HEATERNAL: How CALDERYS is powering the energy transition

A PROMISING DECARBONIZATION SOLUTION

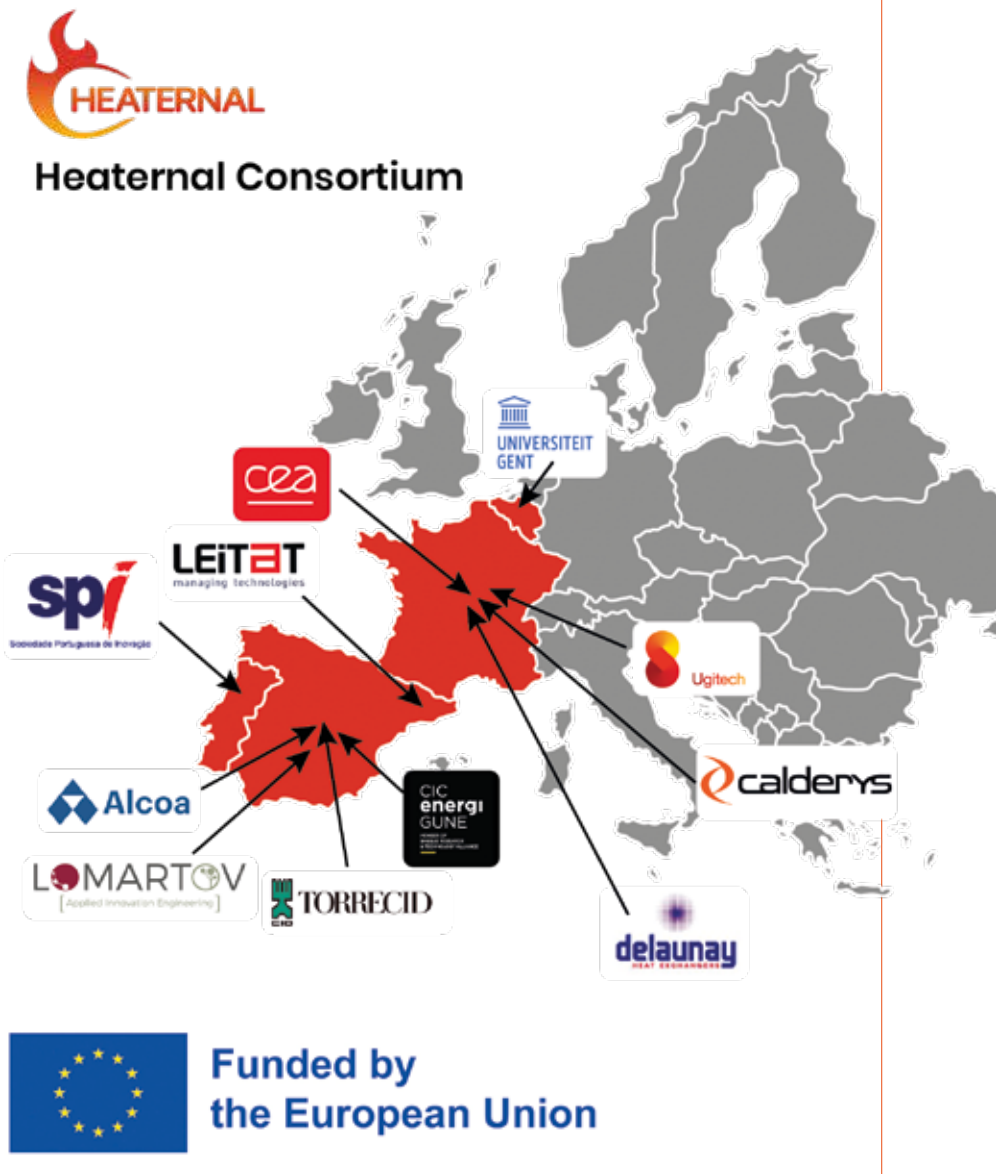
The glass industry is under intense pressure to decarbonize, driven by EU regulations and global sustainability goals. Across Europe, industrial processes, including glass production, emitted 1.13 billion tons of CO2 equivalent in 2023, according to the European Environment Agency. While this number represents a 15.5 percent improvement over 2022 rates, the manufacturing community has yet to implement viable decarbonization solutions for continuous high-temperature operations. Determining innovative approaches is vital and the European HEATERNAL project is working to provide a promising path forward.

THE HEATERNAL INITIATIVE

Launched in May 2023, HEATERNAL (High tEmperAture ThErmal stoRage for iNdustrial AppLications) is an EU-funded project coordinated by the French Alternative Energies and Atomic Energy Commission (CEA). It unites four public research teams and seven private companies with the overall objective of creating a Thermal Energy Storage (TES) system for high-temperature industries such as glass, steel, and cement.

As ever-mounting decarbonization pressures continuously prompt the glass industry to advance energy-intensive operations, CALDERYS' Technical Support Manager for Iron EMEA, Bertrand Hiot, explores how the EU-funded HEATERNAL project that features his company's refractory innovation -and of which he is a Consortium member- is developing high-temperature Thermal Energy Storage to recover waste heat - all while slashing emissions in manufacturing.

HEATERNAL's TES will recover industrial waste heat or possibly renewable energy to replace natural gas. The initiative focuses on two main components. First, to develop inventive Phase-Change Materials (PCM) and unit designs that amplify unit energy density by 350 percent compared to ceramic bricks. Second, it aims to achieve manufacturing proficiency that will enable the integration of TES units into factories by 2030. The project is developing a 50-kWh prototype (at Technology Readiness Level 5) to evaluate the energy benefits and test the robustness of the design, along with scaled-up storage system models that can be customized for factory integration. The TES units will capture waste heat from manufacturing processes, storing it for up to 48 hours using advanced PCMs integrated into high-performing refractories. The PCMs, primarily aluminum alloys mixed with magnesium, copper or zinc, are tailored for specific melting points to suit varying manufacturing process needs. The significance of the initiative lies in producing a material with unprecedented heat storage capacity that can effectively change its form to transfer latent



energy for use in operations and then ensuring that the TES units can be manufactured for ease of use by various industries. This capture and 'recycling' of energy through TES units will help reduce reliance on fossil fuels and CO2 emissions, with an initial goal of up to 30 percent.

ROLE OF REFRACTORIES

As the only refractory manufacturer in the HEATERNAL consortium, Calderys' expertise in refractories is essential to the project's success. The refractories that integrate with the system's PCMs must withstand severe stresses: high temperatures, thermal cycling, and chemical interactions. Because the PCMs are fully integrated into the refractory material, not just housed, the TES system is designed to deliver years of reliable performance. Unlike standard bricks, these pre-fabricated refractories utilize additives and anti-wetting agents to minimize porosity. They interact with the refractory matrix to enhance the integration of PCM, ensuring longevity. The programme achieved a milestone in March 2025, as Calderys selected refractories for the pilot unit, collaborating with the University of Ghent and CEA

on thermo-mechanical studies to validate durability. Looking ahead, the compact pilot unit will be assembled at CEA in collaboration with Calderys. Completion is underway, with a target storage capacity of 50 kWh.

MANUFACTURING SCALABILITY

HEATERNAL's innovative approach also includes a study on 3D-printed TES unit designs that enhance energy density by more than 350 percent compared to traditional ceramic bricks, while increasing energy efficiency due to a higher exchange surface. Promising 3D technology consequently enables the creation of compact, cost-effective units with a minimal footprint. The compact units, manufactured off-site and adaptable via 3D printing, will reduce installation costs and fit within space-constrained manufacturing facilities.

GOALS AND IMPLICATIONS FOR GLASS MANUFACTURERS

The project's focus on dense, durable materials ensures a lifespan exceeding ten years, offering a rapid return on investment (ROI) driven by significant energy savings. While steel may adopt the technology faster due to process similarities, the system's flexibility makes it ideal for glass and other manufacturing processes. HEATERNAL aims to deliver a scalable TES prototype by end-2025, with industrial implementation targeted for 2030. For glass manufacturers, the system promises significant benefits. Preliminary studies project a return on investment within three years and a levelized cost of stored energy below EUR 6/MWh-60 percent lower than molten salt storage, which is unsuitable for glass manufacturing's extreme temperatures (800–1500°C). In float glass production, for instance, the TES system has the potential to capture and store lost heat from the melting zone and then distribute it where lower levels of heat are needed, such as in the annealing zone. Consider that in a glass manufacturing facility, energy savings of 1-2 percent in large-scale plants could translate to EUR 500,000 annually. In addition, it would result in substantial CO2 emissions reduction - potentially 100 kilotons per plant, which would dramatically ease EU carbon tax burdens. By enabling the use of waste heat, the HEATERNAL initiative is helping to position glass and other manufacturers to meet decarbonization goals, reduce costs and enhance competitiveness in a sustainability-driven market.