

Cement sector decarbonisation: a HERCCULEan task?

Supported by the EU's Horizon Europe initiative, the HERCCULES project aims to accelerate the scale-up of carbon capture, utilisation and storage (CCUS) projects in southern Europe.

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In recent years, the European Commission has been consistently supporting carbon capture, utilisation and storage (CCUS) technologies in hard-to-abate industries, including the cement industry. This is the case of the HERCCULES project (Heroes in Southern Europe to decarbonise industry with CCUS¹), coordinated by LEAP² and supported by the EU's Horizon Europe research and innovation programme with a EUR29m grant over five years. The 23 project partners – half of which come from industry – aim to accelerate the scale-up of CCUS technologies in Mediterranean Europe, demonstrating the feasibility of the entire CO₂ CCUS value chain with a focus on energy-environmental performance, safety, optimisation of CO₂ logistics, and economic and social acceptability aspects.

Taking into account the two most advanced geological CO₂ storage sites in southern Europe – Prinos in Greece and Ravenna in Italy (see Figure 1) – the project will focus on Italy's Po Valley region and Greece. It will initiate concrete actions for the mitigation of CO₂ emissions with an innovative, integrated and replicable

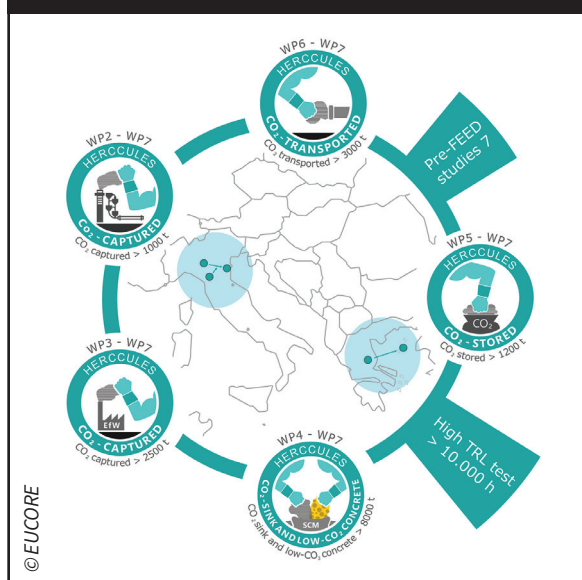
approach, driven by the cement sector in Greece and by the synergetic integration of cement and energy from waste (EfW) industries in northern Italy.

Significant industrial activity is present in the areas selected for the HERCCULES project. In particular, the Po Valley in northern Italy hosts 11 cement plants³ and 26 out of the 38 Italian municipal solid waste – energy from waste (MSW-EfW) facilities.⁴ The cement industry in Greece has a production capacity of ~15Mta, installed in cement plants of three companies.⁵

Cement sector application

In terms of the cement sector, the HERCCULES project objective is to enable

Figure 1: HERCCULES project locations for CO₂ capture and storage in Italy and Greece, and the most relevant scientific and technical activities and targets



flexible and optimised carbon capture by designing, building and demonstrating high-purity CO₂ capture technologies in an industrial environment (EU Technology Readiness Level 7 – TRL7). A new hybrid configuration, HERCCULES, will be assessed, advancing the technology to TRL7. The HERCCULES hybrid CO₂ capture technology for cement will consist of:

- oxyfuel calcination + CO₂ processing unit (CPU) to efficiently capture the calcination process emissions
- new-generation solvent-based post-combustion capture (PCC) to efficiently capture the rotary kiln emissions and the CO₂ contained in the CPU vent gas.

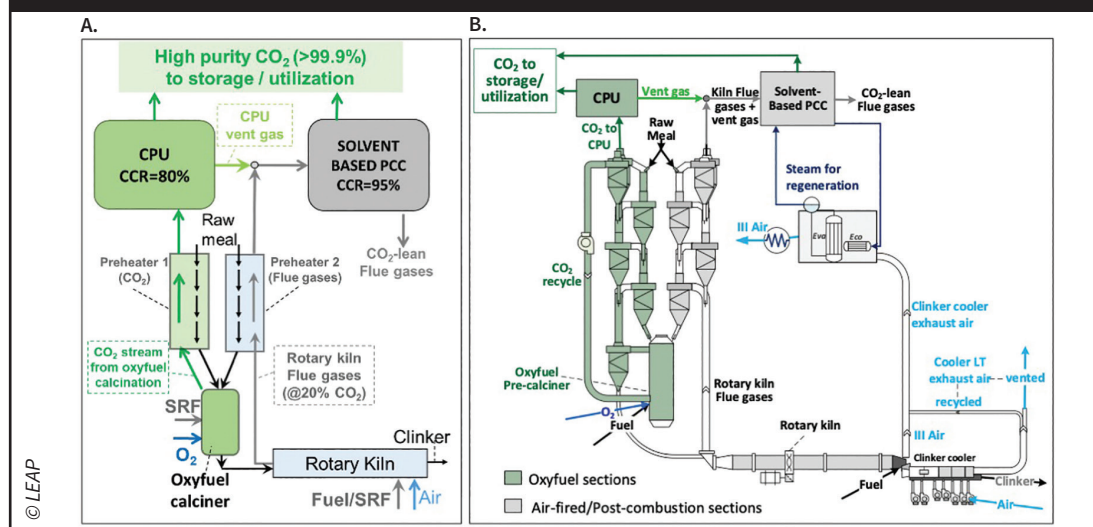
Both parts are to be combined in an innovative way to achieve HERCCULES hybrid CO₂ capture technology (see Figure 2).

HERCCULES is very versatile as it cannot only be exploited as a full integral capture solution in a retrofit but also as a sequence of separate oxyfuel and PCC

HERCCULES project partners

- LEAP (coordinator)
- EU CORE Consulting (Italy)
- Energean Oil & Gas (Greece)
- Buzzi (Italy)
- TITAN Cement (Greece)
- Sumitomo SHI FW (Finland)
- Air Liquide (Italy)
- Fraunhofer ISI (Germany)
- Politecnico di Milano (Italy)
- BCG (Italy)
- CSIC (Spain)
- Celitement (Germany)
- Utrecht University (The Netherlands)
- Wiersdorfer Alpacem GmbH (Austria)
- Artidek (Ukraine)
- Shogenergy (Estonia)
- LUT University (Finland)
- Tecno Project Industriale TPI (Italy)
- Cluster Greentech (Italy)
- CRES (Greece)
- A2A Ambiente and A2A Spa (Italy)
- Eni (Italy)

Figure 2: A. conceptual scheme of the hybrid technology for cement plants and B. full-scale layout of the hybrid configuration retrofitted to a dry-process plant with a double-string preheater



sections, enabling investors to take a two-step approach. They can undertake the decarbonisation of the kiln or the calciner first with full capture to be implemented in a second phase.

Project description

The PCC and oxyfuel calcination (solid recovery fuels (SRF)/biomass-fed + CPU) will be built and tested separately in two cement plants: Buzzi SpA's Vernasca works in Piacenza, Italy, and one of TITAN Cement Group's plants in Greece. Three configurations will be used:

1. An oxyfuel calcination system, combined with cryogenic purification, capable of separating CO₂ with high efficiency and purity, will be integrated into the TITAN plant in Greece. The purification system will be carried out by Tecno Project Industriale, an Italian company belonging to the SIAD Group, which specialises in the design and engineering of CO₂ conditioning plants.
2. A post-combustion capture unit, based on a process using innovative solvents and implemented by Tecno Project Industriale, will be installed in the Vernasca plant.
3. The post-combustion unit tested in Vernasca will be transferred to Greece, where it will be integrated with the oxyfuel calciner and CO₂ purification system. Together they will create a so-called hybrid configuration, potentially characterised by high energy and capture efficiency. This hybrid oxyfuel/PCC configuration will be demonstrated to capture up to 8tpd of CO₂ at high purity, targeting ultra-high CO₂ removal efficiency and negative

emissions when co-firing biomass in the calciner.

To close the loop, part of the flow of purified CO₂ captured at the TITAN and Buzzi cement plants will be allocated to mineralisation processes for the production of new cement-based materials that may be used in the production of low CO₂-embodied concrete, or the purified CO₂ will be used as industrial gas. The characteristics of the hydraulic binding agents, to be reused in the concrete production process, will be evaluated and compared with the existing materials, taking into account that any requirements regarding the standardisation activities needed not to preclude its commercial use.

The high purity-CO₂ that will not be used for these processes will be sent to storage. The geographic location of the cement plant in Vernasca, about 300km from the CO₂ storage-hub, will also enable the project to investigate issues related to intermediate storage and CO₂ transport. The geological storage will be evaluated in projects at the implementation stage in the Ravenna district, Italy, (operated by Eni) and in Prinos, Greece (operated by Energean).

Finally, the main industrial partners of HERCCULES will work together to better exploit the experimental results of the chain obtained throughout the development of the project. Engineering studies related to retrofitting activities on HERCCULES technologies will be applied to seven cases of cement and waste-to-energy plants, and then compared with CO₂ capture solutions already available on an industrial scale, thus completing the activity with a solid benchmarking study

led by Air Liquide, leveraging on its consolidated carbon capture expertise and technology offer.

Project timeline

The HERRCULES project started in January 2023 and its expected duration is five years.

The engineering and construction of the pilot plants in Italy and Greece will take place in the first two years. The third year will cover

the experimental activities related to the capture process, while years four and five will focus on CO₂ use and storage. Across its lifetime the project will be supported by activities to engage the public and societal stakeholders.

All-round innovation

The HERCULES project aims at bringing innovation both at a technological and supply chain level. In this way, the research activities will also consider clusters of emitters and integrate technical aspects with detailed evaluations on safety, public perception, social impact, legislation and financial aspects. ■

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