

ELEKTRA

ADVANCED ELECTRIFICATION OF KEY INDUSTRIAL REACTIONS

Project Public Presentation

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Agenda

1. Project background
2. Project objectives
3. WP and responsibilities
4. Project Partners
5. Project organization



Project objectives



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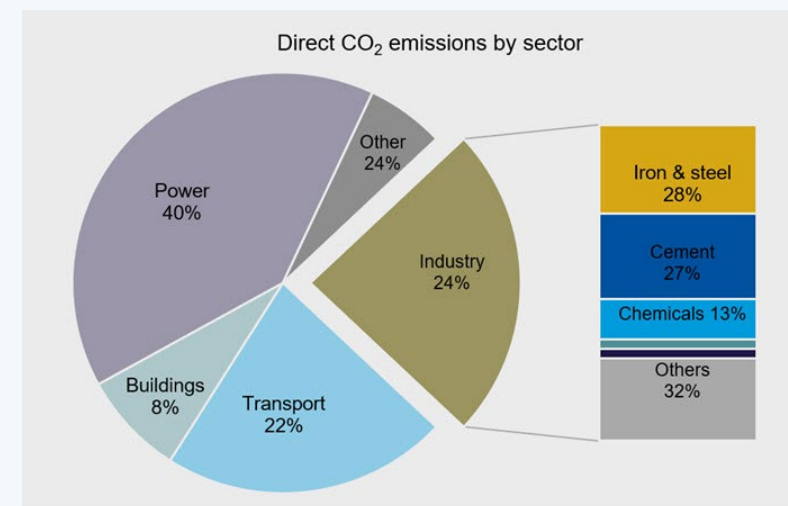
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Steel Sector Context

- Steel industry accounts for **7-8% of global CO₂ emissions**.
- Steel sector has strong **pressure to decarbonise** (EU ETS, CBAM, net-zero targets).
- Transition towards **low-carbon steel technologies** is necessary to reach ambitious objectives.
- High CAPEX and operational risks **slow down the adoption**.
- **Market uncertainty** on costs, value chains, and business models.



Current Steelmaking Routes

Steelmaking Routes

Main current route options

BF-BOF

1.8 ton CO₂/ton steel
60% EU production
Strong dependence on coke and carbon-based reductants

NG-DRI + EAF

1.5-1.7 ton CO₂/ton steel
Reformer and NG dependency

H₂-DRI + EAF

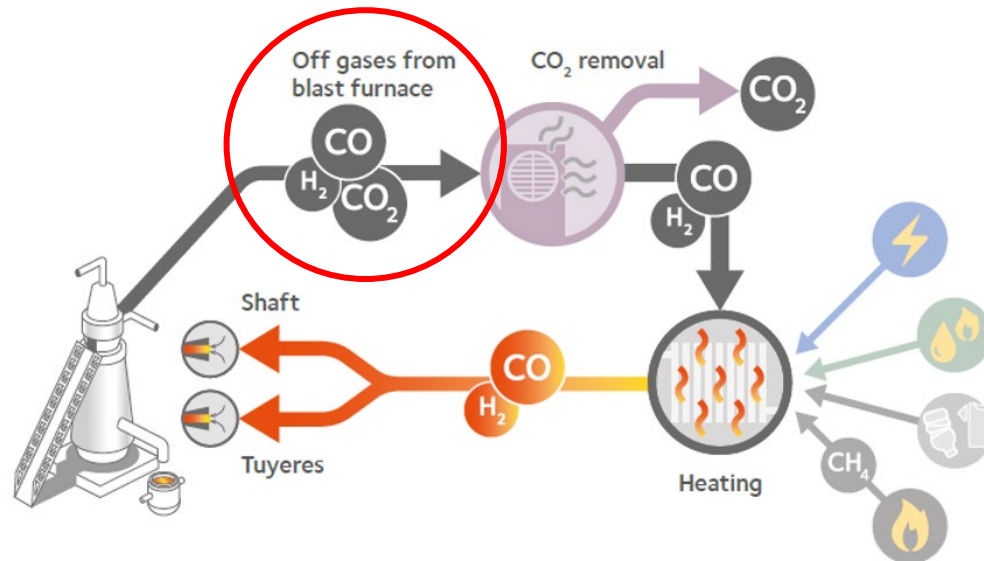
Potential net-zero emissions
Limited by high H₂ and renewable availability and cost

Decarbonization pathway (depending on how we produce reducing gases)

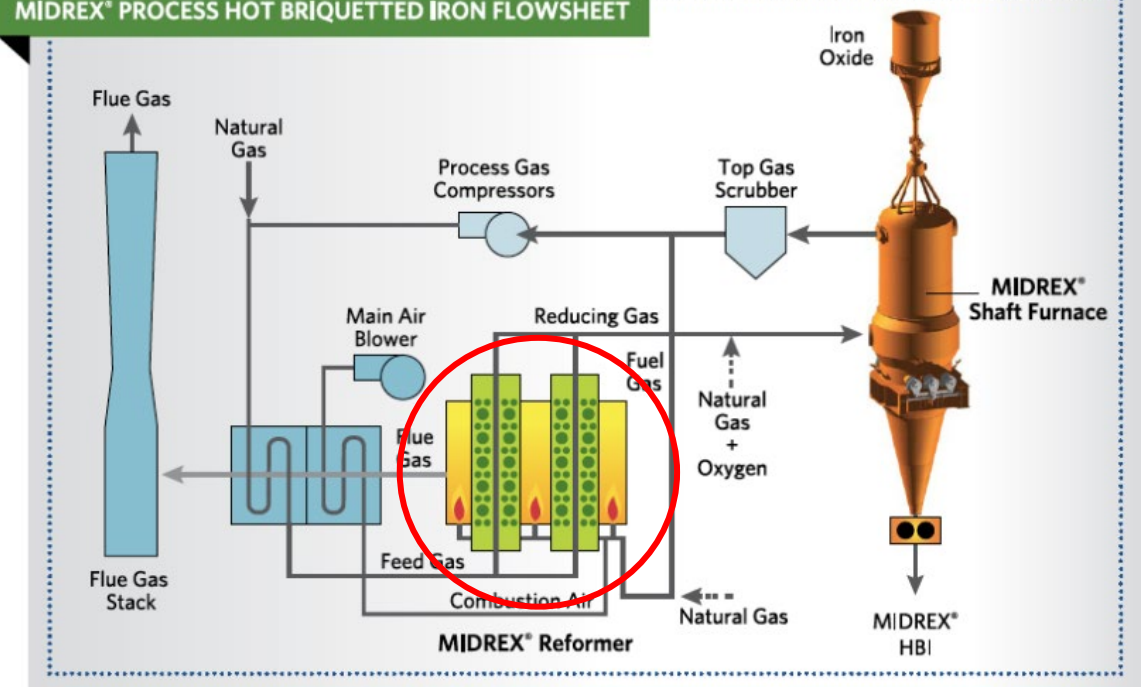


Current Steelmaking Routes

Steelmaking Routes



MIDREX® PROCESS HOT BRIQUETTED IRON FLOWSHEET



Source: ArcelorMittal Climate Action Report



Project objectives

Main Objectives

ELEKTRA's main objective is to accelerate the decarbonisation of steelmaking by replacing conventional fossil-fired, heat-driven reactor units with compact, efficient and flexible electrified technologies. Steel is one of the most difficult industrial sectors to decarbonise because it relies on high-temperature processes and carbon-based reducing agents. ELEKTRA addresses this challenge at the point where emissions and energy losses are concentrated: the production, upgrading and recycling of reducing gases used in ironmaking.

The project will design, build and demonstrate a technology platform based on three intensified electrified reactors. Each reactor targets a different bottleneck in the transition from today's carbon-intensive steel production to future low-carbon and hydrogen-based steelmaking.

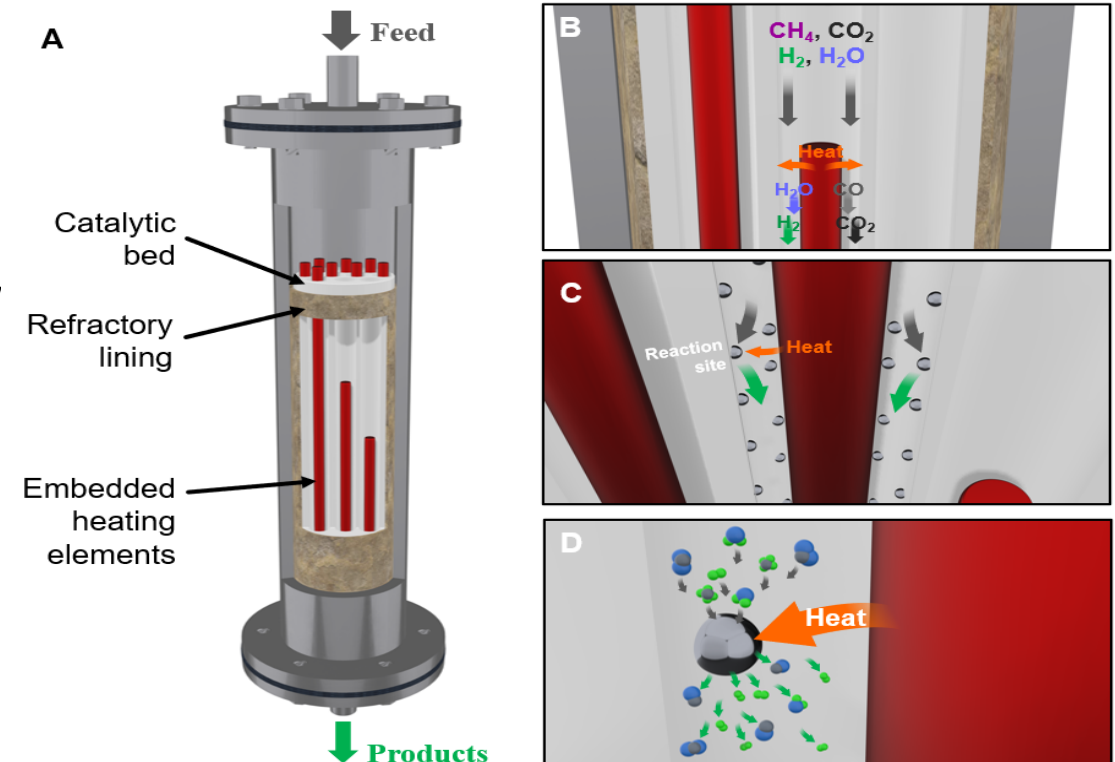
ELEKTRA aims to create a new generation of electrified reactor technologies for climate-neutral steelmaking. By combining renewable electricity, hydrogen carriers and carbon recycling, the project offers a practical bridge between short-term efficiency improvements, medium-term hydrogen integration and long-term circular steel production



Project objectives

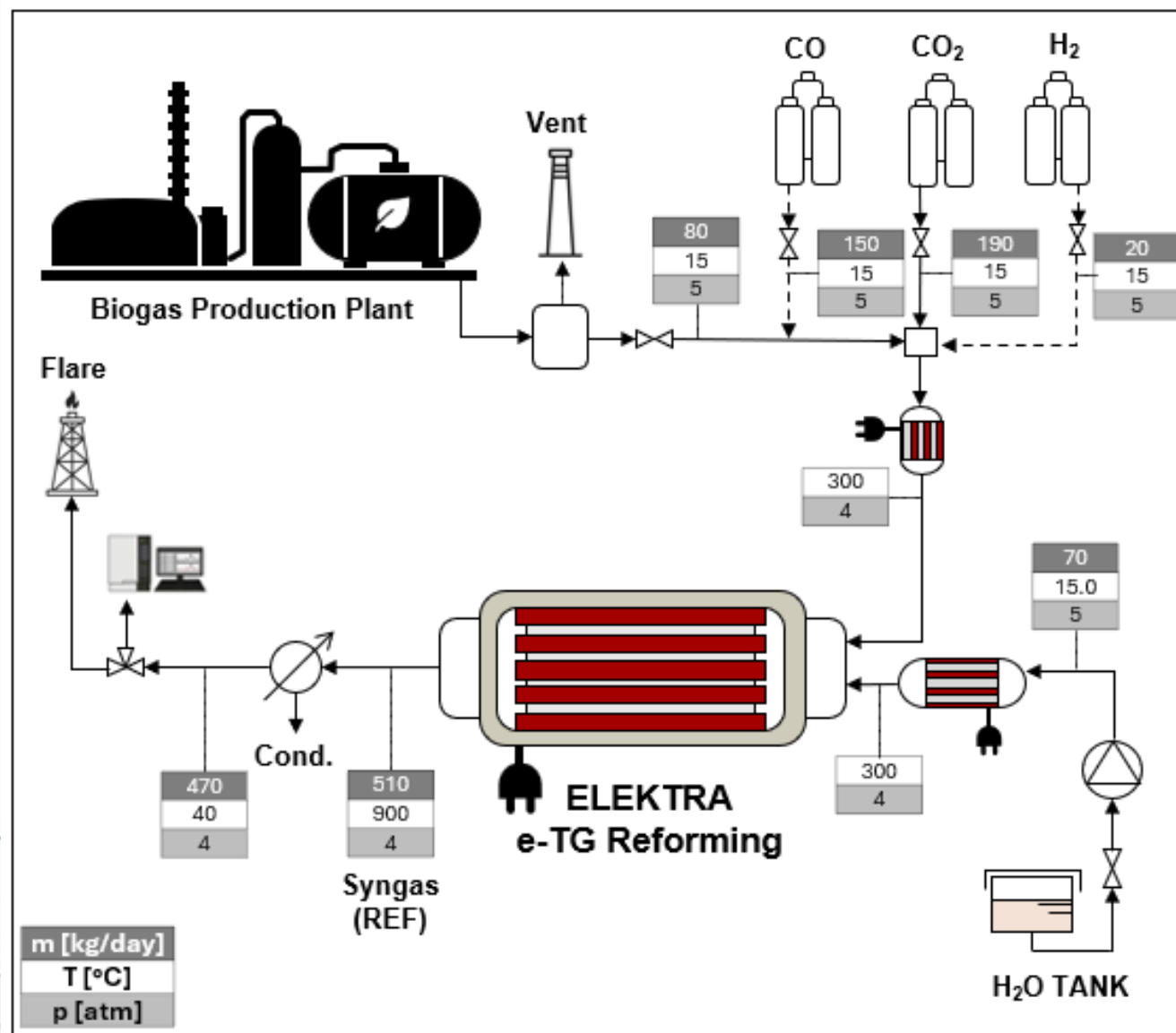
Objective 1

The first objective is to demonstrate an electrified reformer for natural gas and direct reduced iron top gas. This Joule-heated reactor will replace conventional fired reforming units, which currently consume fuel, generate flue gas emissions and suffer from limited flexibility. By supplying heat directly with electricity, the reactor aims to improve thermal efficiency, eliminate combustion-related CO₂ emissions and produce flexible syngas streams suitable for DRI processes. The system will be validated under industrially relevant conditions, with steel-specific requirements such as gas composition, ramping behaviour and integration into existing DRI loops.



Project objectives

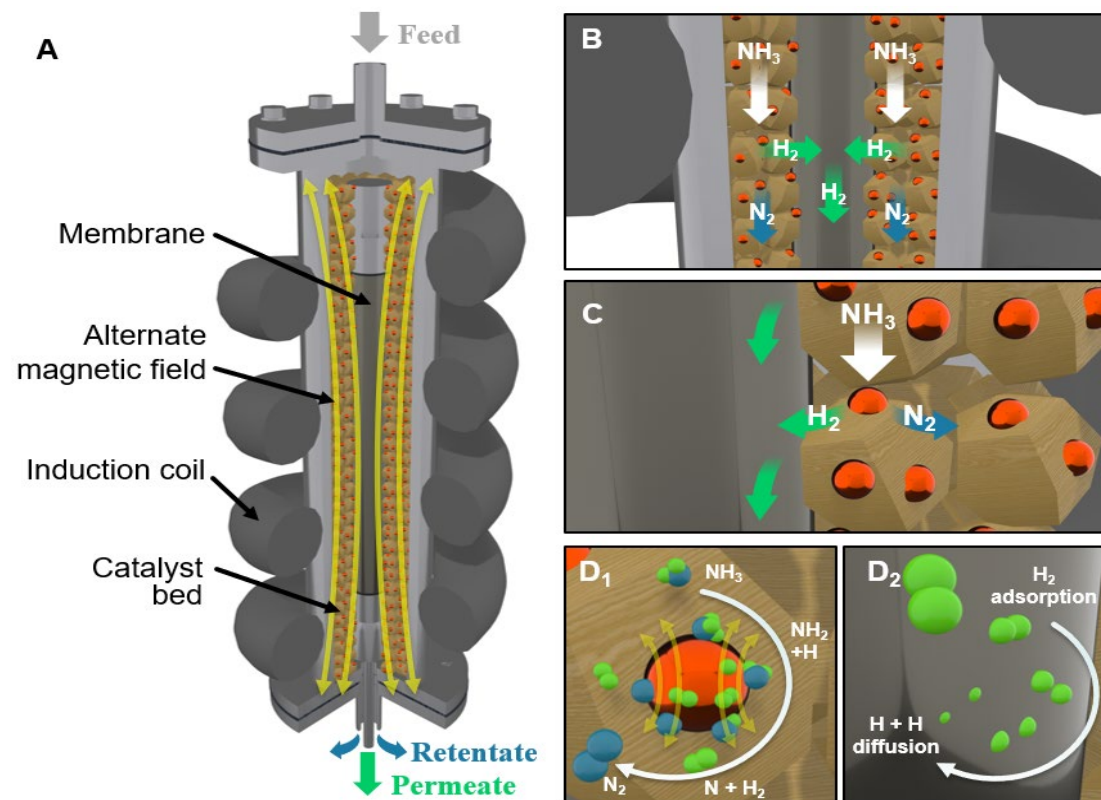
Objective 1



Project objectives

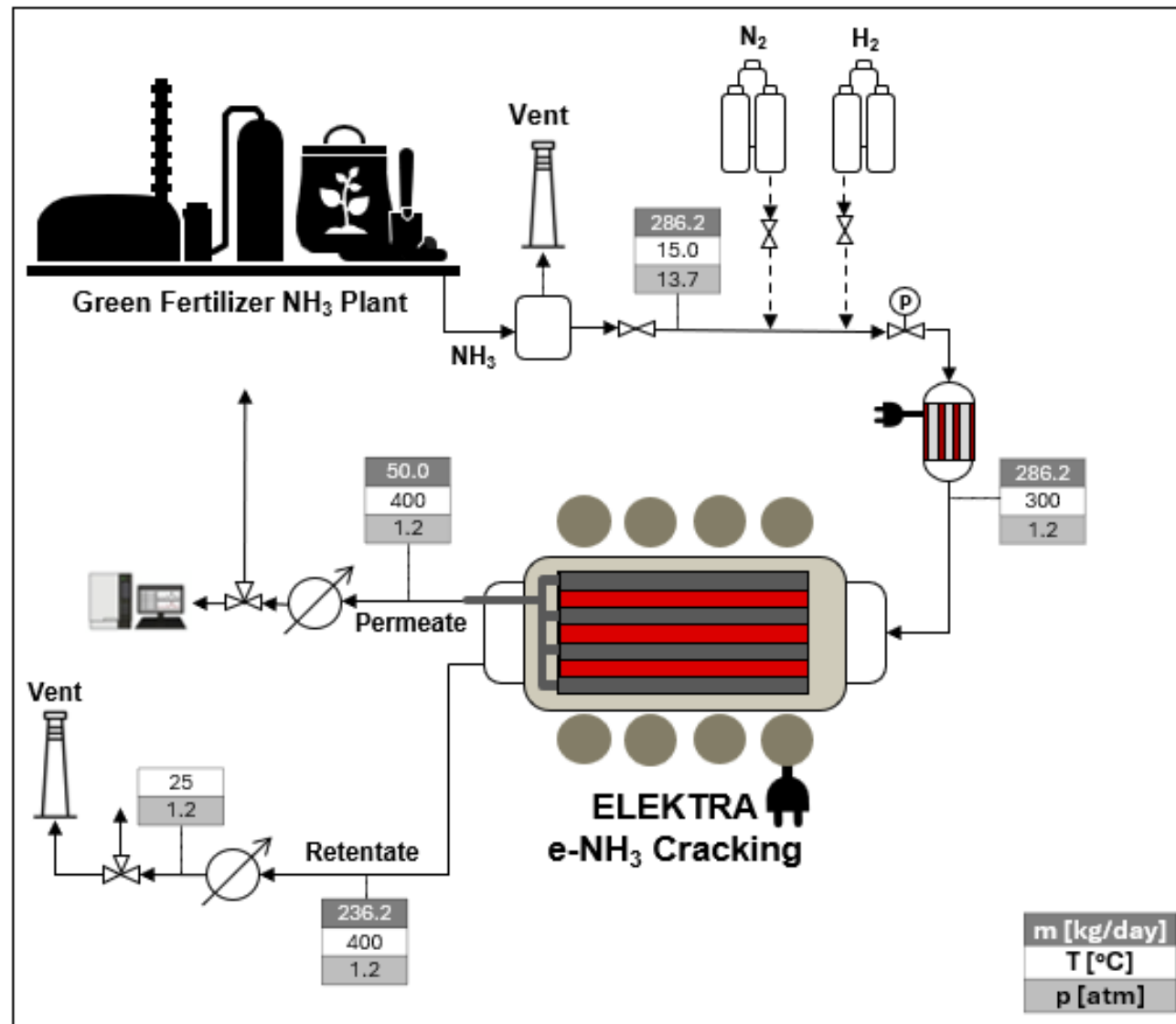
Objective 2

The second objective is to demonstrate an electrified ammonia cracker able to provide high-purity hydrogen for green steelmaking. Ammonia is expected to become a major carrier for imported renewable hydrogen, but today's crackers are often bulky, energy-intensive and dependent on downstream purification. ELEKTRA will develop an induction-heated catalytic membrane reactor that combines ammonia decomposition and hydrogen separation in a single compact unit. The goal is to produce pure hydrogen with very low ammonia slip, lower operating temperatures and reduced energy demand. This hydrogen can support both hydrogen-based DRI and blast furnace hydrogen injection.



Project objectives

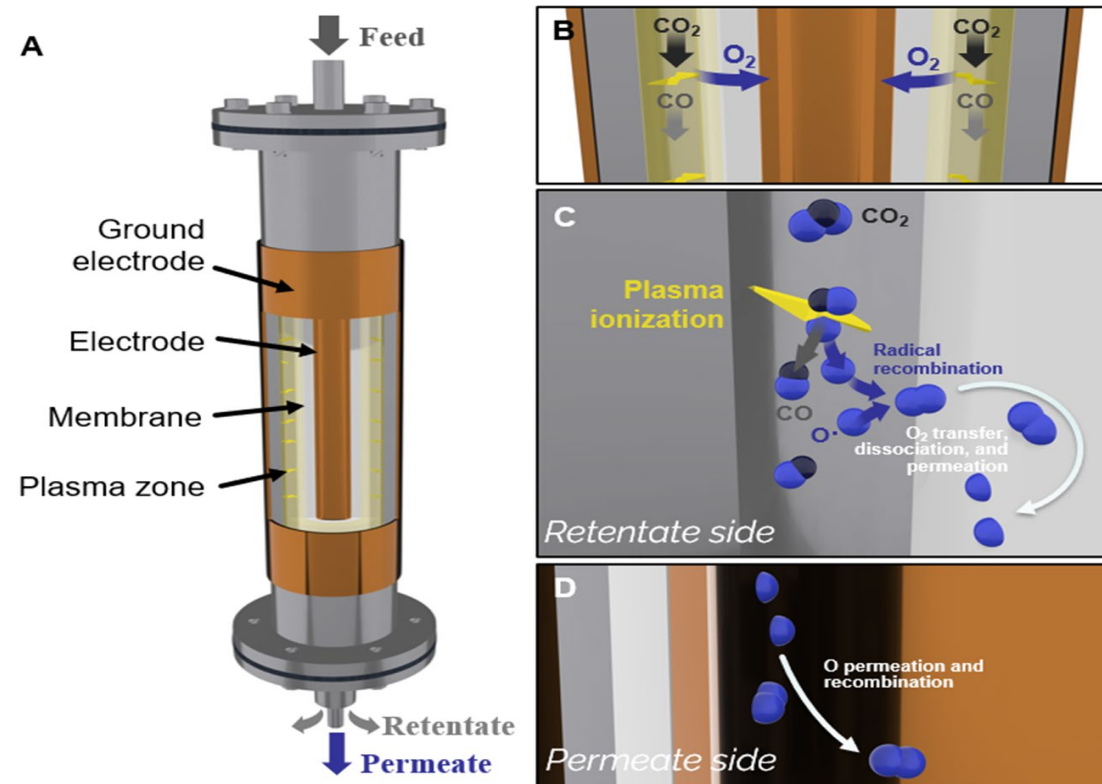
Objective 2



Project objectives

Objective 3

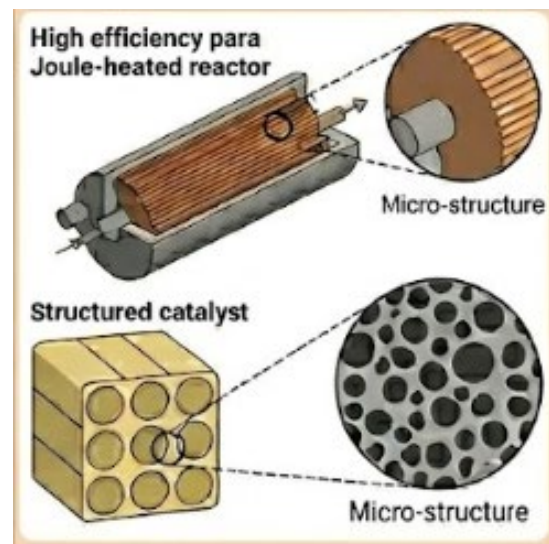
The third objective is to develop a plasma-assisted CO₂ recycling reactor that converts process CO₂ into CO for reuse in ironmaking. Instead of treating captured CO₂ only as a waste stream to be stored or exported, ELEKTRA aims to transform it into a useful reducing gas. The plasma-membrane reactor will split CO₂ into CO and oxygen, allowing CO to be reinjected into blast furnace or DRI processes. This can reduce coke demand in blast furnaces, lower hydrogen demand in hydrogen-DRI, and create a more circular carbon loop inside the steel plant.



Project objectives

Materials

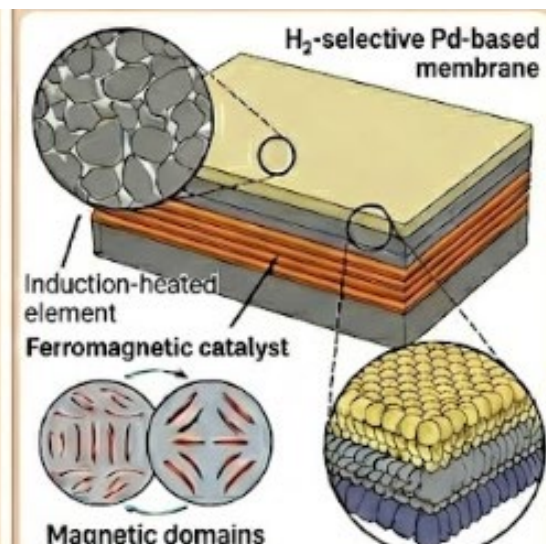
Joule reactor



*High efficiency
>95% - Joule-
heated reactor*

*Catalyst:
Conversion >90%
Selectivity >85%*

Induction reactor

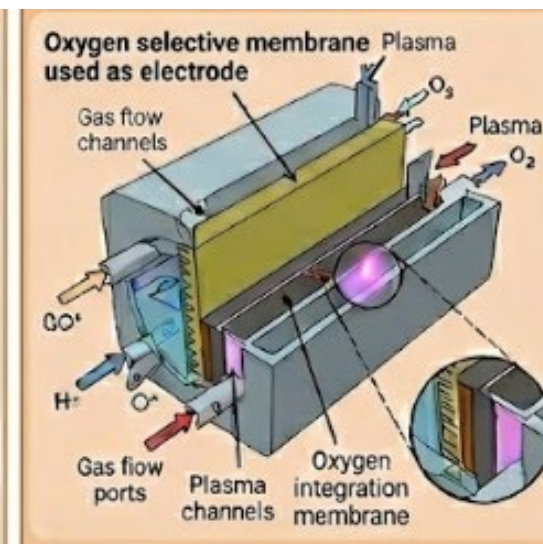


*High efficiency >95% -
Inductive heating*

*Catalysts:
Highly active*

*Membrane:
H₂ purity and recovery
(99.97% and 99%,
respectively)*

CO₂ Converter (Plasma)



*High efficiency /
Plasma converter*

*Membrane/electrode:
Highly stable - O₂
selective
Free-catalyst*

O₂ purity > 90%



Project objectives

KPIs

ELEKTRA – System specific objectives

ELEKTRA TG REFORMING

Industrial objectives

A novel electrified Top Gas Reforming process to decarbonise Direct Reduced Iron



- **>90%** CO₂ emissions reduction vs conventional reformers
- **Energy** use = 0.34 kWh/Nm³_{syngas} vs 0.421 kWh/Nm³_{syngas} for industrial TG reforming

Prototype objectives

A novel **Joule-heated Top Gas reforming Reactor** to decarbonise Direct Reduced Iron processes based on:

- High **efficiency** (>95 %) Joule-heated reactor with fast response time (**start-up time <2 h**)
- Highly **selective** (>85 %) and **active** (conversion > 90 %) structured catalyst



Demonstration unit:

- **200 kg syngas/day** and **3,500 h**
- Long-term **stability** >90% initial syngas production



ELEKTRA NH₃ CRACKING

A novel electrified Ammonia Cracking process



- **>95%** CO₂ emissions reduction vs industrial crackers
- **Energy** use = 6 kWh/kg_{H₂} vs 9.5 kWh/kg_{H₂} for fired heated cracker
- Renewable **H₂ cost** of 2.2 to 4.7 €/kg_{H₂})

A novel **Induction-heated Membrane reactor** to decarbonise Industrial Ammonia Cracking based on:

- High **efficiency** (>95 %) Induction-heated reactor operating at <425 °C with fast response time (**start-up time <1 h**)
- **Highly active** ferromagnetic catalyst (**no CRMs**).
- **H₂-selective** (99.97% H₂ purity) Pd-based membranes and >99% hydrogen recovery



Demonstration unit:

- **50 kg H₂/day** and **3,500 h**
- Long-term **stability** >90 % of initial H₂ production



ELEKTRA PLASMA CO₂ RECYCLING

A novel electrified Industrial plasma CO₂ splitter



- **>95%** CO₂ emissions reduction vs conventional high temperature CO₂ splitters
- **Energy** use = 3 kWh/Nm³_{CO} vs 6 kWh/Nm³_{CO} for high temperature CO₂ electrolysis

A novel **Membrane/electrode reactor** to improve CO₂ splitting based on:

- High **efficiency** plasma CO₂ converter with fast response time (**start-up time <200 s**)
- **Highly stable** oxygen selective membrane used as **electrode**
- **Catalysts free** CO₂ converter (**25-35% per-pass conversion**) based on plasma with O₂ separation
- **Oxygen purity** >70%



Demonstration unit:

- **25 kg CO/day** and **1000 h**
- Long-term **stability** >90 % of initial CO₂ conversion



Project objectives

KPIs

ELEKTRA – Common objectives



Develop a full **E-LCA, S-LCA** and Health and Safety Analysis (**HSE**) of ELEKTRA, proving technologies **effectiveness towards GHG emission avoidance** and ensure **process safety, flexibility and ease of control**

MANCHESTER
1824



Promote **dissemination and communication** of ELEKTRA's results and **expand its impact** to stimulate commercial interest in the generated know-how

- KPIs > **than 8 scientific papers and > 20 presentations at conferences**
- KPIs > **400 followers, >50 downloads of e-publications**
- KPI creation of **Woman in Steel industry group and H4C-e**



Pave the way for **future exploitation** of ELEKTRA Key Exploitable results attracting **key players in the decarbonisation of energy intensive sectors** such as steel

- KPIs >**15 industrial partners reached**
- KPIs **business models for the 3 technologies**



ArcelorMittal



Project objectives

Long term impacts

In the long term, ELEKTRA aims to support the transition of steelmaking from a fossil-fuel-based industry to a cleaner, electricity-driven sector. By replacing conventional fired reactors with electrified alternatives, the project enables the use of renewable electricity in key ironmaking processes and reduces dependence on coal, natural gas and other fossil fuels.

A major impact will be the reduction of CO₂ emissions from steel production. ELEKTRA targets both existing blast furnace routes and future direct reduced iron routes, making its technologies relevant for current plants and next-generation hydrogen-based steelmaking. The project combines three solutions: an electrified reformer for cleaner syngas production, an ammonia cracker to provide high-purity hydrogen from green ammonia, and a plasma CO₂ recycling reactor that converts CO₂ into reusable CO.

ELEKTRA also strengthens Europe's industrial resilience by supporting diversified energy supply, green ammonia use and greater integration of renewable electricity. Its modular technologies could also benefit other hard-to-abate sectors, such as chemicals, refining, cement, glass and ceramics.

Overall, ELEKTRA's long-term impact is to provide scalable, sustainable technologies for climate-neutral industrial production, supporting Europe's climate goals, competitiveness and leadership in clean manufacturing.



WPs and responsibilities



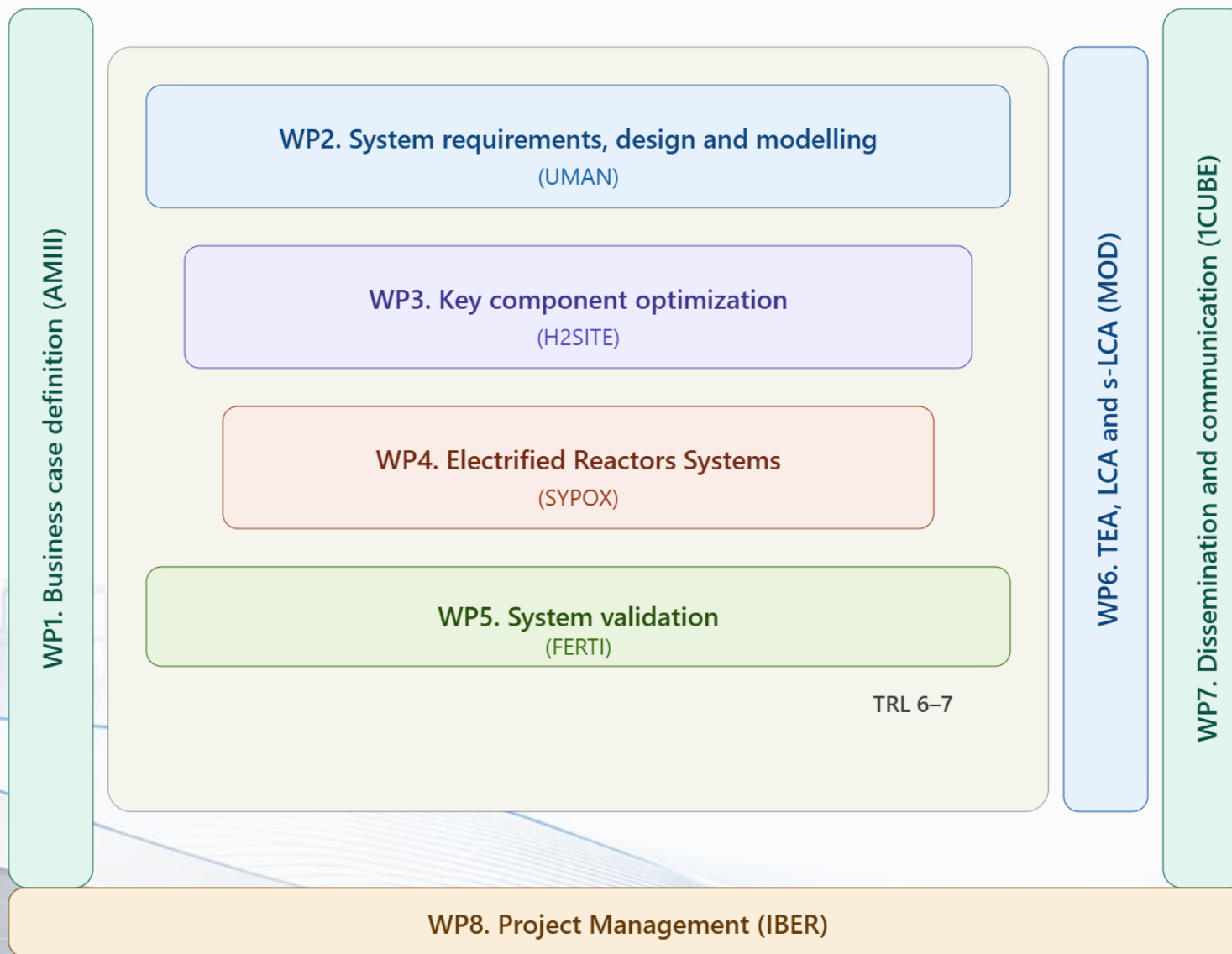
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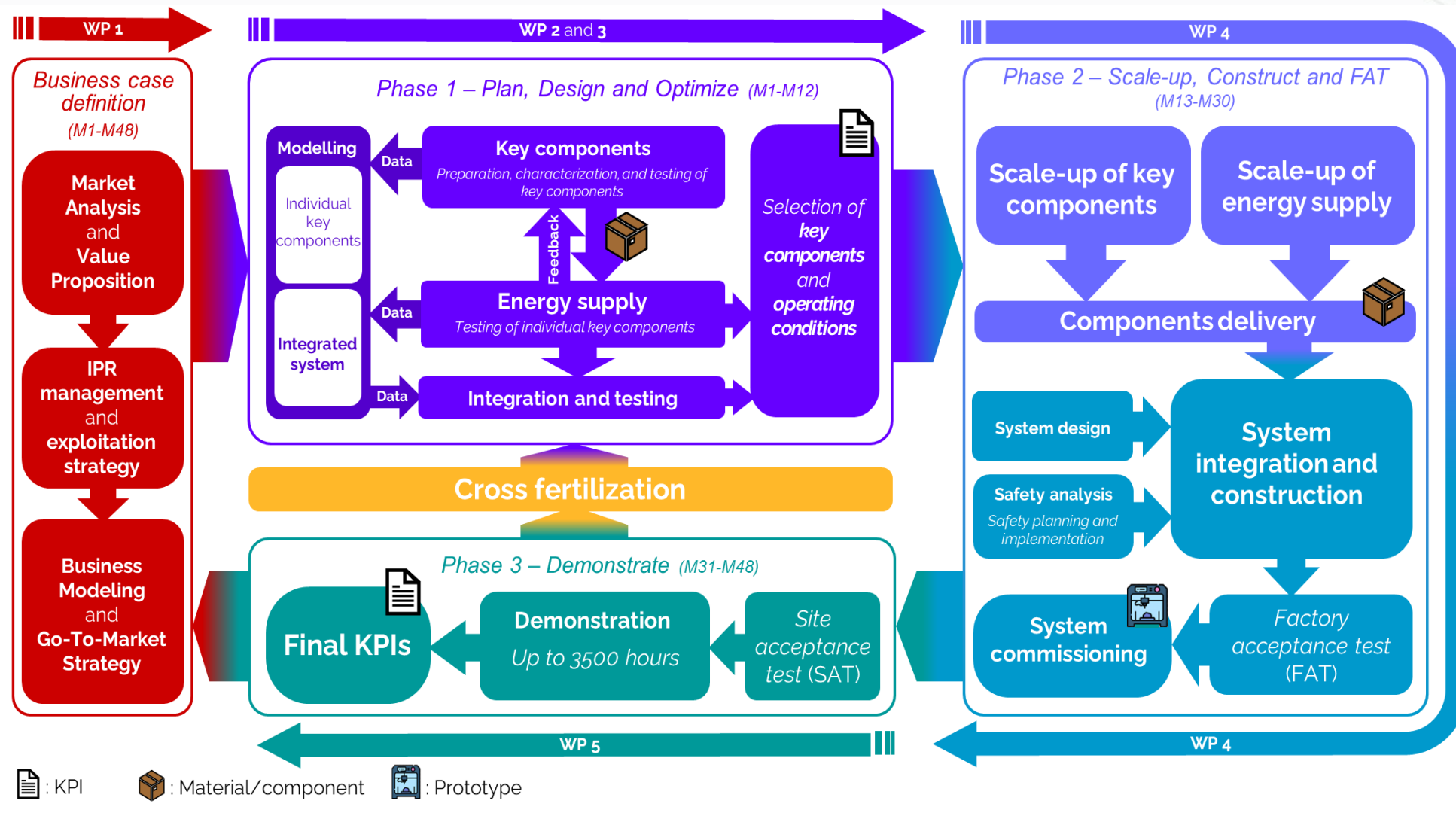
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WPs and responsibilities



Methodology



Partners



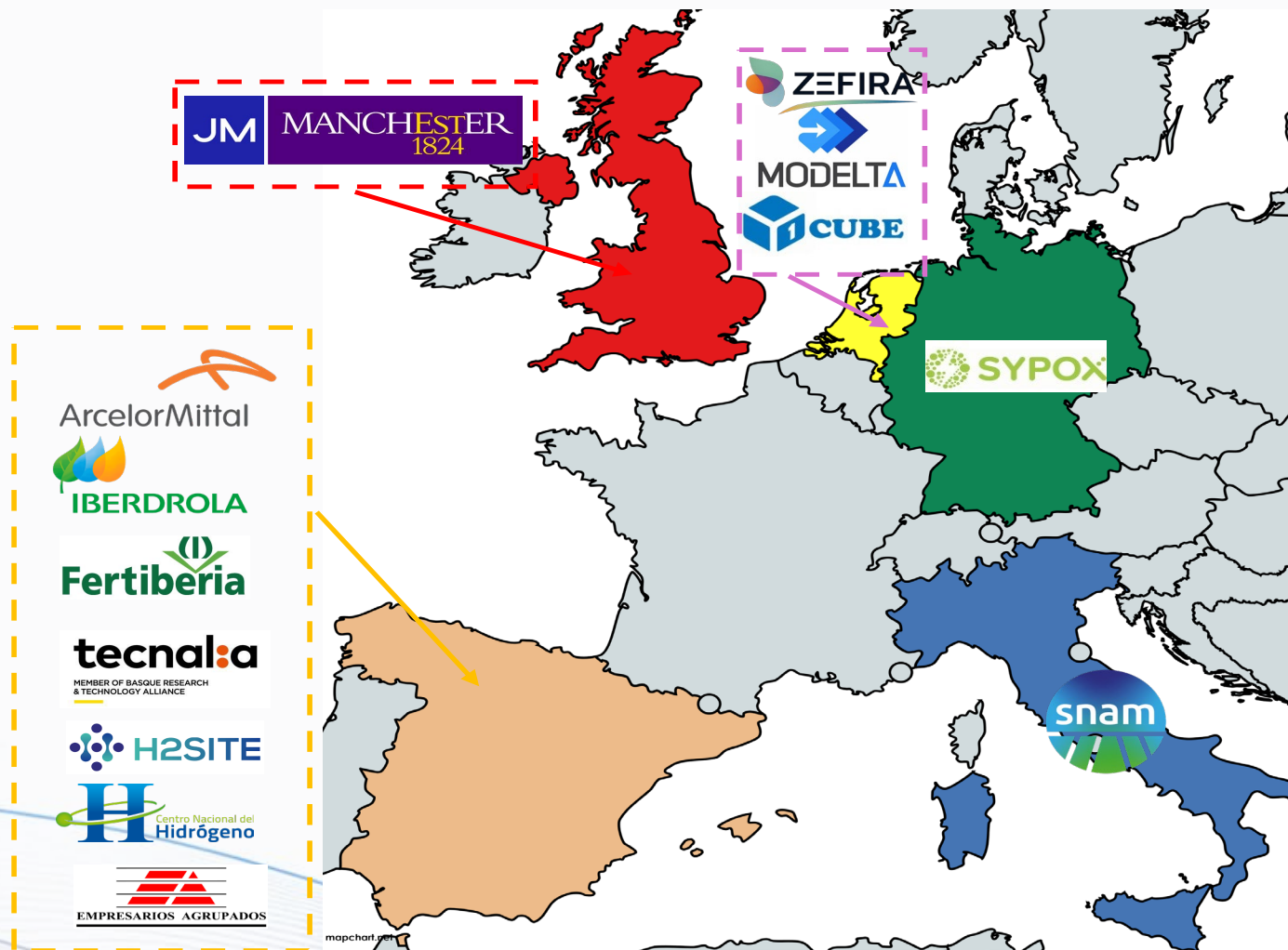
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Project Partners



Project Organization



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Project Organization

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Thank you

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