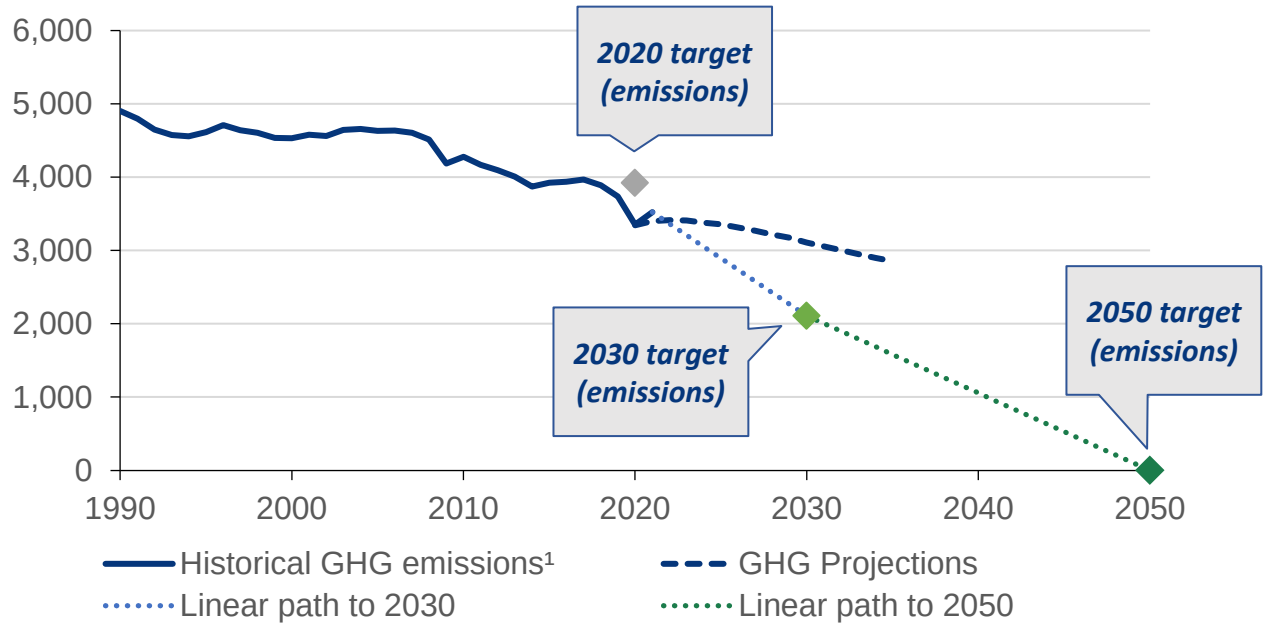
*v. Lotte Kemplar, General Counsel – Fidelis New Energy Europe*

NORNE CARBON STORAGE HUB

27 September 2023

# Significant action will be necessary to reach European climate goals

## CO2 reduction targets in EU-27 (Million tonnes of CO2)[2]




## Danish Climate Goals

***The Danish Climate Act sets ambitious target for reducing emissions.***

**2030:** 70% reduction compared to 1990-levels.

**2045:** Achieve climate neutrality, i.e. 100% reduction compared to 1990-levels.

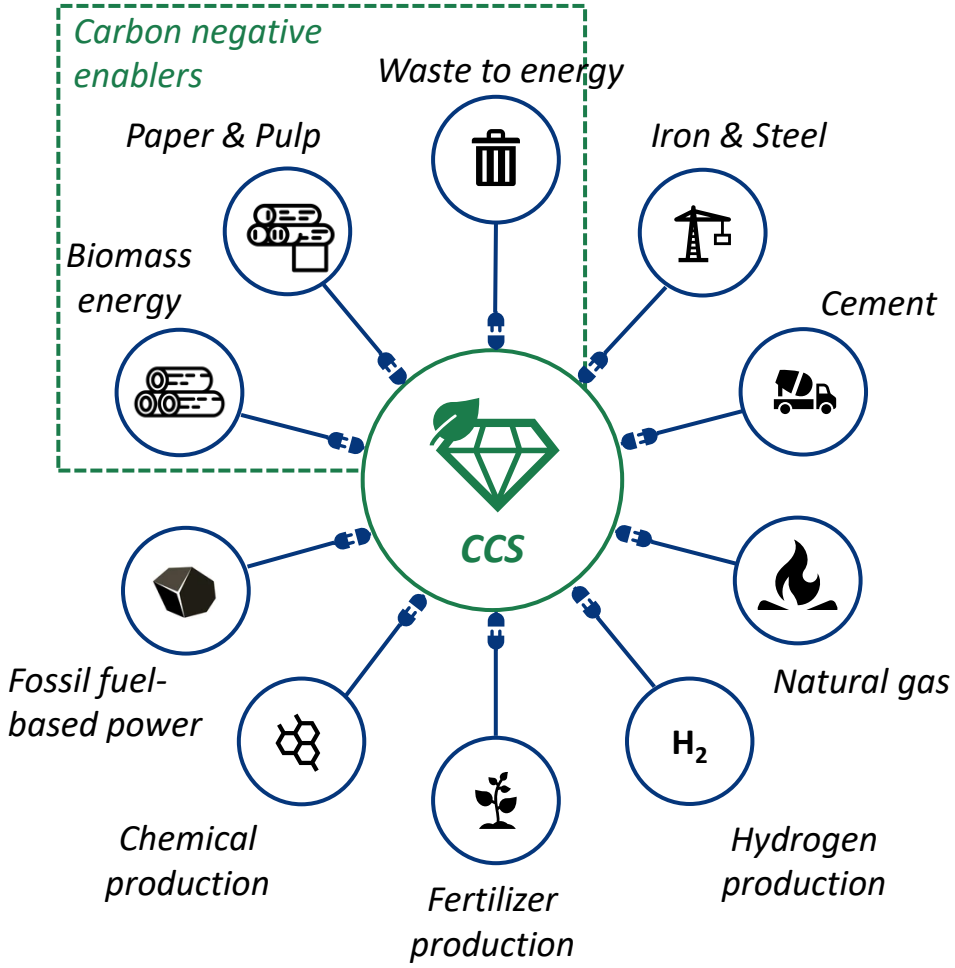
**2050:** 110% reduction compared to 1990-levels.

***CCS is recognized by both the EU Commission and the Danish government as an important tool in the fight against climate change. GEUS estimates that the Danish subsoil can store up to 22 billion tonnes of CO2.***

Source: European Environment Agency & The Danish Ministry of Climate, Energy and Utilities; 1) Green house gas 2) Green house gas in CO2-equivalents

# Hard-to-abate industry is soon going to face an important choice

**Hard-to-abate industries with fossil emissions…**

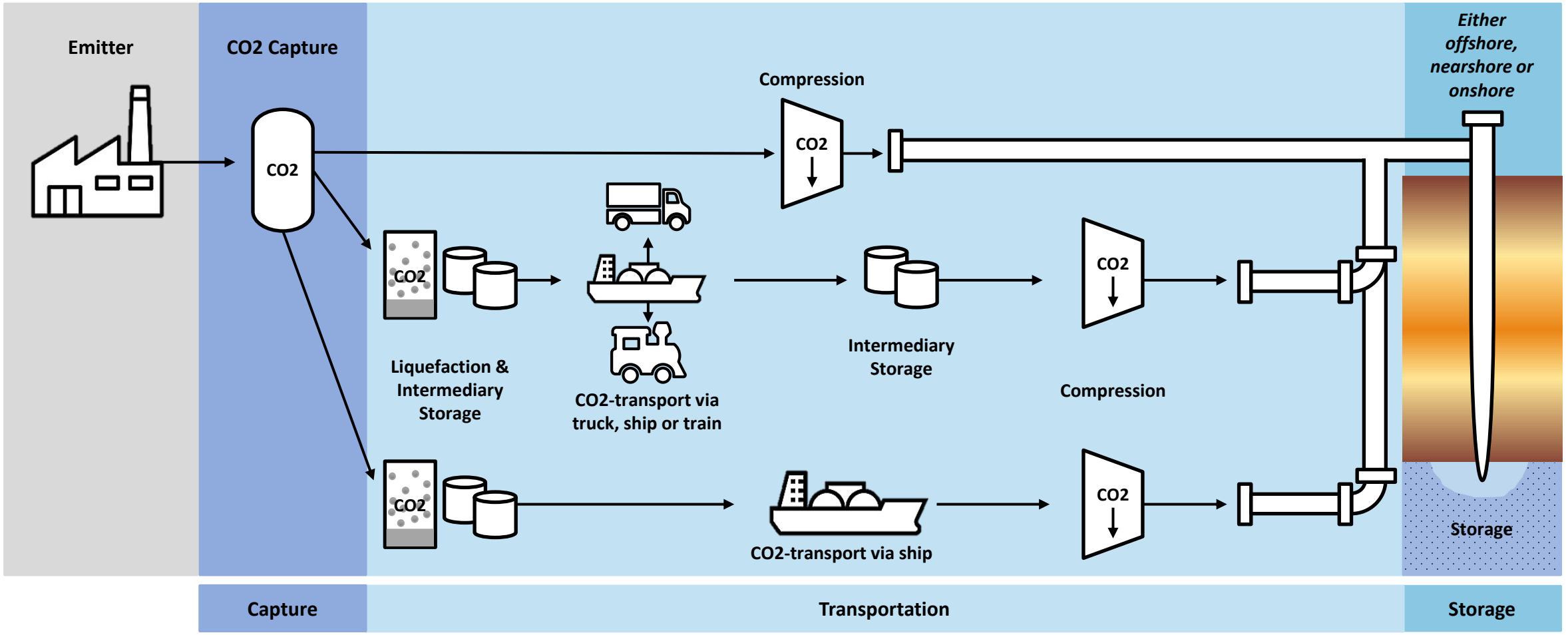



**…have 3 options to consider**

- Pay the EU ETS on its production
- Paying for the CCS value chain
- Close down operations *[as Carbon Border Adjustment Mechanism (CBAM) will offer little to no coverage]*

# The many permutations of the CCS value chain and its complexity

## The CCS value chain



# Immediate challenges of the CCS value chain

**Costs of the end-to-end value chain**

Current **costs of the entire CCS value chain** can be a showstopper for development. Onshore CCS can help with the transition phase.

**Availability and scale-up of equipment**

Ensuring sufficient **availability of capture equipment** to enable all hard-to-abate sectors to progress and execute on capture project can be a challenge.

**Swiftness of permitting**

Extensive and **time-consuming permitting** processes does pose a risk to the execution speed of CCS projects, and thus ultimately its roll-out.

NORNE
CARBON STORAGE HUB

# Denmark has a unique opportunity

The emergence of Denmark as the epicenter of European storage is expected to have multiple benefits.

CCUS
CARBON CAPTURE, USAGE AND STORAGE
ALLIANCEN

D I

Existing industry in Denmark can benefit from improved competitiveness of being close to storage.

Denmark can in the future benefit from new industrial projects wanting the same attractive economics.