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Decarbonisation Leaders Network

Accelerating Industrial Decarbonisation

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Or speak with DLN Community Director; Jack Figg to find out more.


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GLOBAL STATUS OF CCS 2024

COLLABORATING FOR A NET-ZERO FUTURE

GLOBAL CCS INSTITUTE

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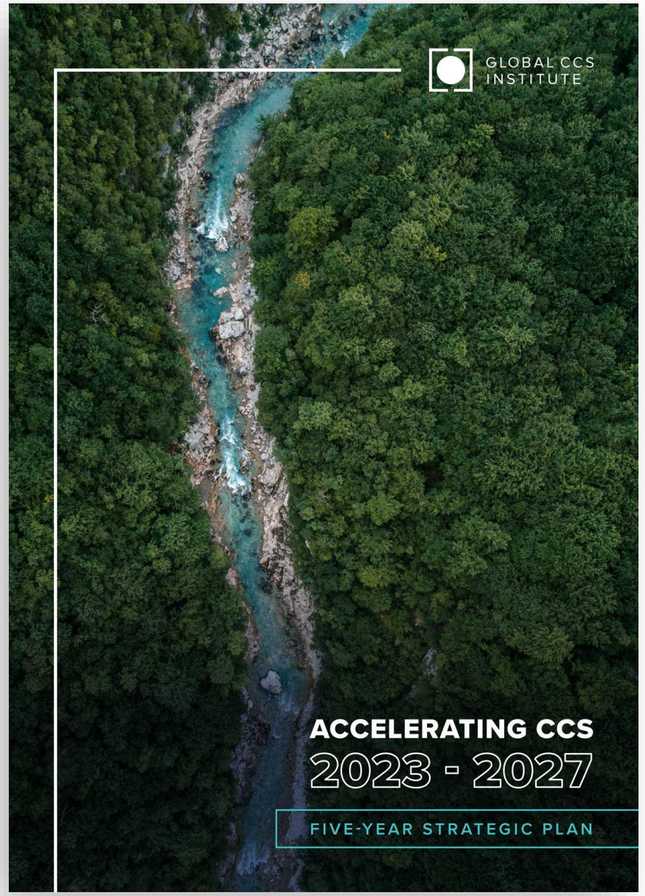
WHO WE ARE
Climate change think tank

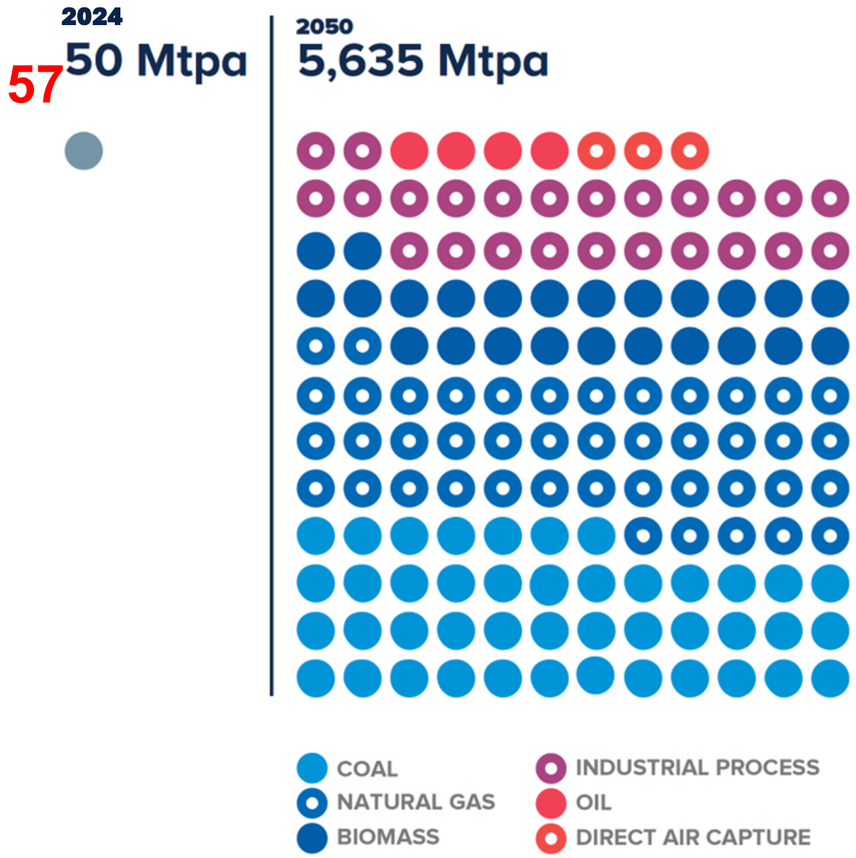
MISSION: Accelerate the deployment of CCS for a net-zero emissions future.

Independent; Not-for-profit; Member-based
Global; government members; single purpose

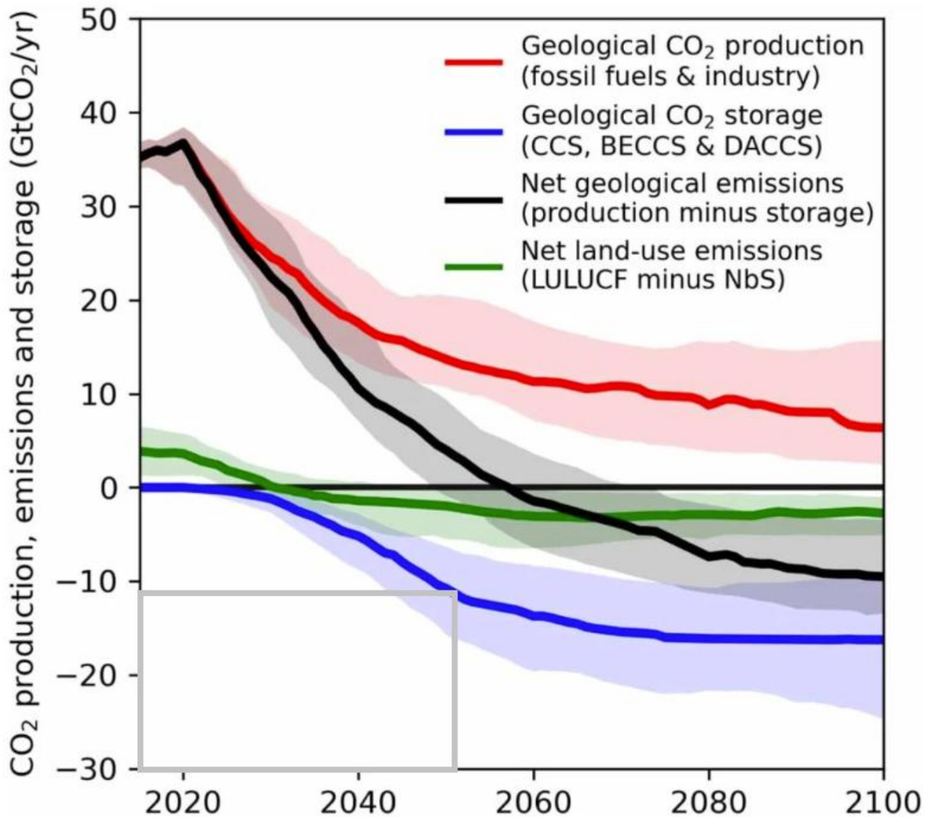
WHAT WE DO
Fact-based advocacy, thought leadership, knowledge creation and sharing, networking.



CCS GROWTH REQUIREMENTS



Updated from IEA SDS report 2019



Source: Jenkins (2023): 1.5◦C- compatible scenario produced from IPCC's AR6 scenario database.[

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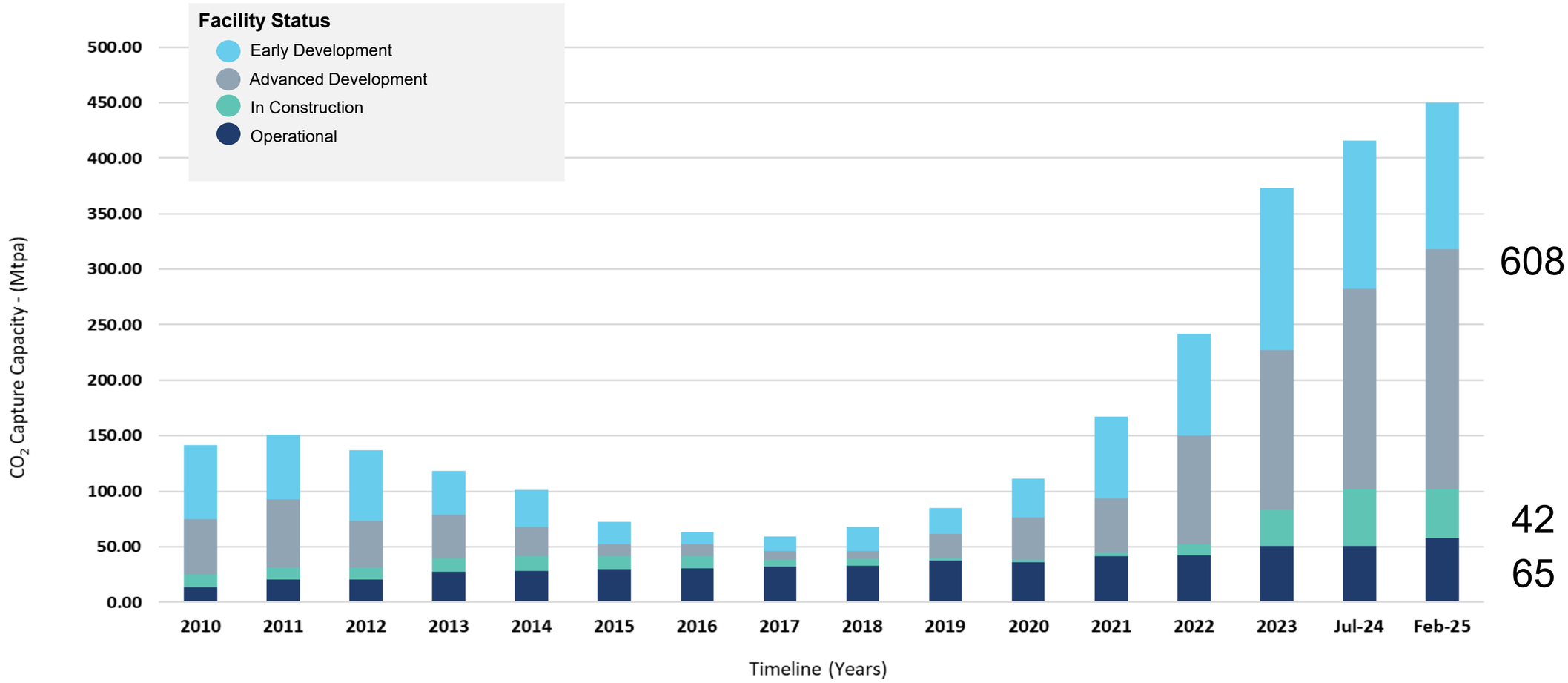
CO_2 CAPTURE CAPACITY TREND YEAR ON YEAR



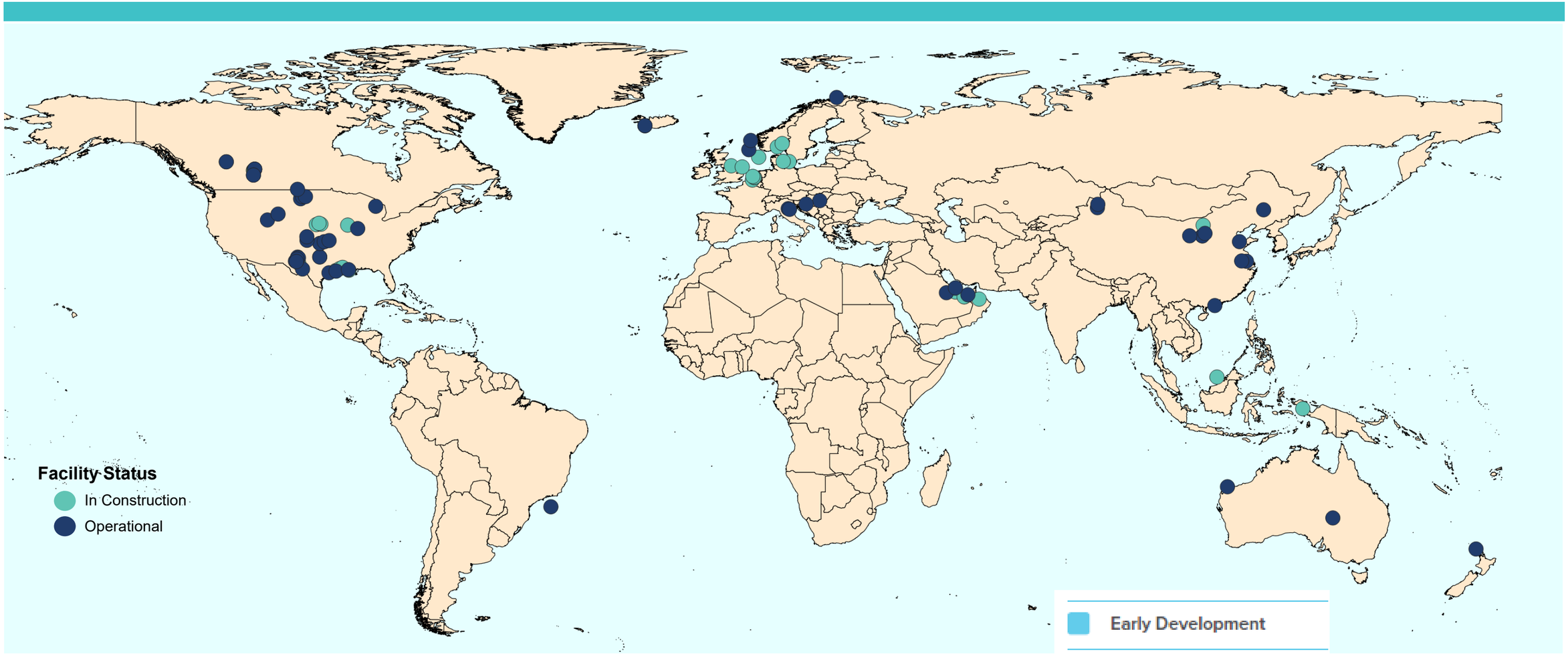
Only commercial projects are included; projects in the announced, canceled, or completed stages are excluded.

Source: GCCSI CO_2RE Database CCS Facilities as of February 2025.

GLOBAL CCS INSTITUTE

Commercial CCS Facilities

Operational & In Construction Projects



Early Development

Advanced Development

In Construction

Operational

This map does not include the following:

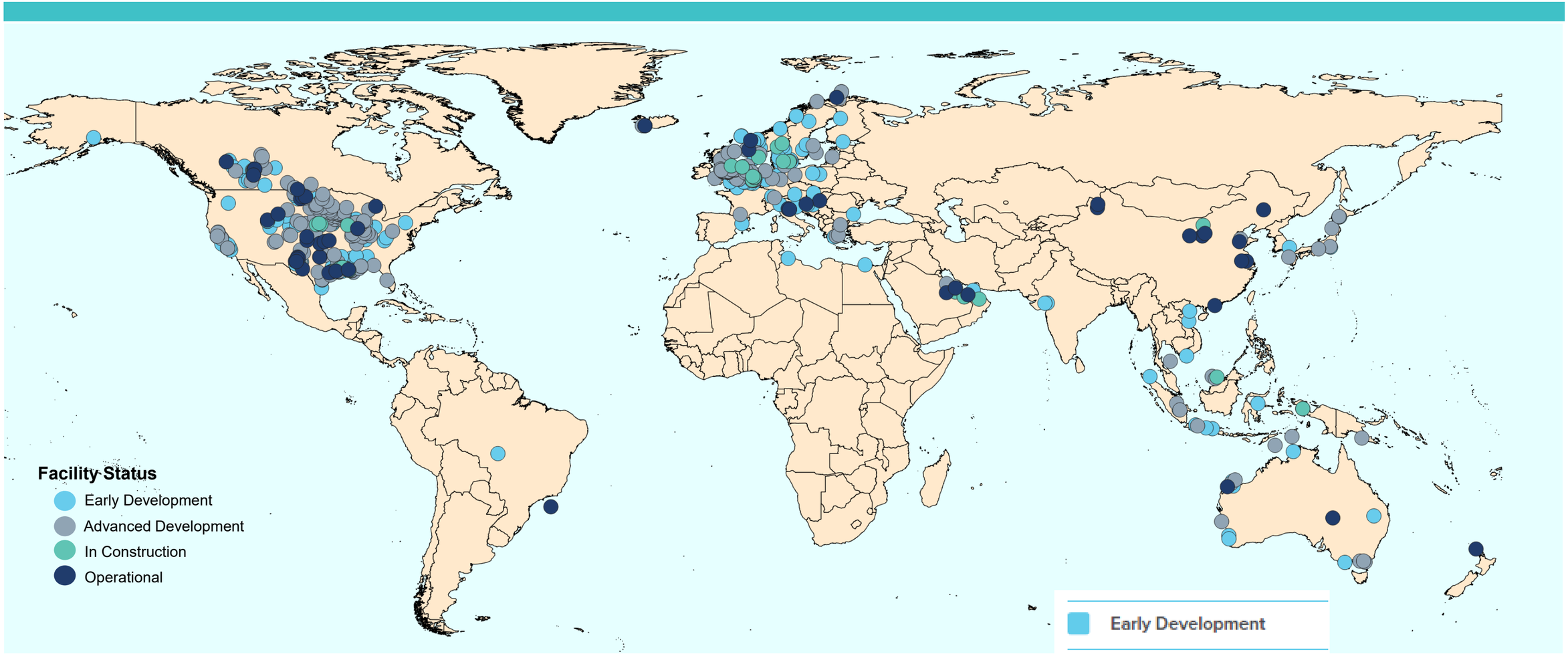
- Pilot & Demonstration and Utilisation Facilities
- Announced Facilities
- Facilities where precise location is yet to be confirmed

Source: GCCSI CO_2RE Database CCS Facilities as of February 2025.

GLOBAL CCS INSTITUTE

Commercial CCS Facilities

Operational, In Construction, Early and Advanced Projects



Early Development

Advanced Development

In Construction

Operational

This map does not include the following:

- Pilot & Demonstration and Utilisation Facilities
- Announced Facilities
- Facilities where precise location is yet to be confirmed

Source: GCCSI CO_2RE Database CCS Facilities as of February 2025.

GLOBAL CCS INSTITUTE


Capture, transport and/or storage capacity (Mtpa CO_2)
0.2
1
5
Direct Air Capture
Aluminium
Waste to energy
Power Generation and Heat
Pulp and paper
Various[1]
Iron and Steel
Oil Refining
Cement
Chemical
Hydrogen/Ammonia /Fertiliser
Bioenergy/Ethanol
Natural Gas Processing
CO_2 Transport / Storage
1972-2010
2011-2020
2021-2025
2026-2030
2031-2035
Timeframe unconfirmed
Key
Early Development
Advanced Development
In Construction
Operational
Capacity Undefined
Not Applicable
[1] CO_2 captured from more than one industry within the project boundary.

GLOBAL DEVELOPMENTS WEST-TO-EAST

CCS DEVELOPMENTS IN THE USA

- 27 facilities **operational** across US, Canada & Brazil; 18 in construction.
- Deployment rates highest in ethanol, nat gas processing, hydrogen/ammonia/ fertilizer
- USA: 276 CCS projects (GSR2024) vs 154 (GSR2023)
- Class VI applications queue growing: 161 applications for 56 projects under EPA review* and additional applications under state primacy, with Louisiana leading in projects and applications. North Dakota, Wyoming, Louisiana and West Virginia have received primacy. Alabama, Alaska, Arizona and Texas next.
- The US EPA is also requiring coal and new gas-fired power plants to capture 90% of CO2 emissions by 2032, partially through CCS: First "stick" mechanism.
- CO_2 pipeline projects have faced social resistance, prompting new state laws in Sth Dakota + Illinois
- The Department of Interior is developing regulations for offshore storage and the Pipeline & Hazardous Material Safety Administration is updating CO_2 pipeline standards.

*As of February 2025

CCS DEVELOPMENTS CANADA & BRAZIL

7 Operational CCS facilities in Canada

5 Facilities in construction in Canada

Canada

- Federal investment tax credit approved by Parliament (up to 50% capex until 2030)
- Federal carbon price increased to C$80/tonne in April (+C$15/yr up to C$170 by 2030)
- Canada Growth Fund established 2nd CCfD for CCS projects (gas and wte)

Brazil

- Petrobras CCS project in the Santos Basin injected 13Mt in 2023 (10.6 Mt in 2022); Aim to inject cumulative total of 80 Mt CO_2 by 2025.
- In Brazil, a CCS breakthrough occurred with the passage of the Fuels of the Future Bill → foundation for CCS regulations – first country in South America to develop such provisions.

CCUS DEVELOPMENTS: EUROPE

UNITED KINGDOM:

4 clusters capturing 20-30 mtpa (2030);
£21.7 billion allocated 2024;
£960 million GIGA fund;
27 storage permits issued;
EU ETS integration with UK ETS anticipated

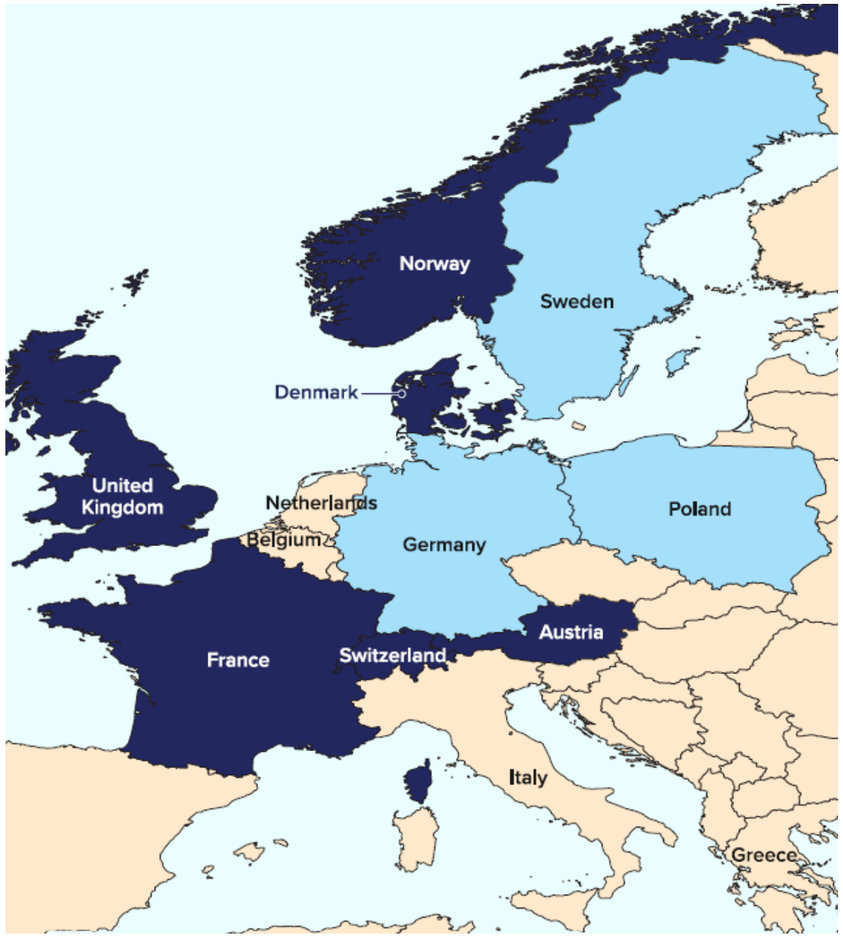
THE NETHERLANDS: SDE++; Aramis; Delta-Rhine and Delta-Antwerp corridor; YARA & Porthos FID & construction; 13 Mtpa storage target; Pension fund interest in T&S; Gasunie green bond;

DENMARK: Government funding, incl. for BECCS. Permits onshore + offshore; 4 Mtpa storage target; Greensand FID & construction; 13 Mtpa

NORWAY: Northern Lights and Brevik now ready; Growth beyond Northern Lights

SWEDEN: BECCS support

POLAND: 4 Mtpa storage target



GERMANY: Key principles for a Carbon Management Strategy; Carbon Storage Act adopted by Federal Cabinet ; CCfDs; 5 Mtpa storage target

AUSTRIA: Nat Carbon Mgmt Strategy

ROMANIA: Delayed adoption of National Integrated Energy and Climate Change Plan; 10 Mtpa storage target

GREECE: EU IF success; active storage regulator; Prinos too small? access to Egypt?

ICELAND: Carbfix onshore permit

ITALY: Injection at Ravenna; CCS committee; 7 Mtpa storage target

SWITZERLAND: call for CCS projects

FRANCE: Draft CCUS strategy released; CCfD's; tender; London Protocol

BELGIUM: Bilateral agreements; pipeline network incl. regional regulation; offshore pipeline to Norway; EU IF success; PCI success

National Carbon Management strategies: Published In preparation

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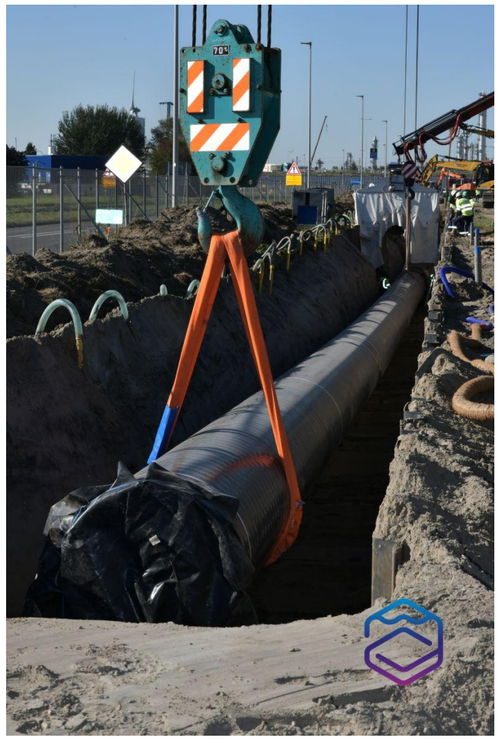
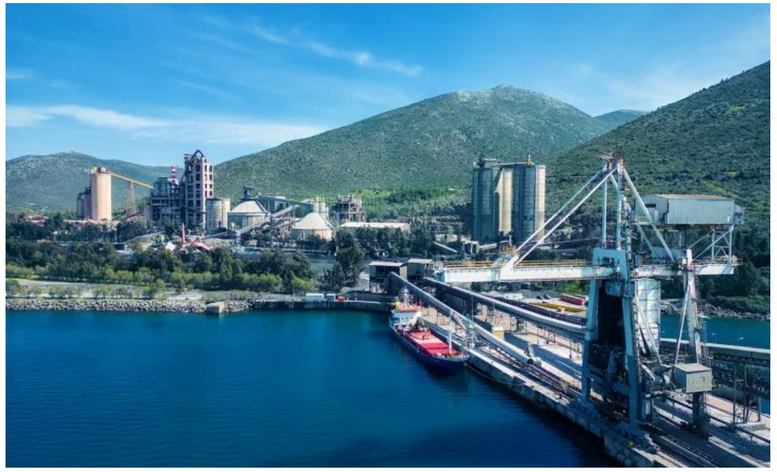
CCUS DEVELOPMENTS: EUROPE (2)

- 7 projects in operation / ready to operate
- 12 projects in construction (FID taken)
- 222 CCS projects (APR-25) vs 120 (GSR23) vs 73 (GSR22)
- Hydrogen, fertilizer, power gen, cement, biomass to power/heat, DAC
- 14 crossborder CO_2 infrastructure projects on the PCI – PMI list
- Bilateral and multilateral agreements – including talks EU-UK
- NZIA aims for 50 Mtpa storage (2030) → 44 O&G companies named
- UK £21.7B; Germany €3.3B; Denmark €3.8B; EUCOM approved €5.2 billion worth of state aid for CCS related investments in Sweden, Poland, and Portugal



CCUS DEVELOPMENTS: EUROPE (3)



Clockwise:

- Brevik Cement (HeidelbergMaterials)
- Porthos (EBN, Gasunie, PoR)
- Yara Sluiskil
- Northern Pioneer (Northern Lights)
- Olympus CCS (Holcim)

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CCS DEVELOPMENTS IN MIDDLE EAST AND AFRICA

PROJECTS: 3 facilities in operation capturing 3.8 Mtpa CO2; 6 in construction
Regional operational CCS capacity = 8% of global total capacity (GSR23)

QATAR: Qatar Gas aiming for11 Mtpa CCS (2035)
KSA:

- Al Jubail CCUS industrial hub targeting 9 Mtpa (2027)
- Aramco aiming for 14 Mtpa CCS commitment (2035)
- National target of and 44 Mtpa (2035)

UAE:

- ADNOC took 1.5 Mtpa FID on Habshan facility; aiming for 10 Mtpa (2030)
- Long-term strategy aiming for CCS = 32% of industrial GHG reductions (2050)

→ Projected regional CCS capacity 65 Mtpa (2035)

CCS DEVELOPMENTS: ASIA PACIFIC

- APAC facility count +22 from GSR2023: 76 CCS facilities (19 operating; 9 in construction).
- Natural gas processing and chemical manufacturing – EOR dominates
- Significant PLR development across the region: Indonesia, S.Korea and Japan have released reg. frameworks; Malaysia expected to follow March 2025. Much to be done (SEACA)

Singapore

- S-hub project: 2.5 Mtpa objective by 2030 (NDC). MoU signed. LoI w/ Indonesia.

Indonesia

- Regulation allowing storage operators to reserve 30% of capacity for imported CO_2. Significant investment needed.

CCS DEVELOPMENTS: CHINA

- Carbon price ETS on power stations.
- 11 operating projects, incl. on/offshore, EOR
- CCUS increasingly highlighted in China's green transition policies.
  - **Carbon Emission Reduction Facility:** Low-cost loan for decarbonization projects.
  - **Green & Low-carbon Tech Demonstration Program** - Direct governmental support
  - **Action Plan for Low-Carbon Coal Power Transformation (2024-2027)** – Financial support to the selected coal power CCUS projects.
- NDRC selected 47 projects, 6 = CCUS

CCS DEVELOPMENTS: CHINA

The CO_2 Storage Tanks at the Qingzhou Oxy-fuel Combustion Cement Project Site (provided by Tianjin Cement Industry Design & Research Institute)

SINOPEC 1 Mtpa CCUS Project in Petrochemical Sector

National Energy 500 Ktpa CCUS Project in Coal Power Sector

CCS DEVELOPMENTS: AUSTRALIA – NEW ZEALAND

- AUS government ratified the London Protocol 2009 amendment
- Federal budget for 2024-2025 makes inclusions for CCS, incl. for characterization
- "Safeguard Mechanism": Carbon baseline reduction targets for industry; ACCU=A$75/t
- New Zealand government confirms CCUS to be recognized by ETS

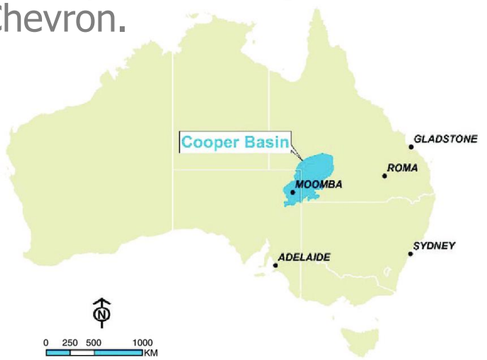
CCS DEVELOPMENTS IN AUSTRALIA – NEW ZEALAND

- Gorgon continues to operate, storing around 1.6Mtpa;
- Moomba operational
- Two QLD storage projects blocked due to deemed groundwater risk.

Gorgon LNG facility, WA. Image courtesy of Chevron.

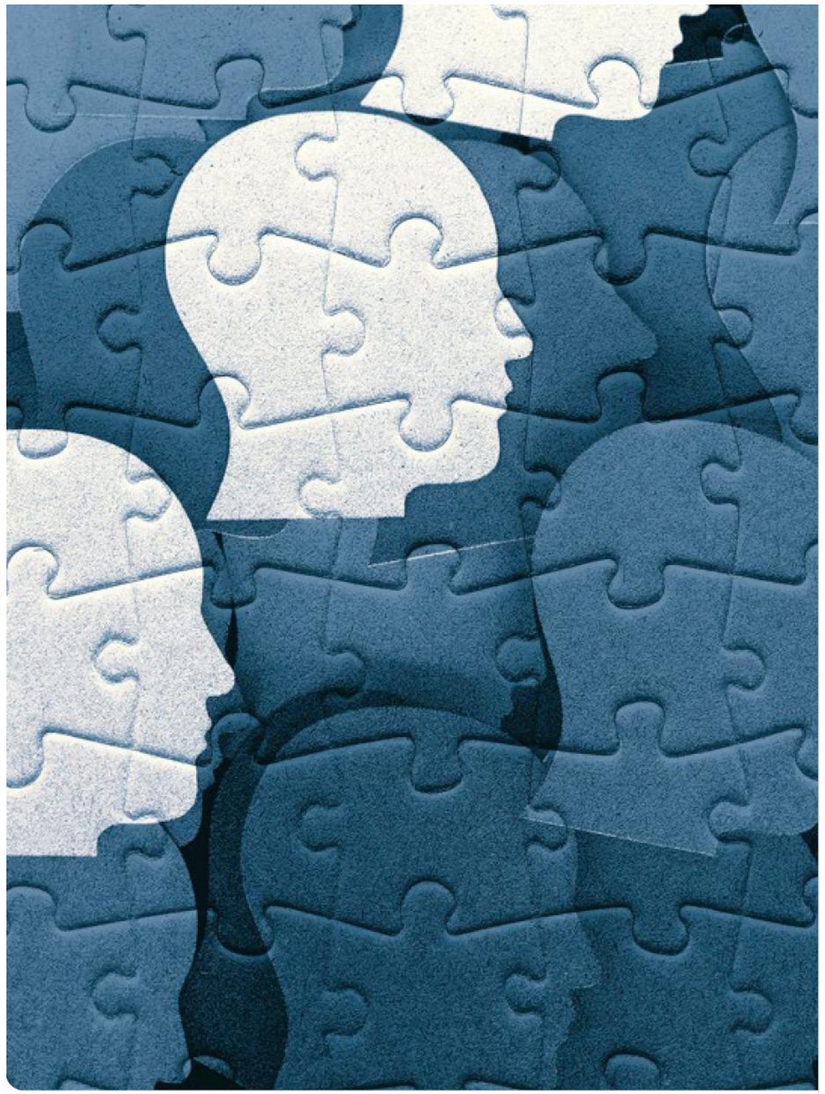
Ngawha 3 geothermal power plant, NZ (source: Top Energy)

Santos Moomba project in the Cooper Basin – 1.7 Mtpa (source: Beach Energy)



GLOBAL CCS INSTITUTE

Global CCS needs global collaboration



Outlook is positive for CCS

Increasing policy support, new investments, & project deployments worldwide

Challenges still to overcome

Difficult investment settings, community concerns, regulatory barriers

Collaboration is key to global CCS deployment

Governments, industry, and research community must work together to remove barriers, lower costs and drive investment

Global Status of CCS 2024

Thank you

FACILITY UPDATES (SINCE JULY 2024)

❑ Operational Facilities

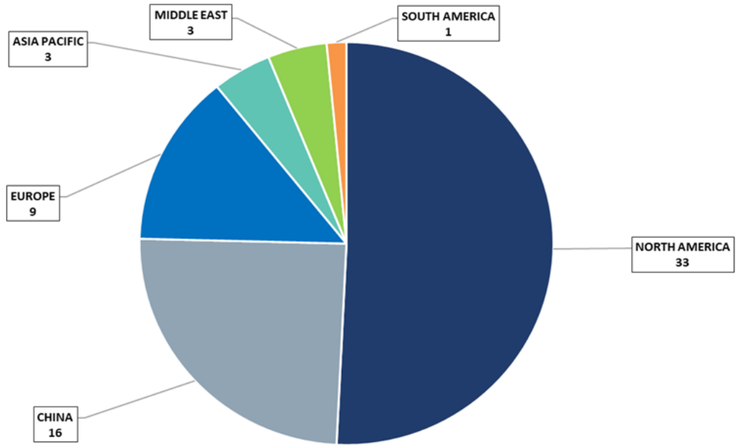
65 Facilities now **operational** with capture capacity of **~57 Mtpa**
6 facilities started operations since July 2024

Italy
- Eni Casolborsetti Natural Gas Plant
- Eni Ravenna Hub

Australia
- Santos Moomba CCS

China
- China National Energy Ningxia
- Xinjiang Jinlong Shenzu

Norway
- Northern Lights Transport and Storage



715 Commercial CCS Facilities *
- 65 Operational
- 42 In Construction
- 272 Advanced development
- 336 Early development

❑ In Construction Facilities

6 facilities entered the construction phase since July 2024

Denmark
- Project Greensand

Indonesia
- BP Tangguh LNG

China
- CNPC Xinjiang Karamay Coal-Fired Power Plant Integrated Project

United Kingdom
- Northern Endurance Transport and Storage
- NZT Power

Norway
- Hafslund Oslo Celsio Waste-to-Energy Plant

Quick Facts
- Average capture capacity size: 1.22 Mtpa
- Largest industry (Count): Bioenergy/Ethanol (123)
- Largest operating capture: 10.6 Mtpa, Santos Basin Pre-Salt (Brazil)
- Oldest operational facility: 1972, Terrell (USA)
- New countries in the CCS industry: Slovakia, Vietnam

❑ Development Pipeline

- 74 (Early/Advanced Development) Facilities have been added to CO_2RE since July 2024

* Only commercial projects are included; projects in the announced, canceled, or completed stages are excluded.

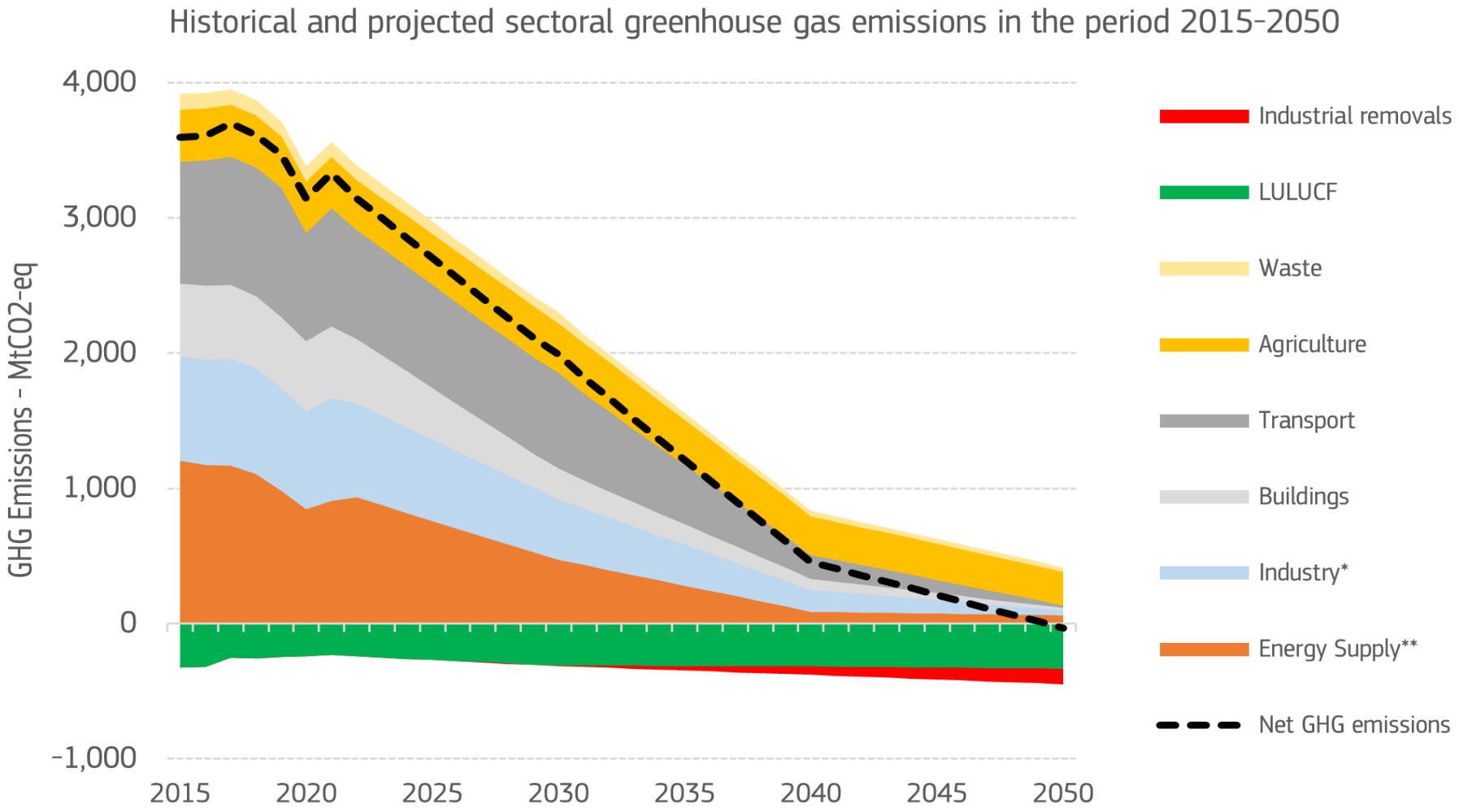
Source: GCCSI CO_2RE Database CCS Facilities as of February 2025.

GLOBAL CCS INSTITUTE

Carbon Capture, Use and Storage

3 June 2025

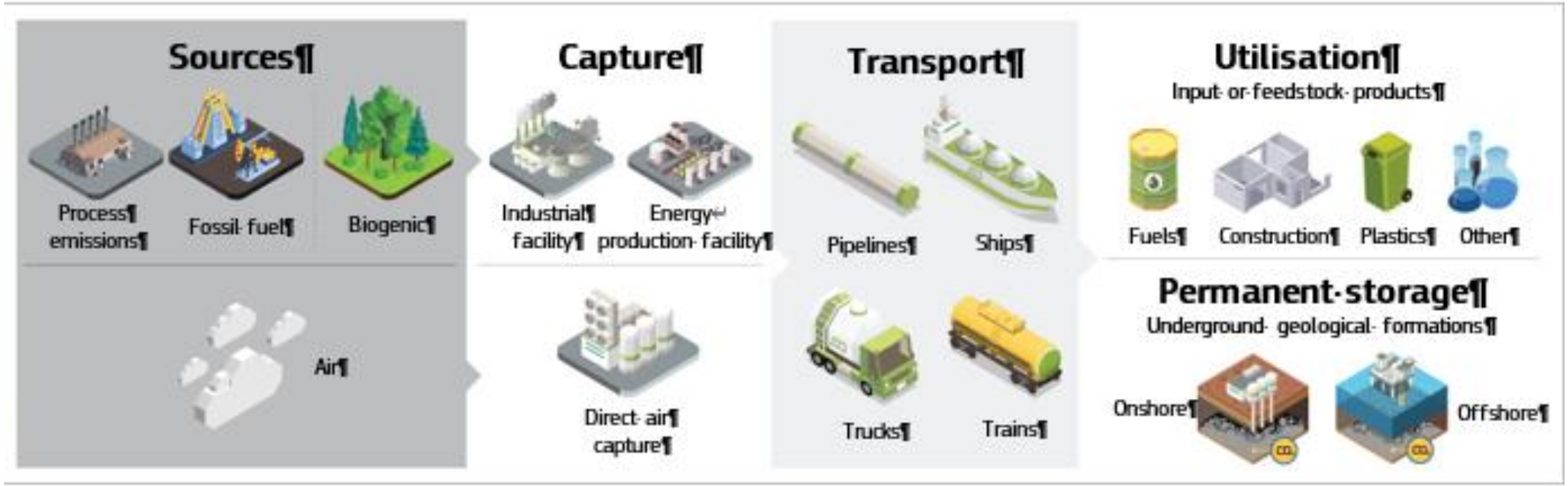
Pathway to climate neutrality

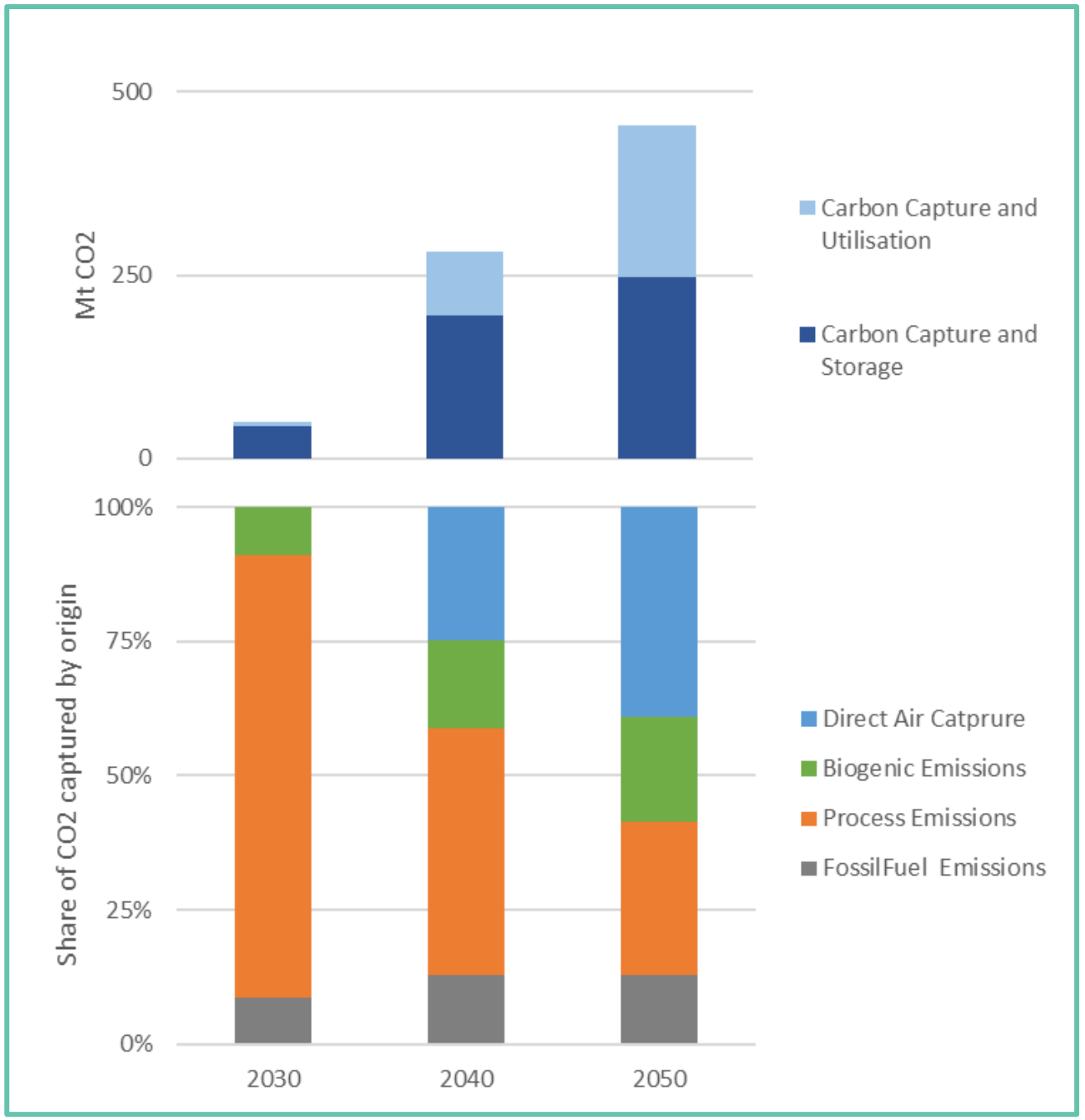


*Excluding non-BECCS industrial removals
**Including bioenergy with carbon capture and storage (BECCS)

European Commission

A circular carbon economy

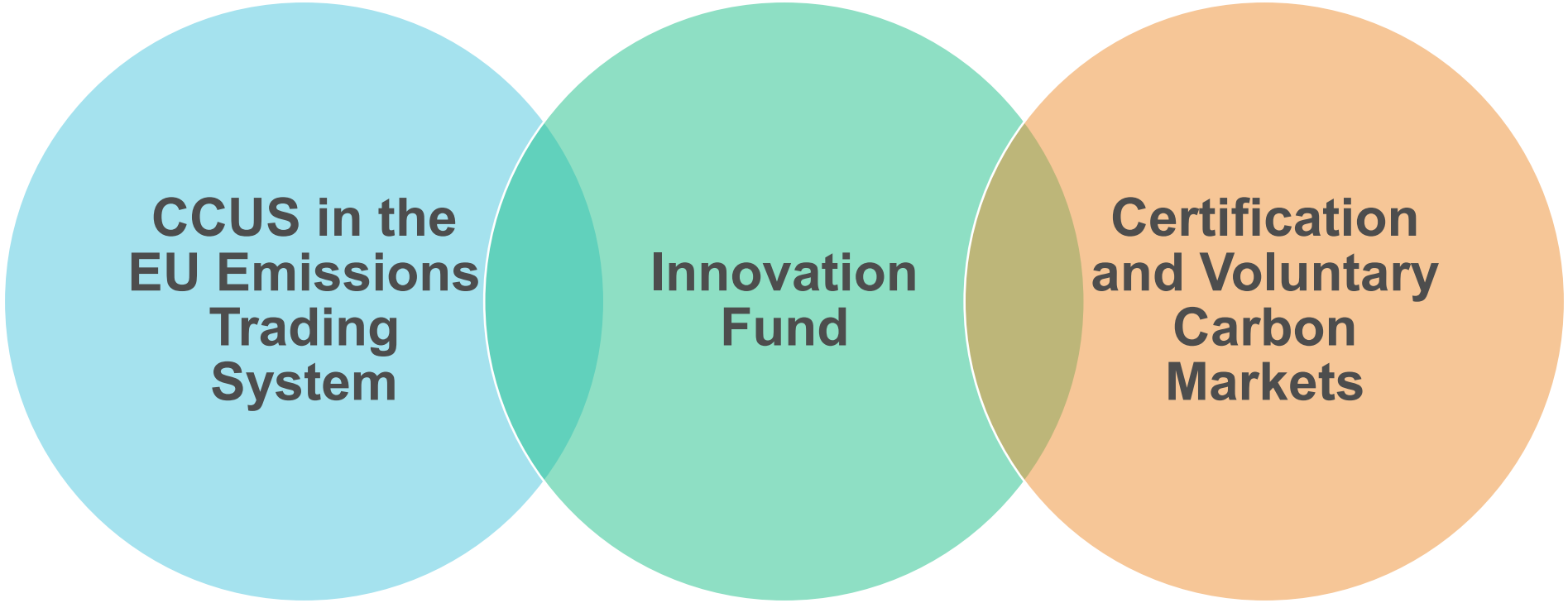




Estimated CCUS market volumes

European Commission

A circular carbon economy



European Commission

Business opportunities in the circular carbon economy

‘Classic’ Carbon Capture and Storage

Capturing fossil CO2 from waste gases and store geologically

Incentivized by EU ETS

Carbon Capture and Use

Capturing CO2 from waste gases or atmosphere to produce chemicals, fuels, construction materials

Carbon Removals

Capturing biogenic CO2 from waste gases (BioCCS) or CO2 from the atmosphere (DACCS) and store it durably

EU ETS review in 2026 and ETS inclusion of waste incineration in 2028

Transport and storage

CCS Directive

Obligation for oil companies to provide 50 Mt injection capacity in 2030

INNOVATION FUND

Funded by the EU Emissions Trading System

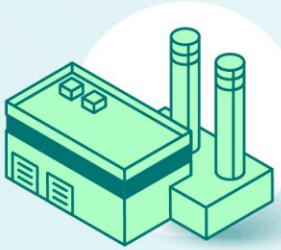
Deploying innovative net-zero technologies for climate neutrality

€40 billion* available between 2020-2030

grants awarded through regular calls and auctions

avoid GHG emissions, boost competitiveness

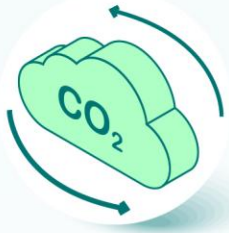
supporting innovation in:



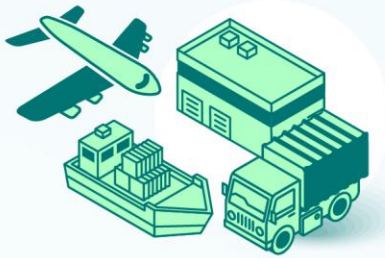
Energy-intensive industries

Renewable energy

Energy storage



Carbon capture, use and storage



Net-zero mobility and buildings

*based on a carbon price of €75/tonne

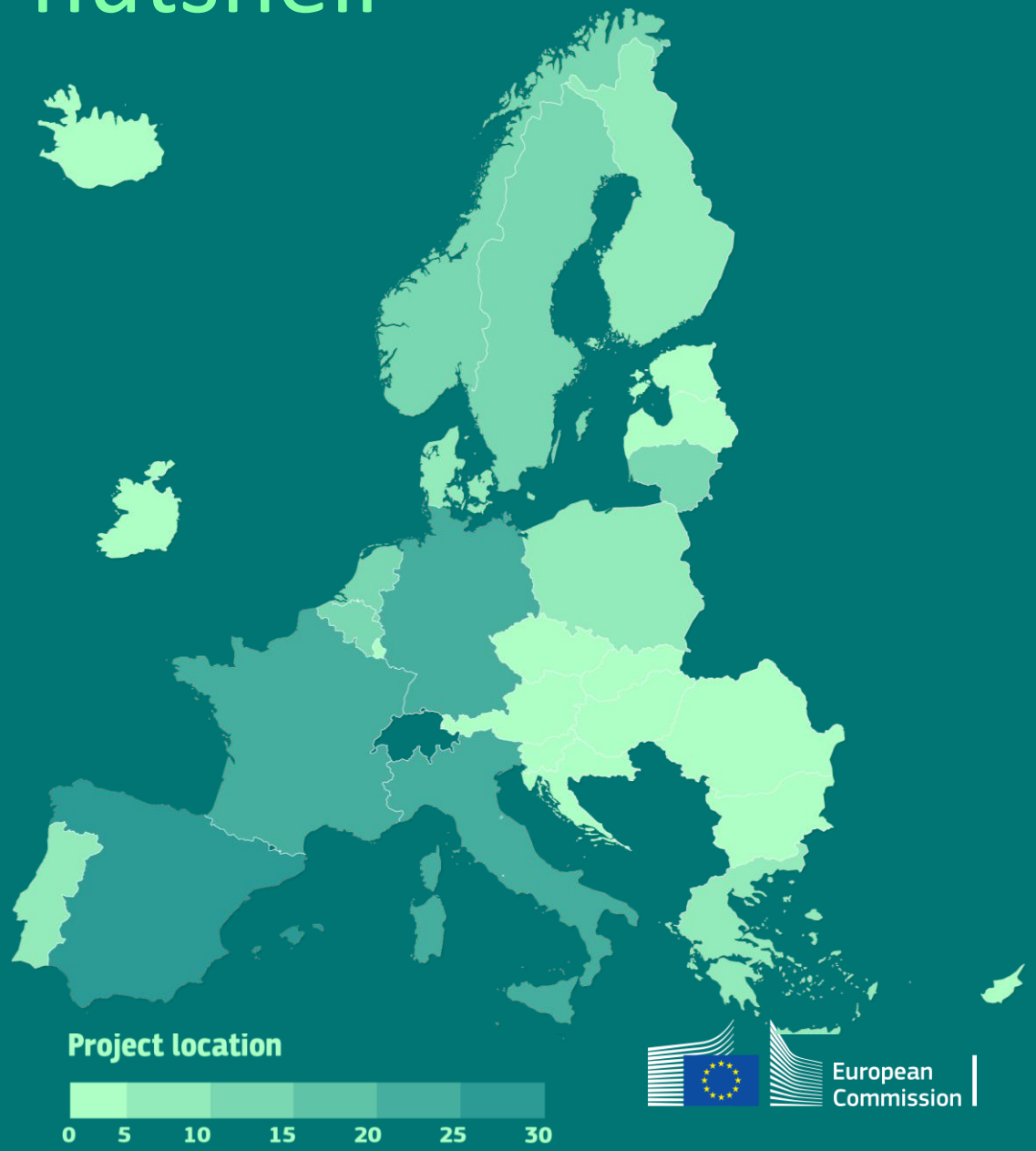
The Innovation Fund in a nutshell

208 projects

€ 12.04 Billion
grants up to now

~929 Mt CO_2 eq
to be avoided**

26
Countries



European Commission

Based on data from the end Q3 2024 & results IF NZT23
*GAP: Grant Agreement Preparation
** estimated based on 10 years operations

Examples of CCUS projects in the Innovation Fund

Carbon Capture and Storage

- CCS from chemicals and hydrogen production
- Bioenergy with CCS in Stockholm
- CCS projects in cement industry
- Carbon storage

Carbon Capture and Use

- Renewable chemical and fibre projects
- Bio-refinery projects
- Waste-to-fuel plants
- Chemical recycling projects from waste to plastics

18.6 Mt CO_2 to be annually captured by current Innovation Fund Projects

High share of CCUS projects in the Innovation Fund

- > 42% by the budget
- ~21% by the number of projects

Certification of carbon farming and removals

Carbon Removal and Carbon Farming Regulation (**CRCF** Regulation)

Carbon Farming

- Soil emissions reductions
- Carbon sequestration in forests and soils

Carbon storage in buildings

- Long lasting use of biomaterials

Permanent removals

- Bioenergy with Carbon Capture and Storage (BECCS)
- Direct Air Capture and Storage (DACCS)
- Biochar

Certification methodologies

- Developed together with an expert group
- First set of methodologies expected to be adopted by end of **2026**

Certification process and registry

- Third-party verification
- EU registry by **2028**

Next steps towards certification

December 2024	Entry into force of CRCF Regulation	Regulation - EU - 2024/3012 - EN - EUR-Lex
2025	Proposal of certification methodologies for permanent removals	DACCS BioCCS Biochar
	Proposal of implementing act on verification and registries	
2026	Start of certification	EC recognition of certification schemes
		First issuance of certified units
2028	Start of EU registry	

European Commission

Regulatory frameworks for voluntary carbon market

Corporate Sustainability Reporting Directive

- Sustainable Reporting Standards on Climate for non-financial reporting

Green Claims

- Commission proposal from March 2023 on environmental claims
- Currently in co-decision

More information:

- DG CLIMA website on Carbon Removals and Carbon Farming
- CRCF Regulation: Regulation - EU - 2024/3012 - EN - EUR-Lex
- FAQ: a8abe1c4-a3c6-4c94-be0e-4b76f7fd0308_en (europa.eu)
- EU carbon removals newsletter

Industrial Case Study: Successful Integration of CCS Projects: A Case Study of CO_2LLECT in Rüdersdorf for Large-Scale Industrial Decarbonisation

We are unable to circulate the slides for this presentation, however if you do have any questions, please direct to Philipp via philipp.roder@cemex.com

Funded by the European Union

4.6.2025

Philipp Roder, Director CCUS EMEA

UC3® Technology - Patented Hydrogen Utilisation to Improve Combustion Efficiency

DECARB CONNECT 3 – 4 June 2025

ULTIMATE TECHNOLOGY

TO INDUSTRIAL SAVINGS

01

WHO WE ARE

UC3® TECHNOLOGY

OPTIMIZATION OF CONTINUOUS COMBUSTION PROCESSES
BY INJECTING SMALL AMOUNTS OF HYDROGEN (H_2) AND OXYGEN (O_2) INTO THE COMBUSTION SYSTEMS

- **UC3®** technology is **protected by an International Patent** under the Patent Cooperation Treaty (PCT) and within the framework of the World Intellectual Property Organization (WIPO)
- **Worldwide** Product Liability **Insurance** of € 10,000,000 for General Civil Responsibility covered by the Insurance Company **AIG**

02
OUR VISION

By 2030, we envision to stand as the **world's leading reference** enabling **unprecedented reductions in global CO_2 emissions**.

By **improving the Combustion Efficiency**

Lower Environmental Impact

Lower Carbon Footprint

03

BUSINESS FOOTPRINT

P2I

Power to Industry

DRIVERS OF OPTIMIZATION

HIGHER PRODUCTIVITY | LOWER EMISSIONS

ACTUAL MARKETS

- CEMENT
- BIOMASS POWER PLANT
- PULP & PAPER
- MUNICIPAL SOLID WASTE POWER PLANT
- SUGAR CANE
- STEEL

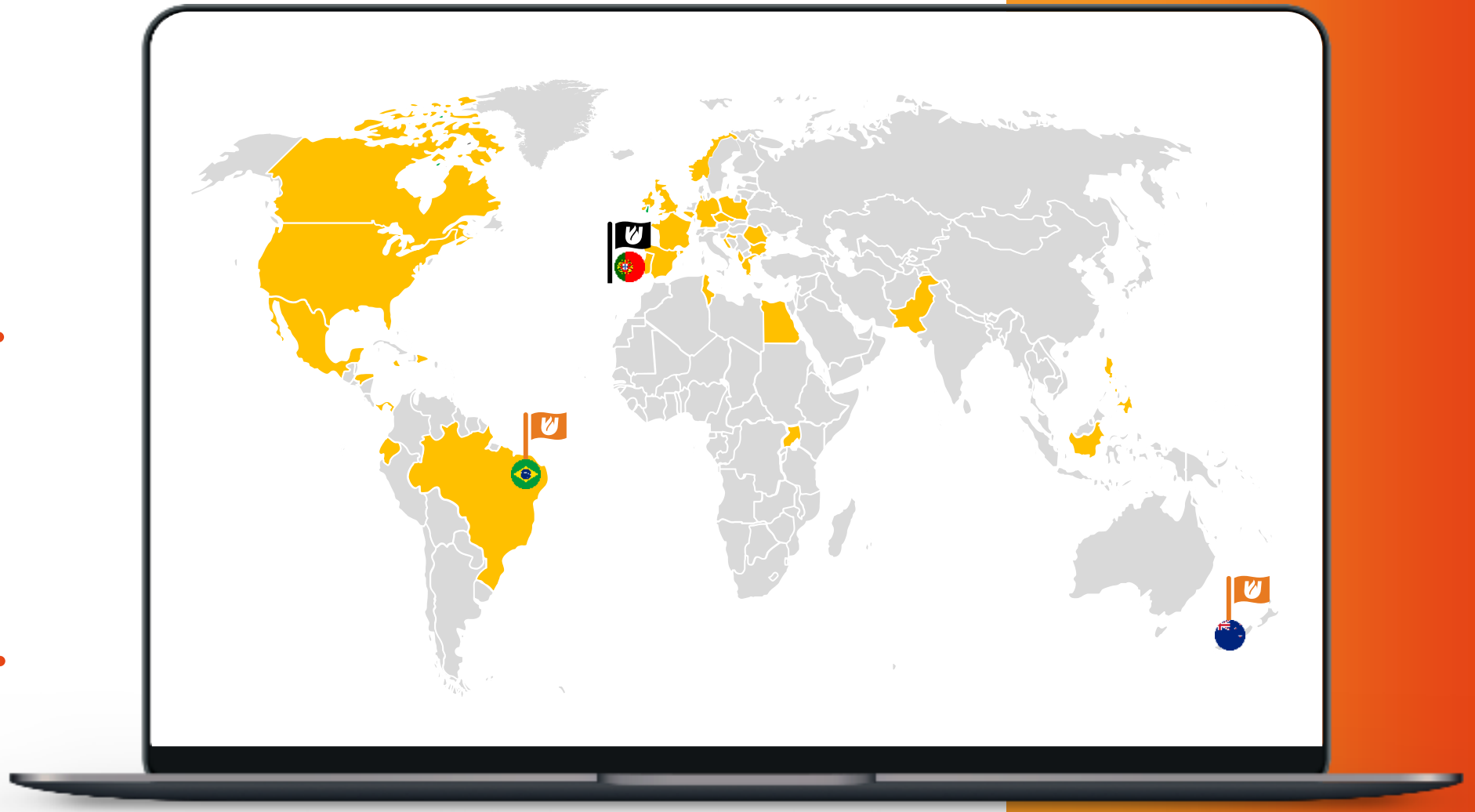
NEW MARKETS

- COAL POWER PLANT
- GLASS

03
BUSINESS FOOTPRINT

150
PROJECTS

29
COUNTRIES



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SUSTAINABLE
COMBUSTION
SYSTEMS

04

UC3® TECHNOLOGY

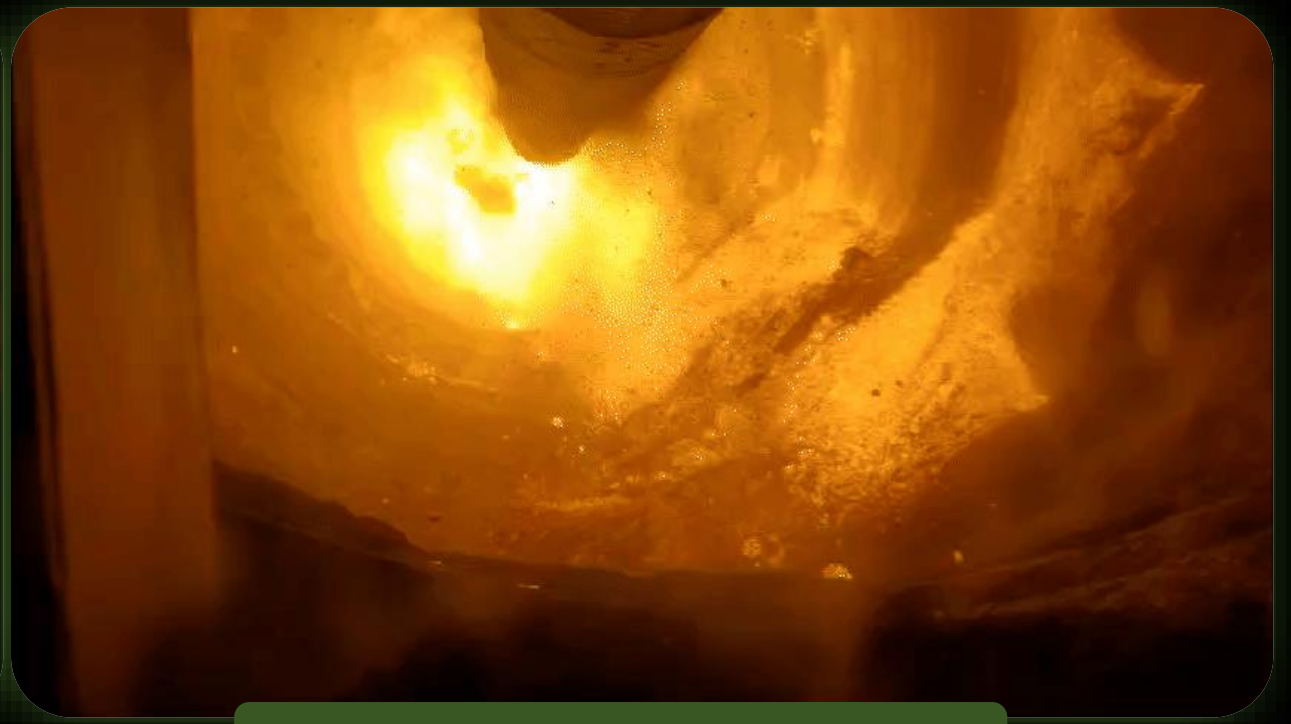
This technology guarantees:

AN IMPROVEMENT OF COMBUSTION, ENSURING A **REDUCTION ON CO** EMISSIONS BY INCREASING THE SPEED OF THE COMBUSTION.

SMALL AMOUNTS of **H_2** and **O_2**, produced by PEM technology, are injected into the existent combustion system.

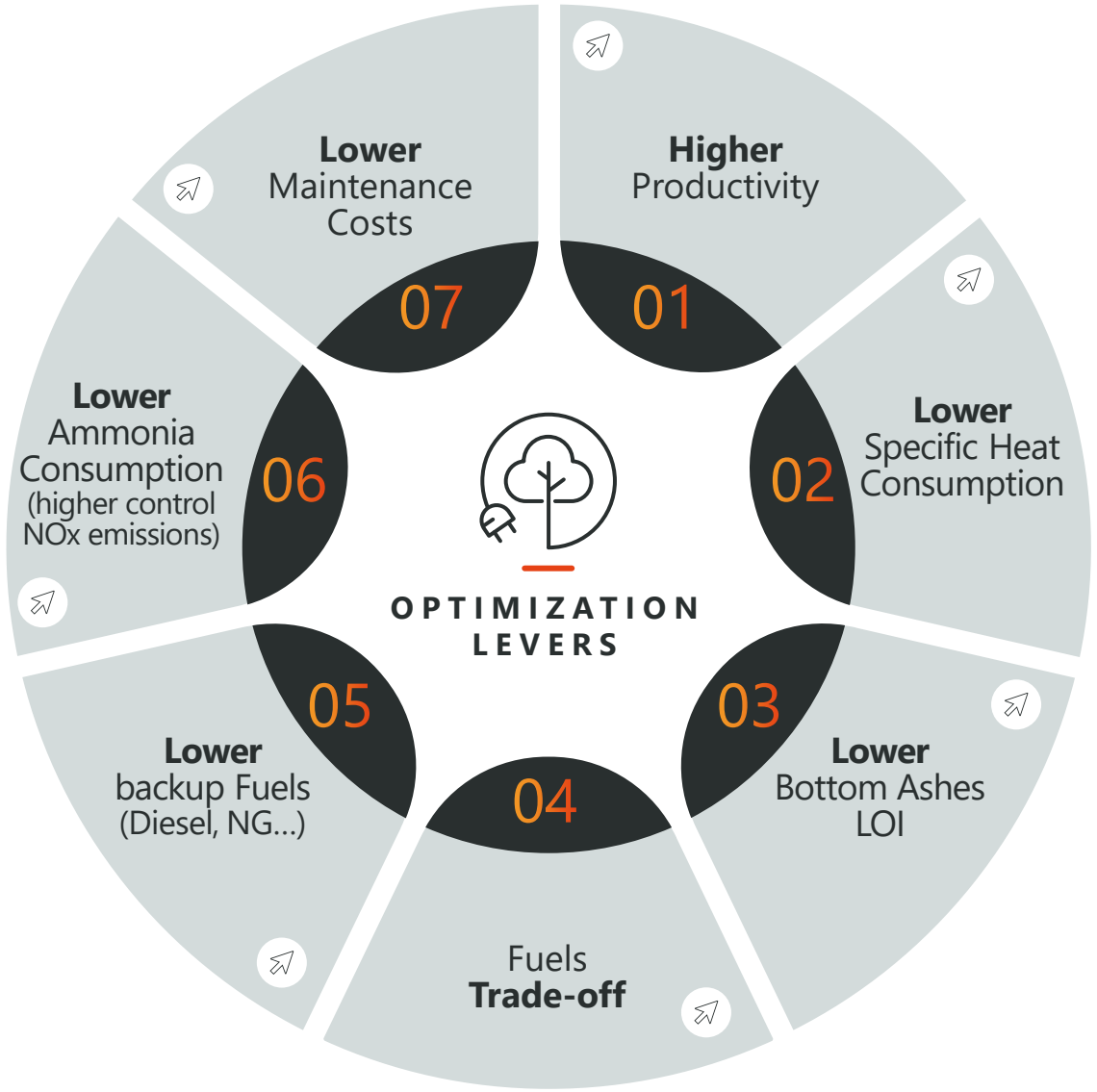
THE **INCREASE IN SPEED OF THE COMBUSTION**, promoted by **H_2** addition, is most a **chemical effect** rather than a thermal effect.

Without UC3® Technology



With UC3® Technology

05
BOTTOM LINE RESULTS
BIOMASS



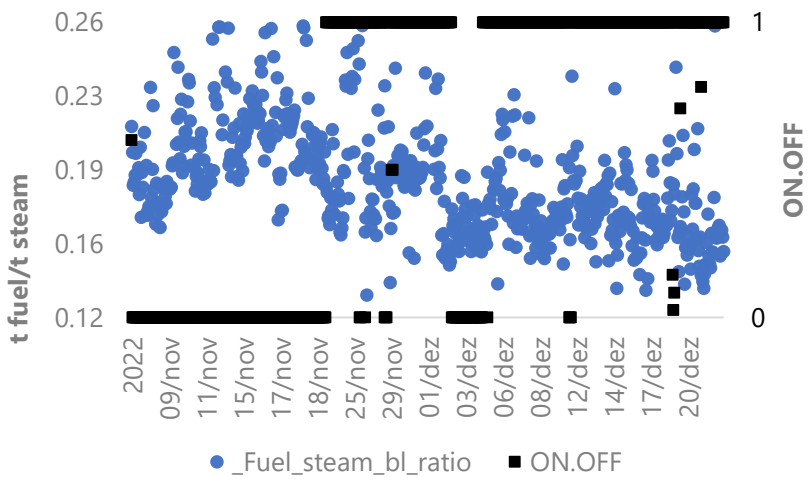
BIOMASS
POWER PLANT

02

LOWER SPECIFIC HEAT CONSUMPTION

CASE STUDY 4

FUEL/STEAM RATIO



+25%

More energy extraction from the same mass of fuel

BOTTOM ASH
without UC3

145g/L
Bulk Density

72,8%
Loss of Ignition
(950 °C TGA)

BOTTOM ASH
with UC3

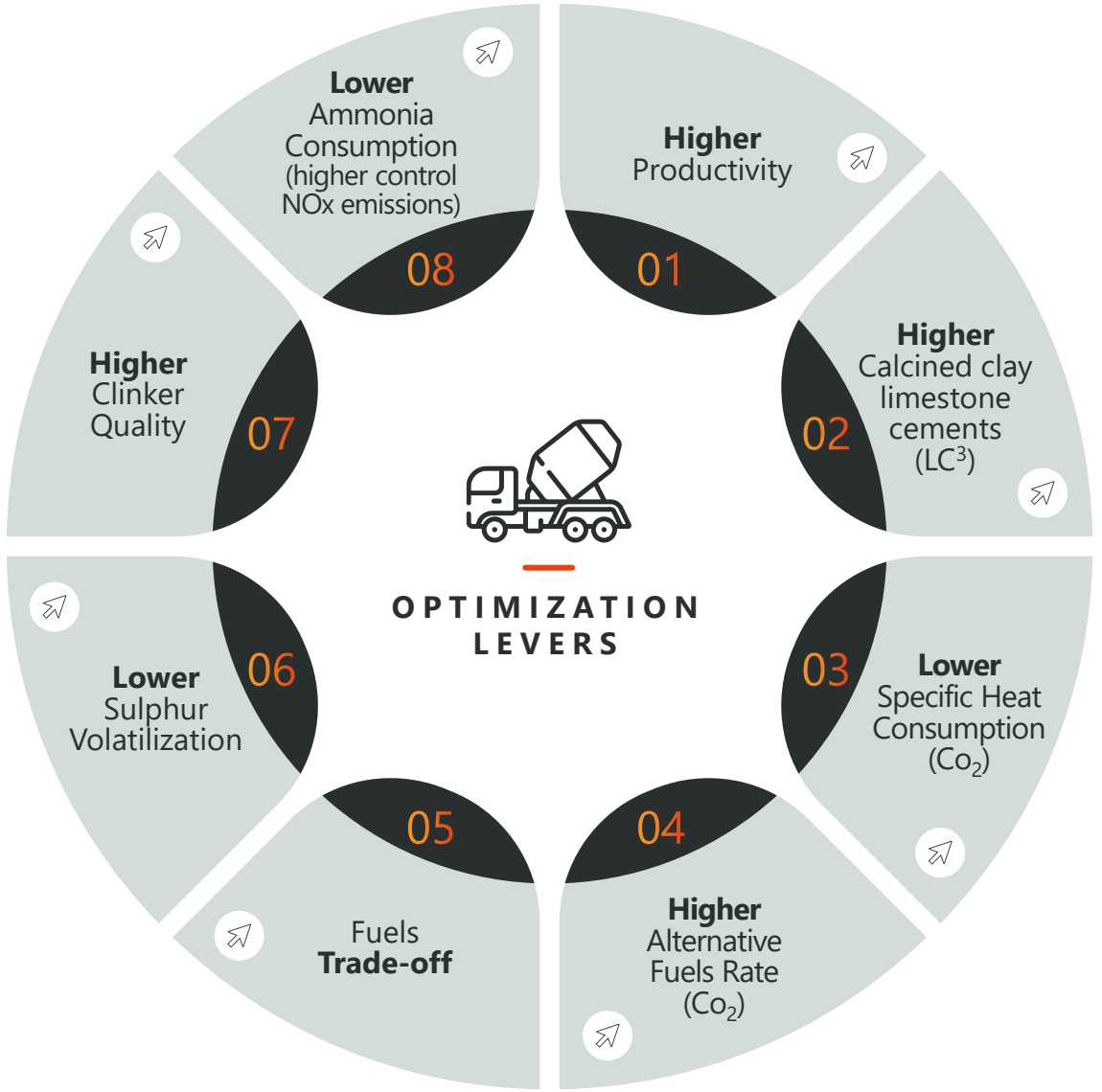
505g/L
Bulk Density

16,9%
Loss of Ignition
(950 °C TGA)

05

BOTTOM LINE RESULTS

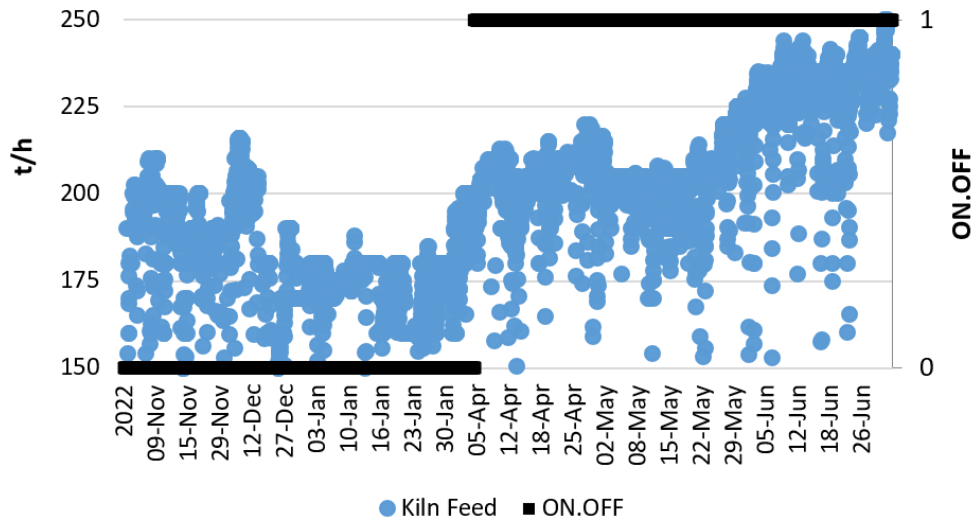
CEMENT



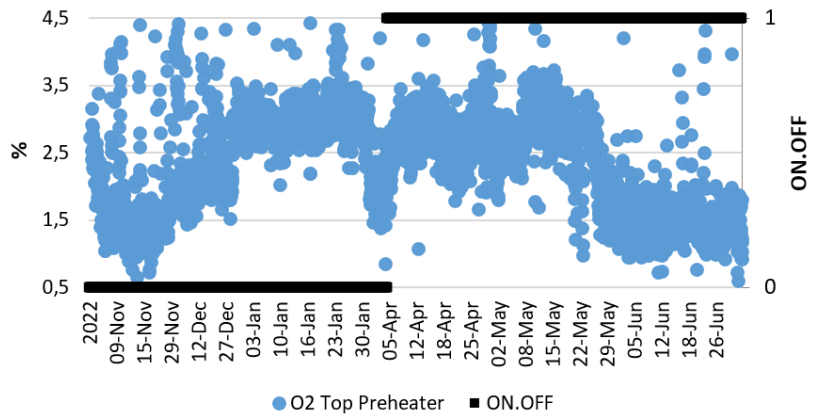
01
HIGHER PRODUCTIVITY

CASE STUDY 1

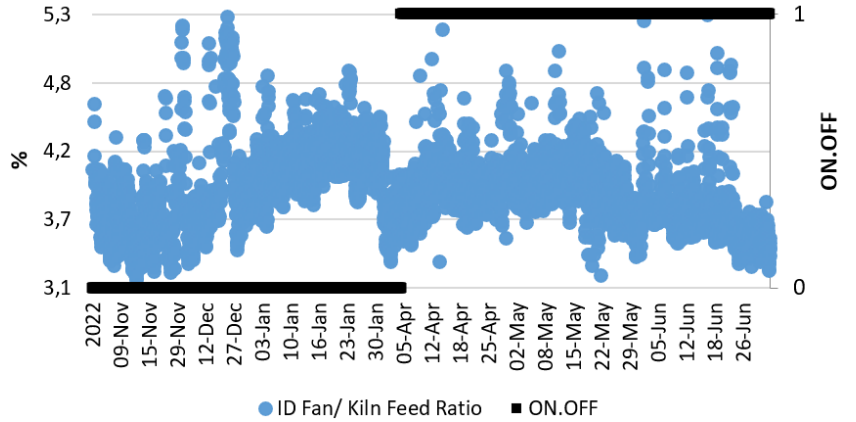
KILN FEED



O_2 Top Preheater



ID Fan / Kiln Feed Ratio



+25%

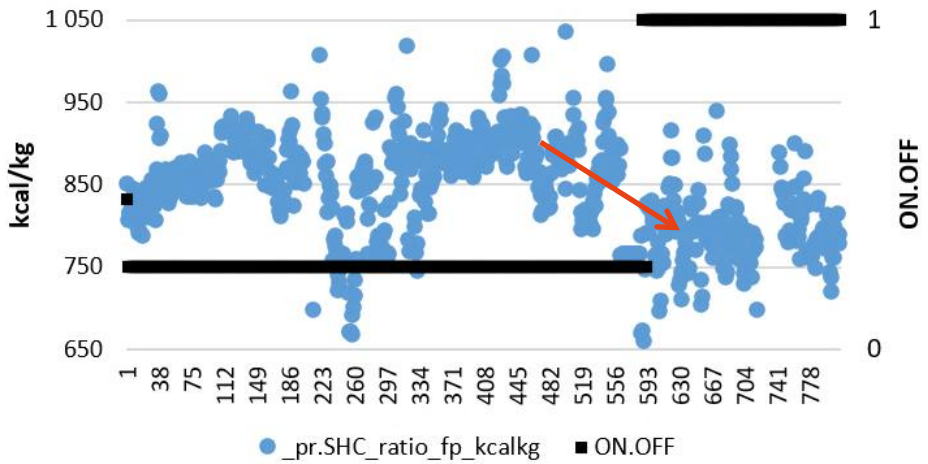
+690
Daily tonnes of clinker

Higher oxygen availability

03
LOWER SPECIFIC HEAT CONSUMPTION

CASE STUDY 1

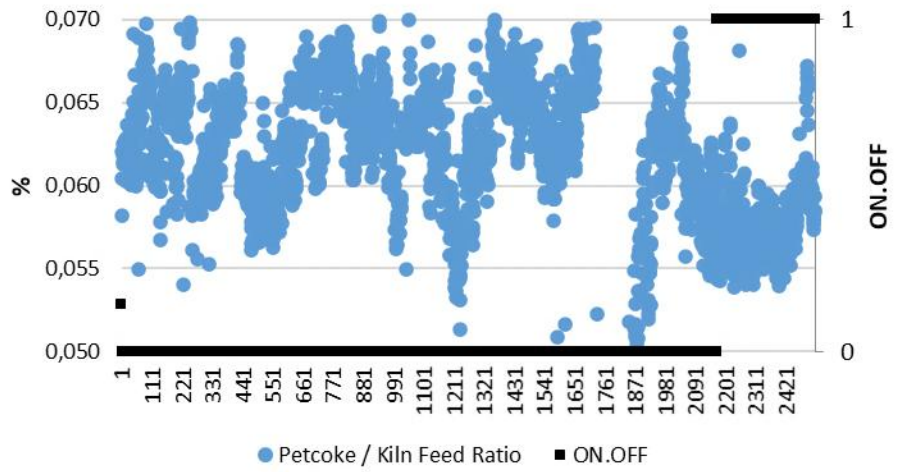
SPECIFIC HEAT CONSUMPTION



1,8t/h
Petcoke Consumption

CASE STUDY 2

PETCOKE/KILN FEED RATIO



1,2t/h
Petcoke Consumption

SHC REDUCTION THROUGH PETCOKE REDUCTION

SHC ▼ **76** kcal/kg

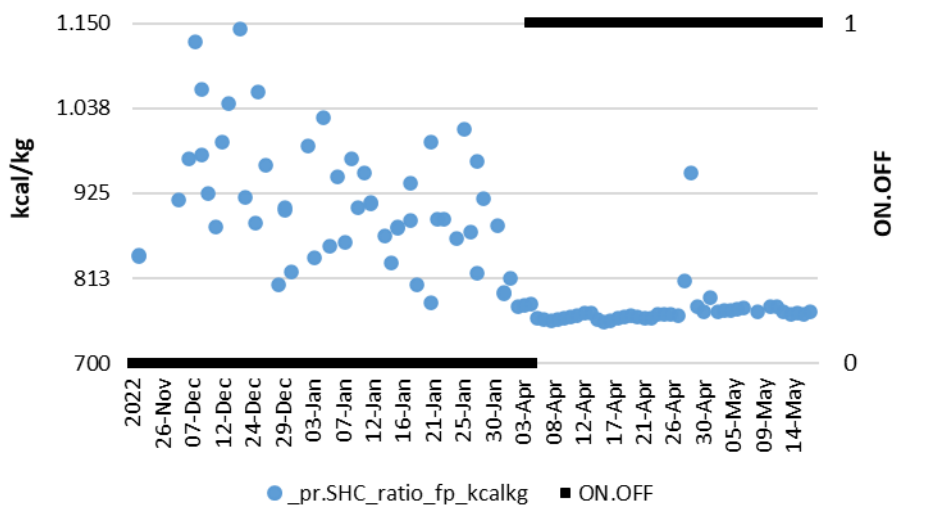
4600 TPD Clinker	**Rated capacity**	**3550** TPD Clinker
100% Solid Fossil Fuels	**Fuels**	**Ptk & AF** Fuels

65 kcal/kg ▼

03
LOWER SPECIFIC HEAT CONSUMPTION

CASE STUDY 3

SPECIFIC HEAT CONSUMPTION



2,0t/h
Petcoke Consumption

SHC REDUCTION THROUGH PETCOKE REDUCTION

SHC ▼ **142** kcal/kg

3300 TPD Clinker < **Rated capacity**

100% Solid Fossil Fuels < **Fuels**

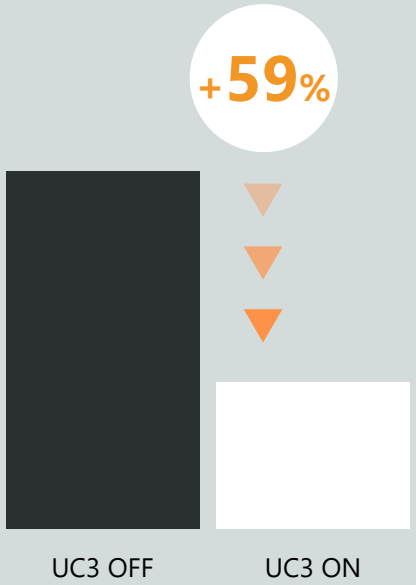
04

HIGHER ALTERNATIVE FUEL RATE

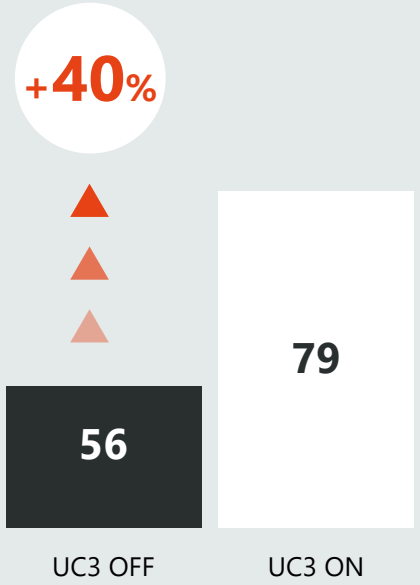
COMBUSTION EFFICIENCY

CASE STUDY 1

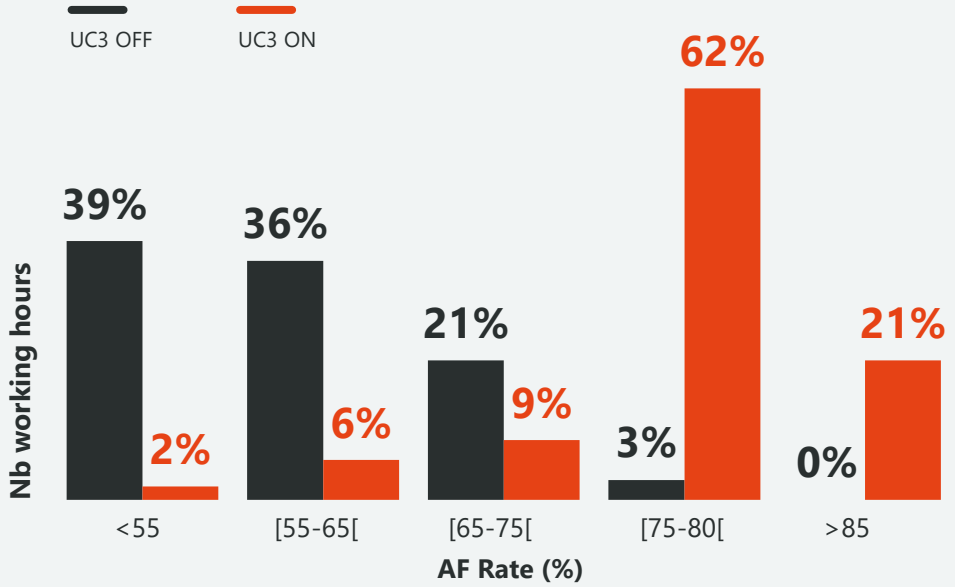
RATIO PETCOKE/KILN FEED



ALTERNATIVE FUELS RATE



ALTERNATIVE FUELS RATE PROFILE



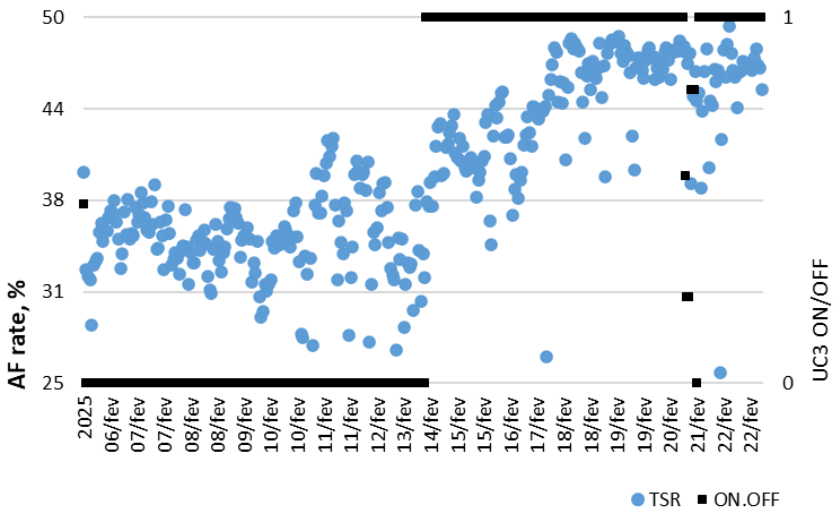
Depending on the Alternative Fuels mix, **CO_2 emissions can be reduced up to the limit of Petcoke reduction**

04

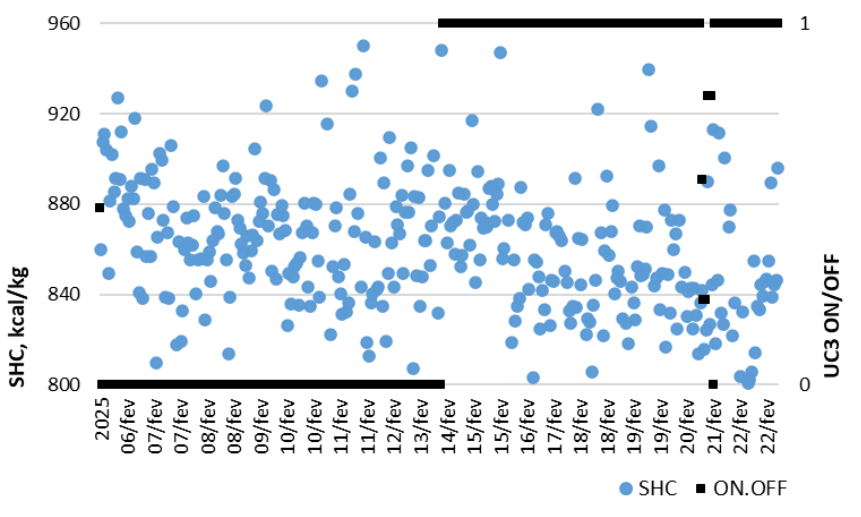
HIGHER ALTERNATIVE FUEL RATE

CASE STUDY 3

HIGHER
ALTERNATIVE FUEL RATE



LOWER
SPECIFIC HEAT CONSUMPTION



The improved combustion efficiency, allows:

HIGHER **THERMAL SUBSTITUTION RATE**

AND

LOWER **SPECIFIC HEAT CONSUMPTION**

▲ Up to **11pp**
THERMAL SUBSTITUTION RATE

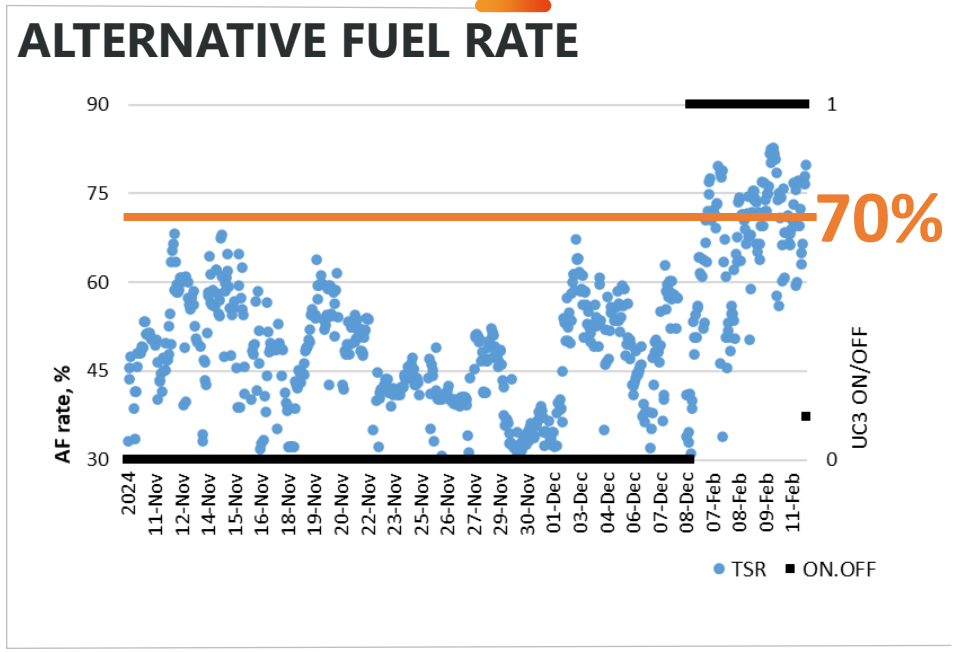
▼ **3%**
SPECIFIC HEAT CONSUMPTION

04

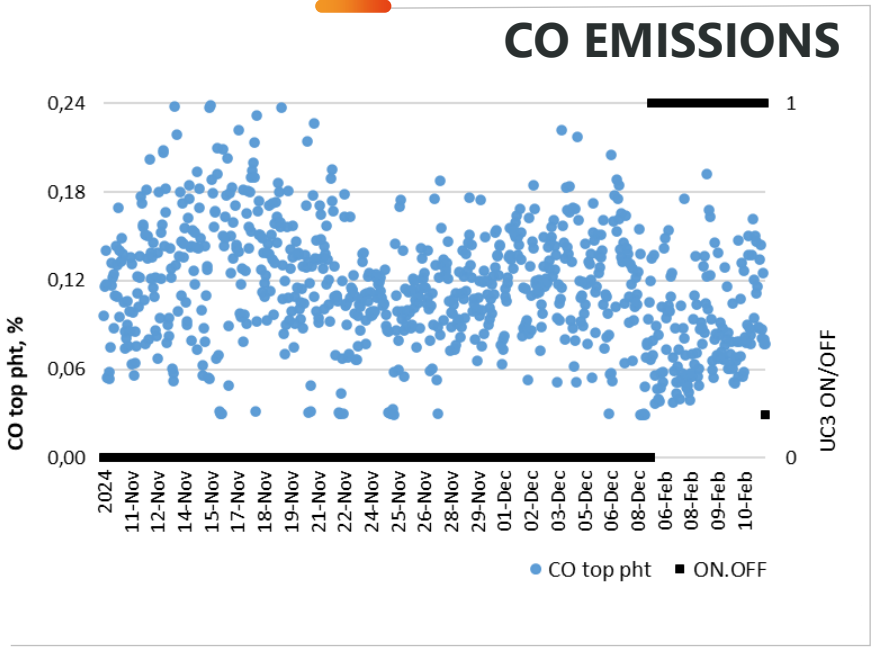
HIGHER ALTERNATIVE FUEL RATE

CASE STUDY 3

HIGHER ALTERNATIVE FUEL RATE



LOWER CO EMISSIONS



The improved combustion efficiency, allows:

HIGHER **THERMAL SUBSTITUTION RATE**

AND

LOWER **CO EMISSIONS**

▲ Up to **13pp**
THERMAL SUBSTITUTION RATE

▼ **31%**
CO EMISSIONS

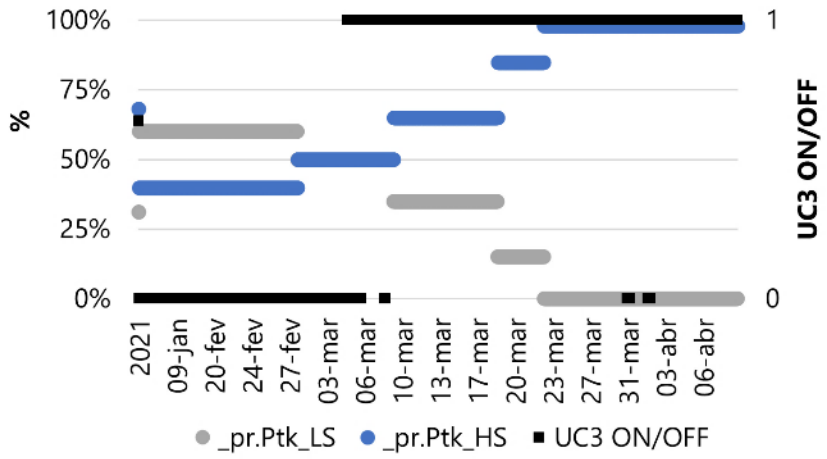
06

FUELS TRADE-OFF & **LOWER SULPHUR VOLATILIZATION**

CASE STUDY 1

FOSSIL FUELS TRADE-OFF

FOSSIL FUELS MIX EVOLUTION



100% Petcoke 6,0%S

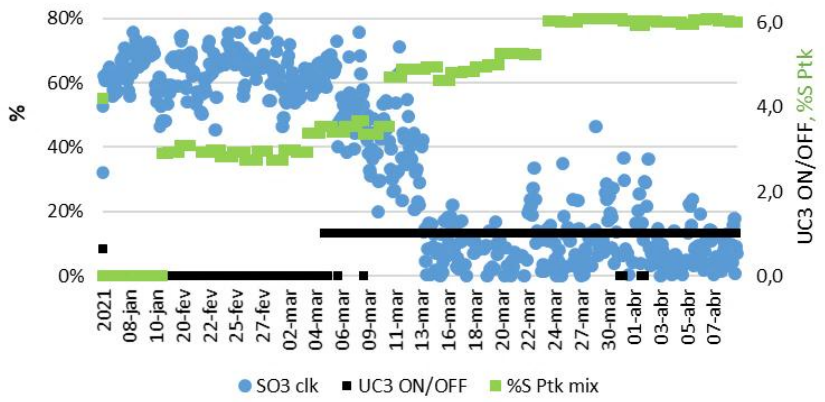
Higher sulphur input through fuels

HIGHER **COMBUSTION EFFICIENCY** ENABLES NA ACCURATE **CONTROL** OF **SULPHUR** VOLATILIZATION CYCLE

Trade-off of solid fossil fuels to a **higher sulphur** content

ACCURATE CONTROL OF **SULPHUR** VOLATILIZATION CYCLE

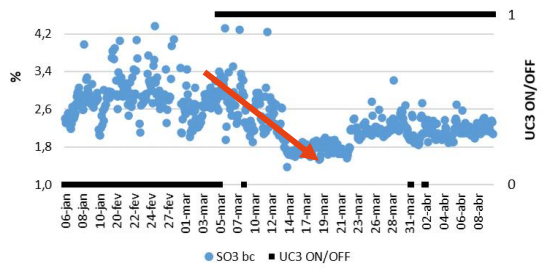
SULPHUR VOLATIZATION vs %S PETCOKE



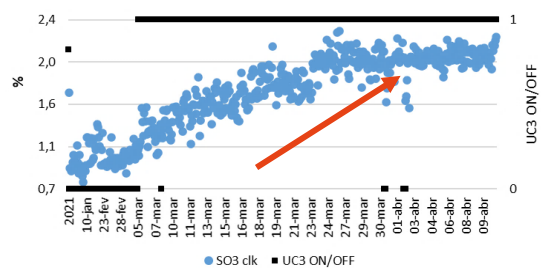
50%

Sulphur volatilization

SO_3 BOTTOM CYCLONE



SO_3 CLINKER



100%

BETTER **SO_3 PURGE** THROUGH CLINKER

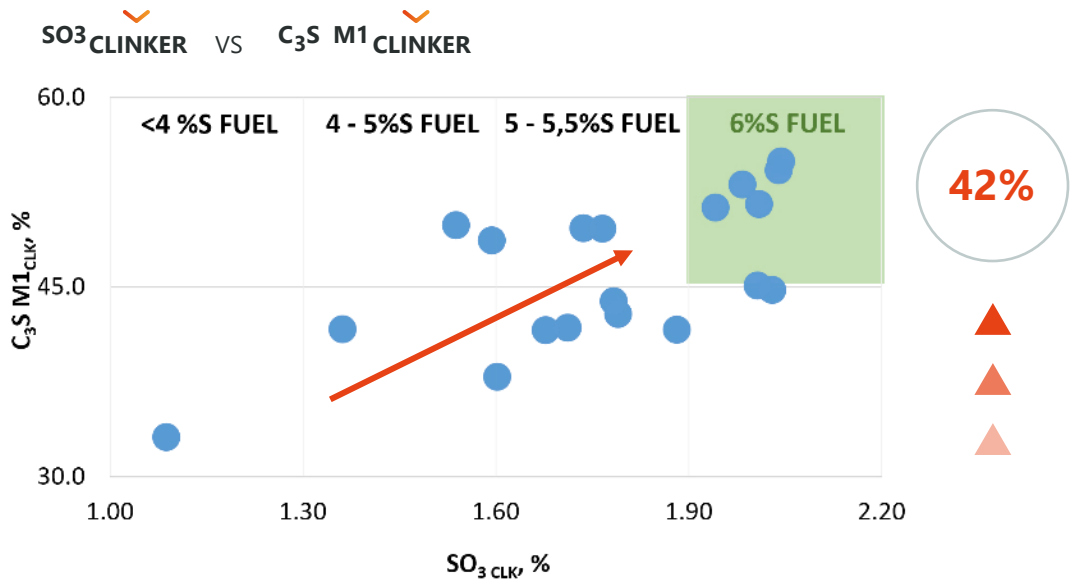
07

HIGHER CLINKER QUALITY

CASE STUDY 1

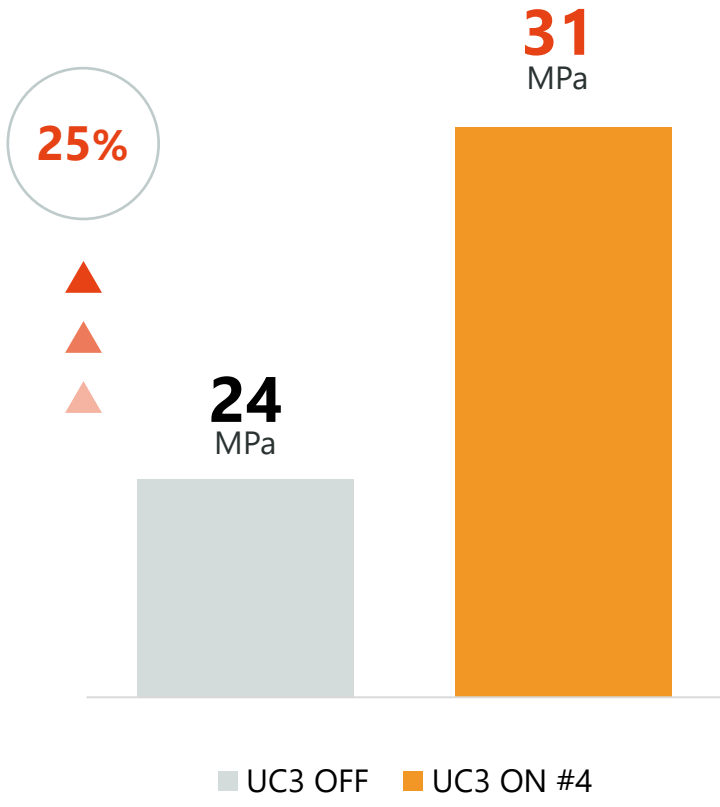
OPTIMIZATION LEVERS

BETTER CLINKER REACTIVITY



HIGHER **CLINKER REACTIVITY** (↑C3S M1)

C_3S M1 is the C3S polymorph that brings more reactivity of clinker



BETTER SO_3 **PURGE** THROUGH CLINKER

08

BETTER NOx EMISSIONS CONTROL

CASE STUDY 1

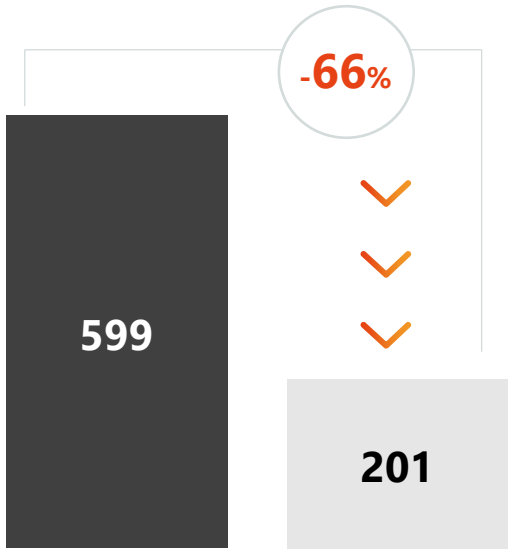
OPTIMIZATION LEVERS

AMMONIA CONSUMPTION

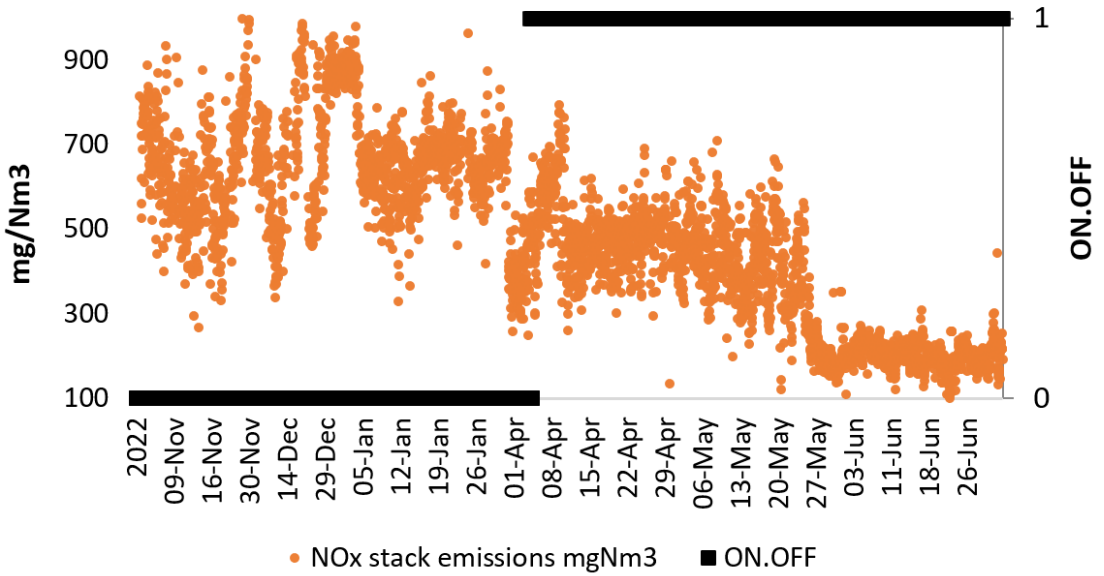
Higher **kiln stability**

Lower **Excess air**

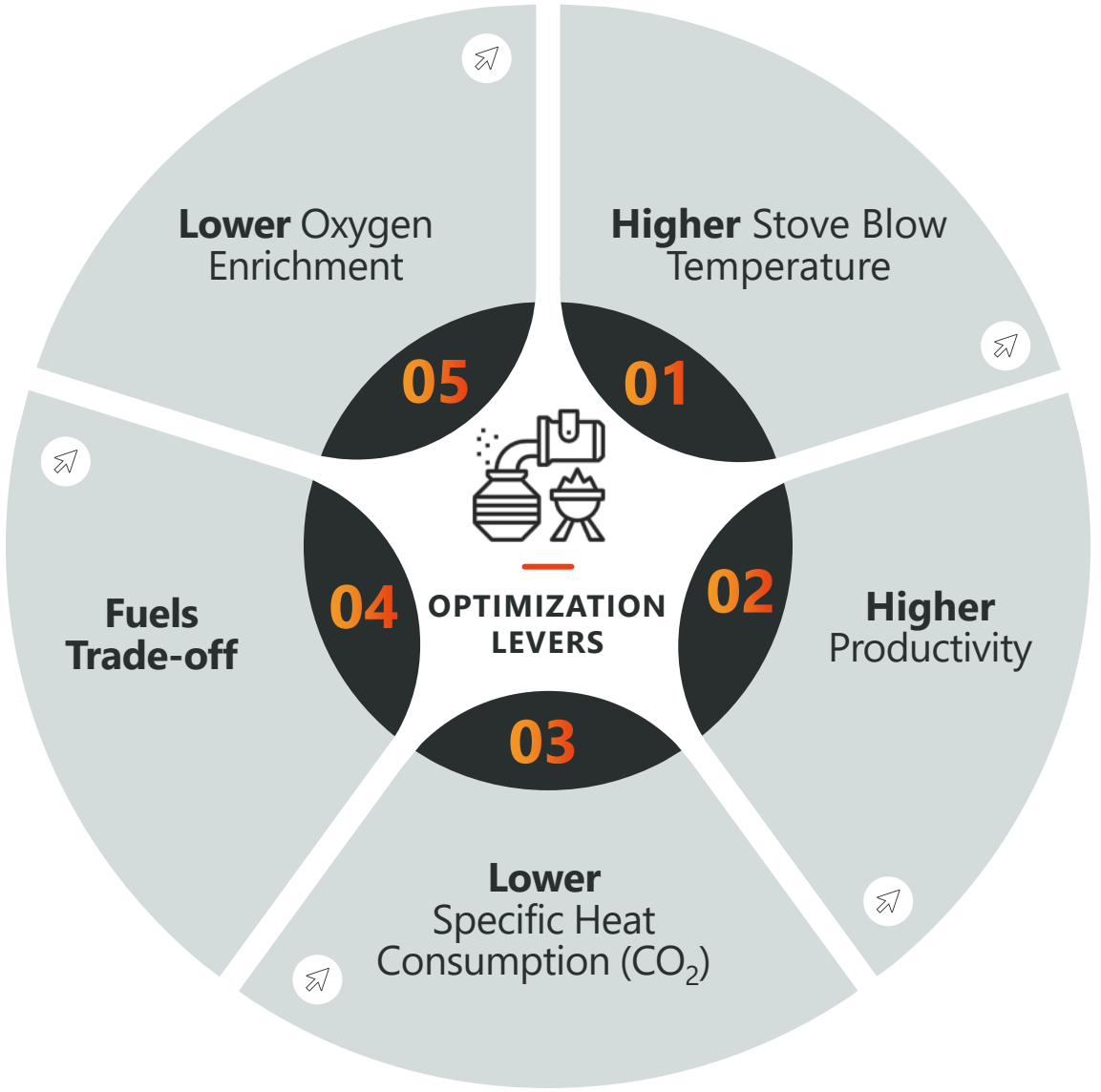
Higher **alternative fuel rate**



Lower NOx emissions
control costs



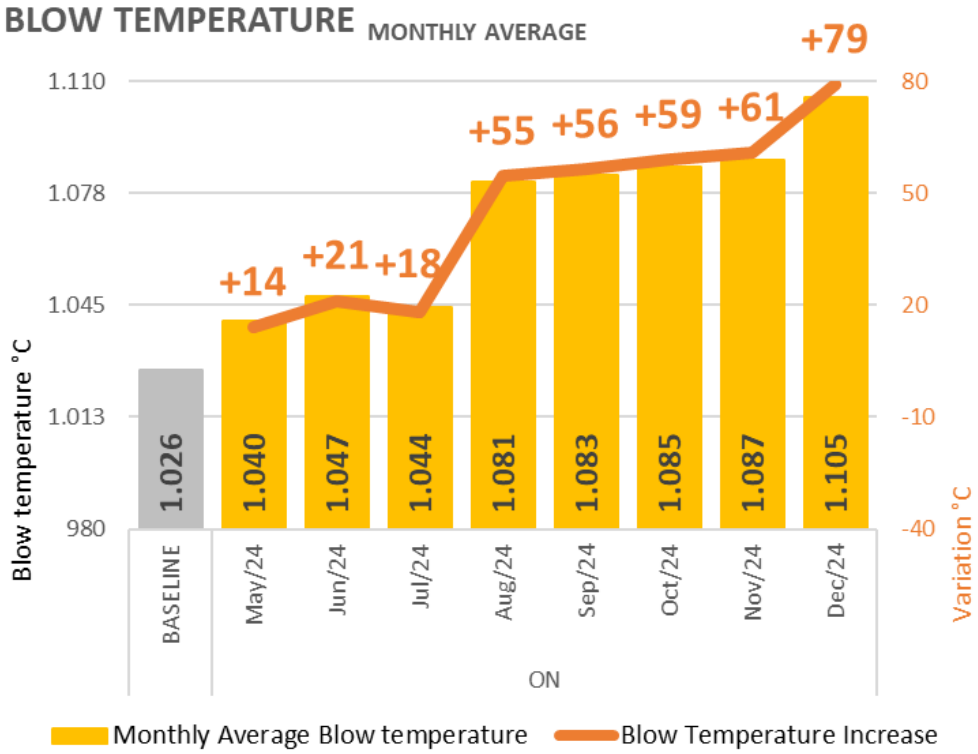
05
BOTTOM LINE RESULTS
STEEL



01

IMPROVED **COMBUSTION EFFICIENCY**

CASE STUDY 1



↑8%

STOVES BLOW TEMPERATURE

↓6%

CO_2 EMISSIONS

LOWER COKE RATE OF THE BAST FURNANCE

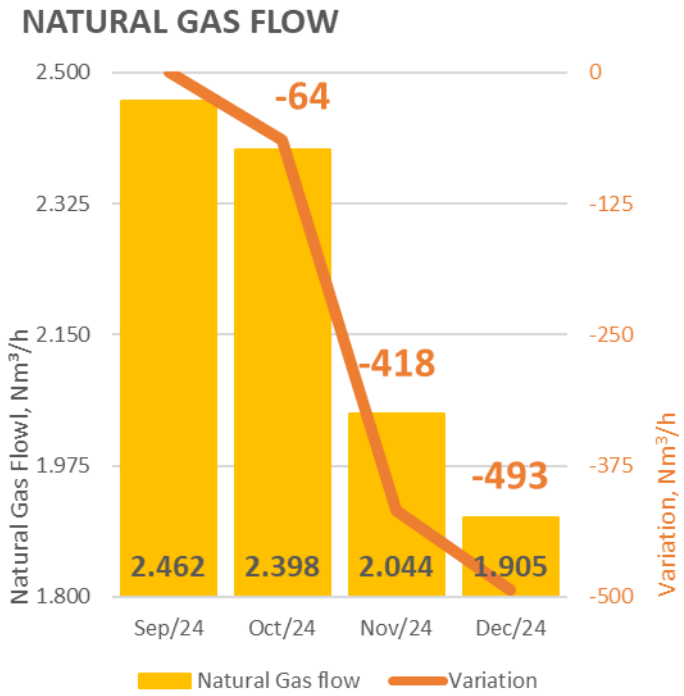
The UC3® Technology allows a higher combustion efficiency of the Blast Furnace Gas.

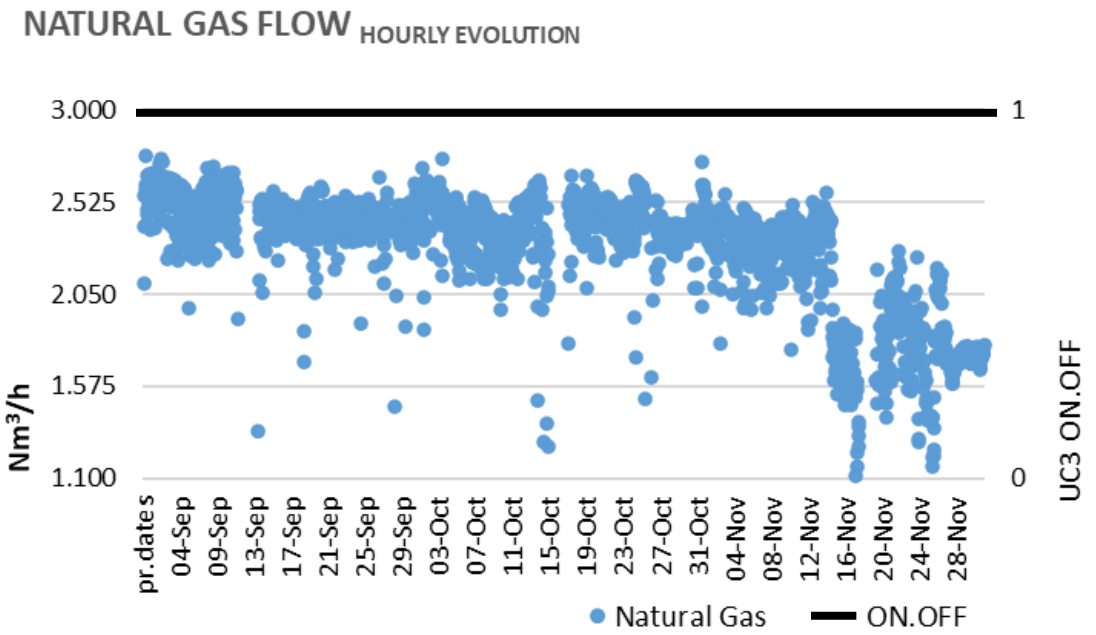
- **HIGHER** STOVES HEAT ACCUMULATION
- **HIGHER** BLOW TEMPERATURES
- **LOWER** COKE RATE IN BLAST FURNANCE

04

FUELS TRADE-OFF

CASE STUDY 1





The UC3® Technology allows a higher combustion efficiency of the Blast Furnace Gas, promoting a lower need of booster fuels, as Natural Gas.

Thank you
for your attention

UTIS®
Ultimate Technology to Industrial Savings, S.A.
Estrada Nacional 249-4, Km 4
2785-035 São Domingos de Rana
Cascais – Portugal

Follow us

How to Decarbonize a Specialty Chemicals Company: Clariant's Journey

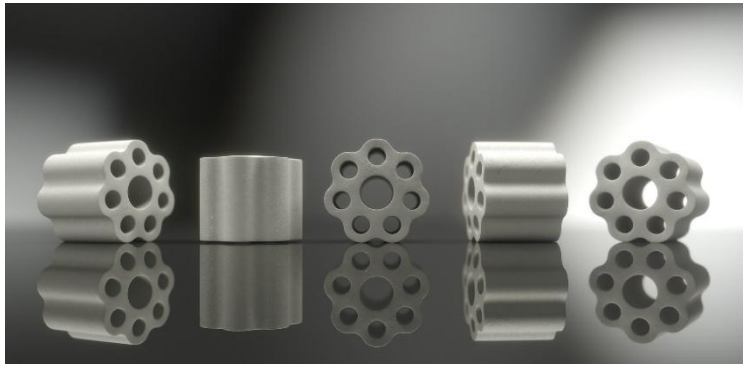
Sustainable Operations

Dieter Regnat
Technology & Sustainability
03.06.2025

Three Business Units – Clariant's Portfolio for long-term sustainable growth

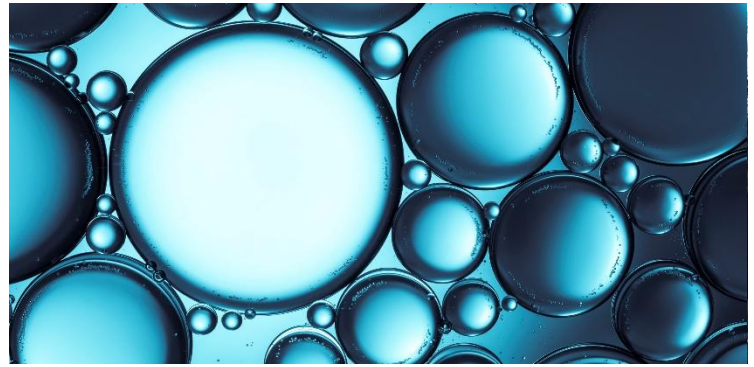
Care Chemicals

The Business Unit Care Chemicals consists of the Business Segments **Personal & Home Care**, **Crop Solutions**, **Industrial Applications**, Base Chemicals, Oil Services, and Mining Solutions. The business unit has a clear focus on highly attractive, high-margin, and low-cyclicality segments with a large share of the business being consumer-facing in Consumer Care and Industrial Applications.



Catalysts

The Business Unit **Catalysts** includes the Business Segments Propylene, Specialties, Syngas & Fuels & Ethylene. The business unit contributes significantly to value creation in our customers' operations, ensuring that finite raw materials and energy are used efficiently and, in turn, ensuring the quality and yield of processes.



Adsorbents & Additives

The Business Unit Adsorbents[1] & Additives comprises the Business Segments EMEA, APAC, and Americas on the **Adsorbents** side, as well as **Coatings & Adhesives** and **Polymer Solutions** in Additives. The business unit creates value through enhanced sustainability benefits, for example by enabling material circularity and by reducing customers' dependency on fossil resources to reduce CO_2 emissions.

[1] The Adsorbents business is primarily divided into the EMEA, APAC and Americas regions, with local representatives for Purification, Foundry & Specialties, and Cargo & Device Protection.

Leading in Sustainability anchored in Clariant's Purpose: "Greater chemistry – between people and planet"

Purpose-Led Strategy

1	2	3	3
Customer Focus	**Leading in Sustainability**	Innovative Chemistry	People Engagement

Indicators to measure success

- **Leading with portfolio share classified as sustainable[1]**
- **Leading GHG Intensity Among Peers[2]**
- **Top quartile in sustainability driven external ratings**
- **On track to Top Quartile Employee NPS[3]**

Strong performance in scope 1&2 reduction

Net zero site in Bonthapally, India

Biomass pellets instead of coal firing of the boiler and purchasing 100% green electricity

Scope 1 and 2: 35% of emission reduction[4]

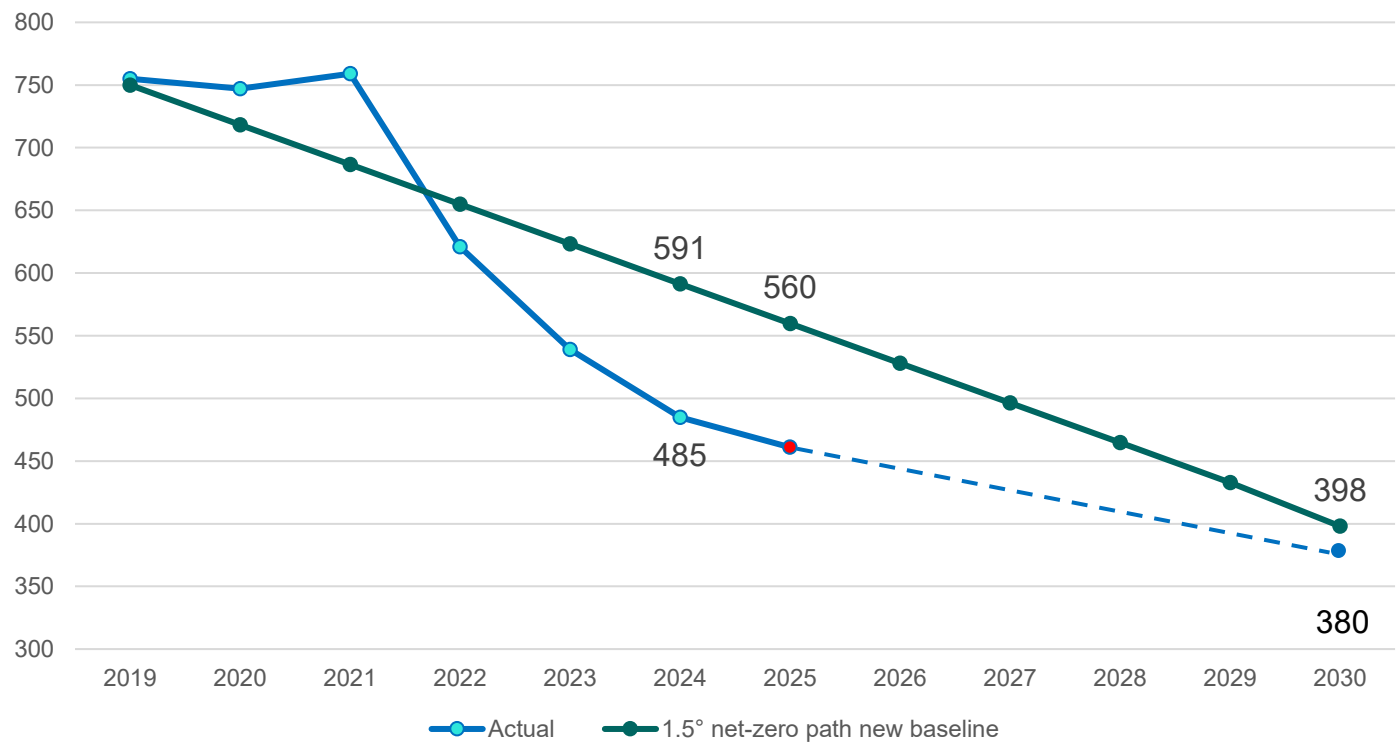
CDP score for "Climate" rose from B to A-

[1] Considering FY 2024 PVP screened portfolio (~ 70 % of sales), disregards "not screened" products and those excluded; excluded from screening are sales not involving third parties, non-strategic items, and internal transactions like joint ventures, licenses, discontinued products, samples, traded goods, and waste [2] Full Scope 3 emissions intensity benchmarked against selected peers with relevant disclosure available [3] Net Promoter Score [4] By 2024 since 2019

Clariant set an ambitious target to reduce scope 1&2 in line with the Paris Agreement by 46.9% compared to the baseline in 2019

Clariant is well ahead of the targeted 46.9% reduction by 2030

Scope 1, 2 emissions [$ktCO_2e$]



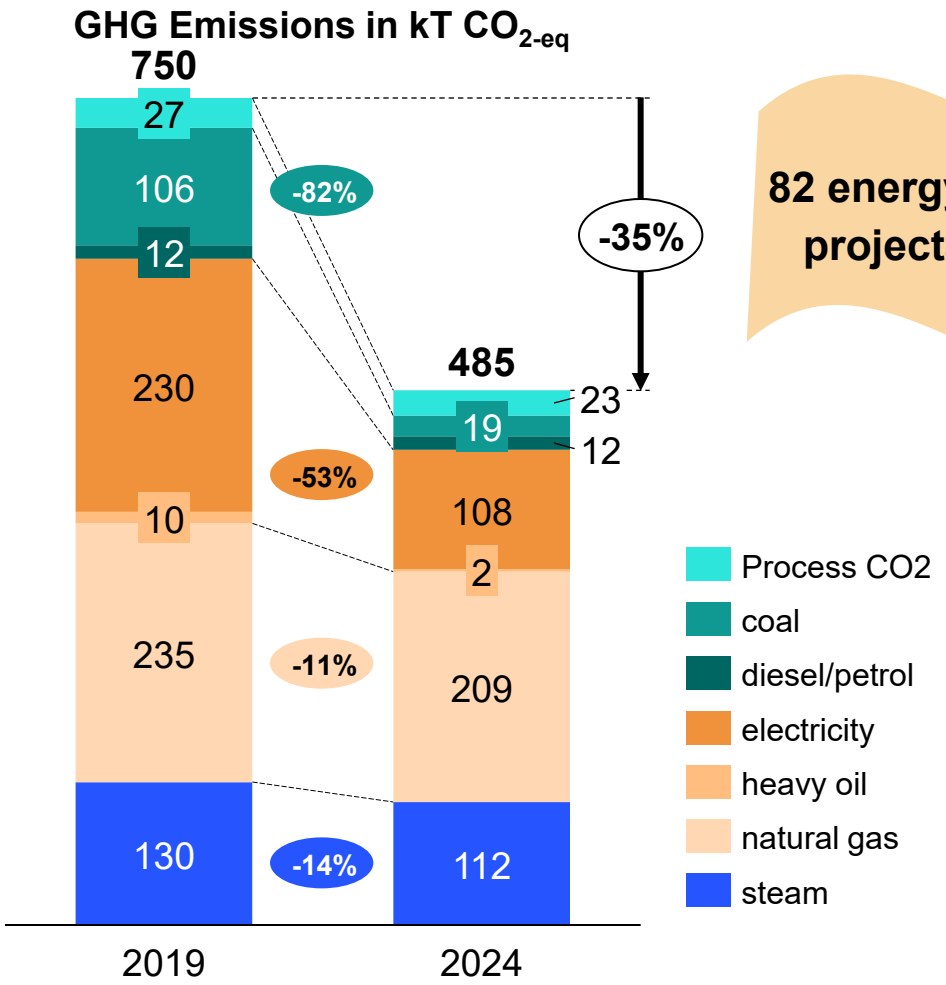
Scope 1&2 reduction

Proven process for **project selection, execution**, and **target setting**

- **Centrally managed global project pipeline**
- **Projects prioritized based on attractiveness** (impact, costs)
- **Regular review based on the latest information**
- **Annual reduction targets in line with pathway goals and CAPEX budgets**
- **Target achievement** is **incentivized**
- **Progress tracked on board level**

Targets are in line with SBTi 1.5°C trajectory and reflecting actual reduction projects as well as budgeted growth for 2025;

So far, energy efficiency, reducing coal usage, and increasing share of green electricity were the main drivers of scope 1&2 emission reduction



82 energy efficiency projects realized

Key drivers for GHG reductions

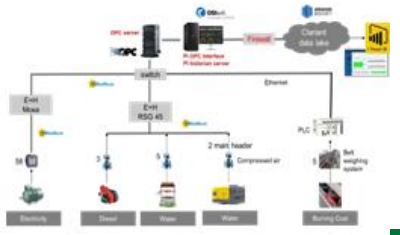
- **Coal** related GHG emissions **reduced by 82% (87kT)**
  - **Sun-drying of bentonites = energy efficiency**
  - **Substitution** of **coal by biomass** in Asia
- **Electricity** related GHG emissions **reduced by 53% (122 kT)**
  - **Green electricity share** increased **from 10 to 65%**
  - **PPAs** in Asia and US: **23 kT** (Germany to come 2026)
  - **Green supply contracts** (bundled REC): **15kT**
  - Unbundled **REC's: 76 kT**
  - **Self-generated green electricity: 8kT**
- **Natural gas** related GHG emissions **reduced by 11% (26kT)**
  - Numerous **energy efficiency measures**
- Purchased **steam** related GHG emissions **reduced by 14% (18kT)**
  - **Energy efficiency measures: -11kT**
  - **Lower carbon steam: -7kT**

Challenges and potential solutions observed in the transformation

Challenge	Potential solution
Green electricity	
– **Fragmented global footprint limits PPA usage** – Energy **consumption pattern determines** PPA **coverage potential**	– **Innovative solutions** aggregate demand and connect with optimal green electricity suppliers
Transition to renewable energy	
– **Coal-to-biomass conversion effective in Asia** and **limited** by availability and costs **in EU/US** – **Replacing natural gas with electrification threatens competitiveness**	– **New technologies**, including **heat batteries**, at attractive costs combined **with low electricity price**
Energy efficiency	
– Measures for **heat integration** in batch production have **long pay back time** – **Low hanging fruits** are **harvested**	– **Combine digitization** (digital eWATCH) **with AI** (“Clarita” AI assistant) to find hidden potentials

Powering Next-Generation Efficiency: Digital eWatch + AI Transforms Energy Management

Data Collect from Sensors

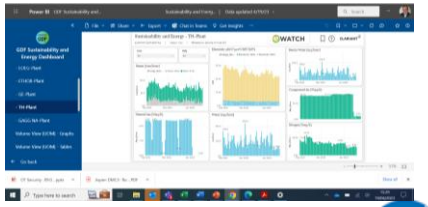


OSIsoft. is now part of AVEVA

Excel

amazon REDSHIFT

Visualizations



Power BI

OSIsoft. is now part of AVEVA

Analytics Platform & AI

jupyter

python

amazon REDSHIFT

Clariant data in Cloud

Plant, process and product data in PI historian and **in the datalake**

Metadata added from Excel spreadsheets, e.g.: **type of fuel**, **conversion factors**

Power BI & PI Vision

Datalake powers advanced analytics for **enhanced dashboards** and **graphics**

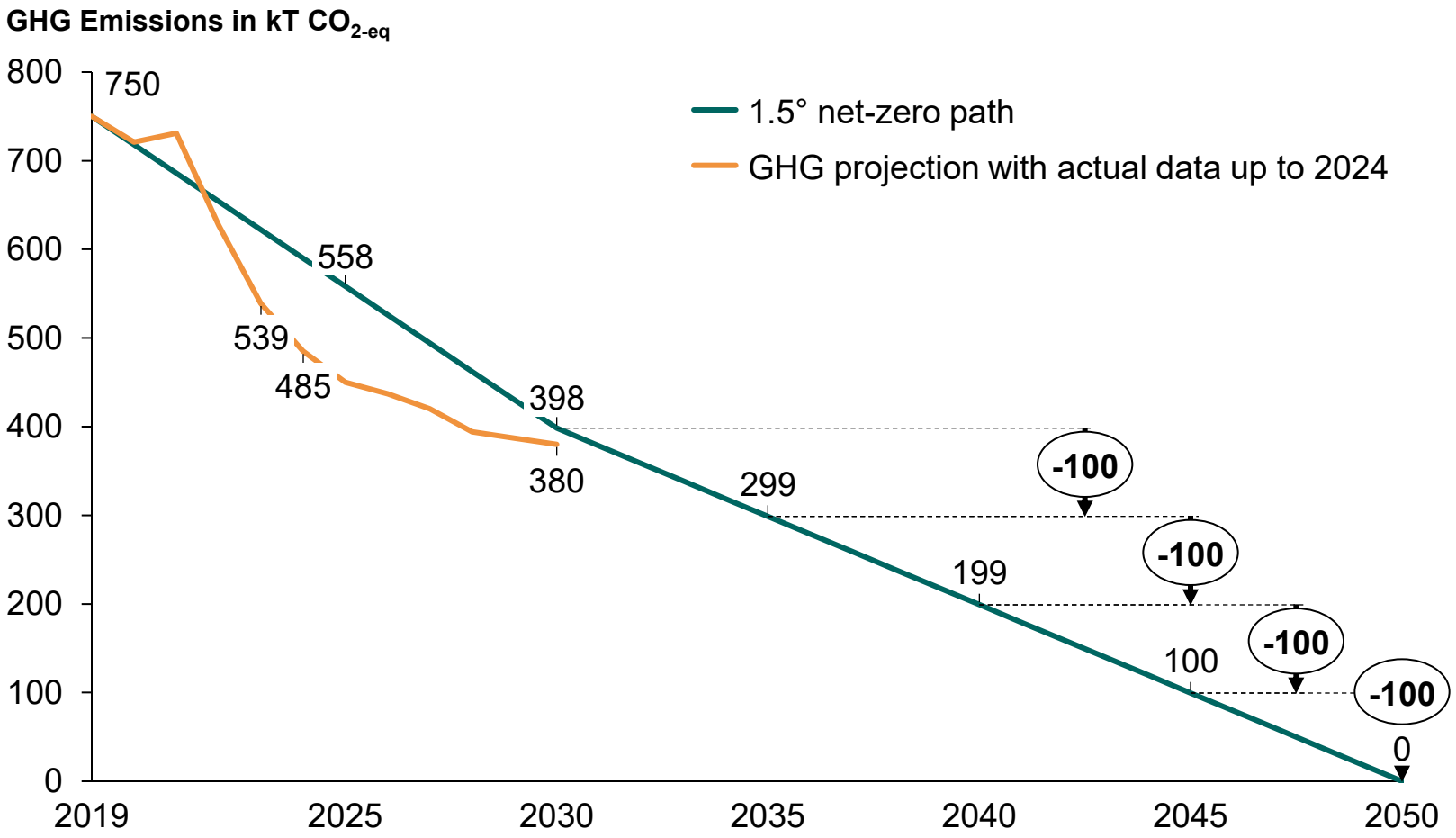
Automated data feed to the **Sustainable Operations Cockpit (SOC)**

Cloud algorithms and GenAI for:

GenAI supported process optimization driving energy efficiency through …

- … providing best process parameters
- … large language model enables dialogue
- … framing of questions

By 2050, Clariant will have to remove 100 kT CO_2 every 5 years to meet the net-zero trajectory



Net-Zero

Removal of

100 kT CO_2-eq every 5 years

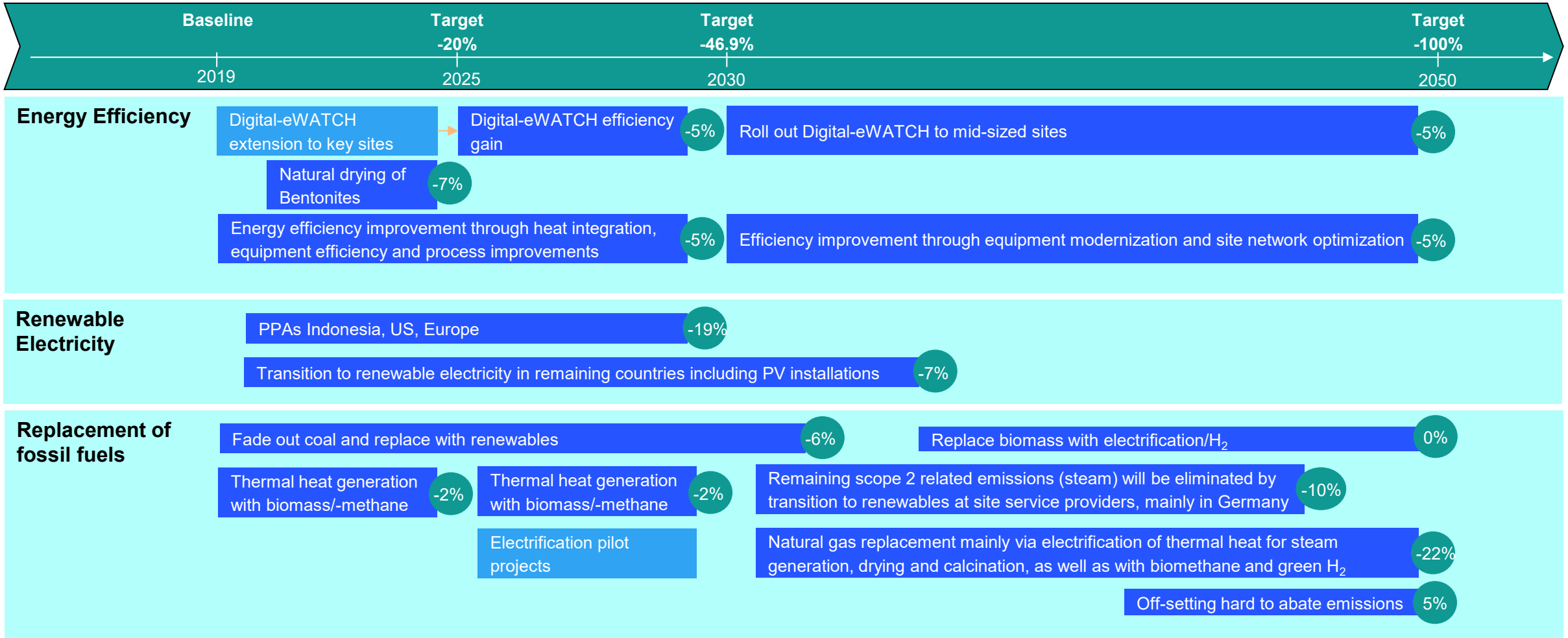
means also

decarbonization of 3 sites per year

Clariant defined Scope 1&2 GHG Net-Zero roadmap to 2050 through 3 key levers

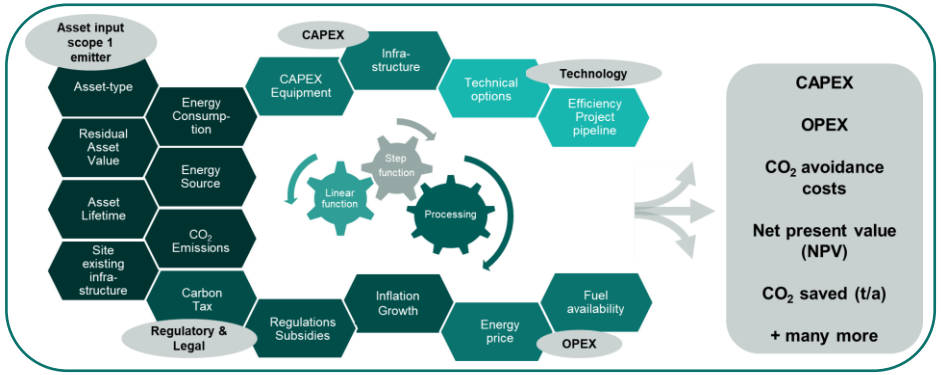
GHG reduction vs. 2019 -5%

Workstream to sustainably reduce GHG: Digital-eWATCH efficiency gain

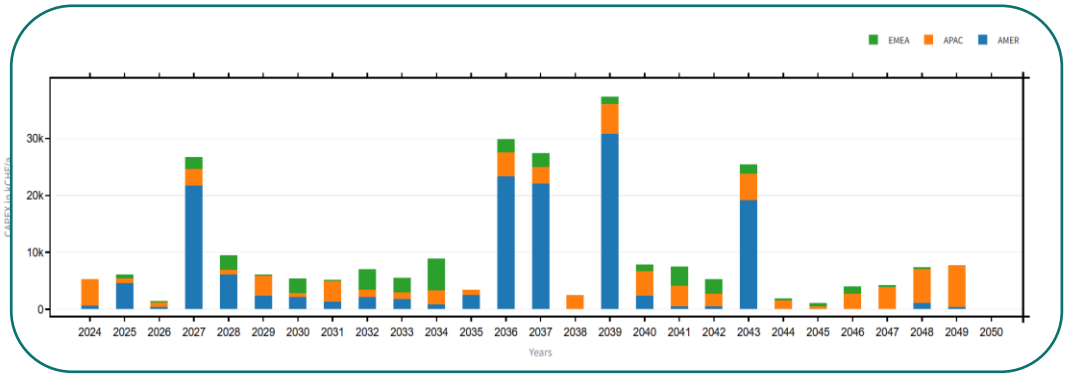


Navigate Decarbonization: Our Modular Net-Zero Scenario Tool Powers Strategic Decisions

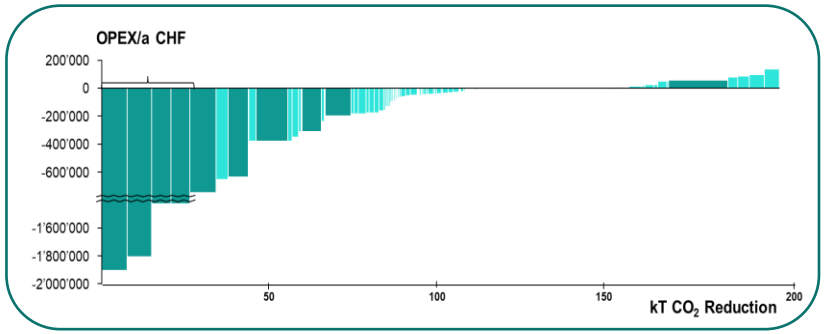
Complex data transformed into interpretable KPIs



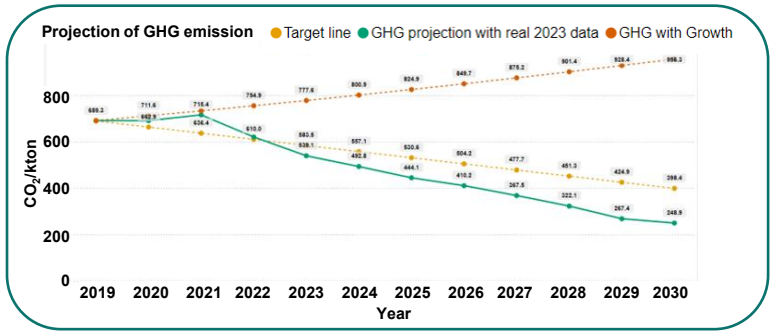
Scenario modeling to navigate uncertainties in energy markets, regulations, and growth



Virtual site modeling: Simulation tool for sustainability investment and financial impact analysis



Net zero trajectory calculations as a result of project planning and execution



MISSION POSSIBLE PARTNERSHIP

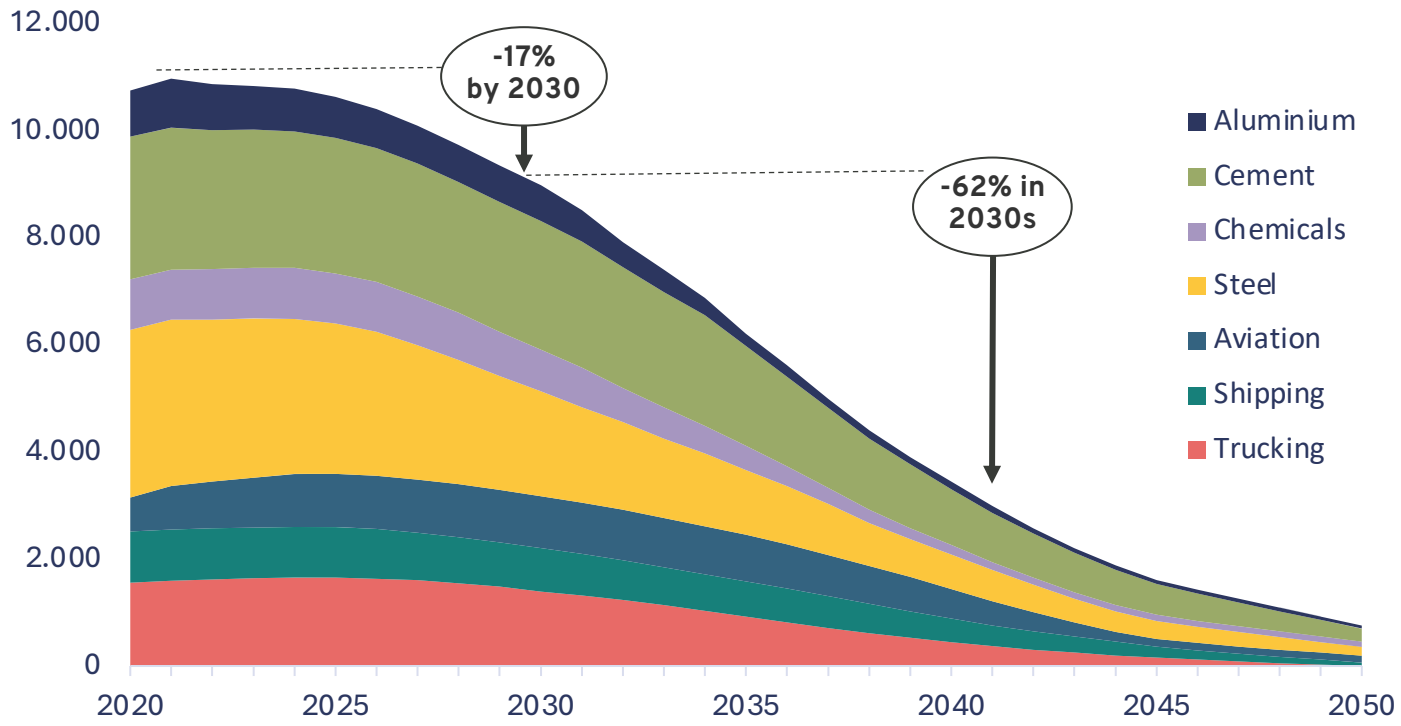
INDUSTRY DECARBONISATION: STATE OF PLAY

Updated Nov. 2024

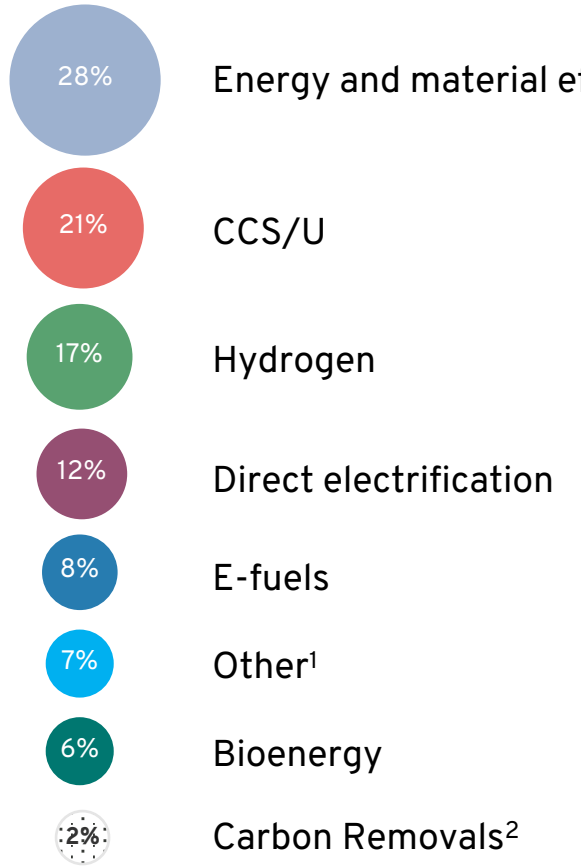
MISSION IS TO DECARBONISE 7 HIGH-EMITTING INDUSTRY & TRANSPORT SECTORS WITH MPP INDUSTRY-BACKED PATHWAYS TO NEAR-ZERO EMISSIONS BY 2050

~23% of all GHG emissions stem from high-emitting heavy industry and transport sectors

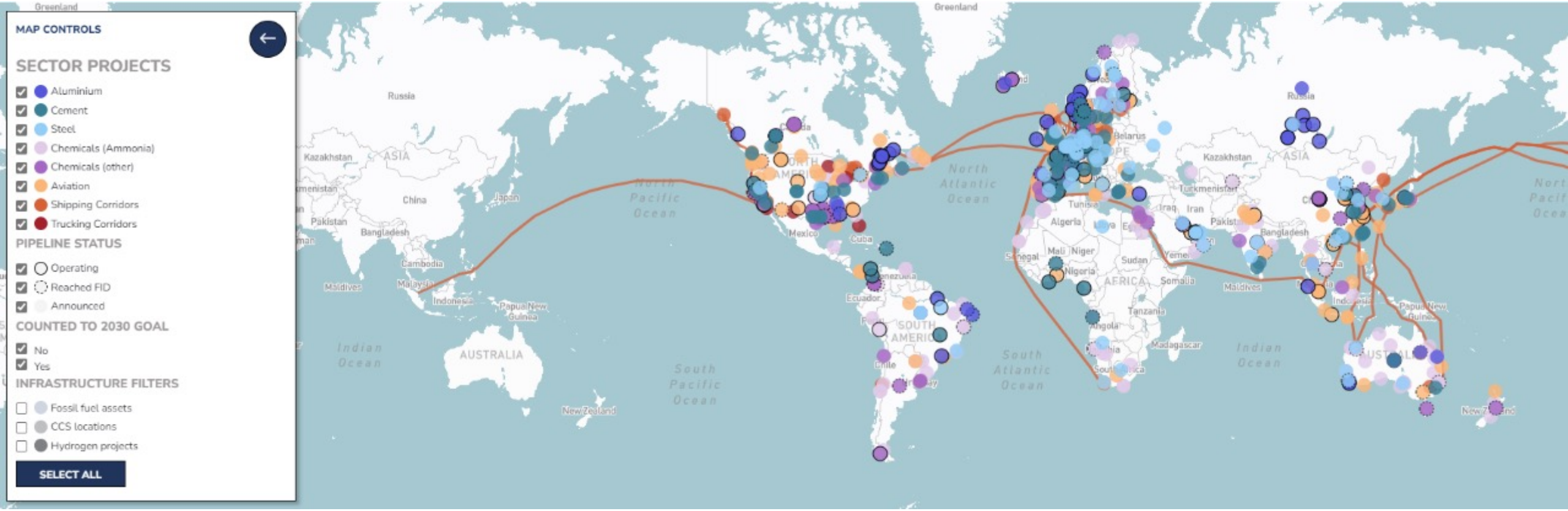
Scope 1 & 2 emissions by sector on 1.5˚C aligned path to Net Zero
Mt CO_2 p.a.



% of cumulative emissions saved, 2020-50



MPP GLOBAL PROJECT TRACKER HAS BECOME THE REFERENCE TO TRACK PROGRESS OF THE PIPELINE OF GREEN INDUSTRIAL PROJECTS ACROSS THE GLOBE



TODAY'S GREEN INDUSTRIAL PIPELINE IS GROWING BUT FALLS SHORT OF WHAT IS NEEDED BY 2030

In operation | Final Investment Decision (FID) reached | Announced | Pipeline Gap

Aluminium

2030 TARGET

70

Low-carbon refineries and smelters

Passed FID

57%

Cement

2030 TARGET

45

Low-emission plants

Passed FID

9%

Chemicals

AMMONIA

2030 TARGET

60

Green and blue ammonia plants

Passed FID

38%

Chemicals

OTHER

2030 TARGET

60

Near-zero emission chemicals plants

Passed FID

20%

Steel

2030 TARGET

70

Near-zero emission primary steel plants

Passed FID

9%

Aviation

2030 TARGET

300

Sustainable Aviation Fuel plants

Passed FID

17%

Shipping

2030 TARGET

100

Near-zero-emissions shipping fuel plants

Passed FID

4%

Trucking

2030 TARGET

7M

Million zero-emission trucks

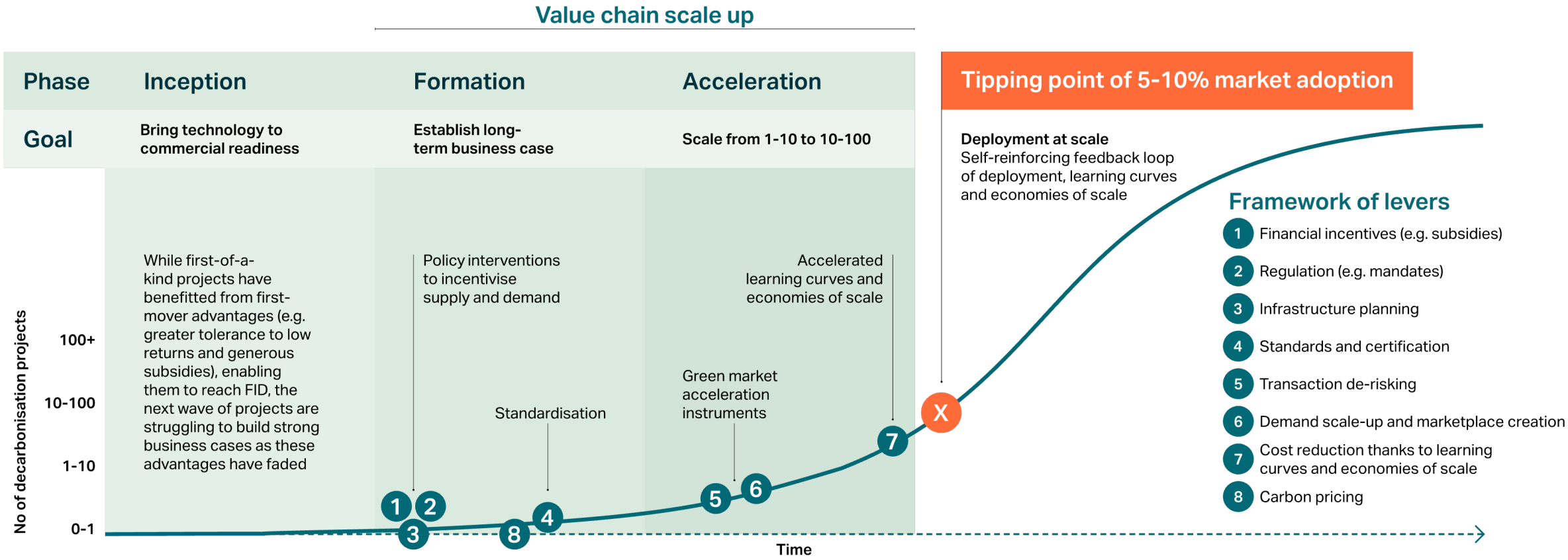
Operational

2%**

*Progress includes zero emission capable assets. Source MPP Global Projects Tracker (2024) **FID is not applicable to Trucking

MISSION POSSIBLE PARTNERSHIP | ITA INDUSTRIAL TRANSITION ACCELERATOR

SCALING GREEN VALUE CHAINS TO REACH A TIPPING POINT AND EXPONENTIAL DEPLOYMENT OF GREEN COMMODITY MARKETS



Source: MPP analysis

THROUGH EXCHANGES WITH PROJECT DEVELOPERS, WE HAVE CONFIRMED THAT 5 CRITICAL CHALLENGES ARE SLOWING DOWN INVESTMENT

1 Green Demand

Struggle to find buyers for low / zero-carbon products given green premium ranging from 10% to 200% – in the absence of appropriate policy incentives.

2 Misaligned Policies

Struggle with country-specific ill-suited policies (e.g. power market design, taxation policy) & with lack of global harmonisation (e.g. EU CBAM & SAF criteria).

3 Clean Energy

Struggle to secure access to large volumes of low-cost, renewable electricity and clean hydrogen, and to develop carbon transport and storage infrastructure.

4 Finance

Struggle to mobilise own balance sheet in low-margin context, to get financing given market uncertainty & to access low-cost capital in developing markets.

5 Technology

Struggle to deploy lower-TRL technologies at commercial scale & to access new technologies developed by competitors (esp. in developing countries).

Source: ITA analysis

GREEN PREMIUM DILUTES THROUGH THE VALUE CHAIN – AFFORDABLE AT END PRODUCT OR SERVICE LEVEL

	Green upstream cost increase in 2030	End product	End-product price increase in 2030	
			100% substitution	10% substitution
Materials	Aluminium *+20%*	Average passenger car	+1.4%	+<1%
	Plastics *+25%*	Average washing machine	+1.5%	+<1%
	Steel *+40%*	New 2000sq. ft house	+5%	+<1%
	Concrete *+40%*			
Fuels & Chemicals	Ammonia fertilisers *+100% ammonia costs*	Loaf of bread	+<1%	+<1%
	Shipping *+480% fuel costs*	Imported pair of shoes	+1%	+<1%
	Aviation *+200 – 300% fuel costs for HEFA*	Flight fares	+75 – 120%	+7.5 – 12%

Notes on materials: premiums are based on estimates of levelised costs of the relevant commodity per production technology without carbon pricing, weighted by the market share of green versus. fossil-based technologies in 2030 to reach net zero by 2050. Upstream premiums are approximations rounded to the nearest 5%. An average car is assumed to weigh 1860kg and to contain approximately 900kg steel, 180kg aluminium and 180kg plastic. An average washing machine is assumed to weigh 70kg and to contain approximately 30kg steel, 3kg aluminium, 4kg plastic and 25kg concrete. A 2000sq ft house is assumed to weigh 124,000kg and to contain 8,000kg steel and require 40,000kg of cement. Notes on fuels and chemicals: SAF assumes fuel makes up 25-30% of a ticket price.
Costs are indicative and based on literature estimates.
Sources: World Steel Association , MPP analysis

INDUSTRIAL TRANSITION ACCELERATOR – LAUNCHED IN 2024 - ACCELERATING PROJECT FINAL INVESTMENT DECISIONS IN SELECT EMERGING ECONOMIES

Co-Chairs

Minister of Industry and Advanced Technology, UAE and COP28 President

H.E Dr. Sultan Al-Jaber

UN Special Envoy on Climate Ambition and Solutions

Mike Bloomberg

UN Climate Change Executive Secretary

Simon Stiell

Leadership Council

Energy Transitions Commission

Adair Turner

Glasgow Financial Alliance for Net Zero

Mary Schapiro

Global Cement and Concrete Association

Fernando Gonzalez

Global Maritime Forum

Johannah Christensen

Global Renewables Alliance

Bruce Douglas

International Aluminium Institute

Pernelle Nunez

International Energy Agency

Mary Bruce Warlick

International Fertilizer Association

Alzbeta Klein

International Maritime Organisation

Arsenio Dominguez

International Renewable Energy Agency

Francesco la Camera

Ipieca

Brian Sullivan

Methanol Institute

Gregory Dolan

Sustainable Markets Initiative

Brian Moynihan

Tata Sons

Natarajan Chandrasekaran

UN High Level Climate Champions

H.E Razan Al Mubarak

UN Industrial Development Organization

Ciyong Zuo

World Business Council for Sustainable Development

Ilham Kadri

World Economic Forum

Børge Brende

worldsteel

Åsa Ekdahl

Additional members may be added

PROJECT SUPPORT PROGRAMMES IN EMERGING MARKETS

Working in Brazil, UAE, Bahrain, Egypt, India and other countries in future to support How ITA Project Support Programmes work

The ITA works with government ministries to:

Phase 1:
Assess opportunity and inform program priorities

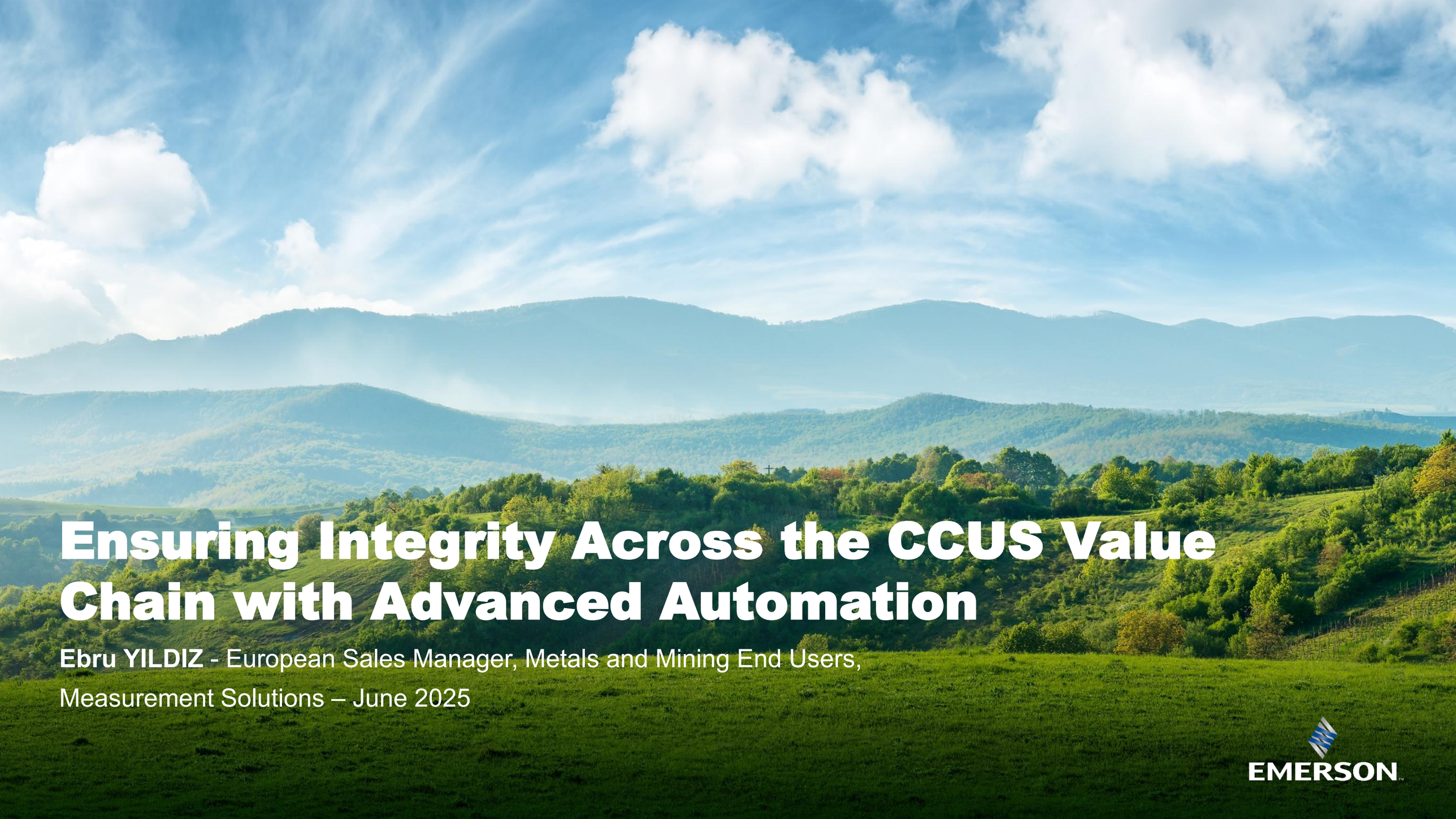
- **Identify existing or desired policy ambitions** around industrial decarbonization
- **Choose 2-4 key sectors for ITA support**, informed by the strength of the existing pipeline of decarbonization projects, domestic industrial profile, etc.

Phase 2:
Identify project barriers and inform solution set

- **Collaborate with project developers** to identify barriers to final investment decision (FID)
- **Consult with wider spectrum of critical project stakeholders needed for investment and offtake** e.g., banks, insurers to understand commitment barriers

Phase 3:
Support solution implementation

- **Support selected projects** in collaboration with existing initiatives & intl. organizations
- **Orchestrate solution implementation** and bring projects to final investment decision



Ensuring Integrity Across the CCUS Value Chain with Advanced Automation

Ebru YILDIZ - European Sales Manager, Metals and Mining End Users, Measurement Solutions – June 2025

EMERSON

EMERSON Global

Ebru Yıldız

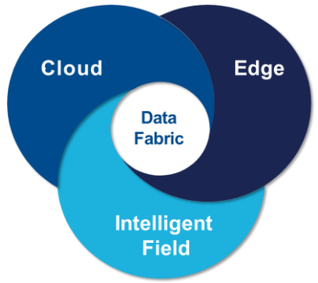
European Sales Manager
Metals and Mining End Users

EMERSON
10 years

COMPANY PROFILE

Emerson is a global leader in automation technology and software. We help customers in critical industries, like energy, chemical, power and renewables, life sciences and factory automation operate more sustainably while improving productivity, energy security and reliability.

BUSINESS SEGMENTS



Boundless Automation

- AspenTech
- Control Systems & Software
- Measurement Solutions
- Final Control
- Discrete Automation
- Safety & Productivity

FOUNDED
1890
HEADQUARTER IN
St. Louis, Missouri
USA

EMERSON™

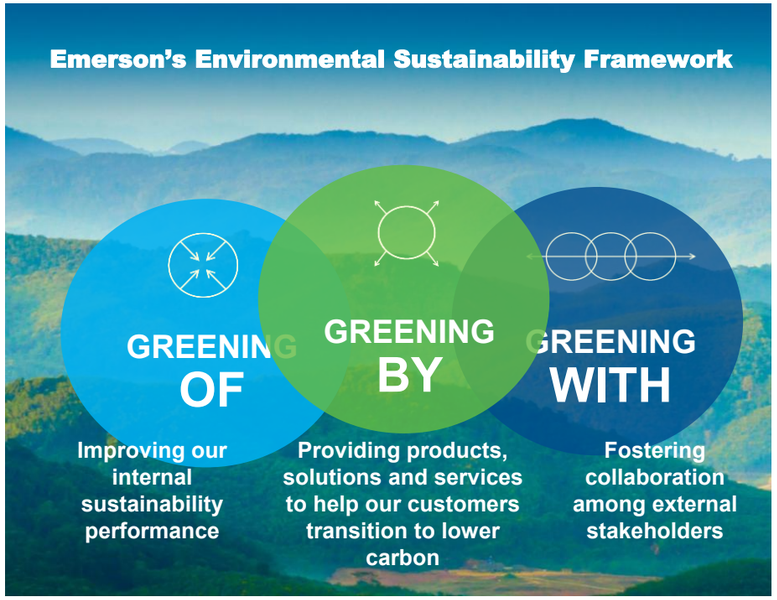
$17.0
Billion
IN GLOBAL SALES
FISCAL YEAR 2023

We address CCUS Challenges

Faster and Smarter Scale-up
Reduce Costs & Accelerate Execution

Auditable Data Management
Validate and Monetize Carbon

Safety and Optimization
Achieve Safe & Reliable Operations



INNOVATION
EMERSON EMPLOYEES WERE AWARDED MORE THAN
+17K
ACTIVE PATENTS

2022 RECOGNITIONS

TOP 50 EMPLOYERS
Woman Engineer Magazine

EMERSON Global

Nicolas Marti

European Sales Manager
CCUS and H2

EMERSON
+12years

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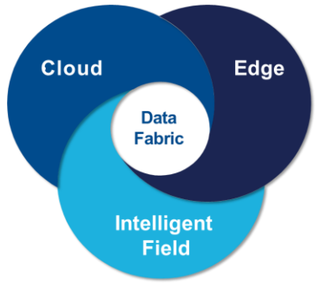
BUSINESS SEGMENTS



Boundless Automation

- AspenTech
- Control Systems & Software
- Measurement Solutions
- Final Control
- Discrete Automation
- Safety & Productivity

FOUNDED
1890
HEADQUARTER IN
St. Louis, Missouri
USA

EMERSON™

$17.0
Billion
IN GLOBAL SALES
FISCAL YEAR 2023

70,600
EMPLOYEES

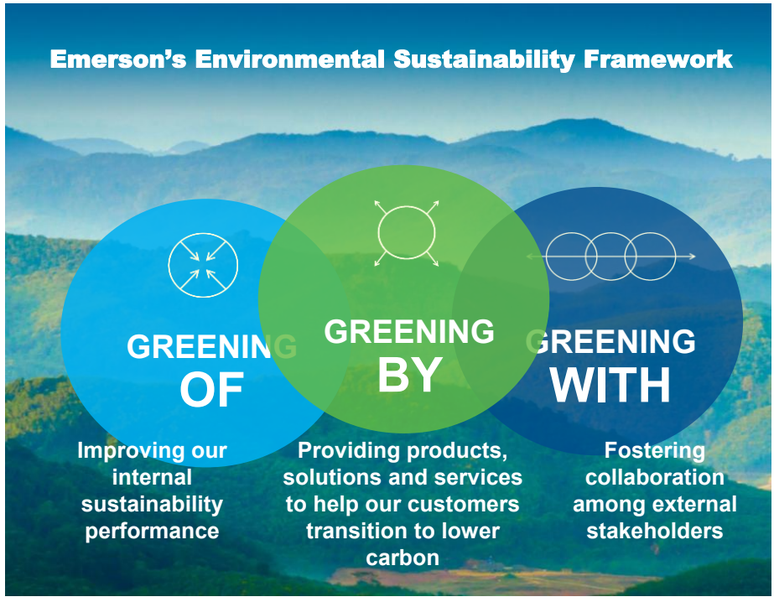
130
MANUFACTURING LOCATIONS

We address CCUS Challenges

Faster and Smarter Scale-up
Reduce Costs & Accelerate Execution

Auditable Data Management
Validate and Monetize Carbon

Safety and Optimization
Achieve Safe & Reliable Operations



INNOVATION
EMERSON EMPLOYEES WERE AWARDED MORE THAN
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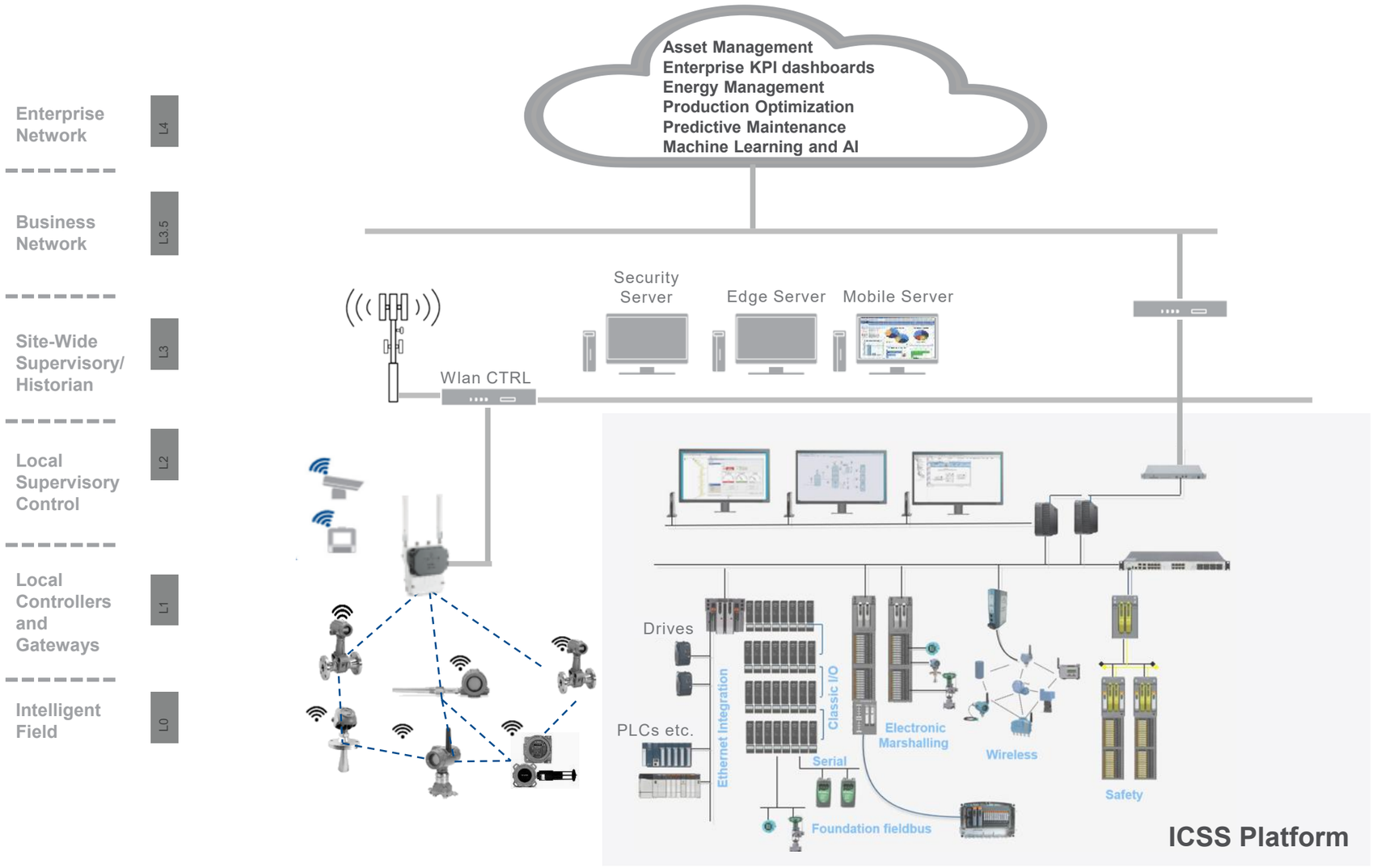
ACTIVE PATENTS

2022 RECOGNITIONS

TOP 50 EMPLOYERS
Woman Engineer Magazine

Flexible and Autonomous Operation: Boundless Automation



- Secure by Design
- Ultimate Salable Architecture
- Software-Defined Infrastructure
- Visualization Anywhere
- Enhanced Connectivity

Data Democratization

IT/OT Convergence

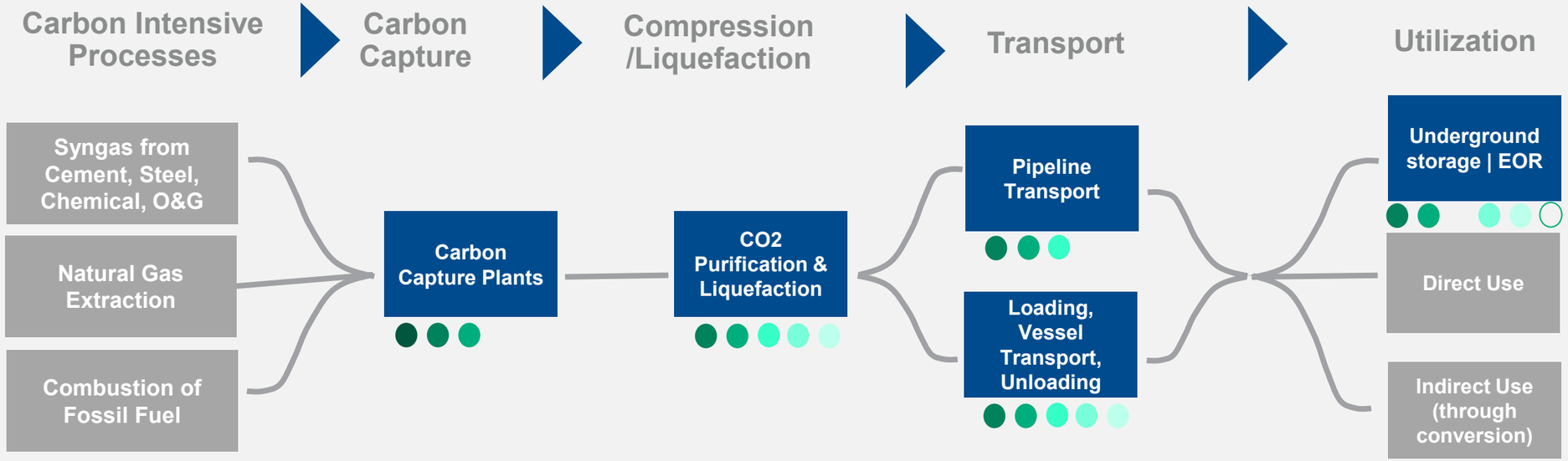
Digital Transformation

Asset Optimization

- Process Automation
- Embedded intelligence from sensors to cloud applications
- Object oriented applications
- Integrated by Design eliminates interfaces

WirelessHART · HART COMMUNICATION PROTOCOL · NAMUR · WiFi · IO-Link · ethernet-apl™ advanced physical layer · EtherNet/IP · HART-IP · PROFINET

Carbon Capture, Use, and Storage Value Chain



Key Operating Challenges

- Energy Intensive
- Poor Process Efficiency
- Loss of Containment
- Liquid Phase Instability
- Compressor Reliability
- CO2 Integrity
- Reliable Underground Storage

EMERSON

Key Emerson Solutions

- Energy Management Information System

- Instruments and Analyzers

- Process Control Industrial Software

- Custody Transfer Solutions

- Corrosion & Erosion Monitoring

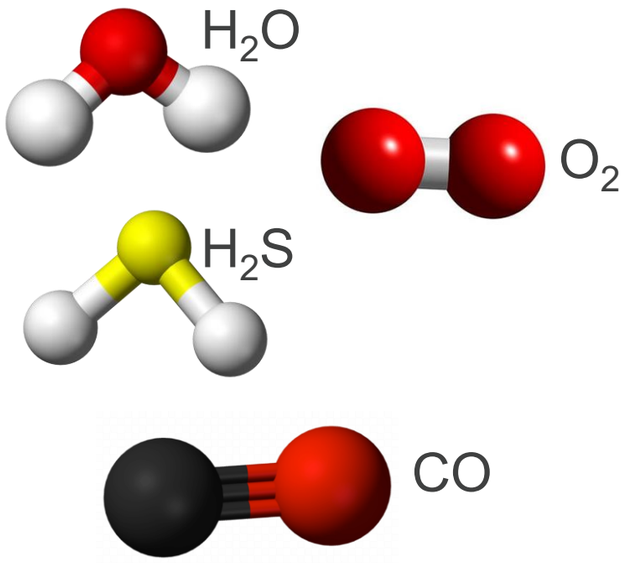
- Absorber & Stripper Valves

Emerson can leverage our existing portfolio of automation solutions, our innovation potential, and our global footprint to facilitate commercial scale-up in the short term, and widespread adoption in the longer term

Carbon Capture
CO_2 Integrity: Impurities and Humidity

Operational Challenges

- Trace impurities in the CO_2 pipelines must be controlled to ensure pipeline integrity and contractual requirements are met



Value Enabler

- Options to utilize a wide variety of technologies to analyze for specific components
- Solutions engineered for your specific process

Impact on Operations

Reduce overall maintenance cost and spare parts requirements and quality analysis uncertainty.

Best-in-industry accuracy for most impurities down to ppm levels

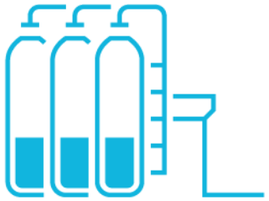
Easy operation and maintenance

Reduced installation costs

40% Lower operation costs vs. legacy technologies

EMERSON

Compression & Liquefaction: Preparing CO_2 for Transportation



Compression/
Liquefaction

Business Objective

Efficiently compress or liquify CO_2 to the ideal, stable state for transport.

Equipment Reliability

"Run to failure" reactive maintenance strategies

Poor visibility to wear and tear on critical assets (pumps, compressors, etc.)

Nature of process contributes to **accelerated corrosion**

Equipment performance can create **CO_2 phase instability** (liquid vs. solid vs. gas)

HOW TO ACHIEVE EQUIPMENT INTEGRITY

Monitor rotating equipment

Implement preventative & predictive maintenance

Lessen impact of corrosion

Compression/
Liquefaction

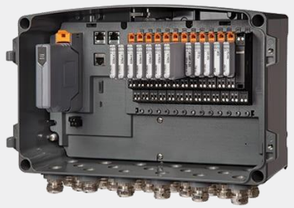
Rotating Equipment and Corrosion Monitoring

Operational Challenges

- Complex, multi-stage process is challenging to control
- Fluid instability may exacerbate mechanical stresses

Value Enablers

Emerson's suite of **vibration monitoring hardware and software** provide real-time monitoring and analysis to prevent failures on critical equipment



Impact / Outcomes

Vibration analytics take the guess work out of predicting failures

Reduce installed cost and enhanced monitoring / analytics for remote assets

---

- Heightened awareness for safe operations when operating at high pressures
- Pressure containment risks can go unnoticed until failure occurs

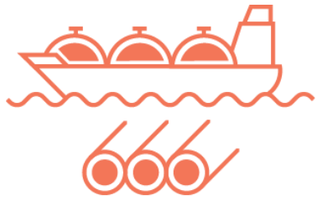
Emerson's **inline and external corrosion monitoring solutions** provide early detection of safety or containment risks

Increased safety thru early detection of potential pipe or vessel failures

Reduced risk of captured gas leaking into atmosphere

Transportation:
Product & Measurement Integrity

Custody Transfer



Transportation

Business Objective

Safely carry condensed and liquefied CO_2 to storage or utilization sites.

Transportation Performance

- **CO_2 can solidify** due to temperature and pressure fluctuations
- **Pipeline inefficiencies** restrict flow, reduce capacity
- **Over- or under-pressurization** compromises product integrity
- **Undetected corrosion** leads to ruptures and contaminants
- **Inaccurate custody transfer** compromises measurements for financial transaction and transparent regulatory reporting

HOW TO ACHIEVE PRODUCT INTEGRITY

Maintain ideal CO_2 state

Enable custody transfer

Transportation

Custody Transfer Measurement

Operational Challenges

- Fluid phase changes can cause inaccurate flow measurement
- Flow range requirements can vary dramatically seasonally and asset to asset

- Measurement accuracy and validation is paramount as the “cash register” for transactions between two parties
- Multiple skids can cause integration irregularities for CO_2 measurement points

Value Enablers

Emerson’s suite of **flow measurement equipment** provide flexibility to accurately and repeatably measure CO_2

Emerson’s **engineered flow measurement systems** provide turnkey solutions for accurate, verifiable measurement of CO_2

Impact / Outcomes

Flow meter diagnostics alert to process disruptions and prevent measurement inaccuracies

Accurate measurement across a wide-range of flow rates

Engineered systems ensure confidence in financial transactions

Turnkey solution ensures system interoperability from design to startup and long-term operations

Proven Results in Europe

EMERSON

Holcim Group (Former: Lafarge Cement)

NCR enables sustainable production and efficiency, in cement plants

Region: *Poland* | **Industry:** *Minerals/Construction*

CHALLENGES

- The performance of the existing legacy devices installed on tanks with hot sand was not satisfactory
- The paddle switch technologies proved challenging to maintain/operate once is covered by media.
- The measurement constantly failed when covered by media, hence required additional manual operation in very sandy, hot and dusty atmosphere (temperature is ~ 80-90 oC).
- Customer wanted to overcome manual measuring's and hence, was after a proper and reliable solution for measuring level on their hot sand tanks
- Application at 15-18 vessels (capacity ca. 60 m3) - measuring of the level very hot sand (component to production cement) after furnace process.

SOLUTION

- Device installed on the top of tank to measure the level of hot sand.
- For better stability in measurement, we offered FMCW, 2-wire device which is powered directly from measuring loop. The instrument is enabled by unique energy efficient radar chip technology.
- Ensuring accurate reading, the smart echo supervision (SES) tracked all echoes including those from obstructions in the tank, distinguished them from the real product surface echo.
- By adopting the 5408 solid radar, the stock visibility is known, hence, the necessary actions can be taken without need of manual rounds. This also helps in improving the safe operation of the process.

KEY EMERSON TECHNOLOGY

- Advanced level instrumentation promotes efficiency, safety, profitability and sustainability, and therefore, Rosemount 5408 non-contacting radar is adopted since the measuring instrument is not in contact with media, physically.
- Rosemount 5408 is a maintenance free, 26 GHz FMCW non-contacting radar with SES and dual port technology which increases signal strength that directly translated into better reliability.

PROVEN RESULTS

Increased personnel safety

Improve asset and people productivity

Reduce logistics and maintenance costs (savings)

Real time data

Cement Production Gas Analysis
Cascade Laser Analyzer CT5100

3 boxes solution (Sample system, Analyzer Cell & Analyzer Electronic)

Main focus – Rotary Kiln Outlet (Process control)

Hot wet solution (Multi-components)

- Hot operation up to 190°C
- No dew point issues with acidic gases
- No moving parts; Less maintenance
- Plug and play unit, no additional adjustments necessary
- Self-diagnostic with fail safe features
- Filter element can be replaced quickly and easily
- Low flow failure alarm
- Temperature Controller for external heated bundle line

Measurement Range			
Location	**Component**	**Range**	**Units**
Cement Kiln	O_2	0-25	%
	H2O	0-40	%
	CO	0-5	%
	NO	0-4’000	ppm
	SO_2	0-10’000	ppm
	CH_4	0-1’000	ppm

Other ranges available

Up to 6 Gases in 1 Analyzer

Pervasive Sensing Solutions in Metals & Mining

- Conveyor Belt Monitoring
- Electrowining Short-circuit Detection
- Heap Leaching Monitoring Wireless Skids
- Wireless Corrosion Monitoring at Acid Plant
- Pig Detection- Ore Pipeline
- Temperature Profile on Rotary Kiln
- Tailing Dam Monitoring
- Underground Hazardous Gases Monitoring

Increase Reliability on Conveyors Belt for Mineral Transportation with Wireless Monitoring System

Safety
Productivity

Impact on Operations

Take preventive actions before the temperature reaches dangerous levels to burn the belt (maintenance & Productivity)

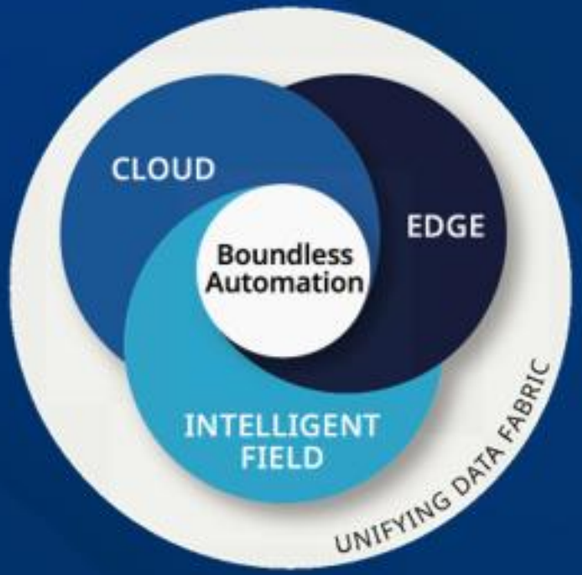
Eliminate manual operator rounds in remote locations (safety)

Avoid slowdown process by keeping the conveyor in optimum condition.

Solution

- 68x 848T Wireless high density temperature transmitters
- 6x 702 Discrete transmitters (as repeaters)
- 36x Magnetic RTD Temperature Sensors
- 01x WirelessHART Gateway 1410S.
- Emerson Commissioning Services

The Future of Automation

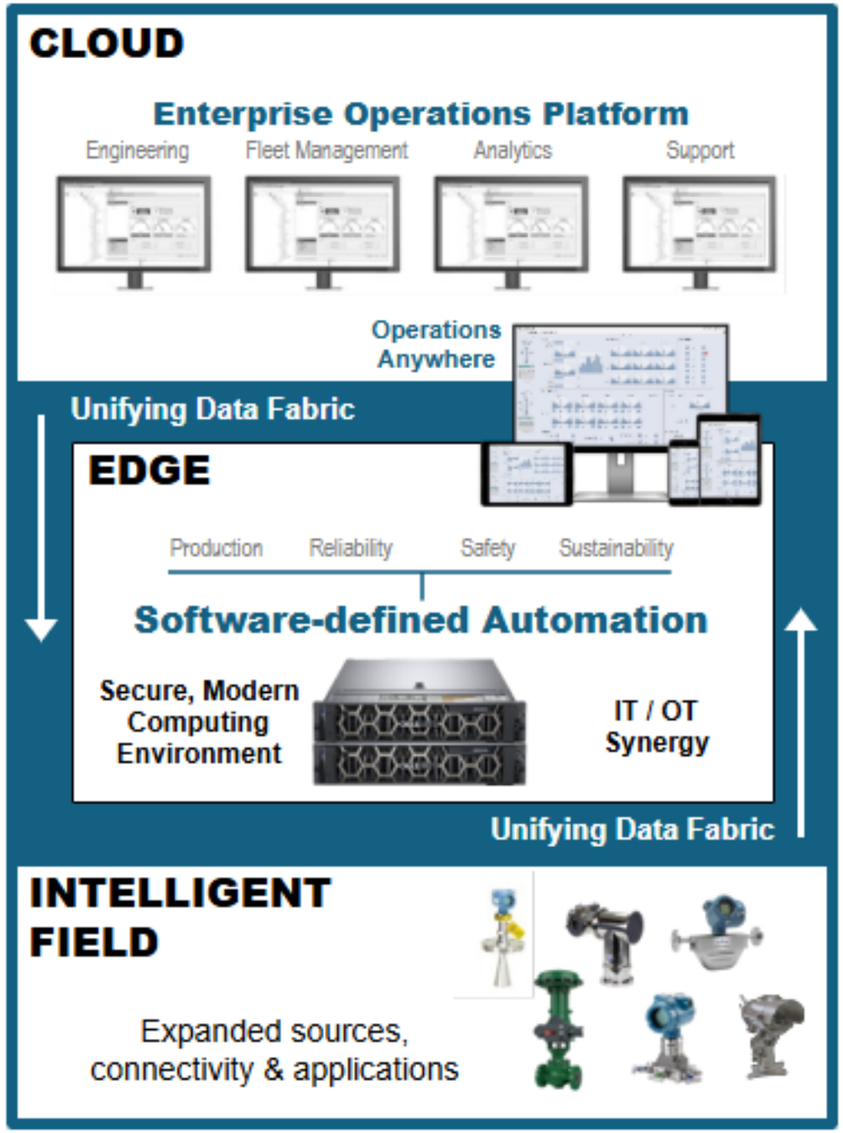


Liberating data to unleash the power of software for world class performance

CLOUD

EDGE

FIELD



EMERSON


EMERSON
Thank You
Q&A
LinkedIn

Building a Climate-Smart future with clean lime technology and CCU

Anna-Maria Béregi Amnéus, CSO

Decarb Connect, Amsterdam 2025-06-03

OUR FACILITIES

SMA Mineral Northern Europe

SMA Mineral Northern Europe brings together the part of the Group's operations that are located in the Nordic and Baltic countries. We currently have production at about 20 locations in Sweden, Norway, Finland and Estonia. Our head office is located in Persberg, in Värmland's largest mining area, dating back several hundred years.

SWEDEN
- Rättvik
- Oxelösund
- Luleå
- Berga
- Boda
- Stucks
- Klintehamn
- Eneby
- Jutjärn
- Kullsberg
- Sandarne
- Gåsgruvan

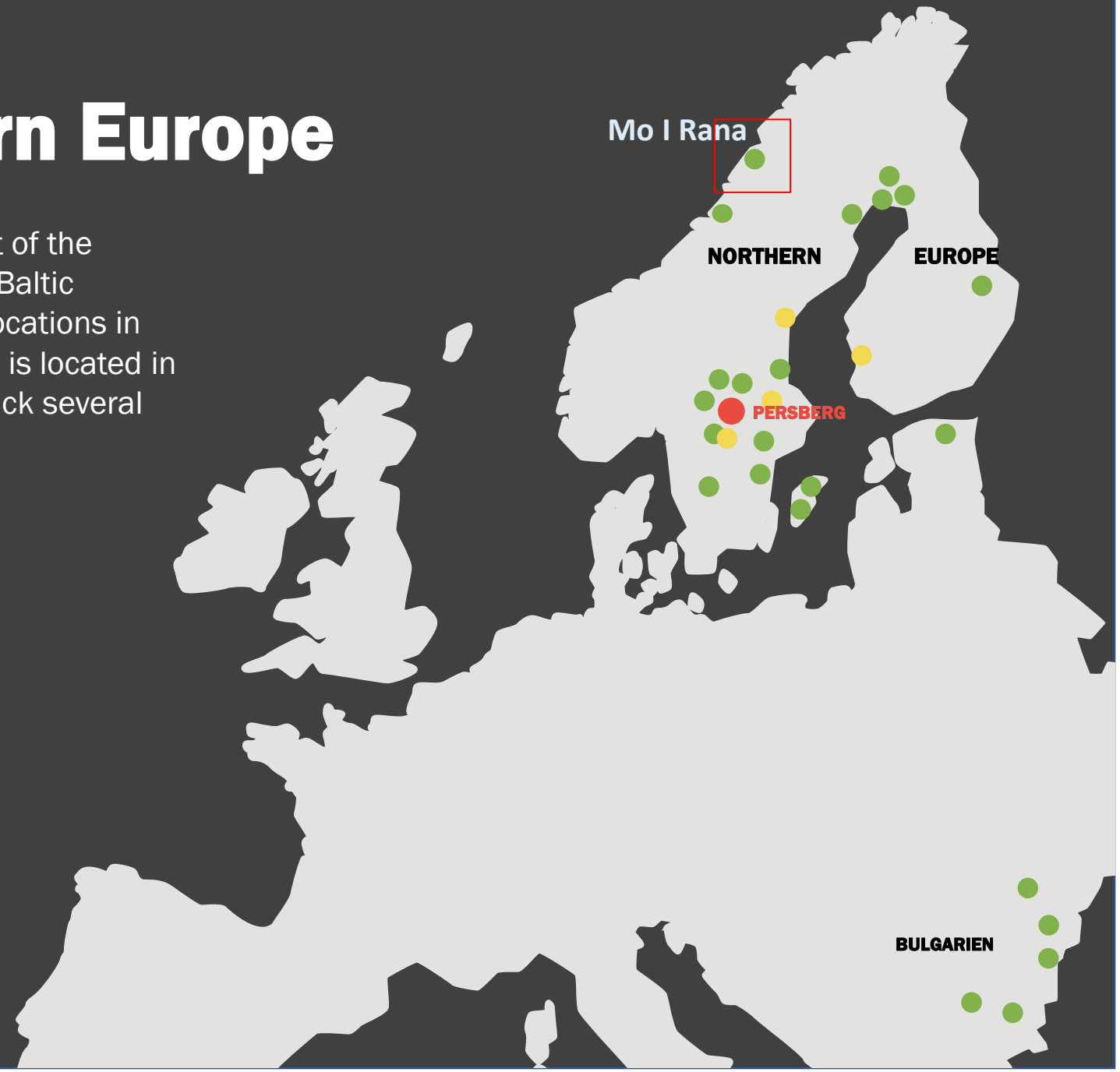
NORWAY
- Mo i Rana
- Seljeli

FINLAND
- Ristimaa
- Loukolampi
- Kalkkimaa
- Röyttä

ESTONIA
- Vöhmuta

BULGARIA
- Shumen
- Dobromir
- Dimitrovgrad
- Malko Tarnovo

TERMINALS
- Otterbäcken
- Kolbäck (Västerås)
- Söråker (Sundsvall)
- Åbo/Rauma (FI)



USES

Zero-emission lime – a crucial raw material

INDUSTRY
STEEL and PULP

A number of industrial processes require lime products to optimize both the quality of the finished product and the lifetime of the production equipment.

ENVIRONMENT

Products with lime are an effective tool for reducing negative environmental impacts.

INFRASTRUCTURE

Paved roads use lime as a filler which in turn Reduces the need for maintenance and provides a longer service life of the asphalt.

AGRICULTURE

In modern agriculture, lime is used to balance the pH of the soil and improve the conditions for good crops.

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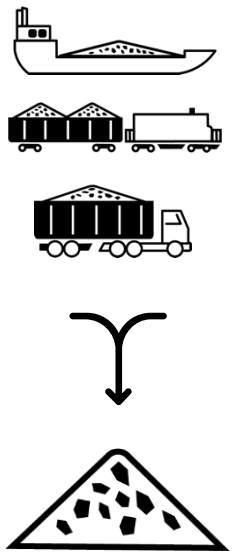
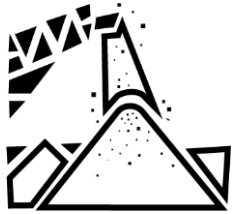
ZEQL – Zero Emission QuickLime

Process – quicklime and dolomite

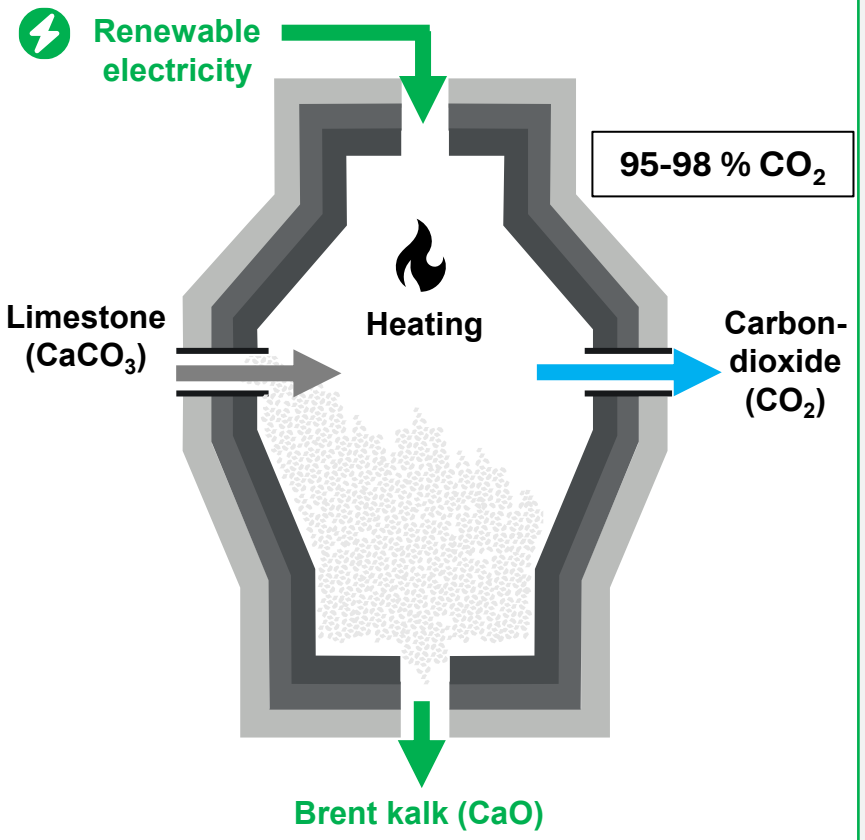


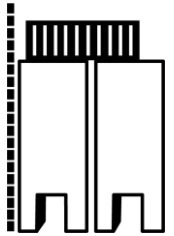
Full utilization of the raw material



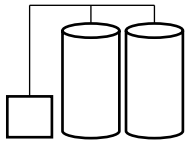
Crushing/ Grinding limestone

Calcination





Quick lime



Interim storage of CO_2

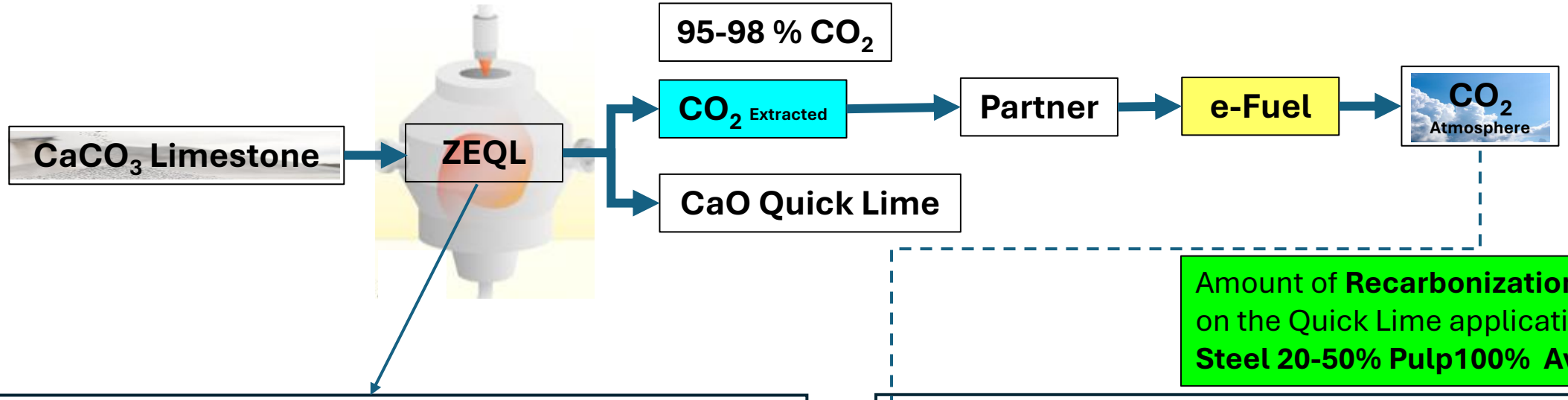
Mixing

Packaging

Powders and Briquettes

Transport

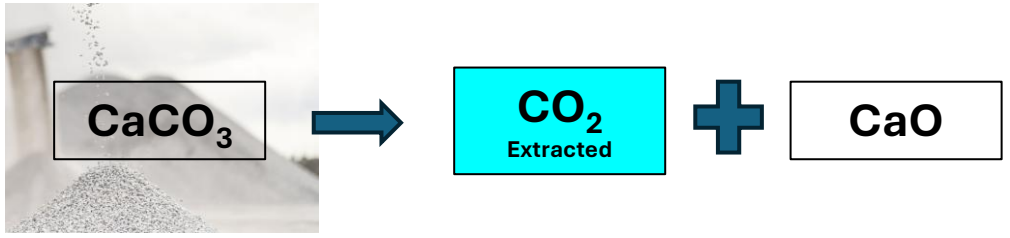
Lime-CO_2 a better alternative for CO_2-utilisation
Recarbonization of Quick Lime back to Limestone



Amount of **Recarbonization** depends on the Quick Lime application.
Steel 20-50% Pulp100% Average 33%

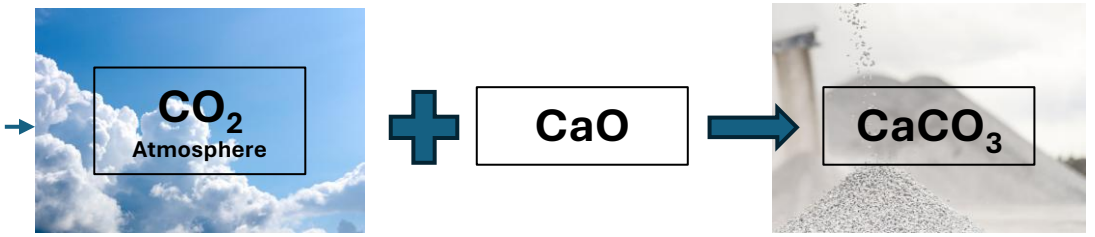
Quick Lime Process in ZEQL

Limestone $CaCO_3$ is heated (calcined) until it dissociates into Quick Lime CaO and carbondioxide CO_2. The CO_2 is extracted and utilised for e-fuel.



Recarbonization Process

CO_2 from the atmosphere is ”sucked up” by the CaO (quick lime) to produce $CaCO_3$ (limestone) again, thus binding the CO_2 permanently. This is a natural process constantly occuring, it can be enhanced industrially.



Acknowledgement of recarbonization as a carbon sink is pushed by EuLA

First with zero-emission lime in the world and e-SAF in Europe

Green transition of a local cornerstone company

The business in Mo I Rana, Norway has existed since 1974 and has been owned by SMA for almost 30 years

A necessary restructuring to offer emission-free lime to the industry

Circular economy in practice:
Significant emission cuts locally and globally

7 Steel Nordic's sustainable steel both locally in Mo i Rana and globally

e-SAF for aviation
80% reduction in CO_2 emissions

A mature project – Ready in 2028

NOK 300 million already invested - including a new transformer station and fully regulated area in Mo Industrial Park

The project is on track for full-scale operation in Q4 2028/Q1 2029

Solid local, regional, Swedish and global partners

Investment decision first production line: Q2 2025

Ennova has granted funding for the Pilot40 (8 times larger than the Hofors Pilot) in Mo I Rana with 287 MNOK

450 MW – Innovation for green transition

A power-intensive project in need of 450MW at full operation

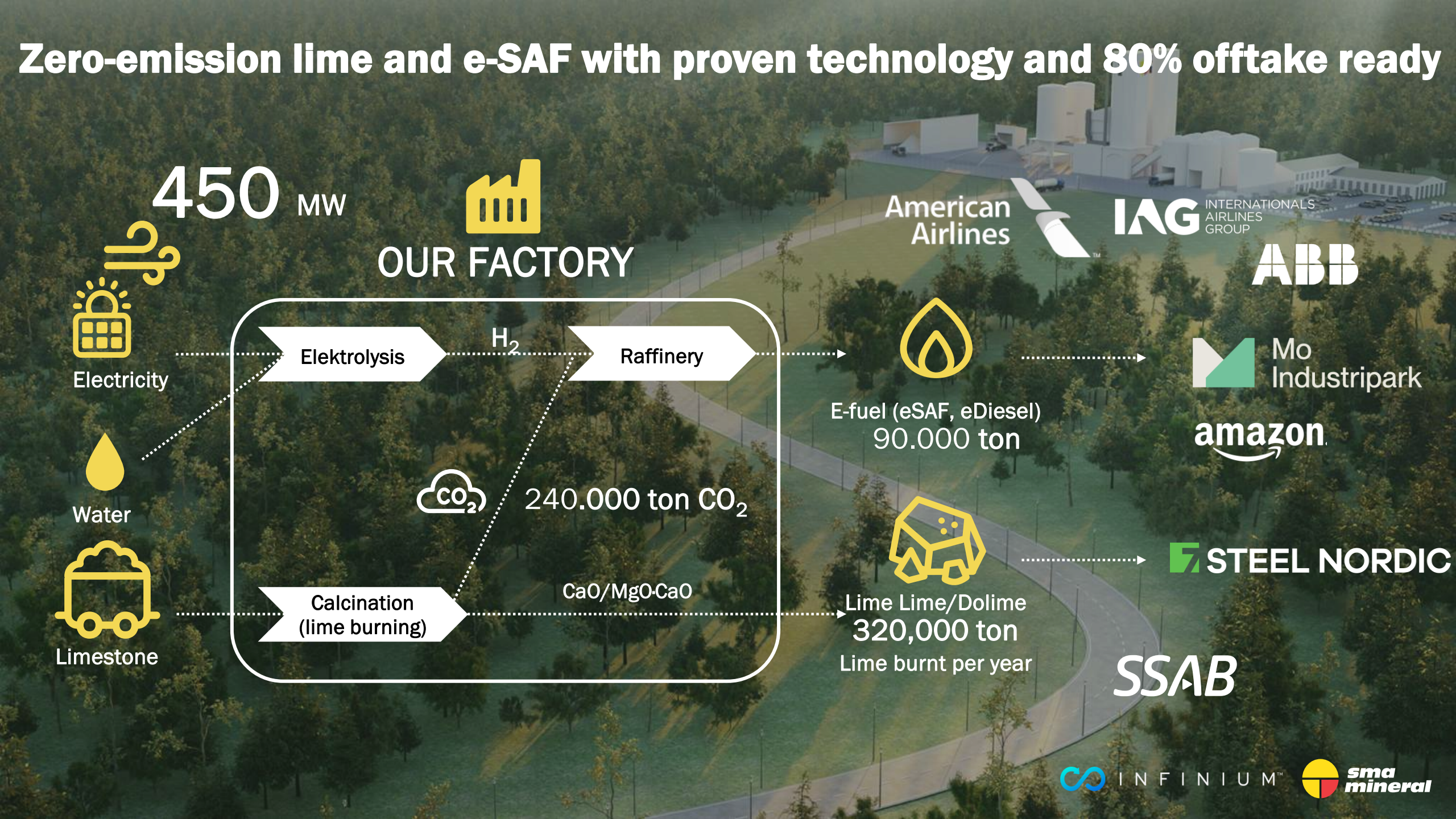
Total investment framework:
NOK 13 billion, of which NOK 6 billion is already secured with equity

Head office with cutting-edge expertise in Mo i Rana
+ 250 jobs

Annual export revenues for emission-free lime and e-SAF: NOK 4.5 billion

INFINIUM™ sma mineral

Zero-emission lime and e-SAF with proven technology and 80% offtake ready



Fully regulated area in Mo Industrial Park in Norway

Foto: Mo Industripark AS

Vision of integrated facility in Mo I Rana

Mo i Rana Integrated Facility

- 320.000 tonnes of green Quicklime
- 90.000 tonnes of climate friendly e-fuels using 240.000 tonnes of CO_2 from lime production as feedstock
- Located in Mo i Rana, MIP Industripark, Northern Norway

INNOVATIVE TECHNOLOGY
SYNERGISTIC PARTNERSHIP
RENEWABLE ENERGY

INFINIUM™

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Project Pathfinder

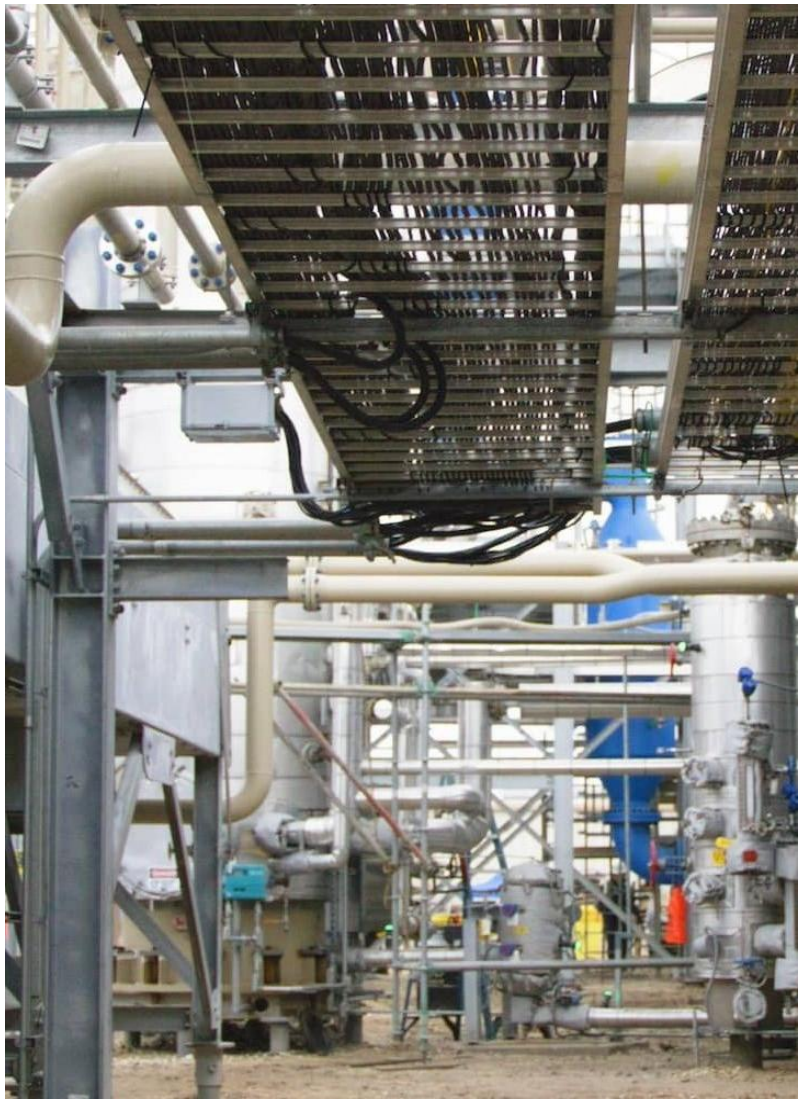
Project Pathfinder is Infinium's, and the world's, first and only facility on a full commercial scale.

The plant is located in Corpus Christi, Texas, and produces pre-treated eFuels.

Project Pathfinder produces synthetic low-carbon eFuels that can be used in modern internal combustion engines for heavy transport, chemical processes and infrastructure without the need for further processing.

Infinium led the construction and commissioning of the project from beginning to end and is responsible for all operations and maintenance.

INFINIUM™



RESEARCH AND TESTING FACILITIES

Zero-emission electric calcination

The technology of an electric plasma generator that heats limestone so that it calcines has now been tested and tested at the ECRC.

ECRC is a research and test facility for the new electrified technology for calcination of limestone. The plant is located in Hofors, Sweden.

The process consists of two main steps in which the painted limestone first passes through a preheating system and then is finally heated in the so-called "electric arc calcinator (EAC)", a cyclone with a plasma generator, so that the desired calcination occurs.

Through EAC, carbon dioxide (CO_2) released during calcination of limestone is handled in a controlled manner and can be used as a raw material for the production of various carbon products, such as eFuel. The process ensures zero CO_2 emissions.

ZEQL + eSAF gives 80% reduction of CO_2 released

Conventional quick lime production and conventional aviation fuel production

- Calcination of Limestone gives 1 ton of CO_2 and additional 0.4 ton CO_2 comes from fossil fuel, total 1.4 ton CO_2
- The recarbonisation* removes 0.6 ton from the air
- Oil is extracted to produce aviation fuel and adds surplus CO_2 to the atmosphere of 1 ton CO_2/ x km
- This gives a total release of CO_2 in the atmospehere with **2.4 ton CO_2**

New novel technology ZEQL quick lime production combined with eSAF production

- Calcination of limestone gives only 1 ton of CO_2, as none of the CO_2 now comes from the fuel
- The recarbonisation* removes 0.6 ton from the air
- The CO_2 is collected and used to produce eSAF. The airplane releases 1 ton CO_2/ x km in the air
- No oil is extracted for aviation fuel, 0 ton surplus CO_2 to the atmosphere
- This gives a total release of CO_2 in the atmospehere of **0.4 ton CO_2**

*Recarbonisation grade is based on Quick lime application:

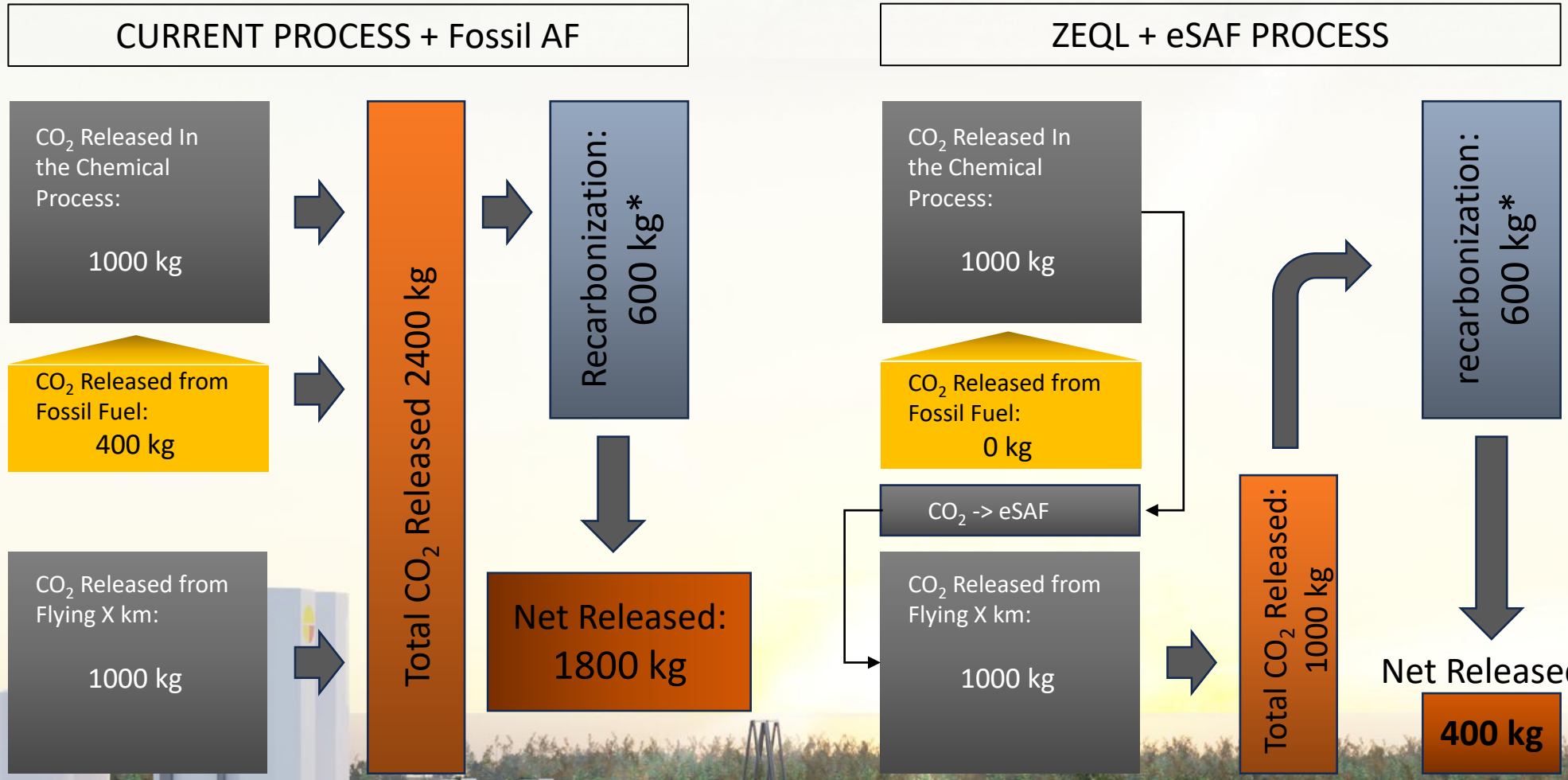
- 50% Steel with 20% recarbonization
- 50 % Pulp with 100 % recarbonization

Comparison between conventional system and novel system:
Novel system gives an **80 % reduction** in released CO_2. Instead of 2.4 ton CO_2 from conventional system. **Only 0.4 ton is released from novel system.**

Additionally eSAF has an 26 % better climate impact than fossil aviation fuel due to it contains no aromates and thus cleaner combustion, which reduces the particles in contrails. *(reference NILU)*

The production of e-fuel requires less energy than fossil fuel, but more renewable electricity (*reference Rapporter – ZERO*)

ZEQL + eSAF gives 80% reduction of CO_2 released



*based on 50/50 delivery of quicklime to pulp and steel production

CO_2 and renewable electricity shortage impede utilzation into renewable eCarbon products and the acceleration of green circular industry

- Bio-CO_2 is not enough for the production of CCU-products/eCarbon products such as eFuels, plastics chemicals etc. The worlds available Bio-CO_2 accounts for 1,5 % CO_2 of the total CO_2 emission yearly. Only, shipping, aviation together needs 5,5 % then there is chemicals, plastic, other transports etc.
- A major barrier to accessing biogenic CO_2 or industrial CO_2 for e-fuel production is the competition from BECCS and CCS. Storage is perceived as a less-complicated option and is associated with better financial and regulatory incentives than CO_2 utilization.
- Lime CO_2 is not fossil. Lime stone is a natural resource with a limit, it is not renewable, though it is abundant in the world. For cement/concrete applications it is possible to shift some part of the material to another materials and reduce the usage of virgin lime. However this can not be done for high quality applications such as steel, pulp and enviroment, maybe some percentage of the slag can be reused from steel. Lime is and will always be a necessary product and as it has the property to recarbonizate, which gives CO_2 emissions between 0-90 % depending on application of the quick lime. Due to quick limes property to recarbonatize it is used in DAC technologies to collect the CO_2 from the athmosphere.
- The recarbonization of lime is not yet established in regulatory frameworks as a carbon sink or sequestration.
- Another large barrier is the availabilty of renewable electricity for both electrification of industrial processes and the production of eCarbon products. It is not always the lack of electricity that is the problem but the grid capacity and the long time to establish enough grid capacity. Which comes with huge costs and delays due to permitting processes. And the queing system to get power and how the projects maturity is defined, is also unclear.

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Take aways

Lime and Cement industry emits 10 % of the worlds total CO_2 emissions annually and transport accounts for 23 % of the total CO_2 emissions annually.

By combining the two novel technologies of ZEQL/SMA Mineral Quick Lime and Infinium eFuel and establish facilities. It gives a potential reduction at least of 10 % of the worlds CO_2 emissions, which would be sufficient for aviation, shipping and partly for other Carbon products such as eChemicals, ePlastic. The high CO_2 content of 95–98 % from the ZEQL-process removes the necessity of costly carbon capture technology.

But the lack of RED eligible CO_2 beyond 2041 is a major hindrance and also availibity of renewable power, to establish renewable eCarbon products as eFuels, ePlastic, eChemicals. Also the incentives för CCS is higher than for CCU mainly in the regulatory field.

As lime has the property of recarbonization, the CO_2 from lime should be treated different than fossil CO_2 and the usage limit for lime CO_2 to be RED eligible (RFNBO) to be extended beyond 2041 to at least 2050, but rather indefinitely.

eFuel production is reliant upon CO_2 as a feedstock, there is simply not enough Bio CO_2 in the world to sustain the need. Several eFuel producers will only take Bio CO_2 due to regulation as they see that 2041 is a to short investment horizon to establish an eFuel facility.

Those who emits Bio CO_2 finds it more lucrative to do BECCS due to regulation (CO_2 offsets) and funding incentives than utilization, which also reduces the supply of Bio CO_2

CCU, eCarbon products also need incentives in form of regulation and funding to be a more viable option to CCS.

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CCU from Lime – A Climate Opportunity

Global Potential

- Lime & cement: **10%** of global CO_2 emissions
- Transport: **23%** of global CO_2
- Combining ZEQL Quicklime + Infinium eFuel could cut emissions by **≥10%**
- Impact areas: aviation, shipping, eChemicals, ePlastic
- ZEQL: **95–98% pure CO_2**, eliminating need for expensive CCS

Why Lime CO_2 is Different

- Lime enables **recarbonization**
- Lime CO_2 ≠ fossil CO_2 → should be treated differently
- Extend RED eligibility for lime CO_2 to **2050 or indefinitely**

Current Barriers

- RED eligibility ends **2041** – too short for investments
- Limited access to **renewable electricity**
- CCS is favored over CCU in current **regulatory frameworks**
- Not enough **bio-CO_2** for global eFuel demand
- **BECCS** more incentivized than CCU → shrinking supply of bio-CO_2

Need for Action

- **CCU needs same incentives** (regulatory & funding) as CCS
- Extend RED eligibility for **lime CO_2** to **2050 or indefinitely**
- Increase availability of renewable power in grid and new installations.

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THANK YOU VERY MUCH FOR LISTENING!

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