

CLIMIT R&D&D program

Norway update – CAPTURE

US-Norway MoU; Washington

31st Oct.- 1st Nov 2023



CLIMIT

CLIMIT

CLIMIT's primary goal is to contribute to the development of CCS technology and solutions, and to reduce the costs and risks for those adopting this technology.

- **CLIMIT targets:**
 - A. *Decarbonisation of industry and energy resources*
 - B. Large-scale CO₂ storage sites on the Norwegian continental shelf
 - C. *Innovative technology development and solutions for CCS*
- **Budget: 148 mill. (14 M USD) kr in 2023** split between CLIMIT-R&D (The Research Council of Norway) and CLIMIT-Demo (Gassnova)

- **Result**

Norwegian's investment in full-scale CCS (the Longship project) would not have been possible without competence development through CLIMIT and centers for environmentally friendly energy (FME)



3.2 billion MNOK CLIMIT Financing

734 CLIMIT projects since 2005

CLIMIT Demo

56% for the development of capture technologies

25% for underground

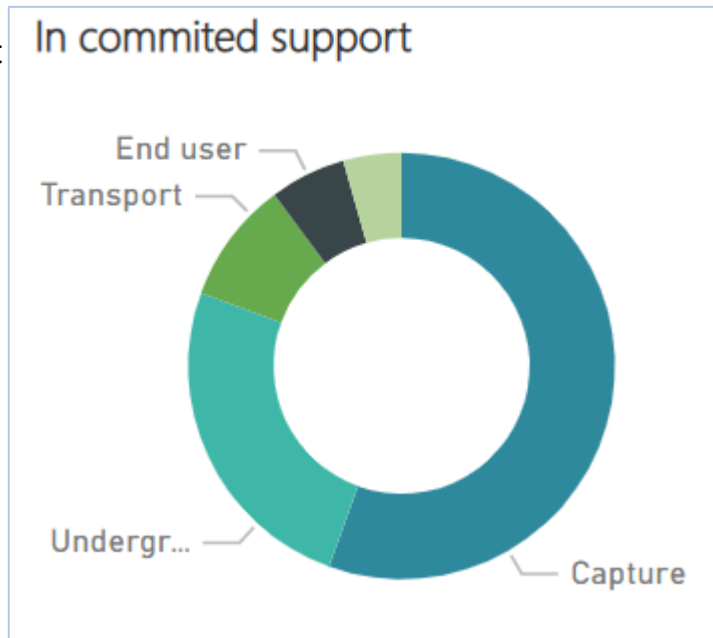
9% for transport

5% for end users

4% for cross cutting

1.5 billion MNOK CLIMIT financing

446 projects



CLIMIT R&D

44% for the development of capture technologies

35% for underground

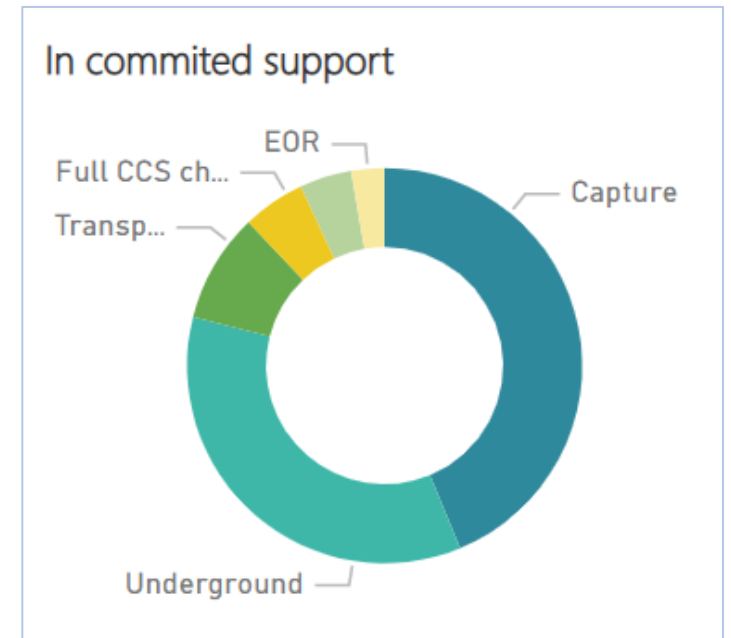
9% for transport

5% for end users

4% for cross cutting

1.7 billion MNOK CLIMIT financing

288 projects

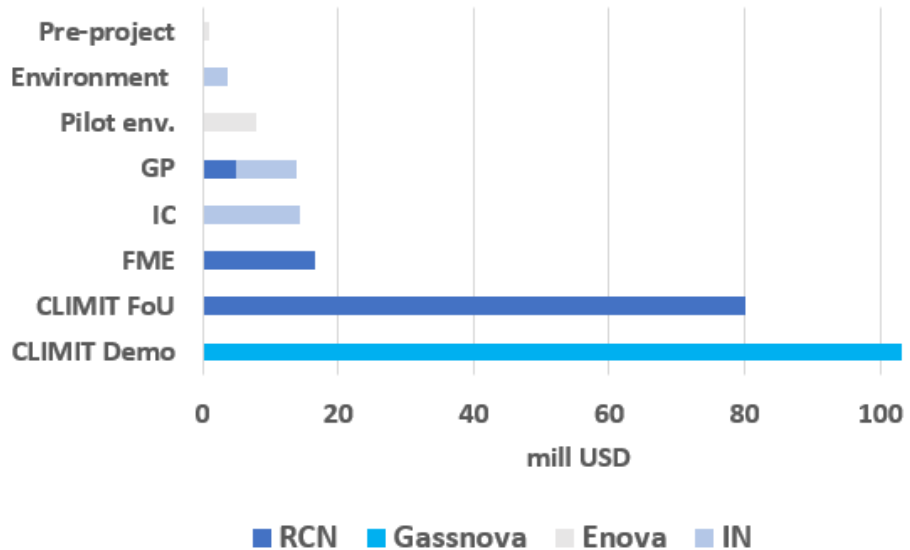


Collaboration between funding instruments

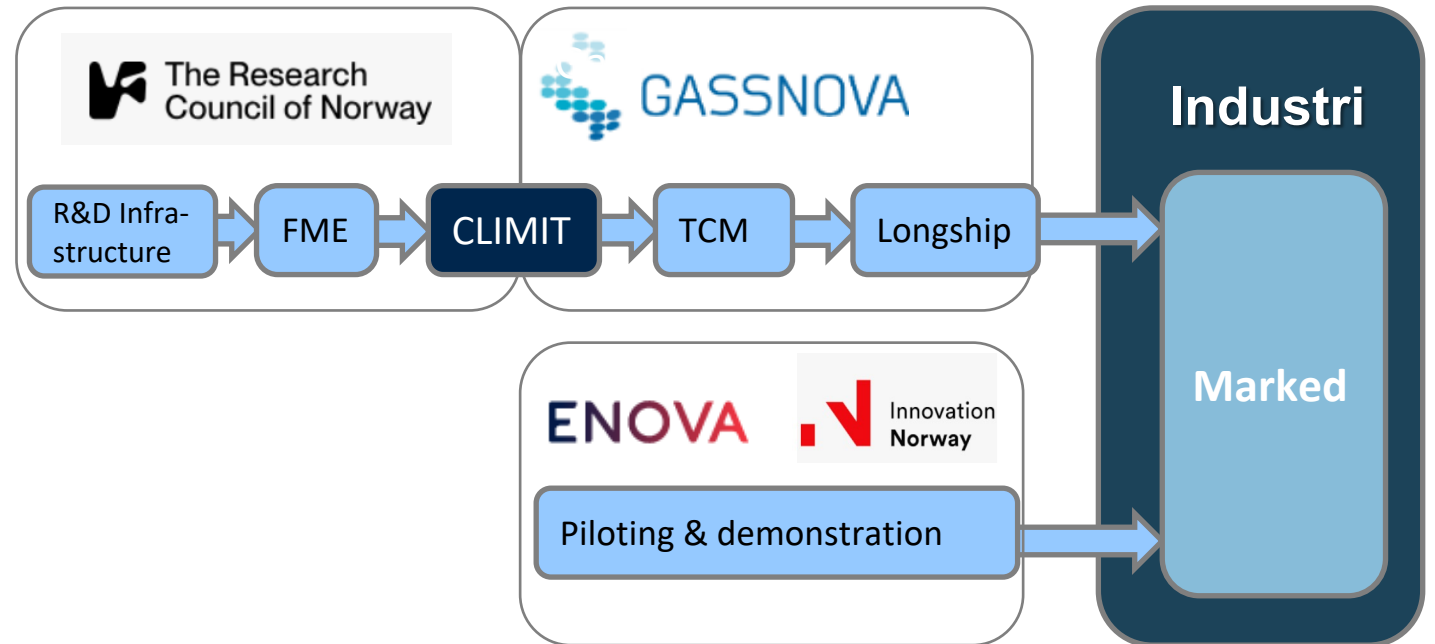
- Several funding instruments for accelerated technology development, piloting and demonstration



Accelerated technology development

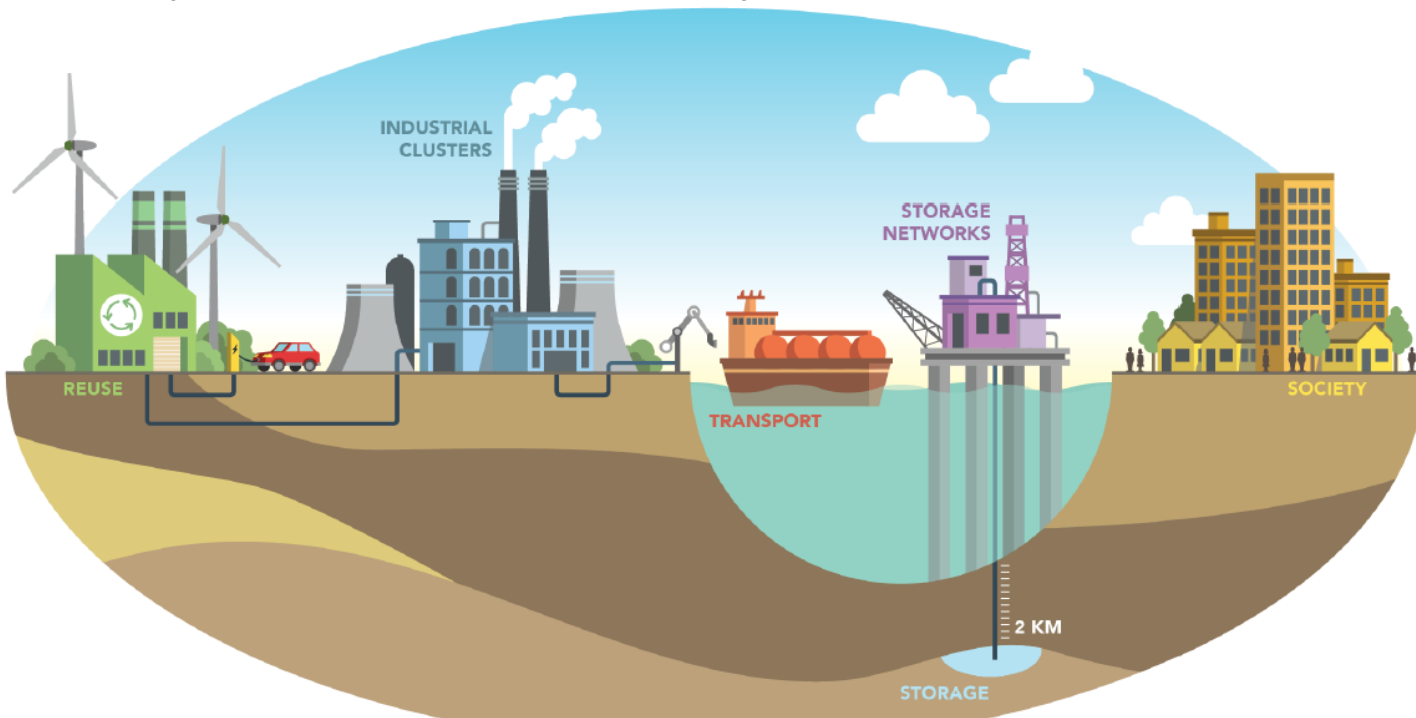


TCM and Longship is not included in the figures



ALIGN ← CCUS

ALIGN addressed specific issues across the CCUS chain, enabling large-scale, cost-effective implementation of CCUS by 2025.



ALIGN delivered actionable blueprints in ERA-NET ACT countries:

- Teesside and Grangemouth (UK)
- Rotterdam (NL)
- North Rhine-Westphalia (DE)
- Grenland (NO)
- Oltenia (RO)

The blueprints should be usable for other industrial clusters.

Advanced energy recovery and CO₂ capture systems for a decarbonised ferroalloy industry

Background:

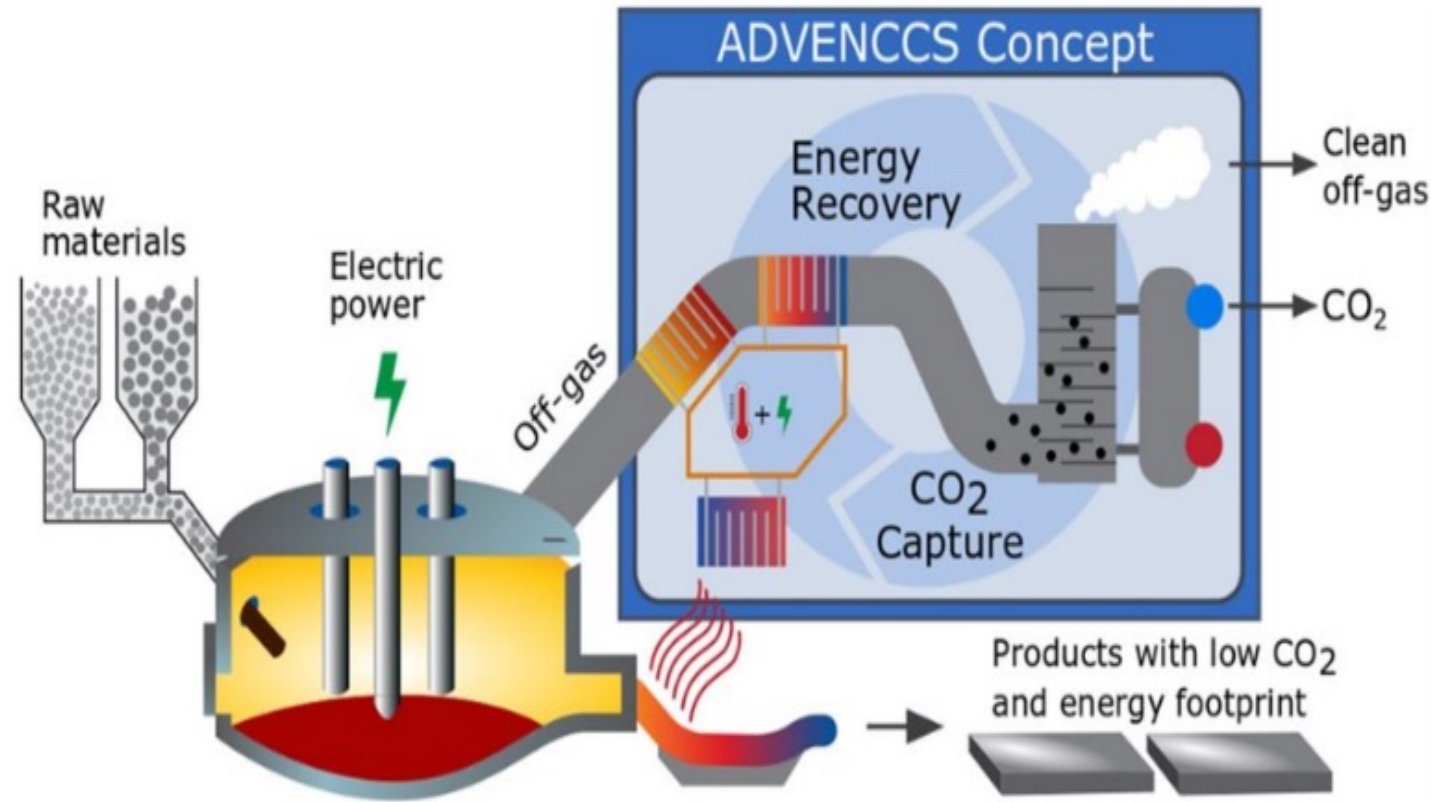
- The Norwegian ferroalloy industry has set ambitious energy and climate goals in accordance with the national goals for sustainable production.

Goal:

- ADVENCCS will develop novel technologies and competitive process concepts integrating CO₂ capture and heat recovery for a decarbonised ferroalloy industry

Results and impact:

- focus on novel solvents and sorbent based technologies
- promoting cost effective decarbonisation of the ferroalloy industry
- optimal development and efficient integration of combined CO₂ capture and advanced energy recovery



Project owner: SINTEF Energy

Partners: Elkem and Industries NCCS

Project period: 2023-2027

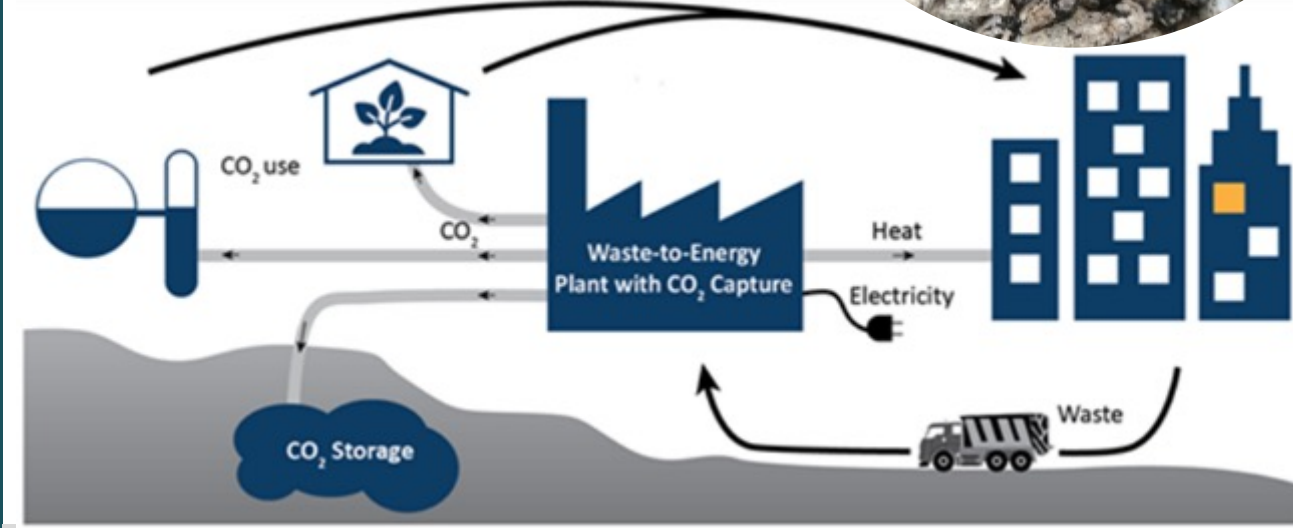
Project type: Competence project for industry

Budget: 20 mill NOK

Financing from CLIMIT: 14 mill. kroner

Project number: 336222

Enabling Bio CO₂ Capture Technologies in the Energy from Waste Sector



Background:

- Waste management and climate change are societal challenges
- BioCCS: Carbon Capture & Storage combined with Waste-to-Energy has carbon negative impact

Goal:

- Assess oxy-fuel combustion of municipal solid waste (MSW) as a potential capture technology for the Waste-to-Energy sector

Results and impact:

- Experimental study on combustion of MSW in CO₂ atmosphere
- Oslo Haraldrud WtE plant modelled with oxy-fuel CO₂ capture
- Collaboration with companion project in Germany

Project owner: EGE, Project manager: mario.ditaranto@sintef.no

Partners: SINTEF Energi AS, AGA, MiljøDirektoratet

Project period: 2018-2021

Project type: Innovation project in industry

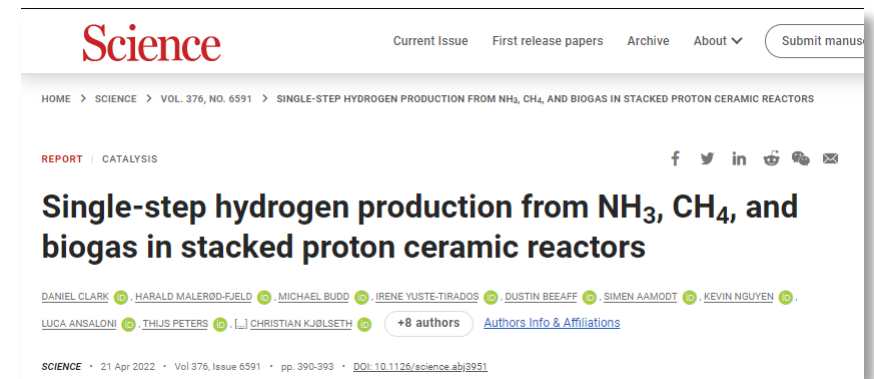
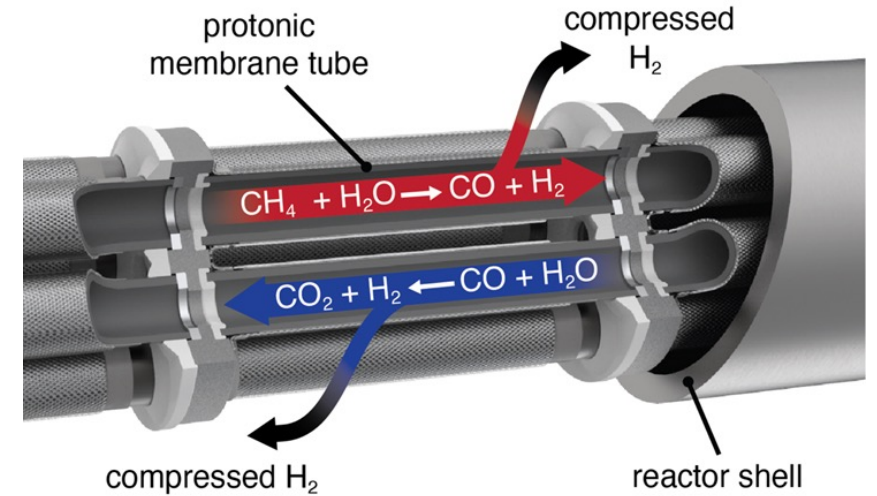
Budget: 12.3 mill. kroner

Financing from CLIMIT: 8 mill. kroner

Project number: 281869

Electrochemical production of H₂ from natural gas

Partners	CoorsTek Membrane Sciences Equinor, ExxonMobile, Total, Shell, Saudi Aramco, ENGIE, Sintef
Project	2019 – 2022 (Phase I & II)
Budget [MNOK]	39 & 31.6
CLIMIT [MNOK]	17 (44 %) & 15 (47.5%)
	<ul style="list-style-type: none"> • <i>Process intensification: reforming, water shift and H₂ compression in one step</i> • <i>Electricity as process energy – no natural gas for heating</i> • <i>Heat integration balances energy demand</i> • <i>Scalable technology</i> <p><i>Targeting:</i></p> <ul style="list-style-type: none"> • <i>90% efficiency</i> • <i>99,99% H₂ purity</i> • <i>Close to 100% carbon capture</i>



Source: www.science.com

Disruptive CO₂ Capture (Adsorption)

Partners	TOTAL E&P NORWAY SINTEF
Project	2020 – 2024
Budget [MNOK]	24
CLIMIT [MNOK]	12 (50 %)

- The overall goal: *To develop adsorption-based CO₂ capture technology that is significantly better than state-of-the-art absorption (solvent) technology.*
- The main tasks in the project are:
 - *Set-up of mathematical framework*
 - *Determination of optimal conditions for each adsorption process*
 - *Parameter validation*
 - *Evaluation of process parameters to improve performance*
- In a final phase of the project the most promising process will be subject to detailed optimization.

ADSORPTION FOR CO₂ CAPTURE

SHELL-VIENNA FLUIDIZED BED

ADA

KAWASAKI MOVING BED

Electricity conso: 1.3 GJ/t CO₂
MB tests → 2021

SRI FALLING BED / CC CO₂

CO₂ avoided: 45 \$/t CO₂ (?)

SINTEF SWING ADS^N REACTION CLUSTER

Key challenge
- How to 'cost' approaches

SVANTE (INVENTYS) ROTATING BED

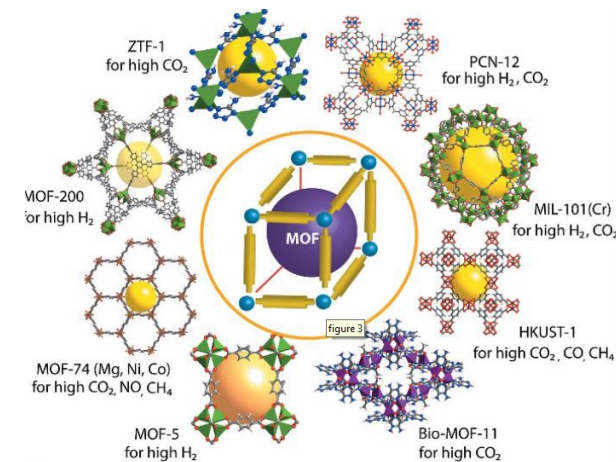
TDA FIXED-BED ALKALIZED Al₂O₃

CO₂ avoided: 40 \$/t CO₂ (?)

TDA HYBRID MEMBRANE+ ADSORPTION

Projected CO₂ captured: 40 \$/t CO₂ (?)
To be tested in Wyoming 2020 (& TCM)

GEORGIA TECH HOLLOW FIBRE



HalZero – Hydro Aluminium

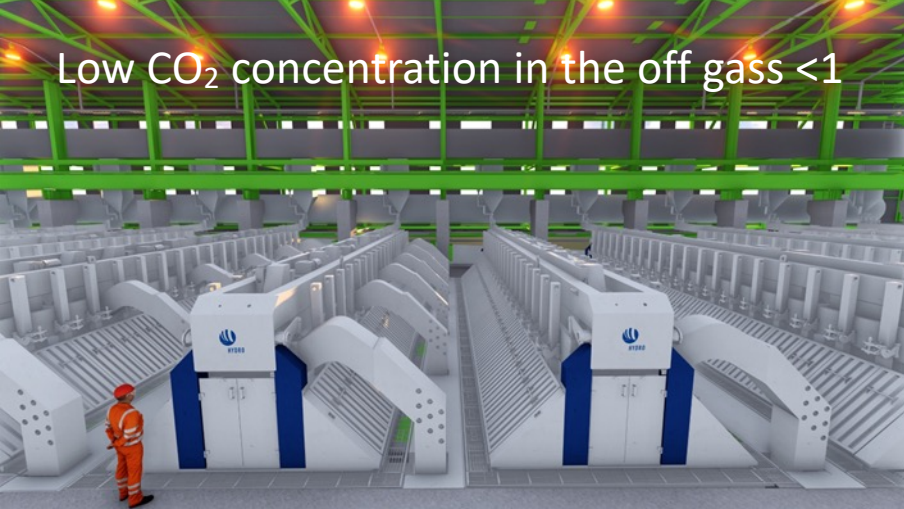
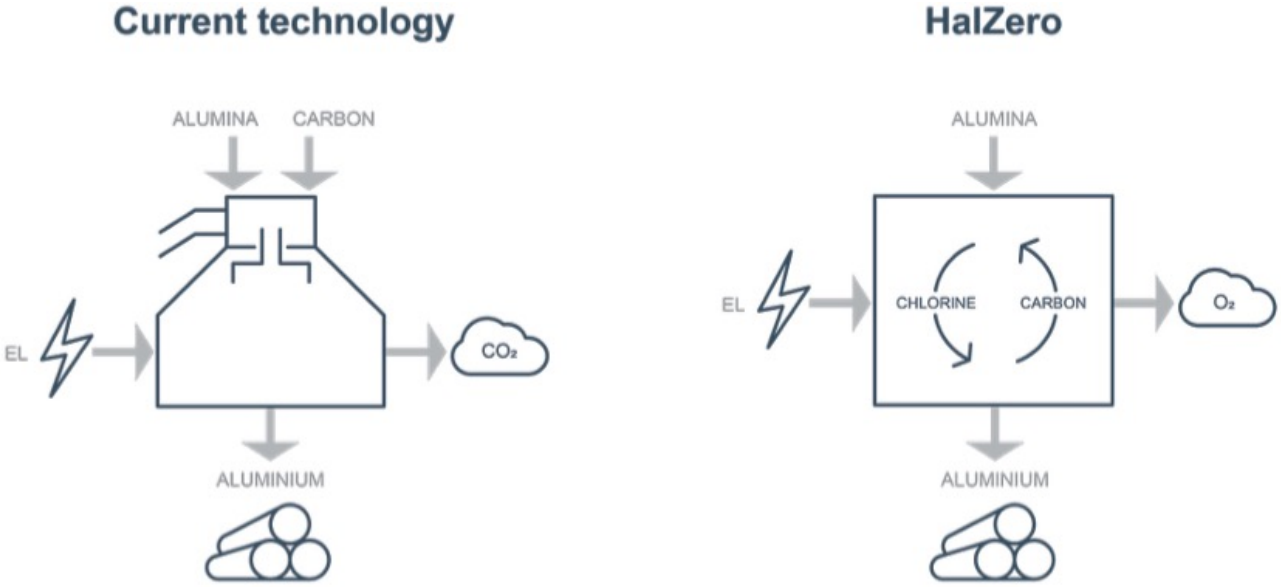
Zero Emission Aluminium Production

Technology development funded by CLIMIT
- announced at
Hydro's Capital Markets Day 2021 as
Hydro's future technology, **HALZero**

HalZero phase2:

HalZero phase 1 development funded by CLIMIT

HalZero phase 2: A joint funding between CLIMIT and ENOVA to reach a higher TRL



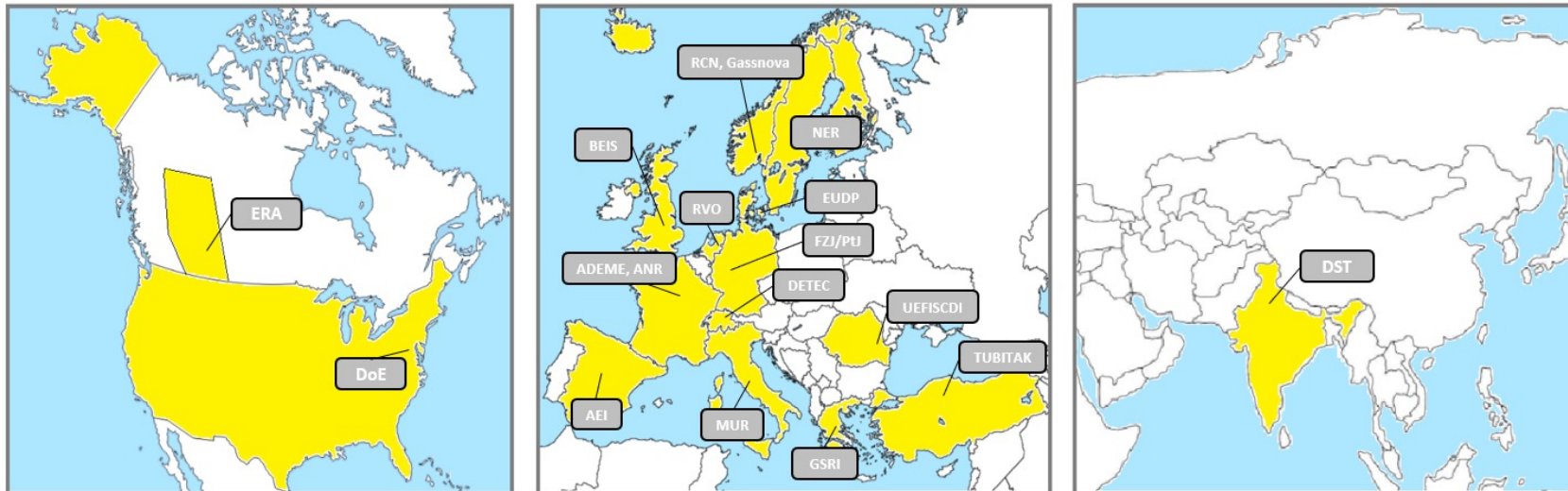
Hydro Aluminium – Illustration of Today's Electrolysis

Illustration of the classic Hall-Heroult smelter technology (left) and our new HalZero chloride technology (right)

Source: Hydro Aluminium

ACT – Accelerating CCS Technologies

- ACT is a collaboration between funding agencies from Europe, India, Canada and USA, coordinated by the Research Council of Norway
- Aims to accelerate and mature technologies for CO₂ capture, utilisation and storage (CCUS)
- ACT makes funds available for R&D and innovation projects and has funded 39 projects since 2017 with a total of € 108 M
- ACT is the best European R&D support scheme within CCUS according to the European Commission



Clean Energy Transition Partnership (CETP)

- CETP is a European partnership covering all low-carbon energy topics
- Funding agencies from 30 countries are participating
- Annual calls from 2022 to 2027
- RCN is the coordinator for activities within CCUS, hydrogen, and renewable fuels
- New call out now with due date for pre-proposal 22nd November
- Norwegian contributions:
 - 120 mill. NOK to the first call (2022)
 - 54 mill. NOK to the second call (2023)
- 46 projects starting this autumn based on the call 2022
 - 10 within CCUS overall
 - 6 of these CCUS projects with Norw. Partner, 4 on storage and 2 on capture
 - 2 of these CCUS projects with US and Norw. Partners, both on storage
 - 5 within hydrogen and renewable fuels

Key messages

Accelerated technology development and deployment

- Investment along whole value chain RD&I
- RD&I has closed important knowledge gaps
- A short way from research to large scale demonstration
- Strong relations between academia and industry established
- Full scale Longship project has not been possible without competence building in CLIMIT and Centre for environment friendly Energy (FME)
- Effective collaboration between funding agencies

The added value of the joint international effort

- Alignment of national RD&I strategies.
- Larger projects with higher impact than what would have been possible with only national projects.
- Well-functioning RD&I collaboration across borders is established.
- Important contributions to dissemination of key messages beyond the scientific community.

