

SUMMARY

Introduction	1
MECALO Partner Spotlight: PDC	4
Work Begins on New Sustainable Raw Materials	4
New PhD candidate joins MECALO at LIST	5
Events	6
Hydrogen Innovation Webinar: Discover MECALO Vision	6
MECALO Presentation at EUBCE 2025	6
Project meeting	7

Introduction

MECALO project aims to change the production of essential materials for European industry, like silicon and manganese.



The transformation focuses on achieving cleaner and more sustainable production methods through the use of hydrogen. MECALO seeks to strengthen the European Union's capabilities and resilience in securing a sustainable supply of these critical raw materials (CRMs), aligning with the objectives of the European Critical Raw Materials Act, while maintaining carbon neutrality.

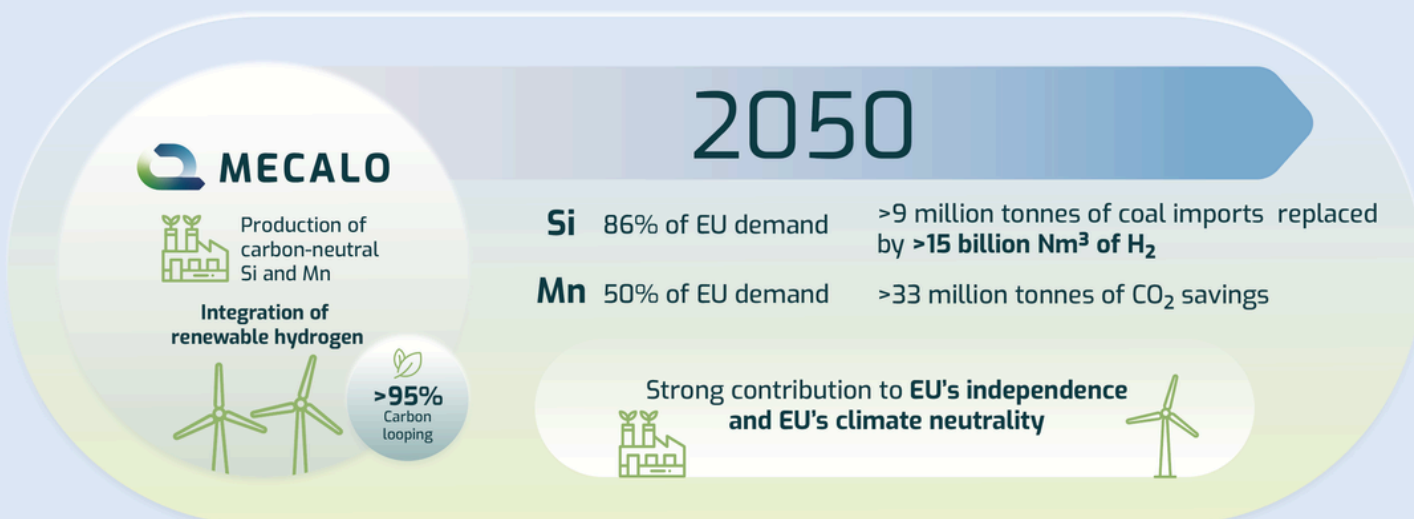
The project's importance lies in its potential to address the growing need for sustainable sourcing of materials vital for various industries within the EU.

Hydrogen, when derived from renewable energy sources, is expected to play a pivotal role in decreasing carbon emissions across a significant portion of the EU's metallurgical sector by 2050. As its use does not generate CO₂ emissions, sustainably sourced hydrogen represents a promising avenue for

decarbonizing industries that face considerable challenges in reducing their environmental impact. This shift towards hydrogen aligns with broader European goals for environmental sustainability and transition to cleaner industrial processes.

There is one big problem: hydrogen cannot directly substitute carbon in all processes.

These metals are indispensable for the advancement of European clean technology initiatives and for achieving the EU's overarching goal of climate neutrality by 2050. Innovative approaches like those being explored by MECALO are crucial for overcoming these technological barriers and ensuring a sustainable future for these vital materials.



Key breakthroughs include:



Hydrogen Integration

using renewable hydrogen to convert process off-gases into solid carbon for metal production.



Innovative Technologies

Employing microwave plasmalysis and methanation for energy-efficient conversion processes.



Carbon Neutrality

Demonstrating the potential for 95% CO₂ emission reduction in Si and Mn production.



EU Resilience

strengthening Europe's independence in critical raw materials by enhancing domestic production capacity.

Innovative Solutions for a Sustainable Future

The project introduces an innovative method that uses **renewable hydrogen** to indirectly replace fossil carbon, opening new frontiers for sustainable metallurgy. For metals where direct hydrogen reduction isn't feasible, such as Si and Mn, MECALO has developed an ingenious solution based on a three-step process that loops carbon through the production cycle. Renewable hydrogen reacts with carbon oxides in off-gases, generating methane (CH₄). Then, this methane is converted into solid carbon powder and hydrogen (H₂), with the hydrogen obtained in this step being recycled back into the process. Finally, the generated solid carbon is used as a reduction material in the metal production phase. This approach enables significant CO₂ emissions

reductions while leveraging existing infrastructure and processes, making it practical and scalable. By integrating renewable hydrogen into traditional metallurgical processes, MECALO is redefining sustainable metallurgy, paving the way for more efficient and environmentally friendly metal production.

We are committed to advancing cutting-edge technologies that contribute to a more sustainable and circular economy. In this edition of our newsletter, we are excited to highlight a series of innovative processes that are transforming the way we produce and utilize energy, materials and metals. Each step, from methane pyrolysis to sustainable metal production, optimizes resources, reduces environmental impact, and supports a self-sufficient energy system.

But how does it work?

Methane Pyrolysis: A Step Towards Circular Energy

Methane pyrolysis via microwave plasma splits methane into solid carbon and hydrogen. The carbon prevents CO₂ emissions, while the hydrogen is recycled to form new methane, creating a closed-loop, energy-efficient and low-impact process.

Methanation: Transforming Emissions into Valuable Energy

Hydrogen reacts with carbon oxides from metal production exhaust, converting them into methane instead of releasing them into the atmosphere. This process recycles industrial byproducts and reduces greenhouse gas emissions, supporting a more sustainable energy cycle.

Raw Material Synthesis: Turning Carbon Powder into Valuable Resources

The solid carbon from methane pyrolysis is processed with bio-binders into a raw material for metal production. It can serve as high-purity carbon or be combined with metal ores to form carbon-metal composites, enhancing efficiency and reducing reliance on external raw materials, advancing a circular, sustainable industry.

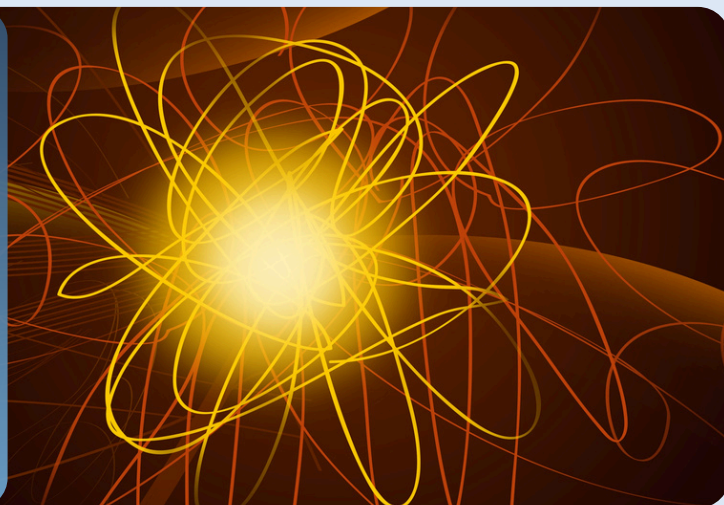
Sustainable Metal Production: A Closed-Loop Approach

In metal production, the synthesized carbon is used in carbothermal reduction to extract metals from their oxides. By relying on internally recycled carbon instead of external sources, the process lowers environmental impact and reduces dependence on non-renewable resources, enabling a more sustainable, closed-loop system.



MECALO Partner Spotlight: PDC

Process Design Center (PDC) is a Dutch company with nearly 40 years of experience in the conceptual design of industrial processes



With a strong focus on sustainability, energy efficiency, and technological innovation. The company supports the process industry in developing, optimizing, and integrating advanced solutions that contribute to greener and more circular production models.

In MECALO, PDC is leading Work Package 4 (WP4), where they are driving sustainability within the SiMn and Si metallurgic industries. WP4 focuses on integrating and optimizing the MECALO concept to enhance **resource** and **energy efficiency** for both stationary and dynamic operations. The mission is to develop **several scenarios** based on defined **reference cases** of varying gas composition, energy mix and integration possibilities while selecting appropriate separation technology to bring the concept closer to the **net-zero CO₂ emission goal**. How do they do it? They build on the experimental insights from the core pieces of the project and

their technical requirements to piece together a functional carbon-looping cycle that operates at a minimized cost. Next, they propose and evaluate solutions using chemical process simulations, their AI/expert software PROSYN built on 38 years of engineering experience, and cutting-edge literature. The scenario possibilities are managed by a superstructure model capable of easy adaptation, updates and extensions to cover many possibilities. The result is a resource and energy-optimized process developed in close collaboration with our project partners. By tackling process limitations early, they transform complex industrial challenges into data-driven, optimized solutions before they scale up to full operation. With MECALO's interdisciplinary powerhouse of experts, they are paving the way for a more sustainable, climate-friendly future—one breakthrough at a time!

Work Begins on New Sustainable Raw Materials

On January 30, the kick-off meeting of Work Package 3 (WP3) took place in Zabrze, Poland, marking the start of a crucial phase in the Mecalo project. WP3 aims to develop innovative technologies for the sustainable production of critical raw materials, focusing on manganese and silicon using H₂-looped carbon. The transition from traditional carbon raw materials such as coal and coke to materials produced by H₂-looped carbon is challenging for several reasons. The carbon material must have similar properties to current

reduction materials, such as reactivity and strength, but the size of the new material is also very different. Typically, the new carbon material is typically a very fine powder. This carbon cannot be used directly in the process as it would create several problems, including being blown out of the furnaces with the exhaust gas. Agglomeration to convert carbon powder into carbon materials with the right properties is therefore very important for further developing the MECALO concept.

The event began with welcome speeches by Michał Rejdak (ITPE) and Anne Gry Messenlien (WP3 Leader, Elkem), followed by a presentation of ITPE's infrastructure by Bartosz Mertas (ITPE). Participants toured ITPE's laboratories, gaining insights into the technologies used for raw material research and development.

Discussions centred on key WP3 tasks, including manganese and silicon agglomeration (Task 3.1), pyrolysis and fractionation techniques (Task 3.2), and the development of new raw materials (Task 3.3). Contributions came from Youssef Berro (Eramet), Kristian Stangeland (Elkem), Hans Heeres (BTG) and other project partners.



The meeting concluded with a visit to the Guido coal mine, strengthening team collaboration while exploring the region's industrial history. The Guido Coal Mine, located in Zabrze, Silesia, Poland, is a historic mine now operating as a museum called the Guido Mine and Coal Mining Museum, and it's an anchor point on the European Route of Industrial Heritage. It is considered the deepest accessible mine in Europe, with routes descending up to three hundred and twenty meters underground. With this milestone, WP3 is now set to advance innovative solutions for sustainable raw material production in the coming months.



New PhD candidate joins MECALO at LIST

We are pleased to welcome David, who recently joined the Luxembourg Institute of Science and Technology – LIST, as a PhD candidate contributing to the MECALO project.

David holds a degree in chemical engineering from ENSCM Montpellier, with a specialization in pollution remediation and environmental management. Before joining MECALO, he gained experience as a process engineer at Veolia's Biothane and as a health studies engineer in France, developing expertise in environmental impact assessments and industrial processes.

In MECALO, under the supervision of Thomas Gibon, David will focus on Life Cycle Assessment (LCA) to evaluate and optimize the environmental impact of new technologies.

His research will include:

- ♦ Developing parametric LCA models, adaptable to different production conditions.
- ♦ Creating online data visualization tools to make LCA results more accessible.
- ♦ Conducting prospective LCA to assess how future technological advancements and energy transitions will impact metal production sustainability.

His work will provide key insights to support greener, more sustainable industrial processes, ensuring that the technologies developed within MECALO contribute to a lower environmental footprint.

We look forward to his contributions. Welcome to the team, David!

EVENTS

Here are some of the events where MECALO is featured. These had and will provide valuable opportunities to showcase our progress, engage with experts and foster discussions on sustainable metal production.

Hydrogen Innovation Webinar: Discover MECALO Vision

MECALO was pleased to participate in the **Hydrogen Innovation Webinar** on May 28, 2025, where seven EU-funded projects showcased their approaches to advancing hydrogen technologies.

During the session on **EU project innovations**, Halvor Dalaker (SINTEF) presented MECALO, offering a unique opportunity to explore the project's mission, its place in the hydrogen landscape and its contribution to sustainable and circular solutions for the metallurgical industry.

The event, hosted online, featured insights from the Clean Hydrogen Partnership, presentations from key EU-funded projects and an engaging roundtable discussion to explore cross-cutting themes in hydrogen innovation.

In the closing Q&A session, Halvor addressed key questions about MECALO's carbon looping approach.

He emphasized that the project doesn't aim to eliminate carbon use, but rather to create a closed-loop system where CO₂ is captured, converted and reused as solid carbon in metallurgical processes.

When asked about replacing carbon with hydrogen, Halvor clarified that in silicon and manganese production, carbon cannot be removed from the chemical reaction, but it can be cycled, using hydrogen to regenerate it sustainably.

He also highlighted MECALO's compatibility with existing furnaces, avoiding the need for radical changes in infrastructure and noted that this makes the technology scalable and realistic for industrial adoption.

In case you miss this, you can find [here](#) the registration!

MECALO Presentation at EUBCE 2025

We are pleased to announce that MECALO has participated in EUBCE 2025 in Valencia with a poster presentation showcasing our work on carbon looping for CO₂-free metal production.

Our poster has provided an overview of the resources and processes we are working with, starting with the motivation behind our approach: why carbon looping is a promising solution for sustainable metallurgy.

The presentation illustrated how MECALO (Bio-materials in CO₂-free metal production with carbon recycling) aims to avoid CO₂ emissions by introducing a closed carbon cycle process that recycles CO₂ emissions within the production cycle, instead of releasing them into the atmosphere. This approach maintains the fundamental chemical reactions of metal production, which would otherwise inevitably produce CO₂ due to carbon's role as a reducing agent.

We outlined the key steps in our process, including methanation and pyrolysis, before diving deeper into material synthesis.

A particular focus was given to the role of bio-based binders, exploring their potential in creating more sustainable metal production pathways.



Project meeting in Enschede

The next MECALO partners meeting is scheduled for June 24-25, 2025 and will be hosted by BTG in Enschede, Netherlands. This in-person gathering will provide a valuable opportunity for all project partners to discuss ongoing progress, share insights, and align on the next steps.

With MECALO moving forward, this meeting will be essential for reviewing recent advancements, addressing challenges, and ensuring that all aspects of the project remain on track. Particular attention will be given to the latest developments in our research, upcoming deliverables, and future dissemination activities.

Beyond the technical discussions, this meeting will also reinforce the strong collaboration among partners, fostering exchange and synergy across different expertise areas. We look forward to productive discussions and a successful meeting in Enschede!

Stay tuned for updates on the key outcomes of our discussions.

