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EMPHATICaL Project

Funded by the European Union

The EMPHATICaL project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No. 101177725.

Public

EMPHATICaL: project overview

A 4.5-year project developing an integrated route from metallurgical residual gases to e-methanol and storage ready CO_2.

Industrial feedstocks

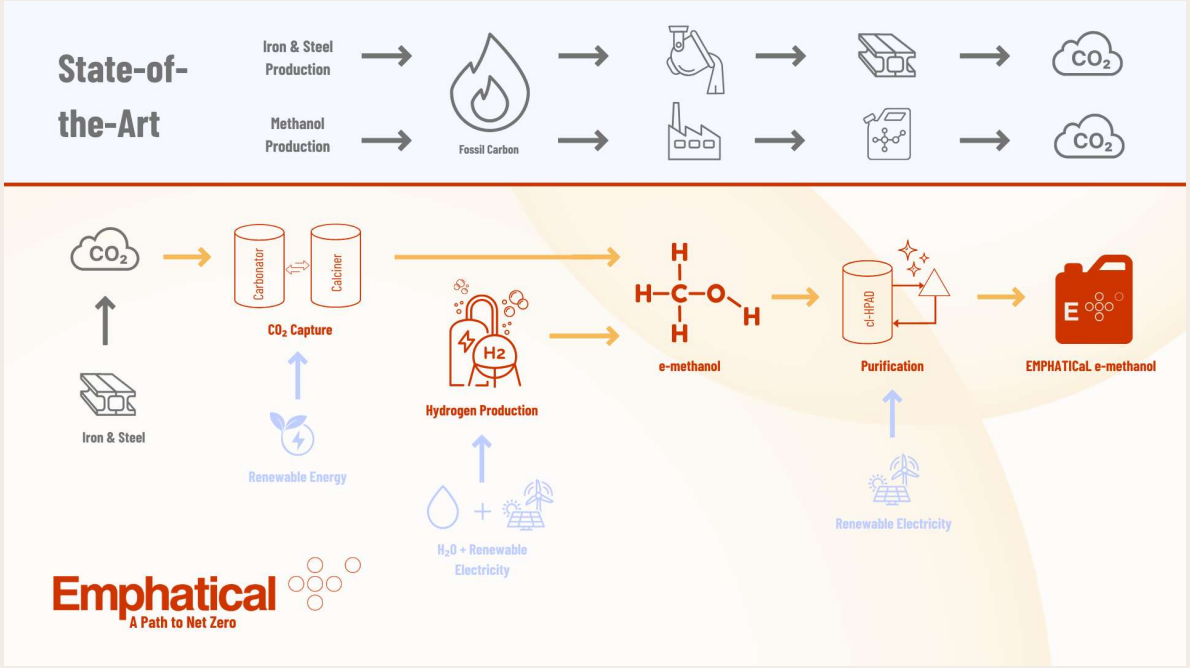
Residual gases from electric arc furnaces and ferrochrome alloy production

Integrated process

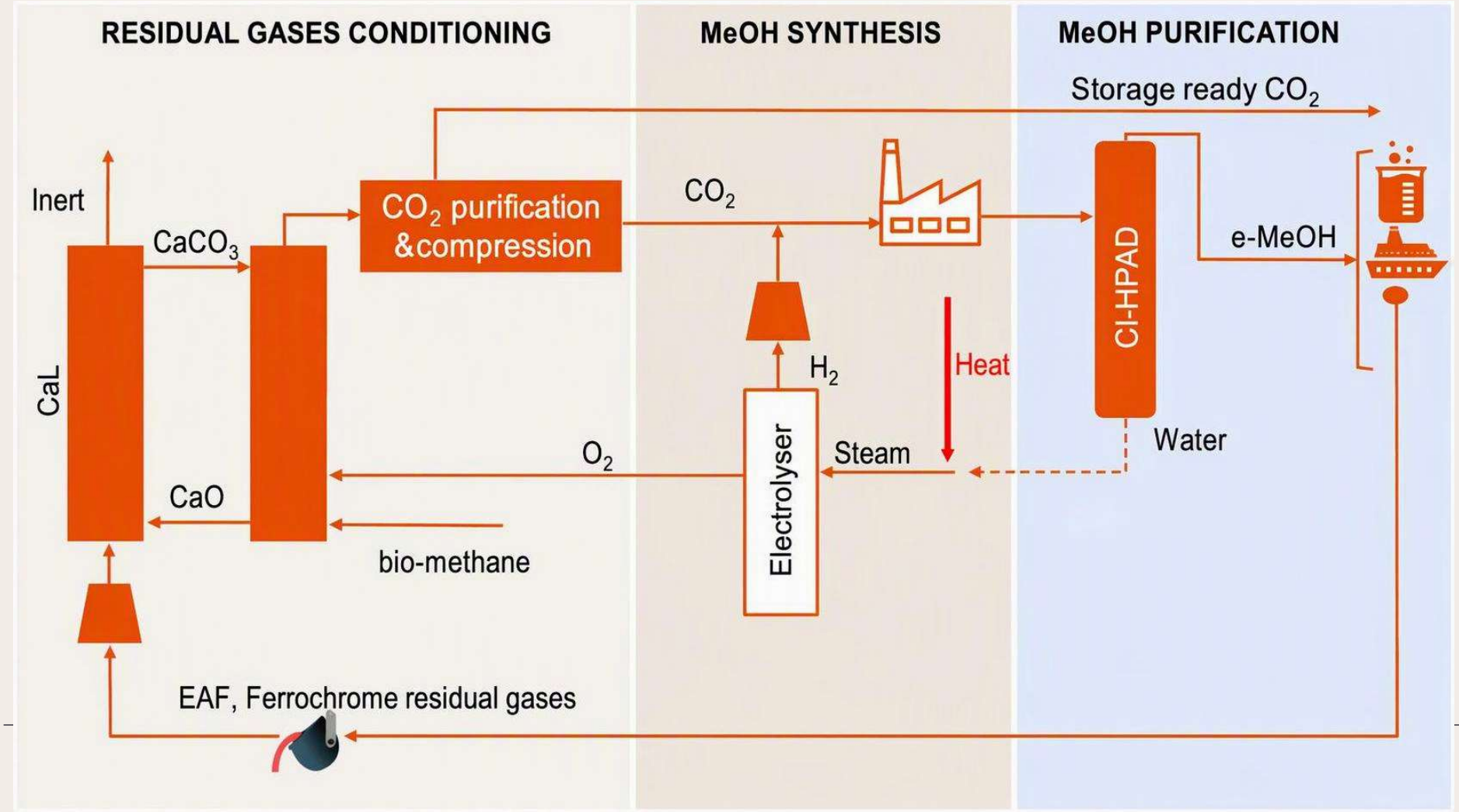
Oxy-blown calcium-looping CO_2 capture and purification, linked to methanol synthesis using green hydrogen

Project purpose

Develop an energy-efficient, lower-cost route to e-methanol and storage ready CO_2.



EMPHATICaL Concept



EMPHATICaL: demonstration and scale-up targets

25% **Lower specific energy consumption**

Project targets, with potential carbon neutrality through biogenic energy

TRL 7 demonstration

Design, procure, construct and integrate the EMPHATICaL components.

Two 6-week campaigns using simulated EAF and SAF residual gases, each producing up to **1 t/day** of fuel-grade methanol.

CaL: steady flow from two residual gases via solid storage. CCR ≥90% with CaO and >99% with $Ca(OH)_2$. CO_2 purity ≥98 vol% after purification.

cI-HPAD: >60% energy savings versus conventional distillation.

Flexible operation

AI controllers: **≥5%** higher system energy efficiency with variable feedstock and renewable power.

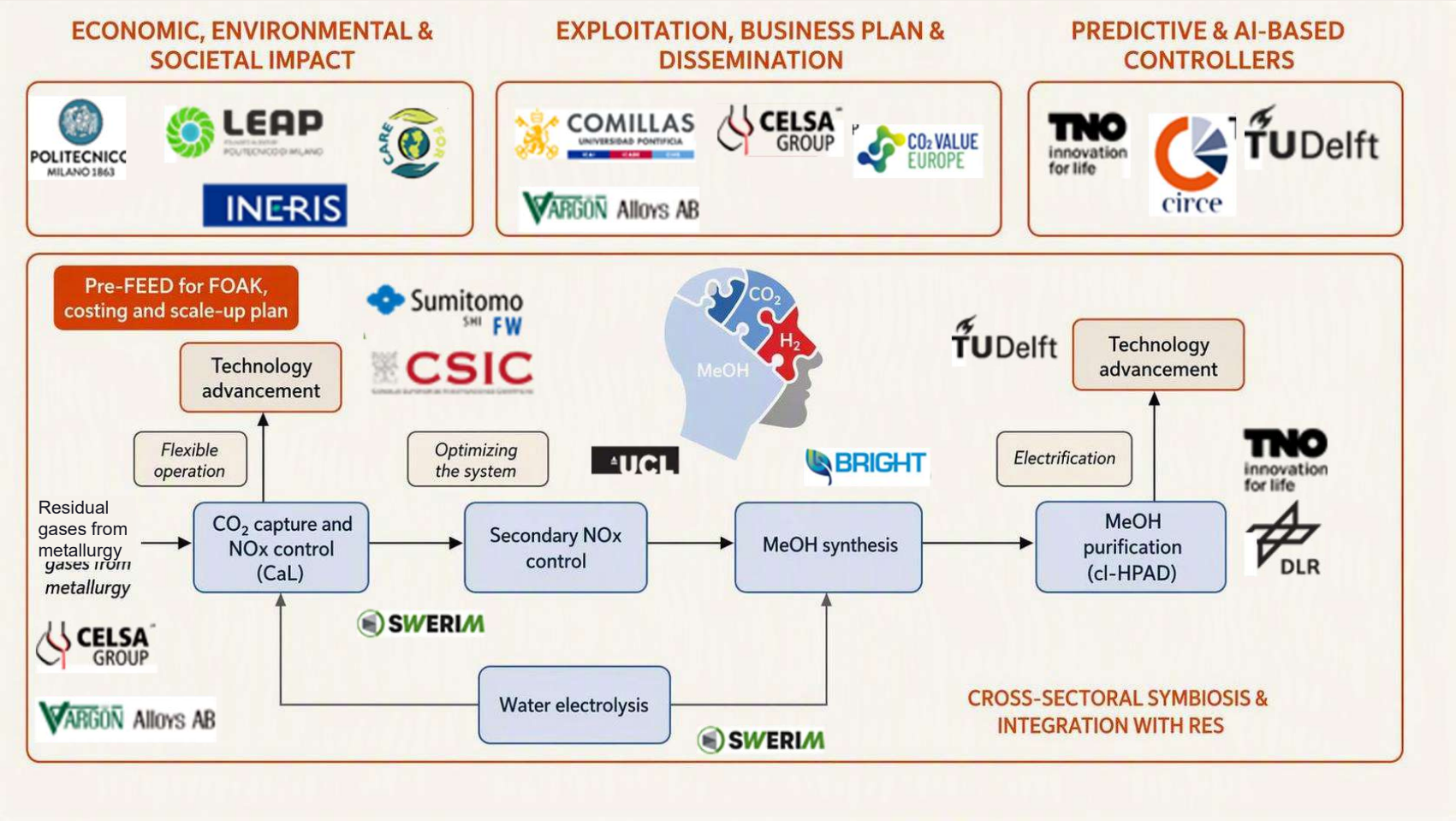
Scale-up and economics

Pre-FEED for a modular first-of-a-kind **100 kt/year** methanol plant. IRR **>12%** and **≥15%** lower e-methanol production cost.

Commercial implementation

Market and customer analysis, competing solutions and business models

EMPHATICaL Partnership



17 partners
4.5 years
Nov. 2024 –April 2029

17.3 M€ EU funding

101177725
HORIZON-CL4-2024-TWIN-TRANSITION-01

Enabling technologies

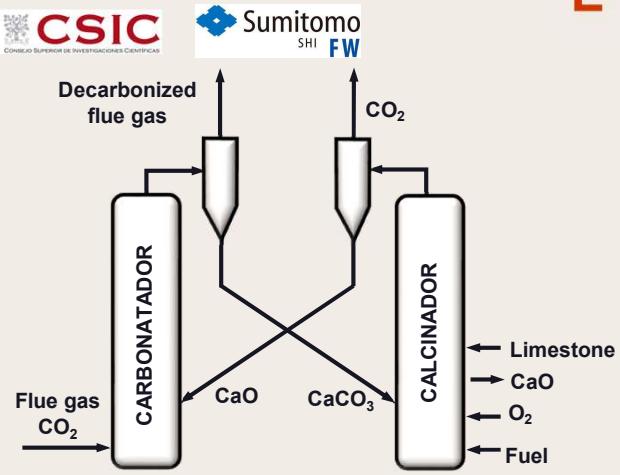
CALCIUM LOOPING (CAL)

Steady, high-purity CO_2 despite variable gas composition and flow.

Oxy-fuel calcination upgrade for CO_2 capture and methanol synthesis.

Deep SO_2 removal with lower efficiency penalties (5–8%).

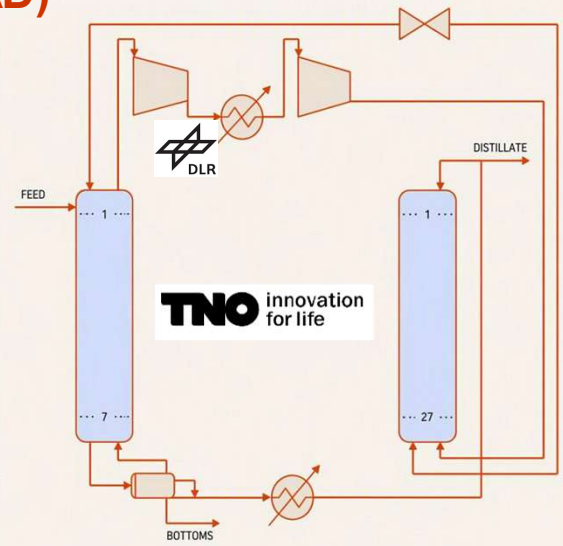
NO_x control supported by virtual off-gas sensors and optimised CaL conditions.



CLOSED-LOOP HEAT PUMP ASSISTED DISTILLATION (cl-HPAD)

>60% potential specific energy savings

Electrified distillation with integration options tailored to separation demand



Calcium looping roadmap

Proof of concept

Reaction kinetics

Sorbent deactivation and reactivation

Small pilot Tens of kWt

Twin-CFB lab validation

Reactor and process modelling

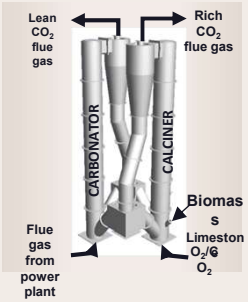
TRL 7 pilot 1.7 MWt

Large-scale CaL demonstration

CaOling

FP6 2009–2013

Process development and industrial integration



Recarbonation and O_2-rich combustion

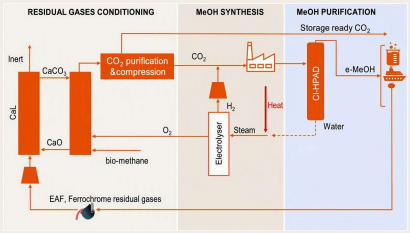
Flexible gas loads

Bio-CHP and waste-to-energy integration

ReCaL 2012–15, CaO2 2014–17

FlexiCal 2016–19, Calby2030 2023–26

EMPHATICaL Horizon Europe 2024–2029



Complete CaL capture system with oxy-calciner

Steady captured CO_2 from two residual-gas streams

Dynamic capture with alternative reactors, e.g. moving beds

2004 2008 2009 2012 2018 2025

cl-HPAD roadmap: TRL 4 to first-of-a-kind plant

Proof of concept at ECN (TNO) and TU Delft

Models and C_2-splitter application

50 kg/h test bench (TRL 4)

Stripping or rectifying mode only

Application shift

C_2 splitter not feasible

$MeOH–H_2O$ shows promise

Potential 200% productivity increase

REMAP²

TEA and LCA to confirm benefits

Basic TRL7 pilot engineering

Build Horizon Europe pilot consortium

EMPHATICaL TRL 7

Integrate cl-HPAD with compressor

Front-end engineering for 100 kt/year MeOH production

First-of-a-kind demonstrator

Integrate CO_2 capture, electrolysis, MeOH production, purification and use

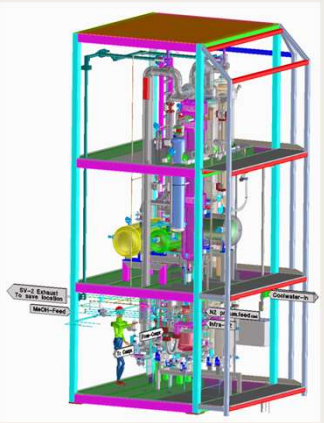


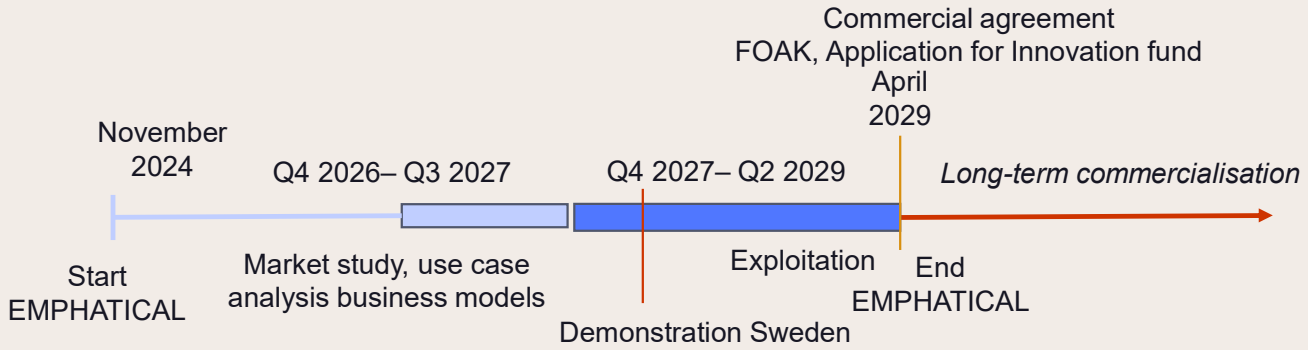
Plate-packing HPAD development

TRL7 Demonstration and scale- up

2004 **2008** **2012** **2016** **2020** **2023** **2026** **2029**

Commercial implementation plan

Focus: Long-term implementation plan including a collaborative strategy to align stakeholders' needs
Through the definition of the FOAK and the long-term vision



TRL 7 plant demonstration

Scale-up and demonstration
in an industrial environment

FOAK demonstration

Scale-up, commercialisation
and replication

Scale-up and diversification

Scale-up, commercialisation,
replication and diversification

Commercialisation

EU deployment, full potential
and new policy framework

EMPHATICAL project concept and vision

CONCEPT

- Carbon capture from **metallurgical** sector and utilization for **methanol** production

VISION

- Create bankable case for a first commercial size demonstrator at a scale of 100 kt/y methanol production capacity from EAF or ferrochrome alloy residual gases

ROUTE

- The EMPHATICaL project takes **all the steps required to develop the FOAK plant**
  - Demonstration of continues production of MeOH from EAF or ferrochrome alloy residual gases up to 1t $_{meoh}$ /d scale
  - Site identification
  - Business plan development
  - IP&R, ownership, collaboration

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