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CLEAN clinKER by calcium looping for low-CO_2 cement

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CLEANKER H2020 Project

BUZZI UNICEM: Our Journey to Net Zero

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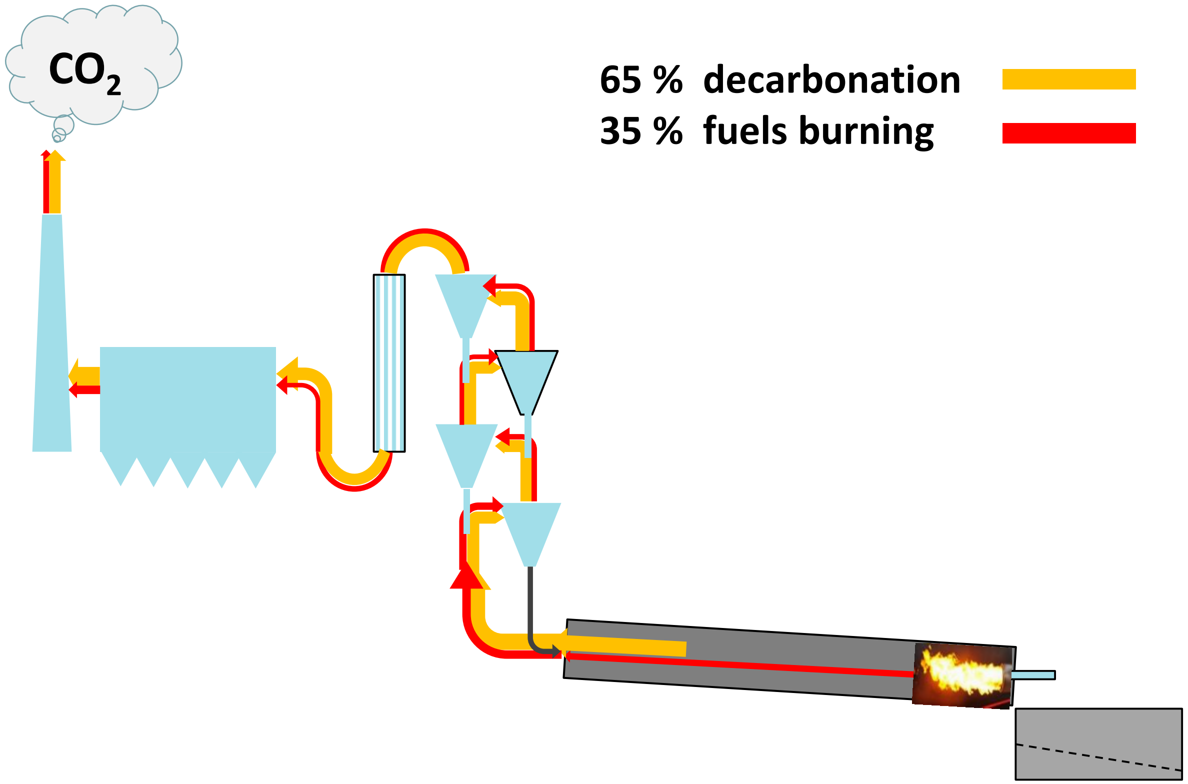
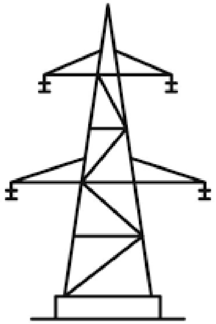
Summary

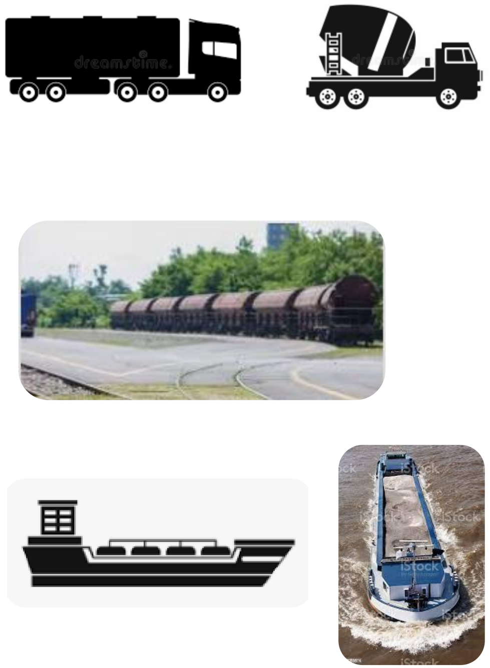
BUZZI UNICEM: Our Journey to Net Zero

- **CO2 Capture Technologies for Cement Industry**
- Key factors for cement decarbonization
- Buzzi Unicem - CO_2 emissions
- Roadmap to NET ZERO
- Buzzi Unicem main CCUS projects

Clinker kiln - CO_2 emissions







Scope 1

Scope 2

Scope 3

CO_2 Capture Technologies

Target: separation of CO_2 from exhaust gas and concentration up to > 95 vol.%

Post-Combustion Technologies:

- Subsequent separation of CO2 from conventional processes by physical or chemical binding to a sorbent
- Chemical processes: Amine washing, Ca-looping, mineralization
- Physical methods: Adsorptive processes (TSA, VPSA),membrane, cryogenic separation

Integrated processes:

- Concentration of CO2 in the process allows a more efficient separation
- Oxyfuel, indirect calcination, integrated Ca-looping

source vdz

Chemical Post-Combustion Technologies

Absorptive processes

- Desorption step is energy-intensive
- Monoethanolamine (MEA) most advanced; but has high thermal energy demand >3.5 GJ/t CO_2
- Further development of liquid solvents (optimized amines, ammonia or potassium carbonate) can reduce energy demand
- Separation rate dependent on available waste heat (from clinker burning process and compression stages) or steam generation
- Degradation of solvents due to NOx, SOx

- First industrial application 2024 at Norcem Brevik, Norway (https://www.norconsult.com/projects/ccs-brevik-norcem/)

source vdz

Physical Post-Combustion Technologies

Absorptive, cryogenic and membrane-processes tested in < 1 t CO_2/d pilot size

Membrane process:

- Selectivity towards CO_2 limited
- Susceptible to impurities (annual replacement of membrane)
- Potential to reduce costs by improving efficiency.

https://www.holcim.de/de/holcim-und-cool-planet-technologies-entwickeln-eine-carbon-capture-anlage-deutschland

Adsorptive processes (PSA, VPSA, TSA):

- Repeated cycle of adsorption and desorption on solid sorbents through pressure/vacuum or temperature cycling
- Reactors more space-saving than, e.g., amine scrubbing
- Level of development and energy requirement dependent on sorbent

https://svanteinc.com/carbon-capture-solutions/

Cryogenic process:

- Separation by phase transformation
- High power requirement, reduced in combination with PSA or membranes

https://netl.doe.gov/sites/default/files/netl-file/22CM_PSC15_Hoeger.pdf

source vdz

Integrated Processes

Oxyfuel-Technology

- Combustion with oxygen instead of air
- Enrichment of CO_2 to 80 to 90 vol.%.
- Implementation criteria: space requirements, condensate treatment, new cycle formation, reduction of impurities
- Thermal energy demand:
  - Retrofit with flue gas recirculation depending on the heat integration -6 to +1%.
  - New installation without flue gas recirculation leads to increase of 10 to 15% with 12 to 15% lower electricity demand due to conversion of waste heat to electricity
- Results of AC^2OCem project available as of 03/2023
- Start of CI4C pilot plant expected in 2024

source vdz

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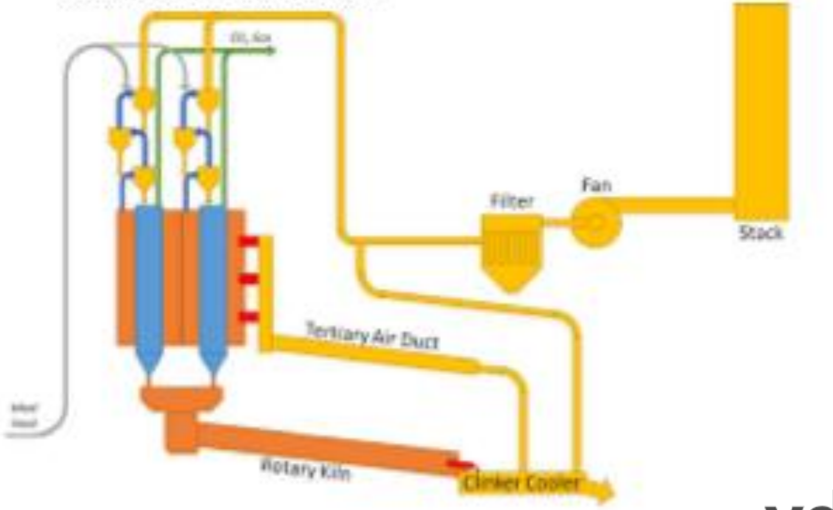
Integrated Processes

Indirect calcination

- Separation of material-bound CO2 by indirectly heated calciner
- Separation rate limited to <60%.
- Complete separation possible through combination with other separation technologies or electrification
- Modular retrofit possible (~25,000 t/a per calciner tube), but scaling limited.
- Purification necessary to meet purity requirements of downstream of subsequent processes.
- Start of construction of LEILAC II in Hannover expected 2023

LEILAC (https://www.leilac.com/)



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Comparison of separation methods

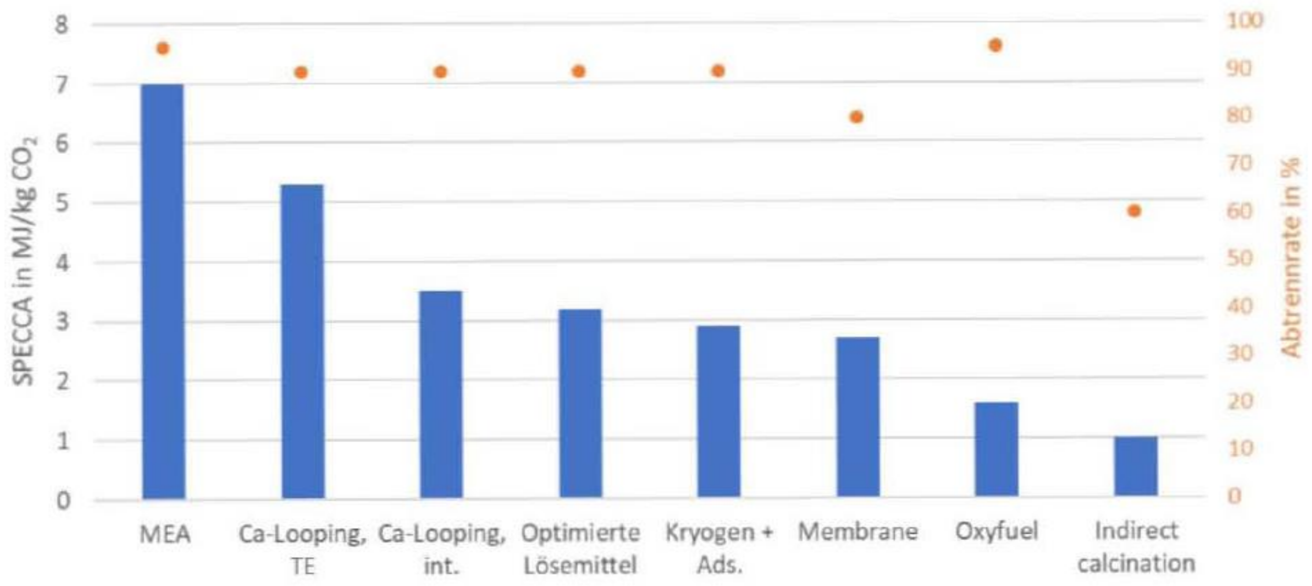
Performance indicators based on ECRA Technology Papers 2022

Separation rate:

- Assessment parameter about the efficiency of the separation

SPECCA (Specific Primary Energy Consumption for CO_2 Avoided):

- Additional thermal and electrical energy required for CO_2 capture
- Includes the generation of indirect emissions (depending on the electricity mix)



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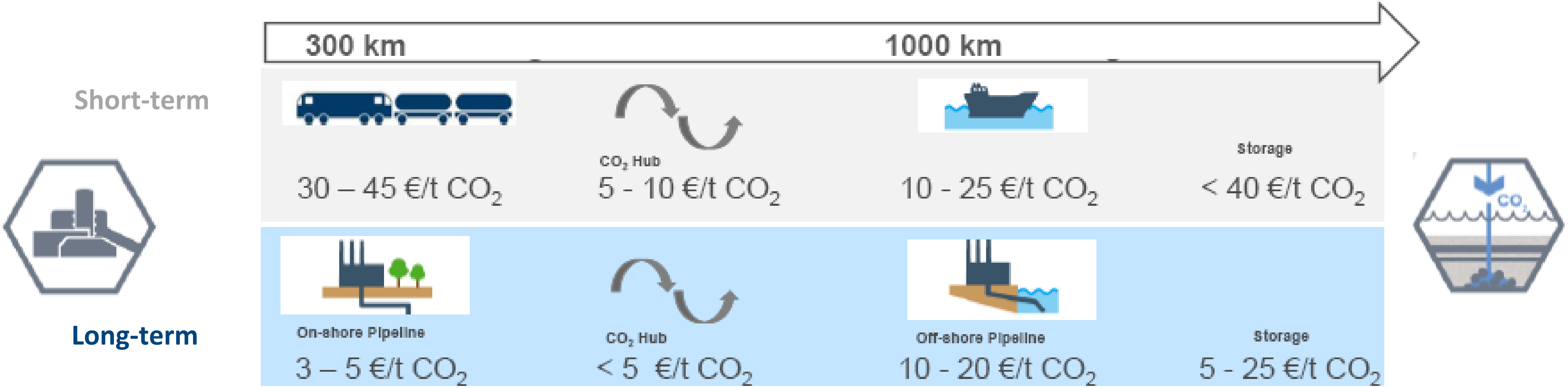
Transport and storage or reuse

Example calculation for transport costs



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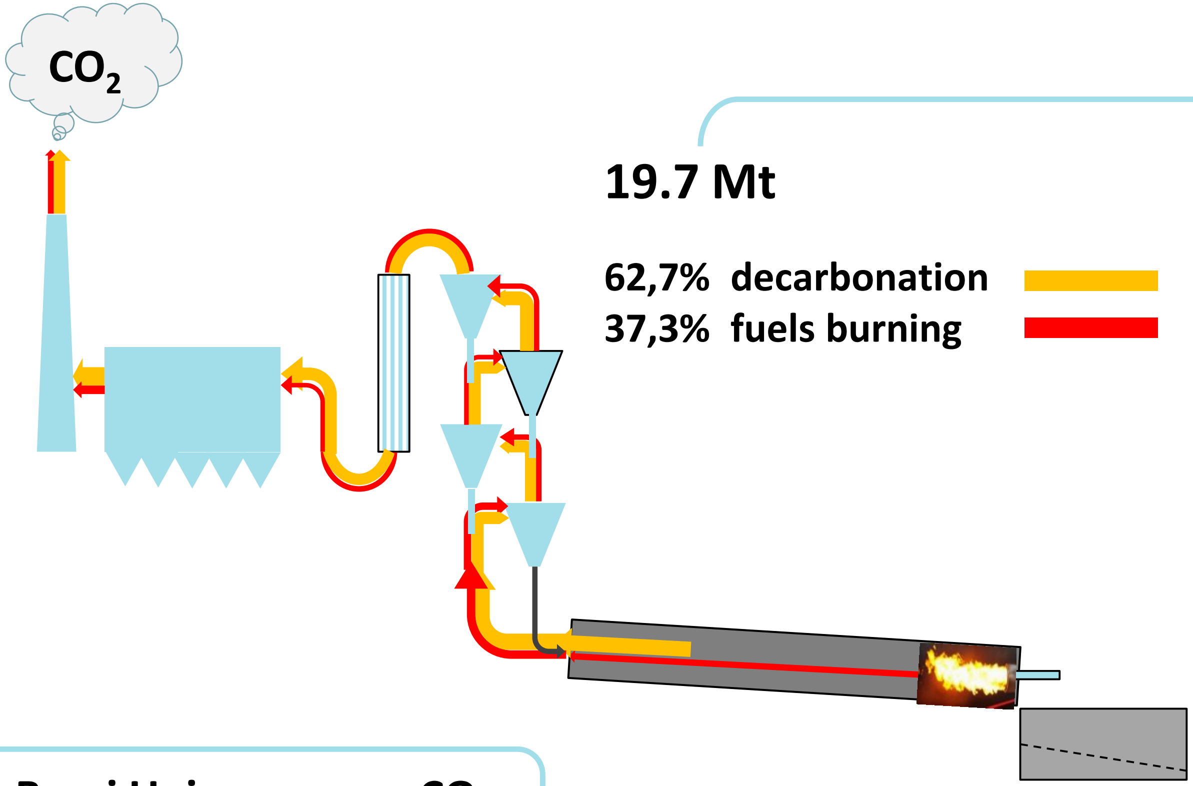
- **Roadmap to NET ZERO**
- **Buzzi Unicem main CCUS projects**

Buzzi Unicem - CO_2 emissions accounting



Buzzi Unicem group CO_2 emissions (2020 data)

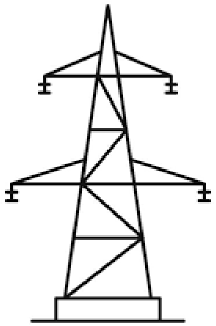
24,82 Mt

19.7 Mt

62,7% decarbonation

37,3% fuels burning

1.6 Mt



~ 3.5 Mt

Scope 1

Scope 2

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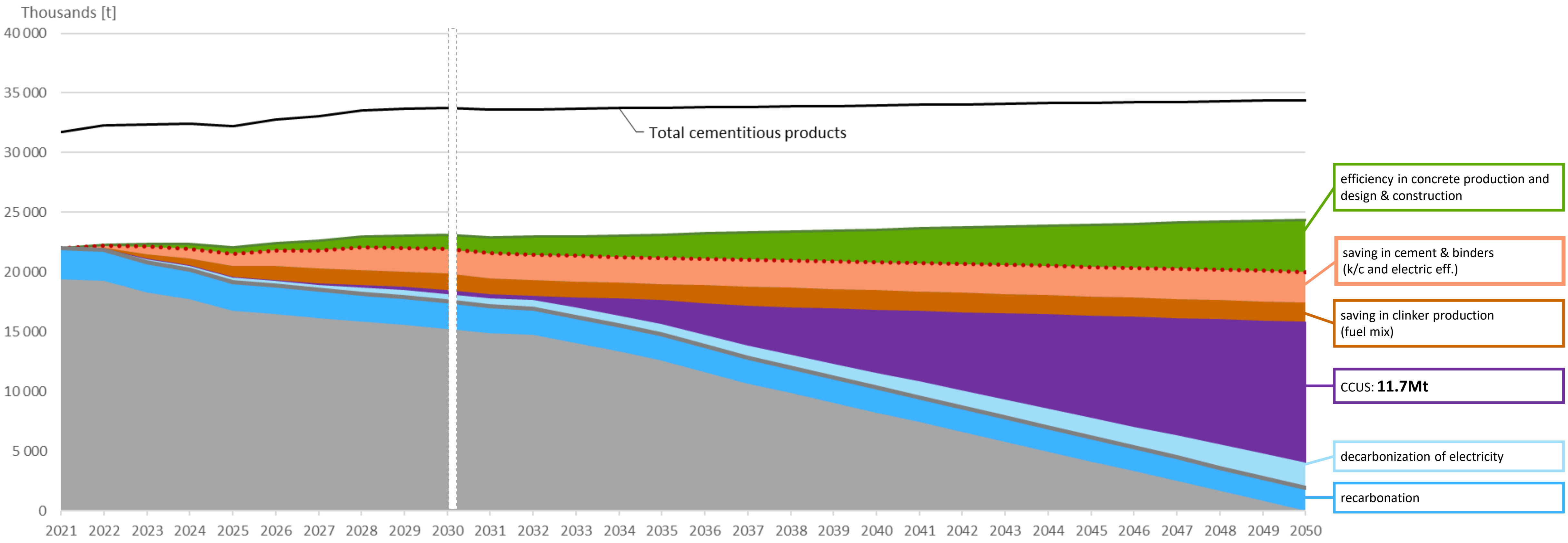
Key Factors for Cement Decarbonization

The 5 Cs approach

- **C**linker
- **C**ement
- **C**oncrete
- **C**onstruction
- re**C**arbonation

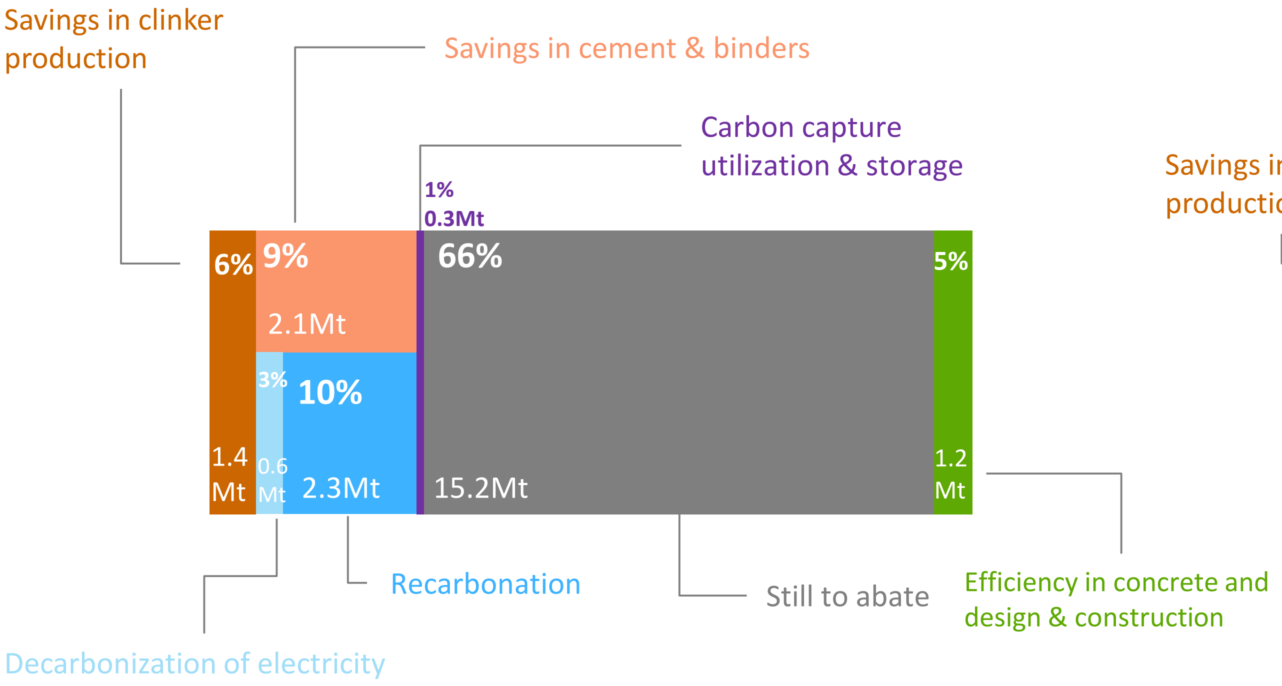
Absolute Emissions scope1 gross + scope2 – [t CO_2]

Breakdown by levers including electricity decarbonization

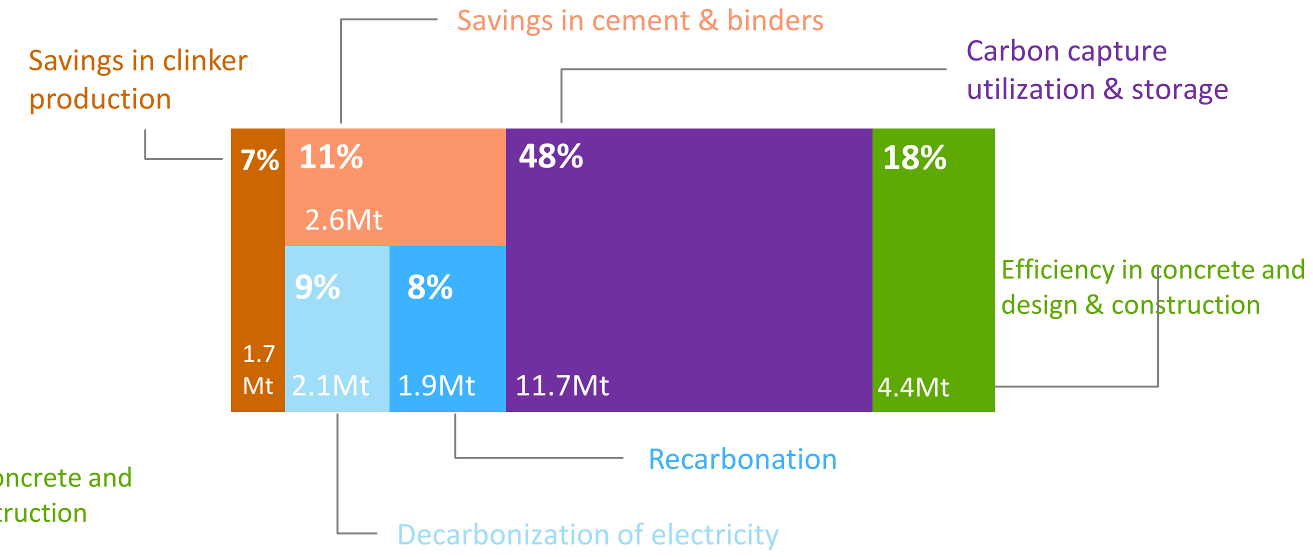


BU: 2030 vs 2050

BUZZI UNICEM 2030 target



BUZZI UNICEM TO NET ZERO



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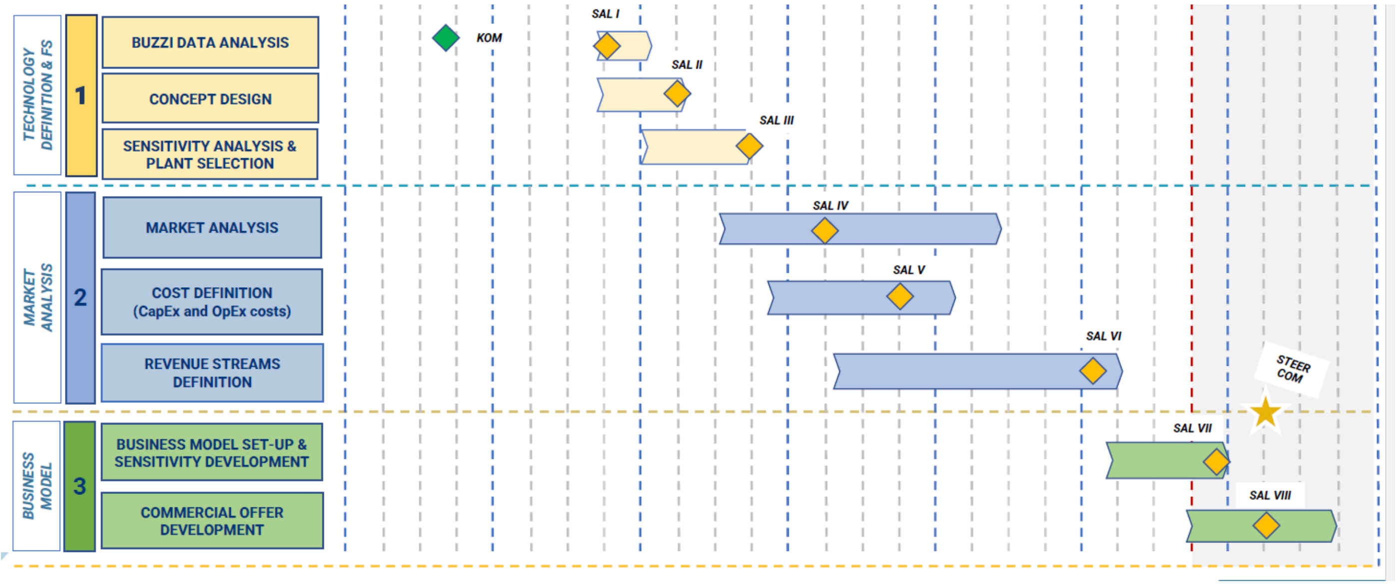
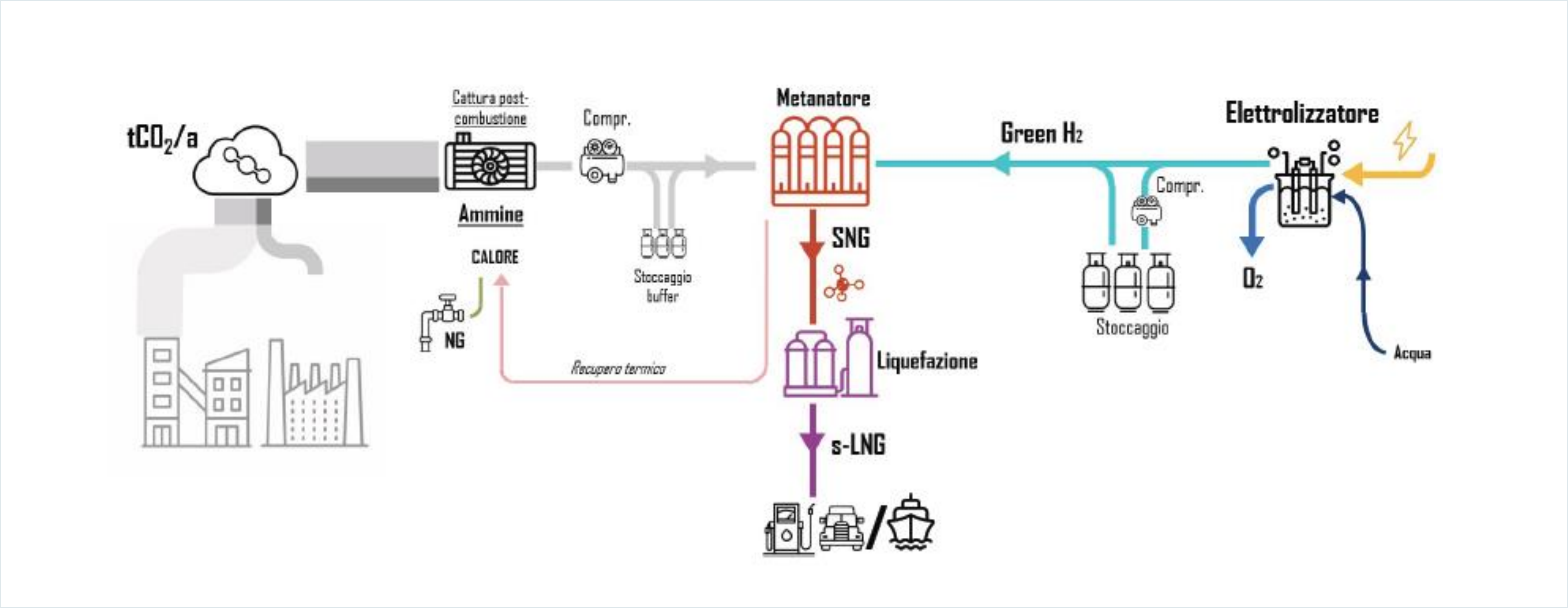
Buzzi Unicem - Italgas: Feasibility Study

- Memorandum of Understanding signed in December 2021
- Scope of work: Development of a feasibility study on the implementation of Power to Gas plants in combination with Carbon Capture Systems at Buzzi Unicem production plants
- Target: Italgas economic offer for the realization of the system assessed in the feasibility study at Buzzi Unicem production plants, in case of concrete opportunities for both parties in terms of feasibility and sustainability
- Scientific advisor: Politecnico di Torino
- Project timeline: Dec. 2021 – June 2022

- Main project steps:
  1. Technology definition
  2. Market analysis
  3. Business model development



Buzzi Unicem - Italgas: Power to Gas Technology



Study on Partial CO_2 Capture at Deuna Plant, Germany

Current situation and background

Dyckerhoff is working with strong partners to decarbonize the Deuna plant

- **TES (Tree Energy Solutions)** offering a full solution to decarbonize the energy and process related emissions
    - Setting up the LNG, green gas, CO_2 terminal in Wilhelmshaven "AvantHy"
    - Building the CO_2 network in Germany together with its partner OGE
- **OGE (Open Grid Europe)**
  operating the largest gas transmission network in Germany
    - 12.000 km pipelines for gas
    - 30 compressor stations (1.000 MW_{total}), 111 GW peak load and 654 TWh gas transported in 2020
    - 17 border crossings and 1.009 exit points

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Study on Partial CO_2 Capture at Deuna Plant, Germany

Project development

TES offer

- TES is setting up a complete value chain which includes the terminal in **Wilhelmshaven** near the Jade bay at northern seashore. This terminal will be connected to the gas-, CO_2-, and hydrogen pipeline network as well as the railway network.
- Together with **Rhenus**, TES offers to pick up CO_2 by train in 2026, latest 1st quarter of 2027
- In a first step, **CCS** is offered
- In a second step, the captured CO_2 will be used for **CCU** in a closed loop
    - Transport to the Middle East as a feedstock is foreseen.
    - The $\mathbf{CO_2}$ will be used to produce "**green CH4**" out of "**green H2**" using the high solar energy potential in this region
    - Methane ($\mathbf{CH_4}$) will return to Europe with the same ships.

CI4C - “Pure Oxyfuel”

“**OXYFUEL**” def.: combustion of fuel by replacing air (ca. 21% O_2 + 79% inert components: N_2, Ar) with pure oxygen as oxidizer

- **CI4C** - **C**ement **I**nnovation **F**or **C**limate: J.V. of four partners
- The **catch4climate project** is intended to create the conditions for the large-scale use of CO_2 capture technologies in cement plants
- First application of so-called "Pure Oxyfuel" technology in the cement production process
- Significant improvement in CO2 capture potential from flue gas expected at much lower electricity costs
- The long-term goal is to establish a process for complete and cost-efficient capture of CO_2 emissions from a cement plant.
- Technology provider is TKIS (Polysius)

The EPC contract with TKIS was recently signed.

Joint Venture:

Project:

CI4C - "Pure Oxyfuel"

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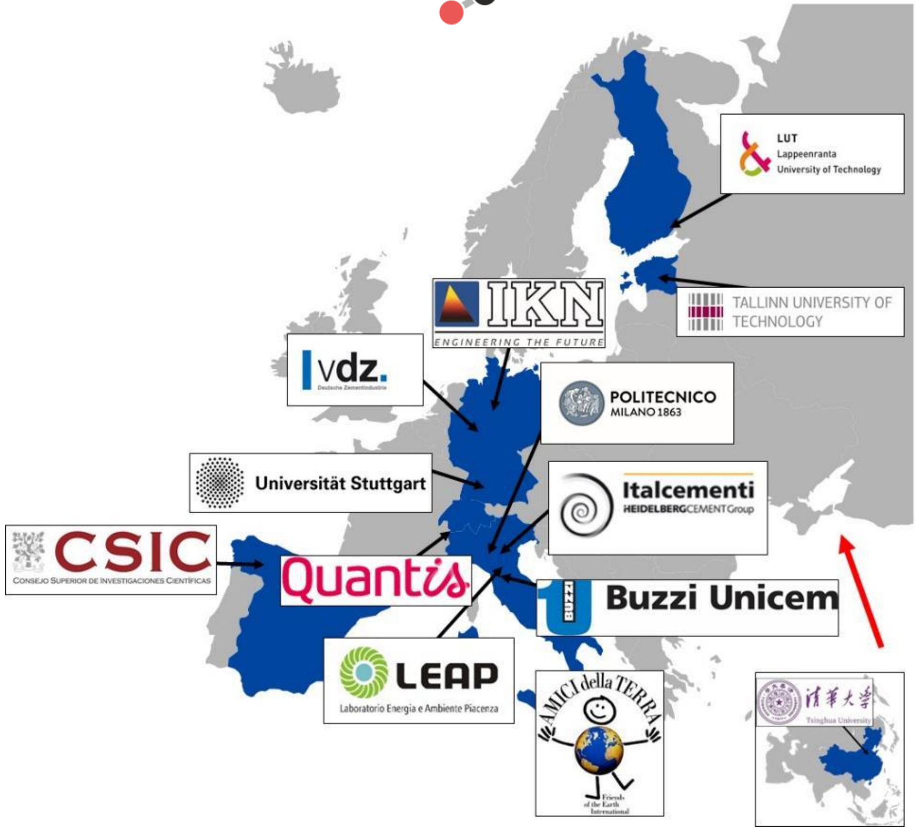
Pilot Plant (450 tpd) in Mergelstetten (SCHWENK Cement Plant, South Germany)

CLEANKER Project – Vernasca Plant

- Ultimate objective: **advancing the integrated Calcium-Looping (CaL) process** for **CO_2 capture in cement plants**
- Primary targets:
  - **Demonstrate the integrated CaL process at TRL 7**, in a new demo system connected to the operating cement burning line of **Vernasca** cement plant
  - **Demonstrate the technical-economic feasibility** of the integrated CaL process in **retrofitted large scale cement plants** through process modelling and scale-up study.
- Starting date: October 1st 2017
- Duration: 4 years + 1.5 years extension (Covid-related delays)
- End date: March 31st 2023
- Partner: 13 from 5 EU member states + Switzerland and China



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