

P4Planet Projects Results

Workshop 1

Modelling industry
transition to climate
neutrality, circularity
and sustainability





Funded by
the European Union



AMIGDALA



AMIGDALA

Sustaining prosperity under non-fossil
limitations



Dr.Ir. Frank WUBBOLTS
TNO

SUSTAINING PROSPERITY UNDER NON-FOSSIL LIMITATIONS

Alliance for **M**odelling **I**ndustry towards the **G**reen**D**eal's objectives **A**nd circularity (2024-2027)



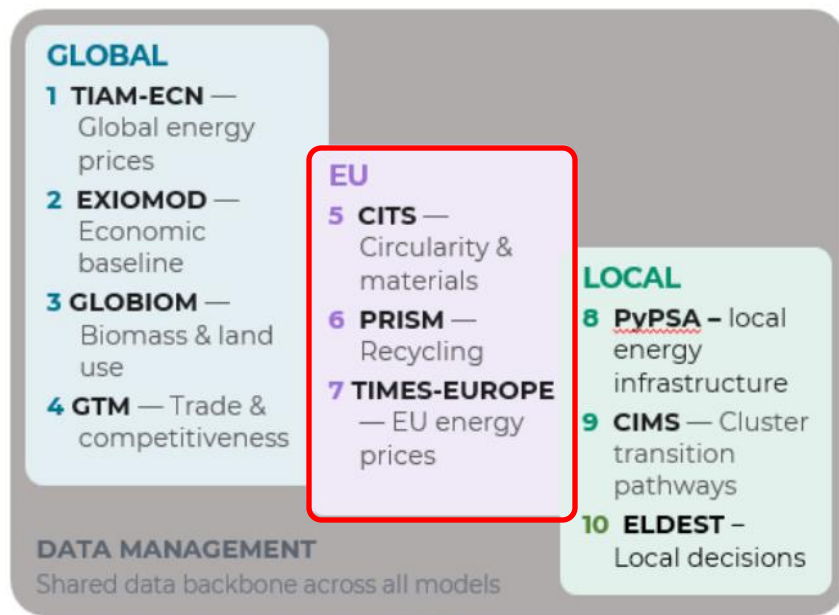
'It takes two to Tango'

Two main messages

- Renewable energy and biomass reaching industry are a robust condition for industrial transition
- Circularity helps limit energy demand in energy-intensive industries

What assumptions shape the pathways?

Models on global, EU and local level

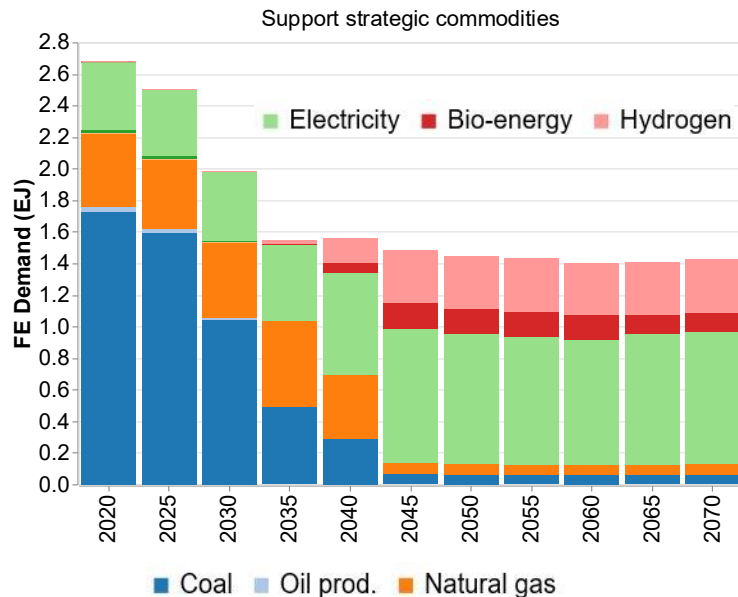


Scenarios reflecting policies on production, energy, products and trade

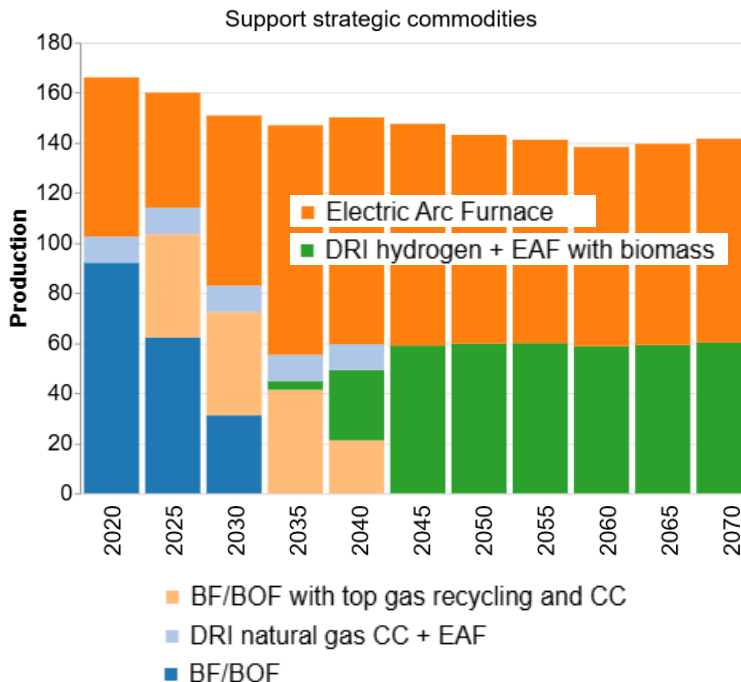
 Scenario	 Main policy lever
 Support for Strategic Commodities + <i>low circularity</i> + <i>low biomass</i>	Financial support for clean strategic commodity production
 New Dependencies	Imported clean energy and molecules and intermediate industrial products
 Industry Relocation	Part of production and intermediates shift abroad
 Global Green Industries	Strong global climate ambition

What pathways emerge for steel?

Final energy demand (EJ)

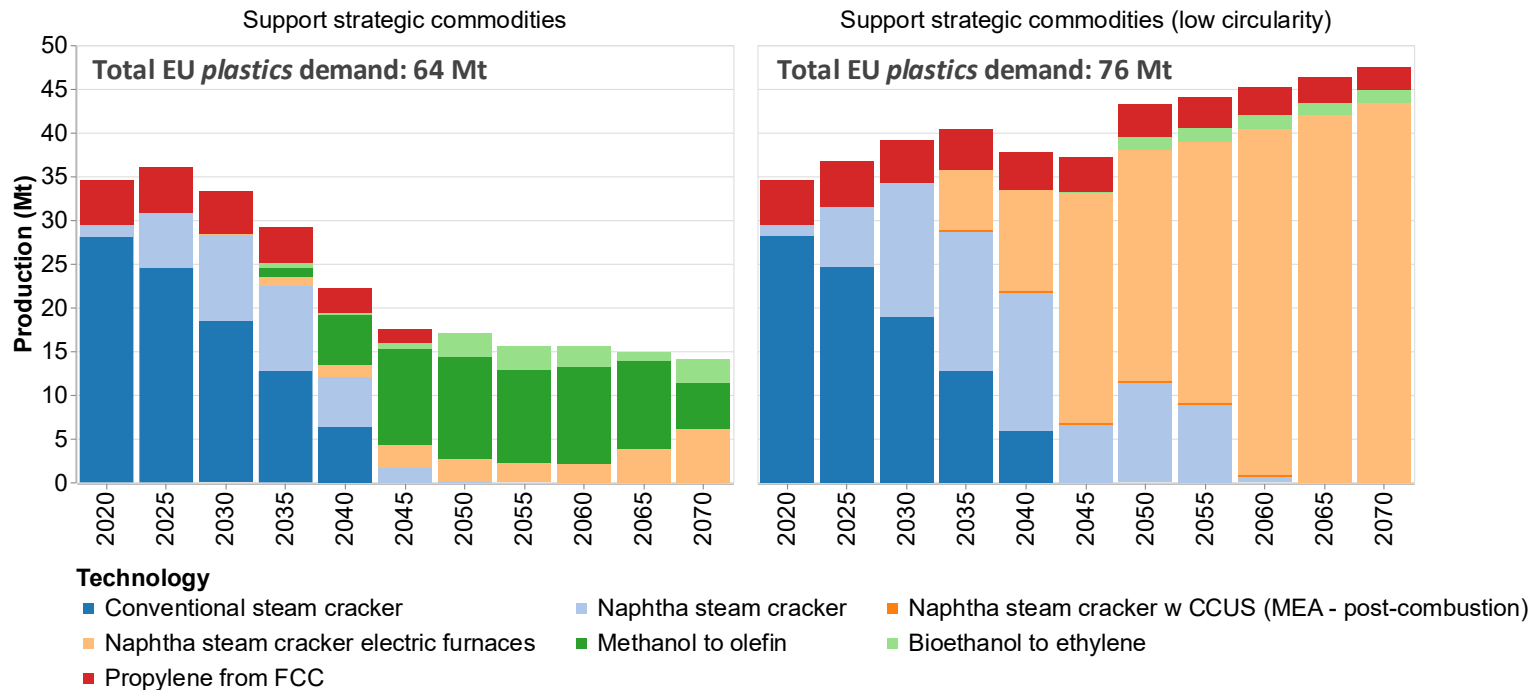


Production pathways (Mt) - technologies



What pathways emerge for EU-chemicals?

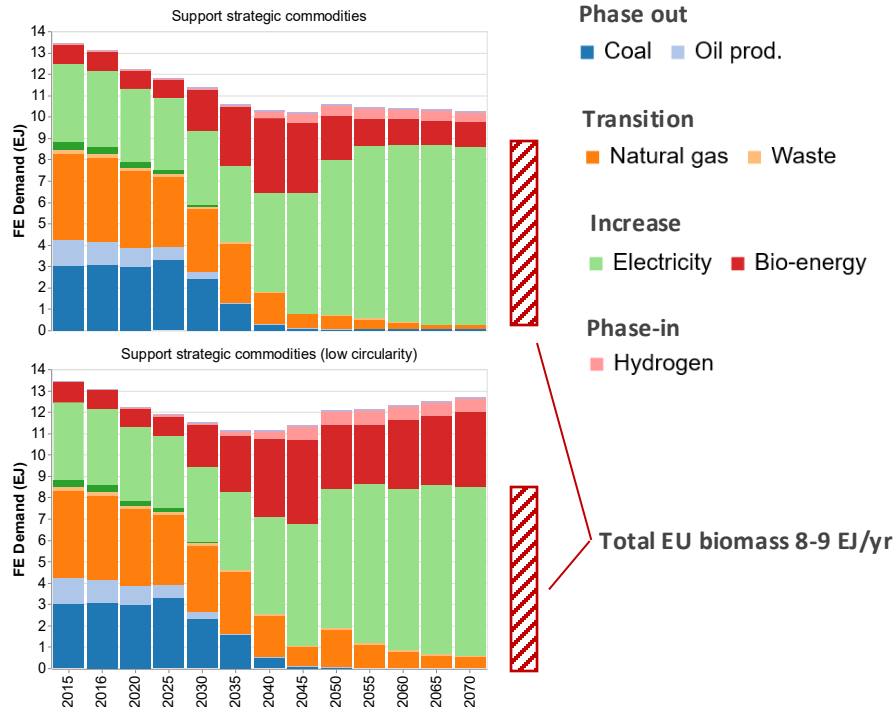
Production pathways and technologies (Mt) – two different scenarios



What does this tell us about the industrial transition?

Total industry final energy demand (EJ)

Note: fuels manufacturing is transformation sector



MESSAGE ON FINAL ENERGY DEMAND

Renewable energy can drive industrial production

- Direct electrification is preferred
- Hydrogen mainly for steel
- Bio-energy for industry (waste is feedstock)

MESSAGE ON CIRCULARITY

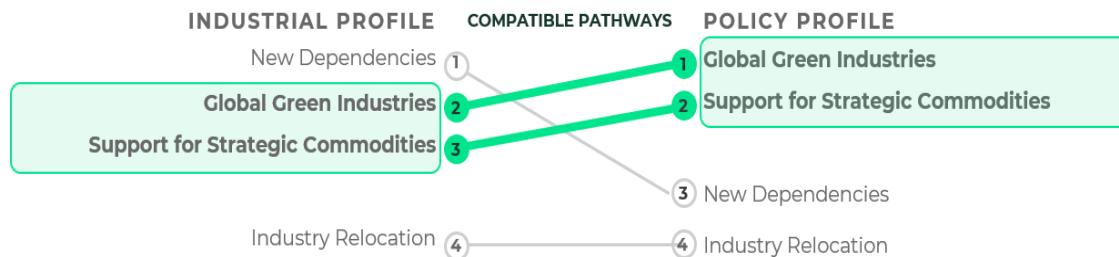
Circularity reduces final industry energy demand by apprx. 2-3 EJ

- Refuse, Reduce, Reuse
 - Recycle
- ‘Recycle’ is constrained by growing material stocks and conversion losses.

MESSAGE ON COMPETITIVENESS AND TRADE

* Expected*

How can modelling evidence support decisions?



“Europe’s clean industry needs competitive resources and fair global markets.”

- ‘Advantaged resources’ and ‘Comparative advantages’ are two sides of the same coin
- Prioritize to provide clean electricity, sustainable biomass supply and infrastructure to industry
- Establish conditions for secondary-feedstock markets and provide circularity infrastructure

What remains uncertain and what comes next?

Key uncertainties and limitations

- Energy prices for industry and infrastructure build-out
- National priorities and competition between EU member states

Requiring further testing

- Product-level policies
- Trade policies

Next steps for the AMIGDALA project (2027)

- “What if analysis” under our main scenarios as sensitivities
- Dashboard with societal and industrial performance indicators
- **25 November 2026** – All stakeholder workshop, Brussels

Implications for future Research & Innovation or Policy work

- Define an industrial basis from critical chemicals and critical sites
- Develop product and consumer level policies and industrial commodity standards
- Engineer the EU-based industrial production backbone towards a competitive system
- Develop direct electrification technologies for highest (cost) efficiencies

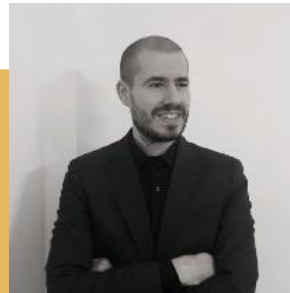


Thank you!



TRANSCIENCE

Modelling the impacts of circularity and decarbonisation strategies
on trade flows and industrial resilience in Europe



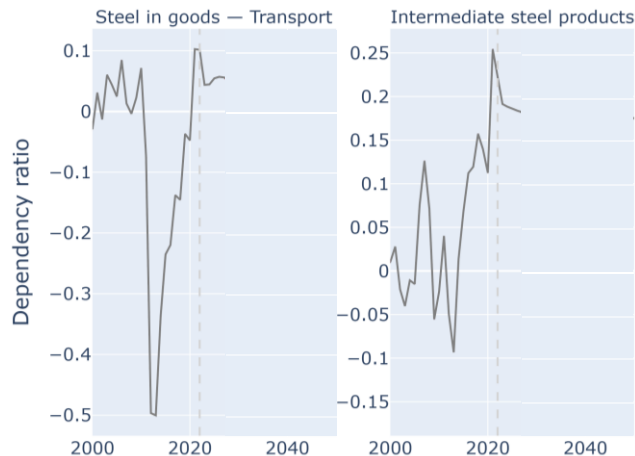
Alexandros NIKAS
ICCS

The challenge and modelling objective

Challenge

Many industrial sectors in Europe are exposed to trade dependencies, as they rely on internationally sourced materials or products.

Example: Import dependency of steel in EU27+UK



Our objective

- **Research question:** Which effect can circularity strategies have on EU trade flows and industrial resilience?
- **Sectors examined:** 1) Steel in passenger cars and 2) PET in plastic packaging
- **Scope:** EU27+UK (cars); EU27+UK+ CH+NO (PET)
- **Modelling used:** Material Flow Analysis

Sectoral differences and similarities

1

In both sectors, Europe's trade dependence sits upstream: in intermediate steel products (such as coils and sheets) and in primary PET.

2

Cars account for only a small part of steel demand in EU27+1, since transport as a whole is about 12%. In contrast, packaging makes up nearly all of PET demand in EU27+3.

What assumptions shape the pathways?

Case study: steel in cars

- 4 circular economy measures: i) Using stronger steel, ii) Designing smaller cars, iii) Redesigning cars, iv) Remanufacturing (i.e., reusing components & car panels)
- 2 ambition levels: i) Conservative, ii) Highly Ambitious

Case study: PET packaging

3 scenarios covering all forms of PET packaging:

- Recycling: Recycled content in bottles rises from 30% in 2030 to 65% in 2040
- Recycling + Reuse: Adds reusable packaging, especially on beverage bottles
- Recycling + Reuse + Reduce: Adds lightweighting, becomes the norm by 2030

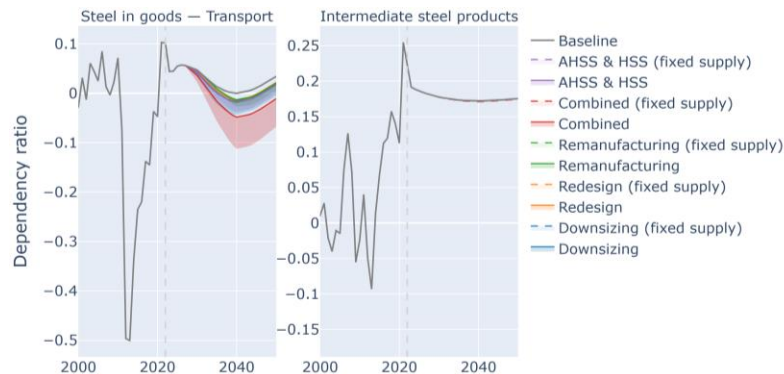


Stakeholder-driven

Modelling assumptions for this and all TRANSCIENCE studies are based on feedback from stakeholders (industry, policy, research) from 7 workshops in industrial clusters at Rhine-Ruhr (DE), Basque Country (ES), Silesia (PL), and Port of Rotterdam (NL) and 2 EU-wide workshops.

What pathway or result emerges?

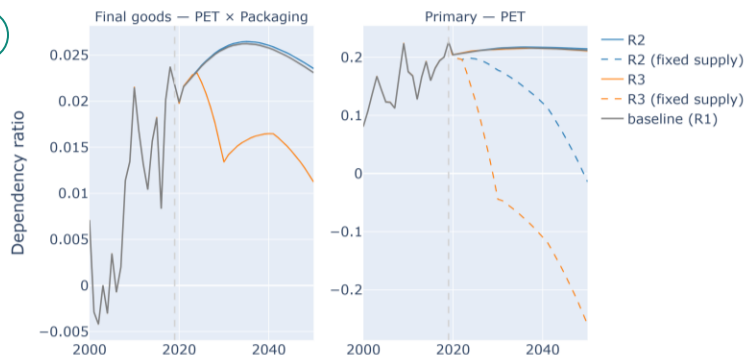
1



Case study: steel in cars

- Combining circular measures can reduce up to 13% of automotive steel demand in 2050
- Efficiency takes effect immediately; reuse is delayed by 15 years (car lifetime)
- At the finished-goods stage, EU can flip from net importer to net exporter (Fig. 1 left)
- Upstream (intermediate stage), EU's import dependency nearly flatlines at 17% (Fig. 1 right)

2



Case study: PET packaging

- Reuse and lighter packaging could cut demand for virgin PET by a third
- Reuse raises total plastic in circulation while cutting virgin demand
- Europe barely trades finished packaging (Fig. 2 left), its dependence is on primary PET
- Net imports of primary PET can fall substantially if local production is defended (Fig. 2 right)

What does this tell us about the wider industrial transition?

Circularity can improve resilience depending on where it acts on the value chain

- Import dependence sits upstream
- Conditionality on measures down the chain

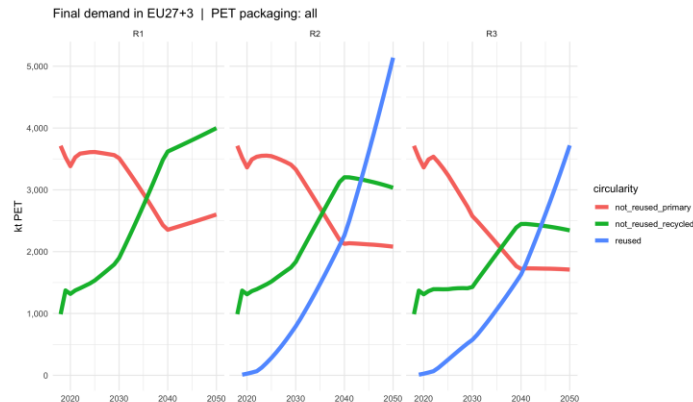
Different circularity measures need to be designed together

- Comprehensive strategies perform better (Fig. 1 – R3, red line)
- Measures also interact (Fig. 1 – blue line)

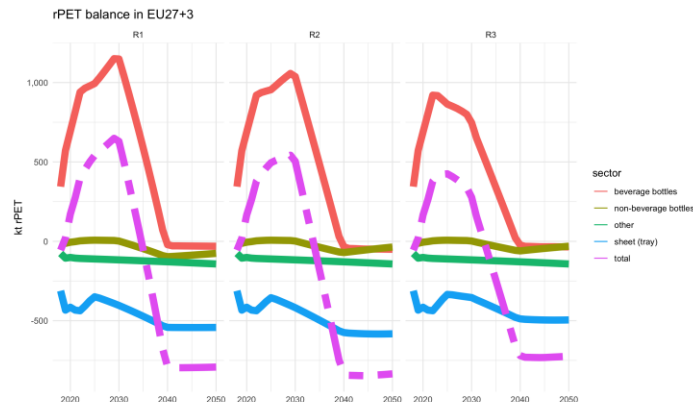
Recycling targets can shift dependence instead of reducing it

- The becomes a net importer of PET recyclate (Fig. 2, purple line)
- Need for collection, sorting, and recycling capacity expansion

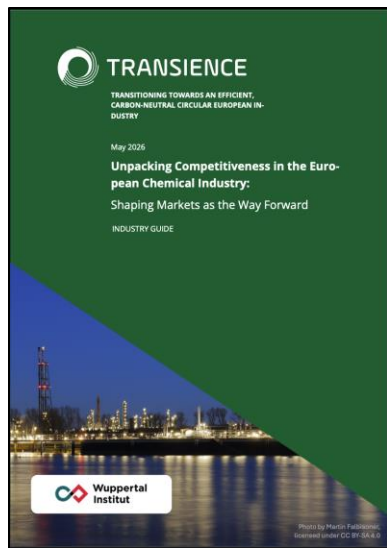
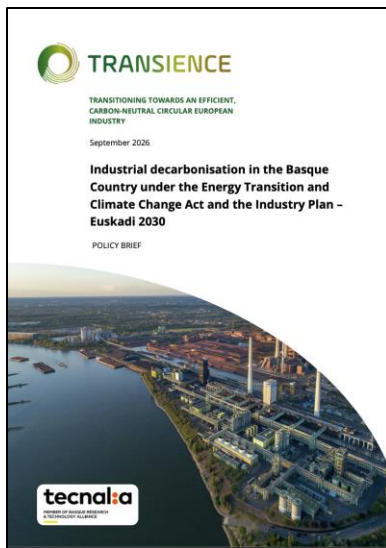
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2



How can modelling evidence support decisions?

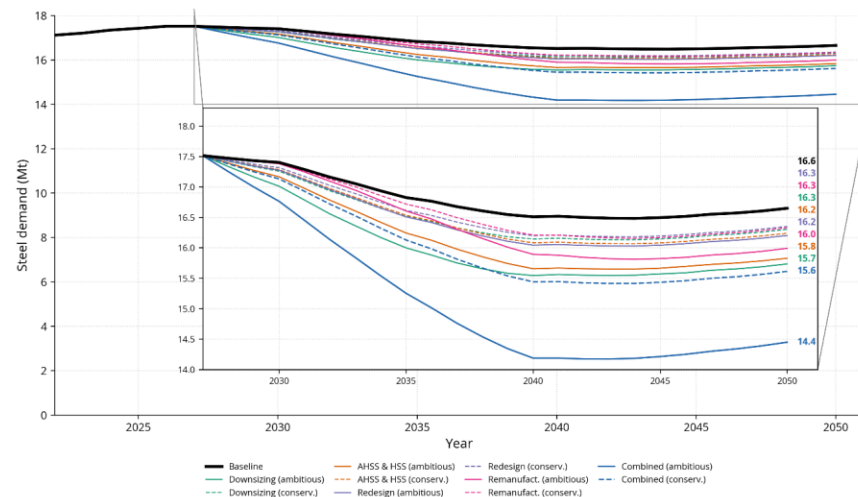


1

Focus circularity where material demand is concentrated

Measures cut automotive steel demand by up to 13% but leave EU steel import dependence at about 17%.

Decision informed: Scope of circular-economy and ecodesign policy. For steel, measures need to reach construction and machinery too, not cars alone.



Find our policy briefs & industry guides at <https://transience.eu>

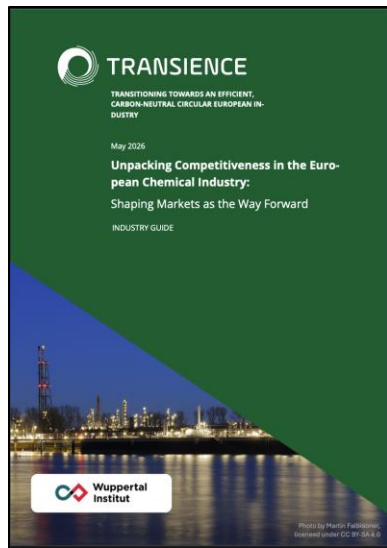
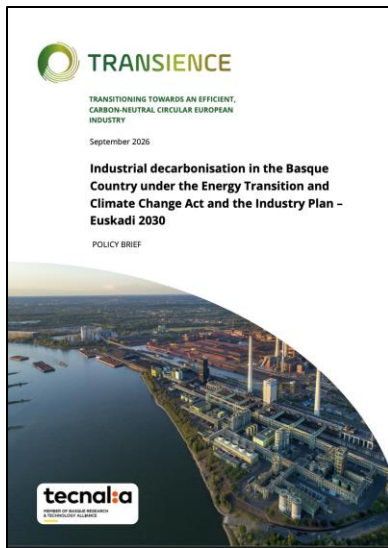
How can modelling evidence support decisions?

2

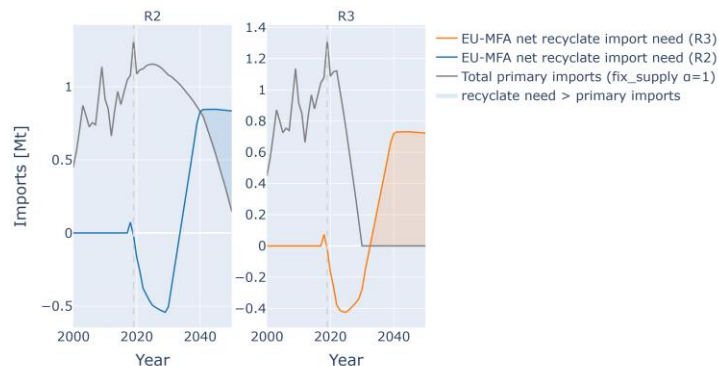
Build recycling capacity before recycled-content targets bind

From around 2035, Europe would become a net importer of PET recyclate in the examined scenarios.

Investment and infrastructure: Improved collection, sorting, and recycling are needed, sized to the targets.



Recyclate import need vs. primary imports — EU27+3



Find our policy briefs & industry guides at <https://transience.eu>

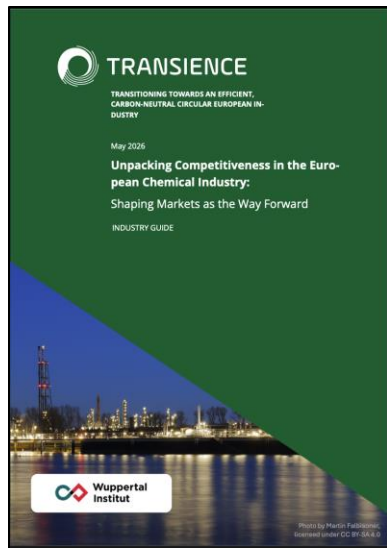
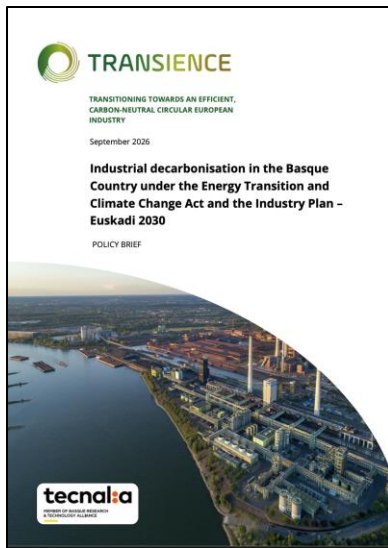
How can modelling evidence support decisions?

3

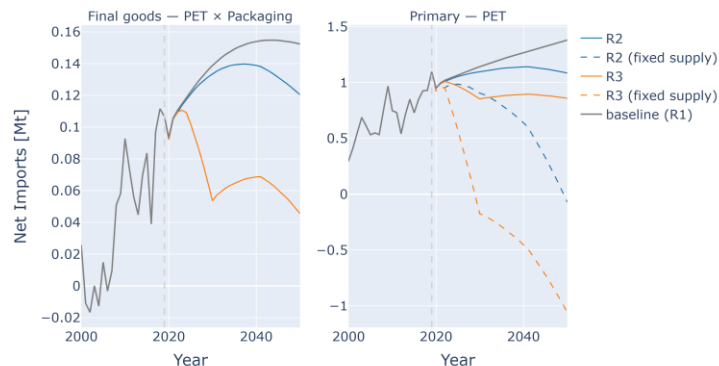
Decide when and where to maintain domestic production

For primary PET, cutting demand through circularity lowers import dependence only if domestic output is held.

Market intervention: Resilience gains from circularity depend on industrial-policy choices.



Net Imports — EU27+3



Find our policy briefs & industry guides at <https://transience.eu>



FORECAST-
Sites

Other indicative model results

Which is the optimal technology configuration and what infrastructure is required for industrial decarbonisation?

Focus: Pathways for glass, pulp and paper, and cement industries in the Basque country

What was modelled:

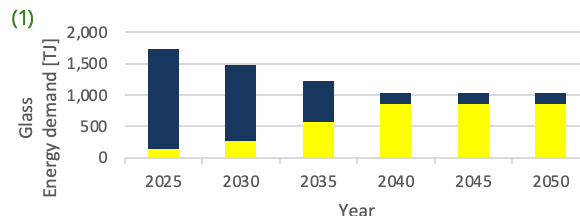
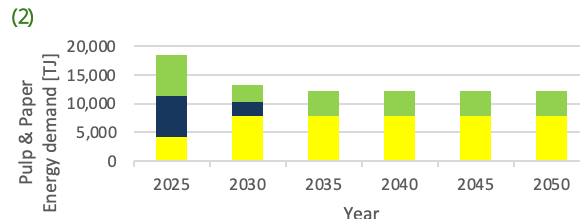
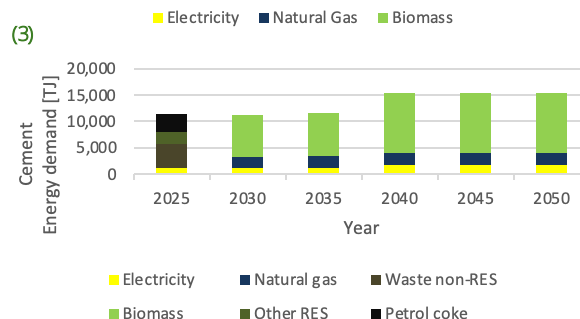
- Glass: alternative furnace processes e.g., regenerative, hybrid, fully electric
- Pulp & paper: various steam technologies, e.g., CHP, biomass boilers, gas, heat pumps
- Cement: different options on calcination, rotary kiln, the burners serving each, etc.

Results

- Glas: hybrid electrification is the most competitive option for low-carbon glass
- Pulp & paper: heat pumps are most competitive for low-temperature steam
- Cement: fuel switching alone cannot eliminate process emissions

Insights

- Electricity increases in all sectors, while biomass is another recurring option (**Fig. 1-3**)
- Regional electricity infrastructure and prices become shared boundary conditions
- Future applications should test sustainable biomass potential limits



More information on TRANSCIENCE studies

Visit the [IAM PARIS modelling platform](#)



What remains uncertain and what comes next?

Limitations

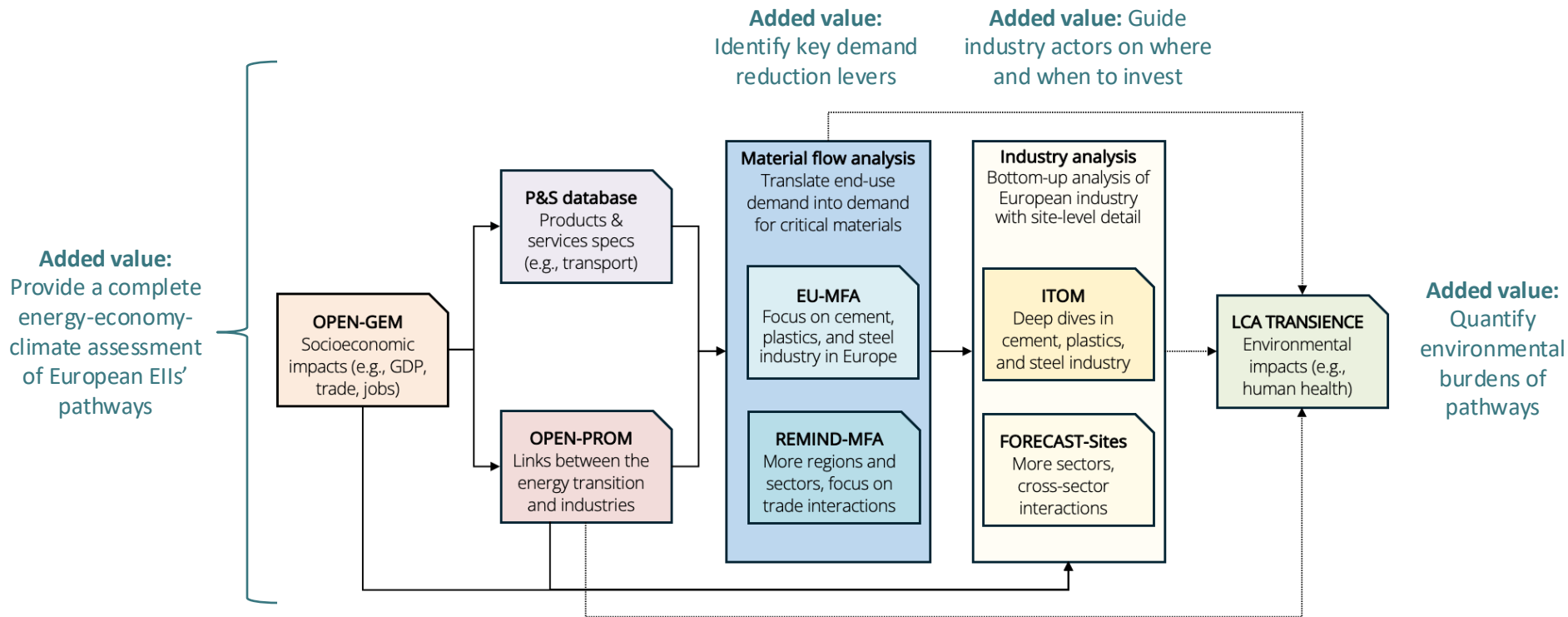
- The analysis is based on physical material and trade flows and does not explicitly account for energy use or emissions, which are also relevant in the context of industrial resilience.
- The study does not incorporate economic mechanisms and, consequently, the trade scenarios represent normative boundary assumptions rather than behavioural and price-driven outcomes.

Future work

- The models used will be linked with other models ([MIC3 framework](#)), which can capture such effects (e.g., macroeconomic model, energy system model, LCA model).
- This integration of perspectives would allow for a more holistic assessment of the impact of circularity on industrial resilience.

How can the project contribute to modelling of EII industry scenarios?

Contributions from each MIC3 module



Thank you!

- What is **expected of industry** when energy generation, infrastructure and prices are **outside** industry's control?
- How should society decide which industries receive **priority access** to scarce non-fossil resources?
- How can sustainable products become the **competitive default**?



P4Planet Projects Results

Workshop 1

Modelling industry
transition to climate
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and sustainability





15:40 – 16:10

**Networking coffee
Project projects posters session**



P4Planet Projects Results

Workshop 2

Low-carbon production of
minerals and materials
Room Roseland



ALCHEMHY

Alternative routes for basic chemicals production
using hydrogen as feedstock



Elena POLLET

PLASMANT, University of Antwerp



The Innovation

- Conventional ammonia and methanol production is characterized by high energy consumption and significant greenhouse gas emissions
- Electrified production routes and green hydrogen enable more efficient and sustainable chemical production:
 - Magnetic-heated-sorption enhanced reactor (MSER)
 - Direct electrochemical synthesis (DESA)
 - Small-flexible methanol reactor (SFMR)
 - Plasma-catalytic hydrogenation of CO_2 to methanol (PCH)

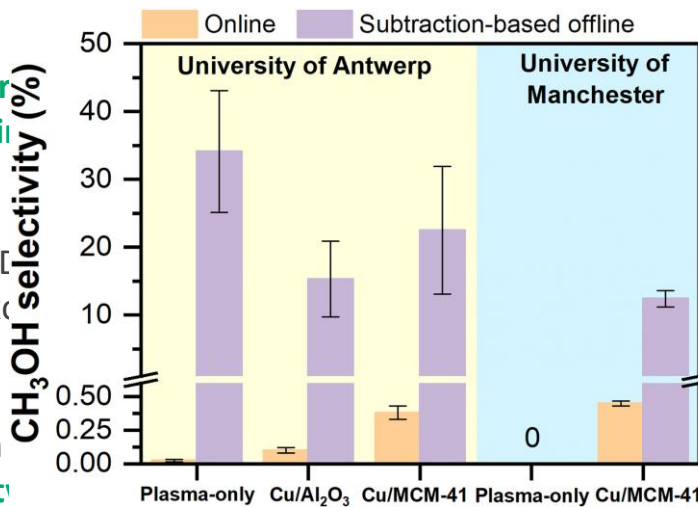
TRL3/4: Experimental proof of concept
→ TRL5

The Results and Impact



- 1 Reported **methanol yields** from plasma-based CO₂ hydrogenation in temperature controlled dielectric barrier discharge (DBD) reactors are **overestimated** due to subtraction-based offline analysis that assumes closed carbon balance

- 2 Pivot to **Reverse syngas as an intermediate**
- 3 Shift from DBD to **electric field** to promote the catalyst surface
- 4 Incorporation of **proximity between catalyst and electrode** to enable **surface build up**



(Van Turnhout, Saud et al. 2026)

Industrial Relevance & Next Steps

Pivot to plasma-based RWGS for upscaling

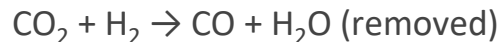
Plasma-based methanol synthesis (PCH)



Reverse Water Gas Shift (RWGS)



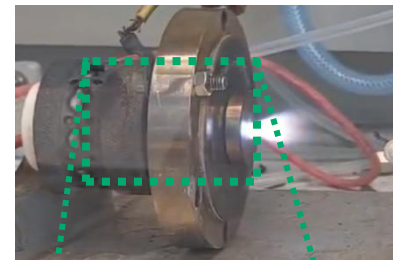
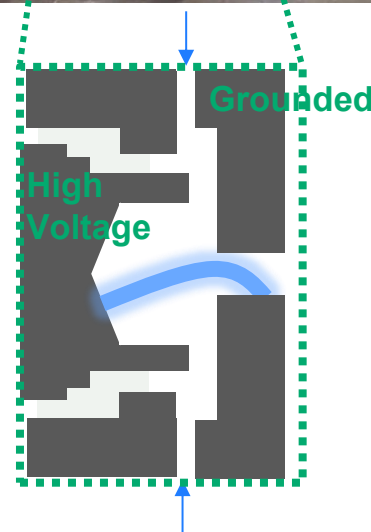
→ **Proposal for methanol synthesis:**



1st step – plasma technology

2nd step via electrified CO hydrogenation

Arc plasma reactor



(Bang, Djettene et al. 2026)



Thank you!



PROCESSES4PLANET

ELECTRA

ELECTRIFYING HIGH TEMPERATURE MINERAL TREATMENT



Halvor DALAKER

SINTEF

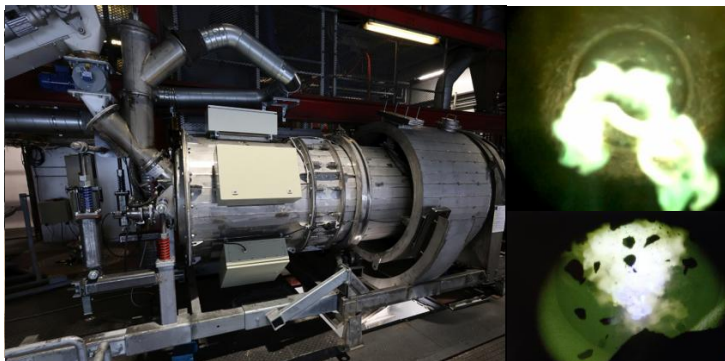


The Innovation

- ELECTRA develops new heating technologies and to decarbonize and electrify high temperature industrial heat ($>1000\text{ }^{\circ}\text{C}$)
- Plasma technology, Resistance heaters, Rotary kilns, FBR

The Results and Impact

High enthalpy plasma (HEP)



- Calcination: 0.43% CaCO_3
- Off-gas: >90 % CO_2
- Continuous Feed: ~100kg/h

1 High enthalpy plasma (HEP)

- Low gas use (<10 NM^3/MWh), facilitates CCS, High thermal efficiencies (scales with power)
- LIMESTONE CALCINATED (TRL6)

Proof of concept clinkering (TRL6)

- ### 2
- Strong 28-day performance
 - Distinct clinker microstructure
 - (Traditional plasma torch)

Industrial Relevance & Next Steps

SCALING FROM PILOTS TO APPLICATIONS

ELECTRA SCALE UP

- HEP: Clinker, lime mud, FBR
- 1 MW Rotary kiln (TRL7)

HEP DEVELOPMENT

- Pilot:
300 kW demonstrated
- Scale up:
300kW→1.5 MW→6 MW

APPLICATIONS

- Cement, limestone, lime mud
- Glass, metallurgy, alumina, etc.

Thank you!

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Coordinator contact:
VTT, toni.pikkarainen@vtt.fi



PROCESSES4PLANET

HYPER

An electrochemically produced oxidiser for modular
onsite generation of HYdrogen PERoxide

Electrification of chemical processes



Richard H. Heyn, Coordinator

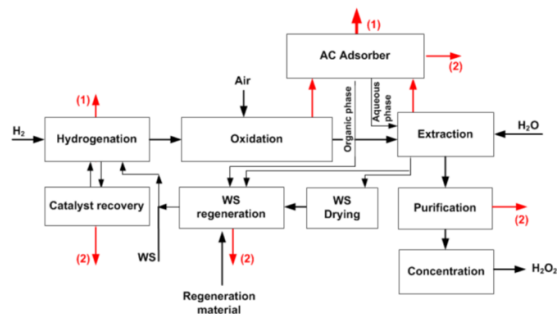
rrh@sintef.no

SINTEF Industry

Oslo, Norway

The Innovation

Current H_2O_2 production process

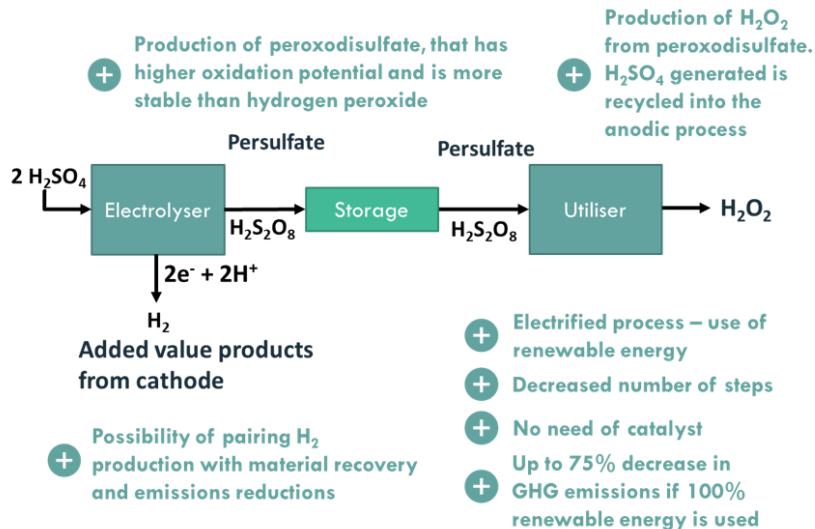


NB: WS: Working Solution. (1) Waste gas. (2) Waste water.

- Complex process with many steps
- Need of catalyst
- Use of aromatic hydrocarbon and polar solvents

Process used natural gas for H_2 production as well as energy

HYPER H_2O_2 production process



Modular, onsite production of sustainable H_2O_2

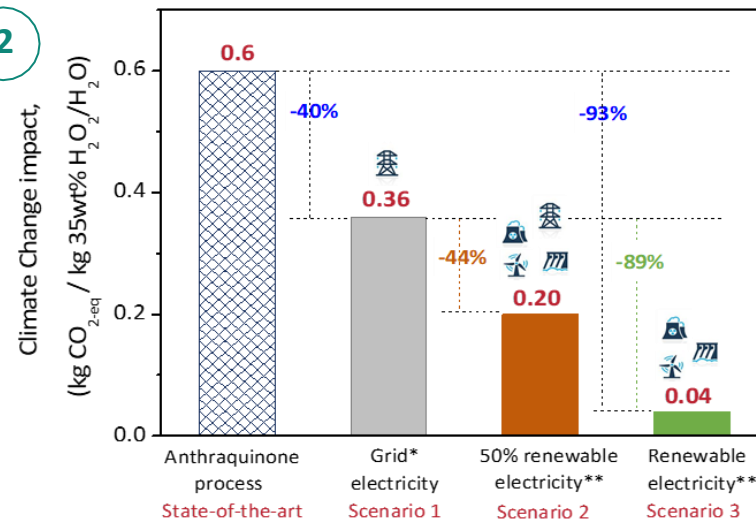
1

The Results and Impact



TRL 6 demo at Belinka Perkemija in Ljubljana

2



> 90 % reduction in GHG emissions vs. state-of-the-art

3

Integrated, automated process with sulphate recycle and reproducible H₂O₂ production

Production and energy efficiency targets achieved.

Industrial Relevance & Next Steps

Many potential applications in a range of industries



Successful project – should be tested at higher TRL

Remaining barriers and needs:

- Utiliser not dimensioned properly and built from glass
- Cheaper electrode available but needs upscaling
- Better heat integration

Looking at potential funding opportunities for a TRL 7 unit for production of 20-50 kg H₂O₂/d (100 % basis), but need a host partner.



Thank you!



PROCESSES4PLANET

MECALO

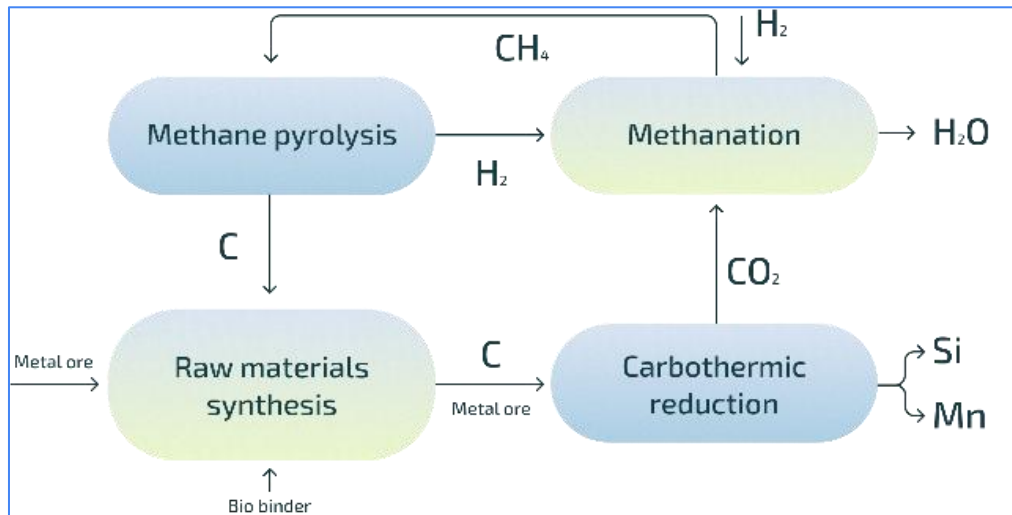
Metal Production with Carbon Looping



Halvor DALAKER

SINTEF

The Innovation



Challenge:

- Metal production reliant on carbon reductant

Mecalo concept:

- Renewable H₂-enabled carbon looping

The Results and Impact

FROM AGGLOMERATES TO METAL

TRL 6 SiMn Pilot

- 200 kg C agglomerates
- 244 kg SiMn alloy
- In-spec carbon and electricity consumption



130 kW Si Furnace run

- >600 kg SiC agglomerates
- Stable operation
- >88% Si yield
- In-spec carbon and electricity consumption

Industrial Relevance & Next Steps

From demonstrators to closed carbon loop

Industrial pilots

Carbothermic processing with:

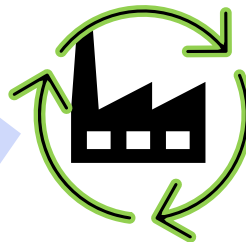
- CO₂ reduction
- Reduced import reliance
- Tailored reductants



Assess
industrial
integration

Validation
of looped
carbon

Complete
Campaigns



Thank you!

Halvor DALAKER

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PROCESSES4PLANET

PRIM-ROCK

Breakthrough Decarbonised Processing Technologies
for a Competitive, Resource-Efficient and
Resilient European Extractive Industry



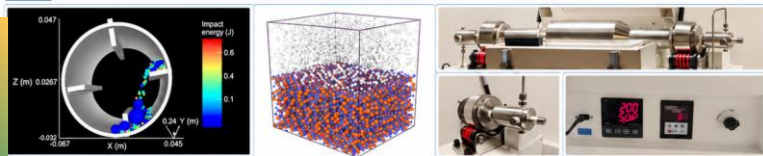
Antonis PEPPAS (Prof.)

National Technical
University of Athens

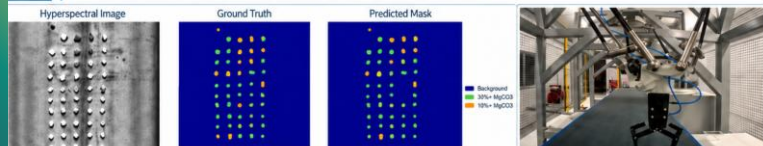


PRIM-ROCK Technology Development

01 AI-assisted thermodynamic and kinetic modelling



02 Multisensing, robotic and pneumatic sorting



03 Online optimisation of electrified processes and H₂S-CO₂ utilisation



The Innovation (TRL 4 ⇨ 6)

Pre

Reduced Order Models of the physicochemical and thermophysical simulation
Optimal, valorisation flow-specific crushing size
Intelligent Decision Support System for raw material valorisation

Process

Electrified rotary kilns in controlled atmosphere
Multirange Spectroscopic Platform, AI-based algorithms for the optimization of the rotary kilns resource efficiency

Post

Plasma treatment for the **recovery of H₂** from hydrogen sulphide gases
CO₂ post treatment for synthetic fuels production

001 Develop new electrified processes and Energy efficiency, ensuring process flexibility and capturing the full potential of renewable energies

002 Replace fossil fuels and feedstock by Renewable H₂ and biomass in processes

005 Design processes for maximum resource efficiency, including the development of materials for circularity

006 Develop new processes for circularity of secondary materials from wastes/residues for all industrial processes

A.SPIRE sectors



Cement



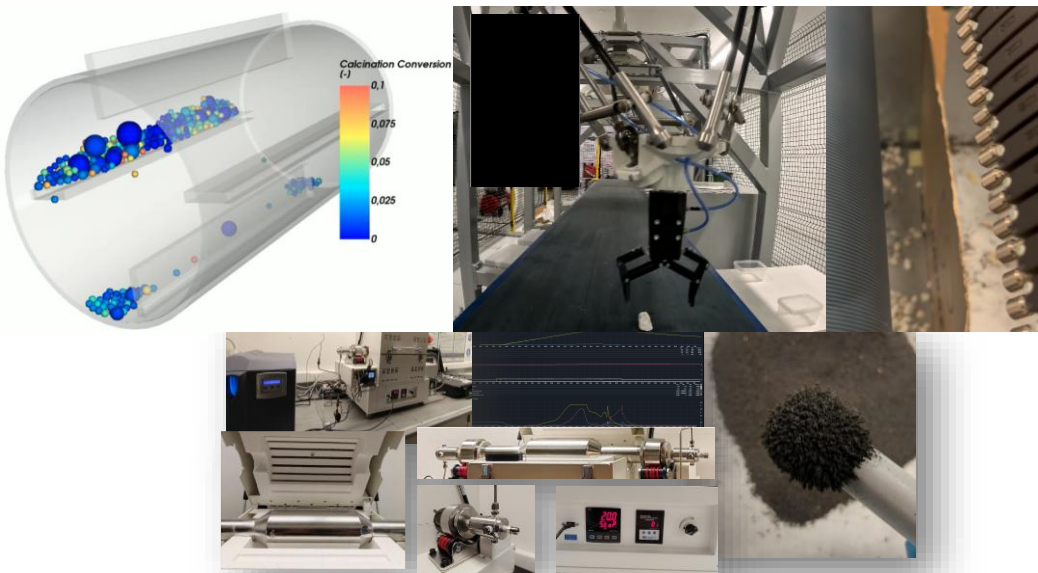
Non-ferrous metals



Minerals

The Results and Impact

Holistic approach centred around ground-breaking process intensification and digital technologies



1

Advanced physicochemical and thermophysical simulations for modelling the microscopic and macroscopic behaviour of the calcination and roasting processes in the electrified kilns

2

Optimal, valorisation flow-specific crushing size, the raw-materials' physical and chemical properties, as well as requirements of the upcoming valorisation flow, such as particle distribution, purity of input stream, etc.

3

Breakthrough resource-efficient decarbonised processing technologies validated at TRL5

- High calcination degree above 98% and recovery rates for fine particles
- Successful pre-reduction trials of Laterite (FeNi ore) at 800 and 1000°C (15- and 30-min processing time)

Industrial Relevance & Next Steps

Progression from conceptual designs to tangible solutions

The focus shifts to demonstrating the developed solutions in relevant environment, accompanied by the various assessments aimed at validating the potential of the technology. A complete and comprehensive assessment of the impact of the PRIM-ROCK solutions will be carried out, including technoeconomic analyses, energy and intensity evaluations and societal and environmental studies



Greek Pilot unit: HyLivingLab, (ATEX IIC area)



Thank you!



PROCESSES4PLANET

P4Planet Projects Results

Workshop 2

Low-carbon production of
minerals and materials
Room Roseland





15:40 – 16:10

**Networking coffee
Project posters session**



PROCESSES4PLANET

P4Planet Projects Results

Workshop 3

Mature technologies for
Industrial Heat
decarbonisation



EEETHOS

Energy Efficiency and Electrification Technologies
for Heat Flow Optimization in Process Industries

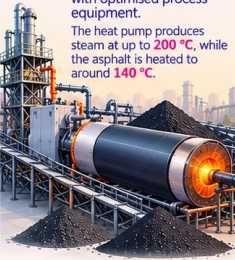
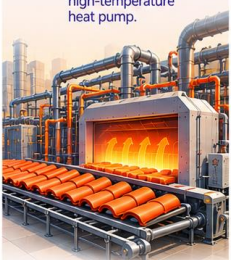
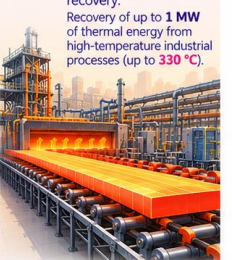


Jonas L. POULSEN

eeethos
CLEAN INDUSTRIAL HEAT

5 Solutions. One Goal: Clean Industrial Heat.

EEETHOS is demonstrating high-efficiency technologies to replace fossil-based process heat across five energy-intensive industries.

<p>1 ASPHALT HTHP + steam compression with optimised process equipment. The heat pump produces steam at up to 200 °C, while the asphalt is heated to around 140 °C.</p>  <p>Steam up to 200 °C Asphalt heating to ~140 °C</p>	<p>2 ROOF TILES Reverse Brayton high-temperature heat pump.</p>  <p>Up to 300 °C Up to 1 MW heat</p>	<p>3 PULP & PAPER Steam-generating high-temperature heat pump.</p>  <p>1 MW steam 180 °C 10 bar</p>	<p>4 BRICKS Flexible airless drying with MVR. Reduces typical drying time from 50–60 h to < 30 h.</p>  <p>Energy use per kg H₂O removal: 0.15 kWh/kg H₂O</p>	<p>5 STEEL Radiative waste-heat recovery. Recovery of up to 1 MW of thermal energy from high-temperature industrial processes (up to 330 °C).</p>  <p>Recovered heat up to 330 °C Up to 1 MW recovered heat</p>
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Lower energy use at the demonstrators



Higher energy efficiency



Increased industrial competitiveness

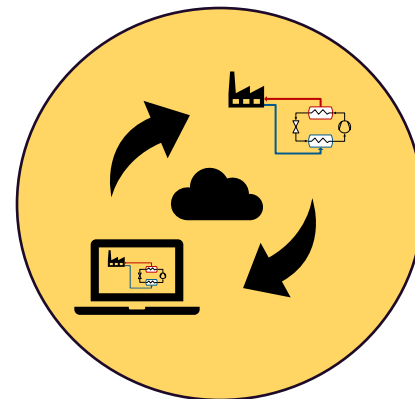


Real-life demonstrations in European industry



Funded by the European Union

Including development of **integrated digital solutions** for process monitoring, optimization, and predictive maintenance.



Targeted services:



Monitoring and benchmarking



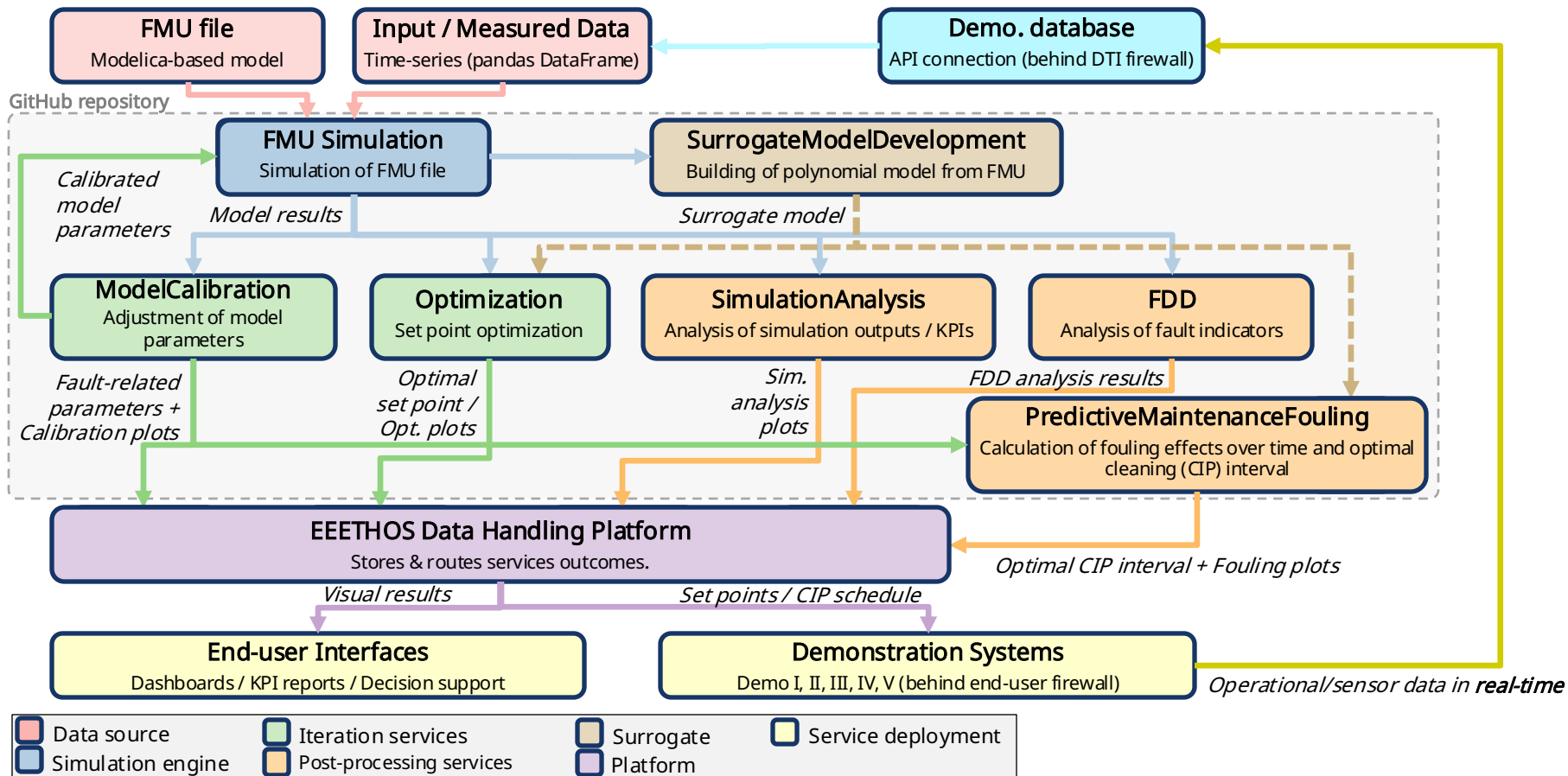
Fault detection and diagnosis / Predictive maintenance



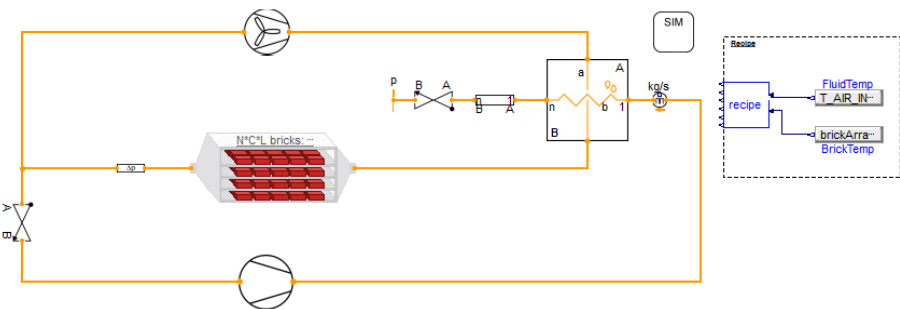
Set point optimization

EEETHOS develops and demonstrate key enabling and scalable technologies to replace fossil-based heating in 5 distinct energy-intensive industrial sectors with **electrified**, high-efficiency systems (TRL 7).

Resulting structure for the integrated digital twin-based services



Industrial relevance – example – brick drying – optimization of shift from air-based drying to steam-drying



Simplified overview of the dynamic brick-dryer model.

1

Digital test bench for drying to virtually screen and pre-optimize operational recipes. Phases with only humid air, air-steam conversion, finally steam drying with MVR in which evaporated moisture is compressed to a higher pressure and condensation temperature, enabling heat recovery through the heat exchanger and reducing the external heating demand. Multiple parameters: Phase durations, ramp times, temperature, humidity, etc.. A key outcome: Candidate recipe that reduces the **drying time from 60 to 40 hours**, with a modelled specific energy consumption of **0.15-0.25 kWh/kg of evaporated water, compared with more than 1 kWh/kg** often reported for conventional air drying.

2

Further EEETHOS examples:

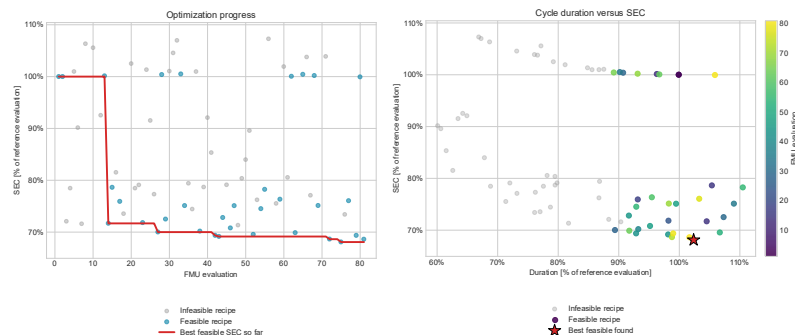
- Optimization of asphalt drum design and its integration with a high-temperature heat pump. Sizing of components, and optimal operation (minimum electrical consumption).
- Influence on fouling of fouling on heat exchangers – optimal time for CIP?

3

Perspectives about maturity from other Horizon project:

- “SPIRIT”, homepage: <https://spirit-heat.eu/>
- **Proven** HTHP steam producing heat pump in real production environment (sugar industry).
- Up to 4 MW and 150 °C and based on natural refrigerant.
- Presentation of heat pump and its integration: <https://www.youtube.com/watch?v=6opq5-K5fRE>

Drying recipe optimization | SEC and duration: evaluation 1 = 100%
Best feasible recipe: SEC = 68.1% of reference | Duration = 102.5% of reference | Final drying degree = 97.19%
Required final drying degree: 90% | SEC reduction from reference: 31.9%



Optimization of phase durations and the MVR activation threshold, showing specific-energy-consumption.



Thank you!

www.eeethos.eu





Co-funded by
the European Union



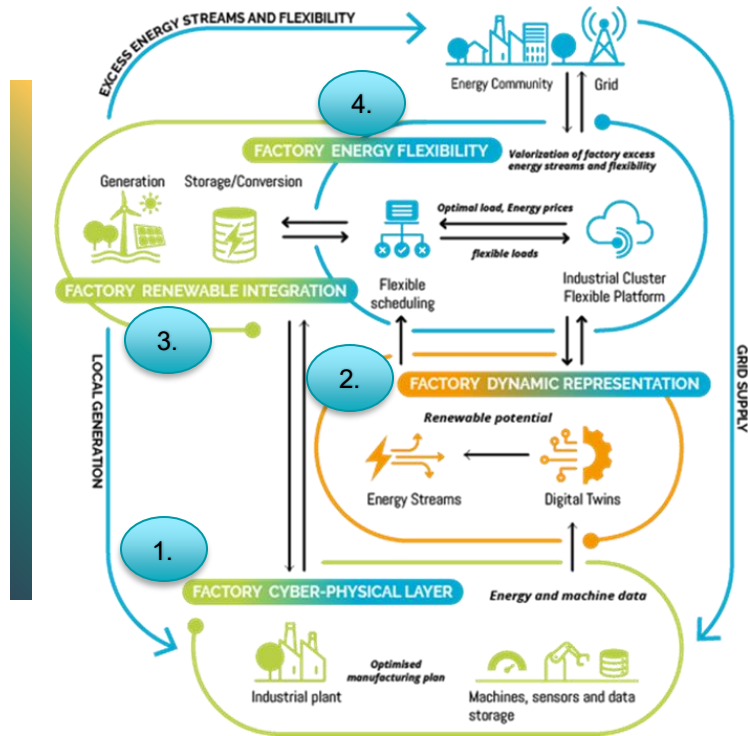
FLEX4FACT

Industrial Cluster flexibility platform for sustainable factories
to reduce CO2 and to enable the Energy Transition



Ragnhild J. Eleftheriadis

SINTEF AS,
Digital Production



FLEX4FACT CONCEPT

FLEX4FACT did not rely on breakthrough technologies. It combined and scale already mature technologies in an ecosystem approach.

The concept is built on a modular and multi-level architecture that leverages the provision of flexibility from the industry through **digital process twinning, machine learning techniques and novel algorithms** supporting modern **manufacturing planning and scheduling system**.

The FLEX4FACT concept consist of four layers:

1. **Factory Cyber-Physical** layer that links the **digital tools** and the physical processes of **five** industrial use cases - Steel maker, sealing production, scuba diving equipment, solar collectors and electronic metering systems
2. **Factory Dynamic representation** layer maps the energy needs and manufacturing constraints of the industrial processes, tools for energy streams, energy digital twins for several assets etc.
3. **Factory Renewable Integration** layer which helps to **identify the potentials for renewable energy production**, energy storage and valorisation of excess streams
4. **Factory Energy Flexibility** layer connecting **the industrial clusters** and sites to the **energy markets** and players. Demand response, aggregator platform and flexibility offers

Main design principles: Open Technologies, Standard protocols and interfaces, Modular Architecture, No vendor lock in, Service revenue streams.

Which lead to energy trading possibilities for Industry with Software as a Service.

The Results and Impact

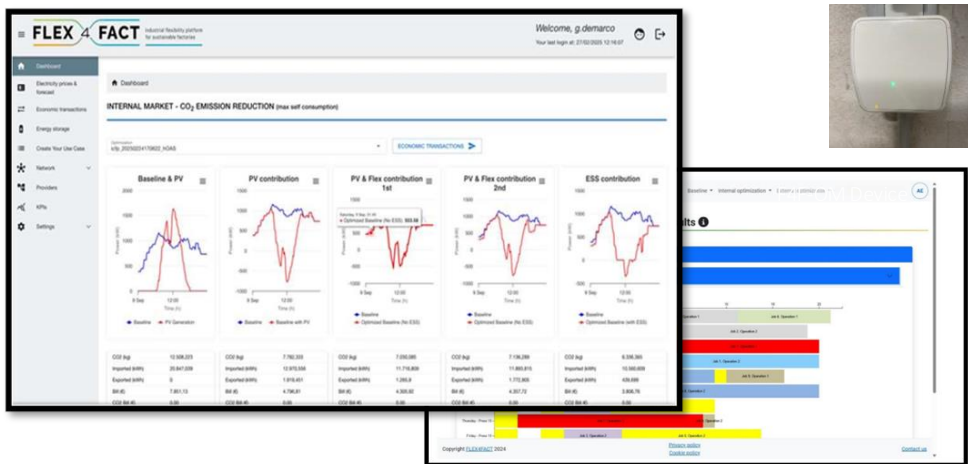
The largest impact is achieved when factories are connected to local energy systems and coordinated through shared flexibility mechanisms

By combining: Renewables like batteries, thermal storage, solar PV you create Industrial symbiosis

Industrial sites can: Increase renewable energy utilisation and reduce CO₂ emission

Create new revenue value streams through flexibility services

- Mature digital technologies can deliver immediate decarbonisation benefits
- Digital twins and advanced scheduling improve both energy and carbon performance
- Interoperability and data integration are critical for scaling



1

Digital twins for multiple industrial processes, enabling real-time monitoring, predictive analysis, and **optimisation of energy use**. EAF, Gas & electric boiler, production lines, heat exchangers, PV etc.

2

Energy-Flex Production Scheduling Platform(EFPSP) TRL7-8 An AI tool which integrates energy considerations directly into production planning and control. Validated in all the five pilots

3

The **Industrial Cluster Flexibility Platform (ICFP)**, TRL7-8 Aggregator platform allowing industrial sites to coordinate flexibility and participate in energy markets. This provides the foundation of the transition.

- Entso-e data and 15 / day-ahead prices for CO₂ forecast, scope 2 equivalents, load testing and scaling, validated in 5 pilots. Standard API, Plug &Play industrial compatible, SaaS.

4

An **F4F-OM prototype device** for industrial use with blockchain solution is also developed (TRL6)

- **San Flex** decision support tool (energy flow TRL6)
- **Energy Model Flex** for renewable integration (TRL7)
- **Industry Opt** combining Energy model flex and LCA (TRL6)

Industrial Relevance & Next Steps

The project established a clear pathway from demonstration to commercial deployment and commercialisation. Proving that existing digital technologies can deliver measurable reductions when deployed together at factory and at cluster level.

FLEX 4FACT project successfully validated a portfolio of digital solution and tools for industrial decarbonization in operational industrial environment

Solutions is applicable and scalable across multiple industrial sectors and assessed through branch-specific KPI's defined by each industrial demonstrators

Some of the measured figures are:

17- 22 %	reduction in energy consumption
7.6 up to 50 %	reduction in energy cost
8.2 - 8.6 % CO ₂	reduction of emission in the pilot implementation
Up to 60%	increase in renewable energy utilisation
Up to 30%	reduction in required battery storage investment
15 -30%	production expansion potential for renewables and storage investments

Flexibility trading with 0.305 MWh/day can generate up to €500/day in cost reduction by use of the combined solutions. See DG Energy & [CELSA Video](#) launched in October.

Read more about our solutions at CORDIS or in the last report from the Commission on electrification launched the 15th of October https://energy.ec.europa.eu/topics/eus-energy-system/electrification_en#electrification-of-industry





FLEX4FACT CONSORTIUM

Thank you!



HyInHeat

Enabling hydrogen-based industrial heat



Felix KAISER

IOB - RWTH Aachen University



The Innovation

Challenge

Replace fossil fuels in industrial heating: HyInHeat investigates hydrogen for aluminium melting & holding, steel reheating, ladle preheating and indirect heat treatment

Preserve production performance: Fuel substitution must maintain heat delivery and product quality while addressing NOx emissions, material durability and safe operation

Approach

Fuel and oxidiser flexibility: Compare conventional fuels with hydrogen and blends, using air, oxygen-enriched air and oxyfuel combustion across different demonstrators

Whole-system engineering: Combine burner development with fuel supply, furnace-pressure control, instrumentation, refractory assessment and safety systems

The Results and Impact

Separate the effect of hydrogen from the effect of oxygen enrichment—and optimize the furnace, not only the fuel



1

Aluminium melting: comparable energy demand to NG and no measurable performance penalty, no additional hydrogen pickup in the material

2

Steel reheating: Combined fuel and oxidizer change lead to ~33% lower energy demand, oxyfuel might increase scale losses

3

Industrial validation: H₂ trials for 1,163 t of steel produced, 10 heats, 4 grades; no reported safety incidents or quality defects; supply pressure drops, piping incompatibilities, control adjustment needs

4

NO_x-emissions: Remained below appl. limits, but 2-3x increase with H₂ (industrial); dependent on excess air, flameless oxyfuel design produced 3.5 mg_{NO2-eq}/MJ_{H2}

Industrial Relevance & Next Steps

Sustained operation with reliable supply, validated equipment and a credible business case

Equipment is mostly retrofittable or available // Further trials for long term effects necessary // Availability, costs and immature infrastructure as barriers.

- ➔ Assess the heating system together with throughput, metal yield, maintenance and retrofit investment rather than energy savings alone
- ➔ Align industrial users, equipment suppliers, hydrogen infrastructure, financing and workforce training before large-scale rollout





Thank you!

hyinheat.eu



H₂GLASS

Enabling Hydrogen-fired glass production



Marie BYSVEEN

SINTEF Energy

The Innovation



The Impact



Provide important **insights** into the **use of hydrogen** in the **glass industry**



Demonstrate that **green** and **clean innovations** are **compatible** with **economic viability**



Potentially result in **10,000 new jobs**



Revenues for industry partners of **€1-5 billion**



Reduce emissions by approximately **80%**

Industrial Relevance & Next Steps

H2GLASS aims to **develop the solutions** that glass manufacturers need to meet **climate targets** and make their sector **sustainable** by replacing fossil fuels with **100% hydrogen**, ensuring the required **product quality** and manage this **safely**.

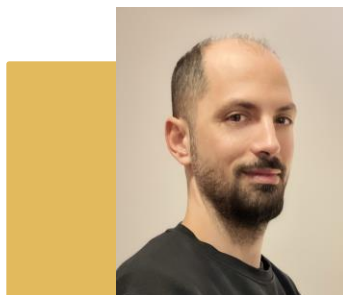


Thank you!



METAWAVE

Electrifying high-temperature process heat with microwave-based systems



Dr Pantelis PAPACHRISTOU

CORE Innovation Centre



THREE PROCESSES

THREE MICROWAVE CONFIGURATIONS



CERAMICS

GRES de Aragón · Spain
Porcelain tile firing 1000–1300 °C
natural gas

→ **Microwave plasma torch kiln**



ASPHALT

COPHA · Spain
Aggregate drying to ~200 °C
heating-oil flame at ~1,400 °C

→ **Direct microwave + hot air**



ALUMINIUM

METLEN · Greece
Carbon anode baking to 1050 °C
natural gas

→ **Direct microwave + induction**



The Innovation



CHALLENGE

Process heat above 400 °C still comes from burning gas or oil: slow to start and stop, lossy, and unable to follow renewable supply.



METAWAVE CONCEPT

Replace fossil-fired high-temperature heating with microwave-based systems, combined with circular materials, in-field sensing and a digital layer.

Volumetric · selective · rapid on/off · fully electric

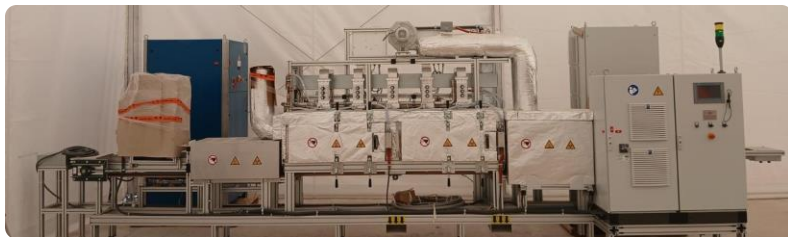


DEMONSTRATION

TRL6 prototypes at two operating plants in Spain (GRES, COPHA) and a pilot in Italy (UNIMORE)

The Results and Impact

TRL6 PROTOTYPES



Asphalt (COPHA): built and factory-tested



Ceramics (GRES): plasma kiln design



Anodes (UNIMORE): hybrid furnace



KEY RESULTS FROM DESIGN AND TESTS

> 30%

Energy reduction potential

vs the state of the art, at 70–90% microwave efficiency

~ 2×

More uniform heating

temperature spread halved or better vs conventional

1300 °C

Circular refractories

from copper slag and recycled refractories; conductivity down to 0.34 W/mK

20–28 h

Hours, not weeks

anode baking at prototype scale, vs a 17-day cycle today

Industrial Relevance & Next Steps

Retrofit, not rebuild



INDUSTRIAL APPLICABILITY

Modular electric units that drop into existing lines; IEC 61499 control wraps legacy kilns and PLCs, so no plant rebuild.



REPLICATION & SCALE-UP

Modular designs built for scale-up; the design method and circular refractories from local industrial waste are reusable for other processes.



BARRIERS & LESSONS

Integration with plant automation took longest on site; sensing above ~1100 °C, CAPEX vs gas-to-power prices and grid capacity remain open.

FROM DESIGN TO DEPLOYMENT



2024–25

Designs and models

Multi-physics models, ROMs, circular refractories selected



2026

Prototypes built

Three TRL6 prototypes built; digital tools developed



2027

Demonstration

Campaigns at GRES, COPHA and UNIMORE; Sustainability and economic viability assessments



2028+

Scale-up & Replication

Scale-up beyond TRL6 along the TRL9 roadmaps; replication in further sectors



Thank you!



SteamDry

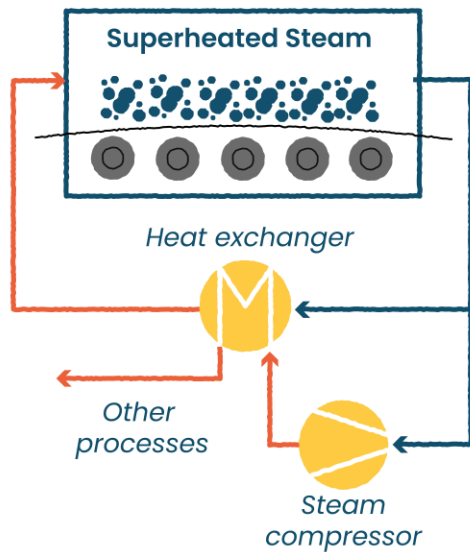
Piloting superheated-steam drying for energy-efficient and low-carbon paper and board production



Sophie KNÖTTNER

AIT Austrian Institute of
Technology GmbH

SteamDry



AIT Austrian Institute of Technology GmbH

www.steamdry.eu

The Innovation

- Superheated steam instead of air as drying medium to remove excess water from materials.
- Circulating and reheating steam in a closed loop and use of surplus steam for other processes within the facility.
- System integration and advanced digitalisation of monitoring and control systems.
- Radically reduce drying energy consumption and CO2 emissions in the paper and board manufacturing industry.
- 60% energy savings in thermal drying and 40% energy savings on a production line and up to 100% CO2 emission reduction.
- Demonstration of substantial improvement potential by pilot-scale measurements at VTT lab (TRL 4 → TRL 6).
- Main technical challenges: Sealing, steam purification and heat durability of drying fabrics

The Results and Impact

- Assessment of dryer concepts with different heat-recovery configurations, supported by steady-state process simulations and simplified component models.
- Pilot superheated steam dryer (two hoods) trials running at the moment: different paper types, drying temperatures, blowing speeds, web speeds, ...



VTT Technical
Research Centre
of Finland Ltd

- 1 High theoretical energy saving potential (above 80%) with SSD concepts based on simplified model results, achieved for low superheated steam temperatures
- 2 Electrification of the drying process results in a 100% reduction in CO2 emissions, depending on the electricity mix.
- 3 Combined Dryer Concept as a Retrofit Solution:
 - Approx. 40% energy savings (based on simulations)
 - excellent runnability
 - Market entry is feasible in ~5 years

Industrial Relevance & Next Steps

SteamDry: Technology with high potential to reduce energy demand and associated emissions in paper industry

Drying is the most energy-intensive process in paper industry (1 157 paper machines in Europe in 2024, Cepi, Key Statistics 2024). Drying accounts for about 70% of the energy consumed in the sector.

The focus in SteamDry is not only on new dryer solutions but also on retrofit solutions.

The next steps and challenges: Up-scaling of the technology to industrial scale and the adaptation of the concepts to other types of dryers.



VTT Technical Research Centre of Finland Ltd



Thank you!



P4Planet Projects Results

Workshop 3

Mature technologies for
Industrial Heat
decarbonisation



17:40

Wrap up and closure
Room Albert Hall

P4Planet Projects Results

Workshop 4

Closing loops through
enabling technologies



PLASTICE

New technologies to integrate PLASTIC waste in the
Circular Economy

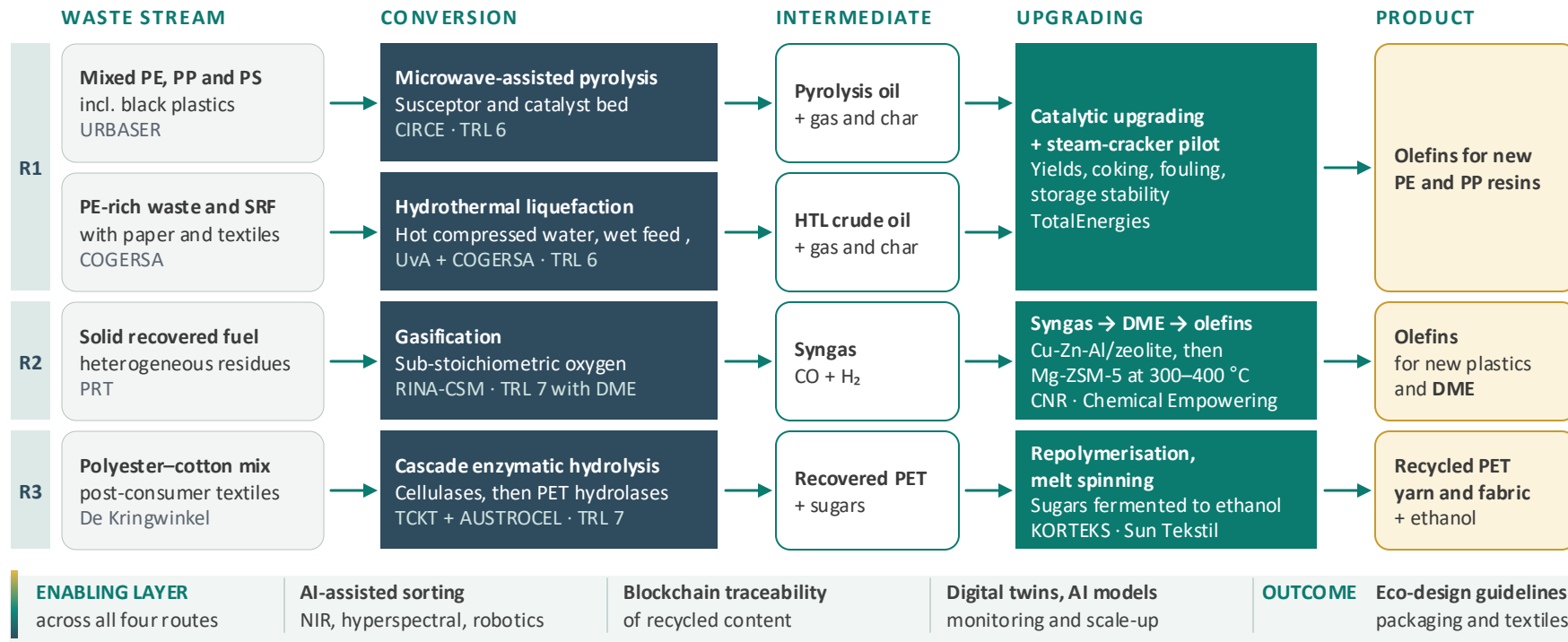


Susana SÁNCHEZ



The Innovation

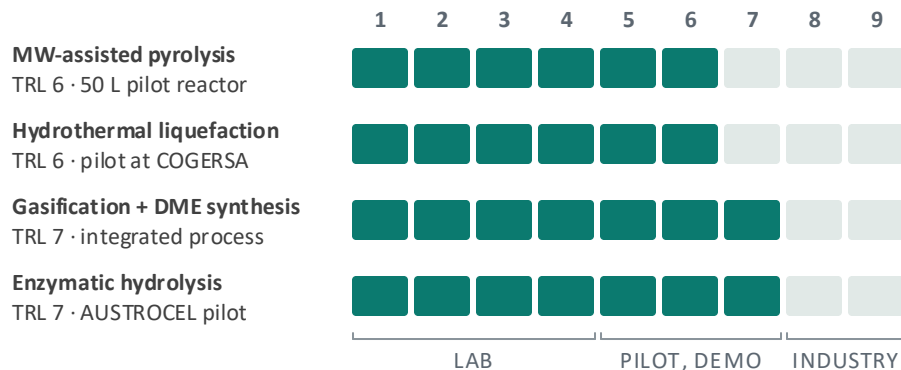
PLASTICE turns the mixed, contaminated plastic and textile waste that mechanical recycling cannot process into circular feedstock, through three routes (R1 to R3) and four technologies at pilot scale.



The Results and Impact

Four routes validated at lab scale and now in pilot demonstration, with the first products made from waste in industrial validation.

TARGET MATURITY OF EACH PILOT (TRL)



Filled cells: level targeted by each PLASTICE pilot. TRL 9: roadmap due at project end.

CARBON FOOTPRINT TARGET · index, current routes = 100



RESULTS

- 1 Thermochemical pilots.** 50 L microwave pyrolysis unit at CIRCE, HTL pilot at COGERSA with UvA, and SRF gasification coupled to DME synthesis with CNR catalysts.
- 2 Textile-to-textile proof.** First fabrics knitted by Sun Tekstil from 100% recycled polyester yarn spun by KORTEKS.

IMPACT

- 3 Tools ready for replication.** Blockchain traceability platform with user guide, AI-based multi-sensor sorting, eco-design guidelines, regulatory inventory and open training materials.
- 4 Recognised at EU level.** PLASTICE technologies feature in the first JRC/INCITE Technical Report on Innovative Techniques (2026) as “waste as feedstock” routes for the chemical sector.

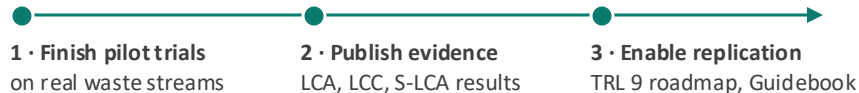
Industrial Relevance & Next Steps

CIRCULAR CARBON FOR CHEMICALS, PACKAGING AND TEXTILES

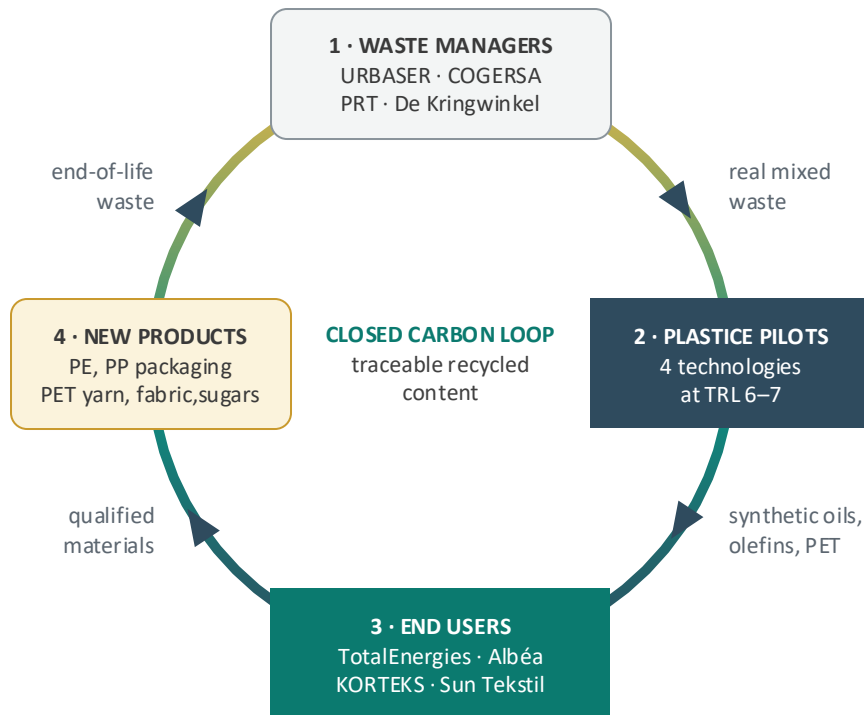
EU rules demand more recycled content, and polymer producers need circular carbon that mechanical recycling cannot supply.

TotalEnergies	Catalytic upgrading and steam-cracker pilot tests of pyrolysis and HTL oils: yields, coking, fouling, stability.
Albéa	Characterization of Recycled PE and PP Resins for Injection-Molded Packaging
KORTEKS, Sun Tekstil	Recycled PET repolymerised, melt-spun into yarn, then knitted and dyed into fabric.

NEXT STEPS



CLOSING THE LOOP WITH INDUSTRY





Thank you!



RecAL | Recycling Technologies for Circular Aluminium

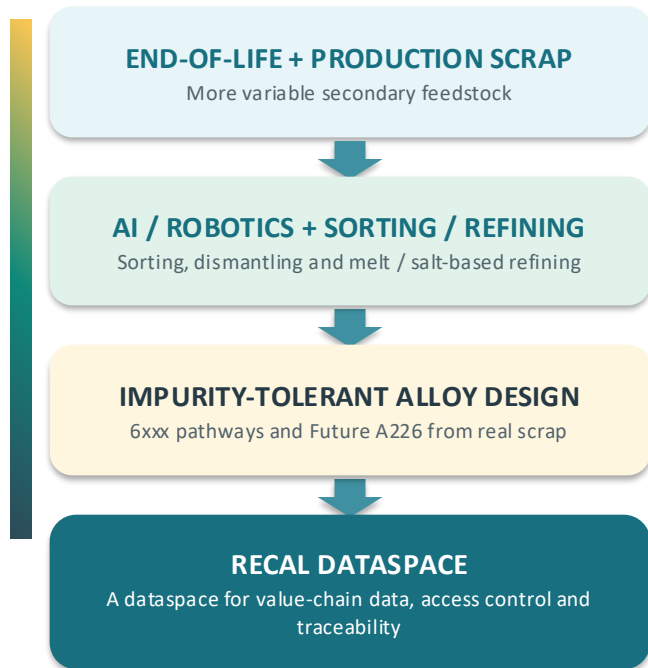
Closing aluminium loops through enabling technologies



Clemens SIMSON

AIT-LKR · RecAL project

FROM SECONDARY SCRAP TO HIGH-VALUE ALUMINIUM

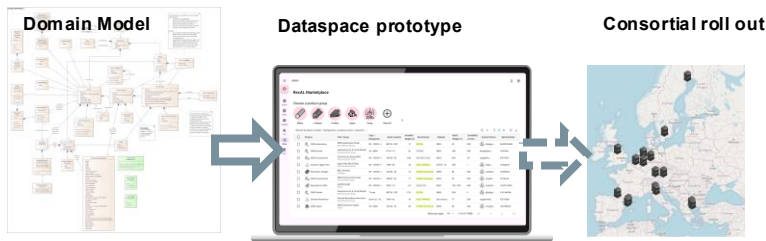


The Innovation

The Challenge: end-of-life and production aluminium scrap can contain mixed alloys and impurities that constrain high-quality recycling.

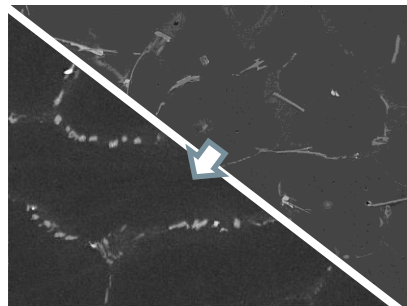
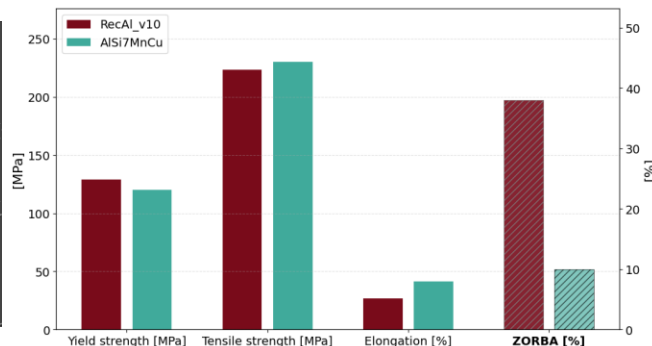
RecAL combines AI and robotics for sorting and dismantling, advanced sorting and melt/salt-based refining, and alloy designs that tolerate more impurities—so recycling is not limited to perfect sorting.

The RecAL circularity hub (**RecAL Dataspace**) is designed to connect actors and data across the value chain while keeping organisations in control of data access. Current status: **RecAL Dataspace** prototype and alloy trials; a demonstration across at least three use cases is planned.



The Results and Impact

RecAL links circularity data with sorting/refining and alloy design. Two alloy routes report quantified trial results, while the Hub prototype addresses value-chain coordination and data access.



Future A226 trial comparison: RecAL v10 vs AlSi7MnCu



Wire casting machine (left) and coiled wire



Cast wire batch (Al6063, Ø 9.5 mm, l 15 m)

1

Dataspace prototype and domain model established; consortium rollout and a minimum three-use-case demonstration are planned.

2

A decentralised data mesh is designed so each organisation retains control of its data and access policies.

3

6xxx alloy trials report >60% secondary 6xxx content, 58% IACS conductivity and >30% elongation.

4

Future A226 trials established ~40 wt.% Zorba content, with mechanical properties matching industrial AlSi7 derivatives.

Industrial Relevance & Next Steps

From trials to industrial validation

Industrial relevance: RecAL targets construction, automotive and cable-related applications, connecting scrap data to sorting/refining and alloy design. The 6xxx pathway includes a cable demonstrator; Future A226 explores greater use of Zorba-derived feedstock.

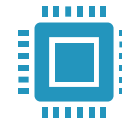
Next steps: roll out the Dataspace and demonstrate it across at least three use cases; continue fatigue/corrosion testing and impurity optimisation. RecAL is looking for industry partners with real scrap streams, process data and target-product requirements to validate and scale results.

Next Gen Recycling Alloys



New alloy designs to **increase impurity tolerance** at level or superior performance.

Applied Digitalization



Use the benefits of Ai, digitalization and robotics for **enhanced waste streams and processes.**

Resilient Circular Economy



Adapt production chains to **fully exploit the potential** of secondary resources and circularity.

Aluminium Recycling Network



Enable communication and **create a platform** for all stakeholders of the Al recycling chain.



Thank you!



RESURGENCE

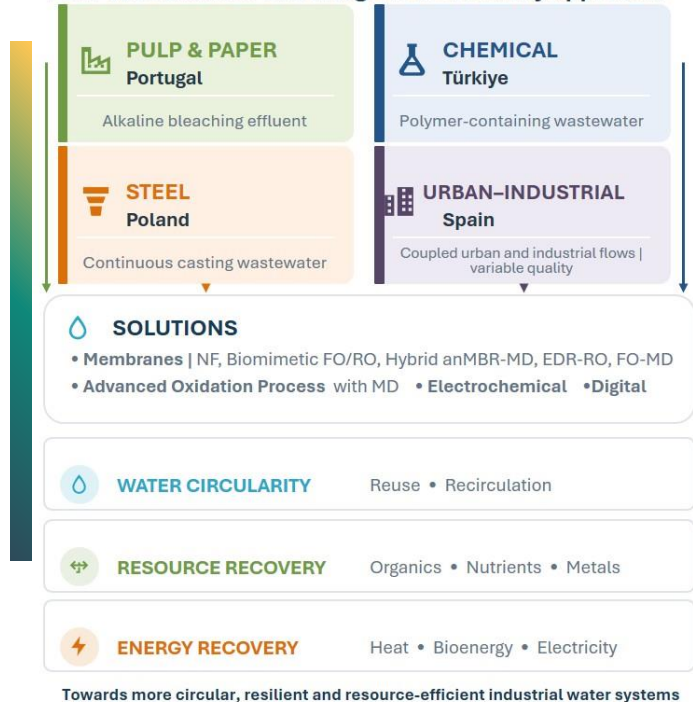
Closing Industrial Water Loops through Reuse,
Resource Recovery & Energy Efficiency



Cristina MARTÍNEZ GARCÍA, PhD

CETIM Technological Centre

Four case studies. One integrated circularity approach.



The Innovation

CHALLENGE

Complex industrial wastewater limits water reuse and resource recovery.

SOLUTION

An integrated portfolio of modular and flexible wastewater treatment technologies, combined with advanced sensors, optimisation tools, AI and Digital Twins, to maximise water and energy recovery and efficiency through an intelligent Decision Support Tool (DST).

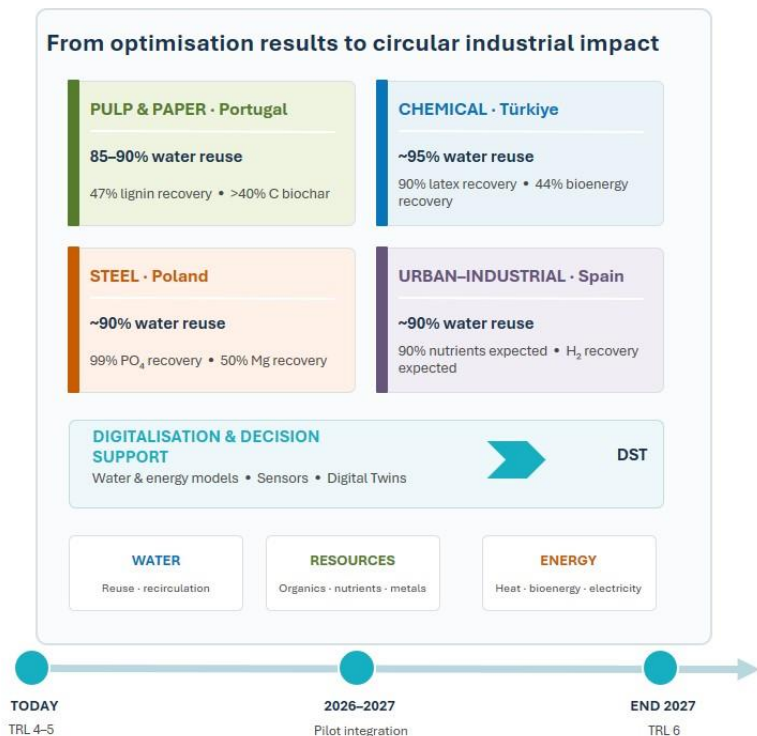
DEMONSTRATION & MATURITY

Four cases: pulp & paper, chemicals, steel and urban–industrial symbiosis.

Laboratory studies of technologies with real wastewater at TRL 4–5 → Selection of the best technology.

Integrated TRL 6 pilots are targeted by 2027.

The Results and Impact



1

Water reuse of 85–95% achieved across the four industrial cases through optimised membrane configurations and waste-heat integration.

2

Resource recovery demonstrated for lignin, latex, phosphate and magnesium, alongside biochar, bioenergy and emerging H₂ routes.

3

Digitalisation and decision support: AI-based water and energy models for 6 technologies, 10+ physical sensors and data-driven soft sensors and Digital Twins to support monitoring, prediction and optimisation through the DST, with integration ongoing.

4

Technology selection must combine performance, feasibility, sustainability and site-specific constraints to identify the optimal solution for each industrial case.

Industrial Relevance & Next Steps

Industrial Adoption Pathway

INTEGRATE

Modular solutions tailored and integrated into existing industrial wastewater treatment plants.

ADAPT & REPLICATE

A cross-sectoral approach adaptable to different wastewaters, industrial sites and recovery targets.

DE-RISK SCALE UP

Confirm long-term reliability, integration, costs and regulatory acceptance.

DEPLOY

Industrial partners and sites for TRL 6 demonstration, replication and preparation for full-scale deployment.





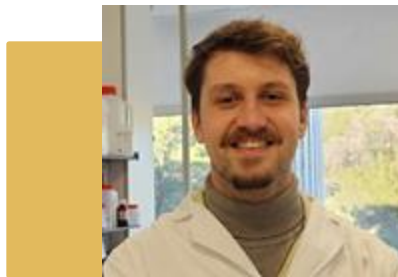
Thank you!



R3VOLUTION

HORIZON EUROPE RIA - GRANT AGREEMENT 101138245

Water reuse and resource recovery through smart,
circular and integrated solution for industry.



David BURRUECO SUBIRÀ
Project Manager and Researcher

CETAQUA
CENTRO TECNOLÓGICO DEL AGUA

The Innovation

Challenge addressed: Energy-intensive brine disposal and freshwater withdrawal in manufacturing processes, facing strict EU environmental regulations and rising water scarcity costs.

Innovation 1: Advanced Membranes

- Nanocellulose antifouling membranes
- Grafted ceramic NF
- Fluorin-free hydrophobic ceramic membrane distillation tubes

Innovation 2: Resources Integration

- Industrial low-grade waste heat upgrade via high-temperature heat pumps
- Bipolar electrodialysis for internal NaOH and HCl regeneration
- Modular ZLD treatment trains

Innovation 3: Digital Assistant

- Digital Twins simulating plant dynamics
- Deep learning computer vision for hydrocarbon detection
- Explainable AI for operational recommendations

Demonstration: **Validated across 4 industrial pilot sites:**

BLOOM

BIOCHEMICAL

REPSOL

PETROCHEMICAL

CELSA

STEEL

FELIX SCHOELLER

PULP & PAPER

- 💧 **High consume** of freshwater
- 🏭 **Complex effluents** to treat
- 💰 **Increasing costs**



Environmental issues ●
Operational expenditures ●
Improvement opportunities ●

INNOVATION



The Results and Impact

BIO-BASED

BL'OM

Cellulose wash stream

- >90% water reuse in washing
- >50% waste heat recovery
- 45% organic fraction recovery



PETROCHEMICAL



WWTP effluent and sour water

- >90% water reuse
- >80% heat recovery
- 40-60% recovery of NaOH, HCl, NH₃



PULP & PAPER



Surface coating wastewater

- >90% water reuse
- >80% heat recovery via V-MD
- >50% CaCO₃ filler recovery



STEEL

CELSA

Heavy industrial effluent

- >94% intake cut
- >80% heat recovery
- 40-60% acid/base recovery



Integration of Digital Process Assistant: Data driven software sensors + Explainable AI

+ 20% in process efficiency

Predictive cleaning schedule

De-risked supervisory control

Cumulative target: **58 million m³ of water saved** and **115.000 tonnes CO₂_{eq} avoided** by 2035.

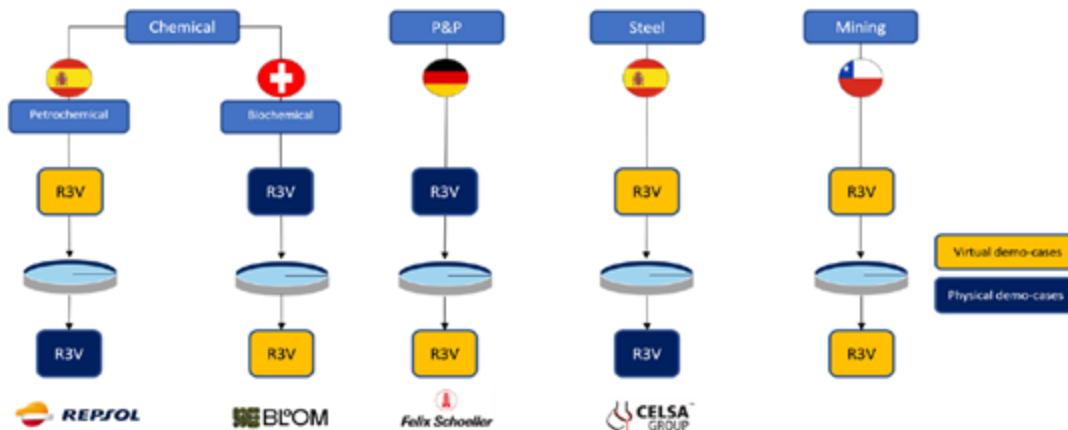
Industrial Relevance & Next Steps

- Direct **industrial validation** in 4 physical sites
- **Virtual replicability** of secondary streams
- Clear **commercial strategy** led by Veolia
- Remaining hurdles:
 - **Technically:** long-term membrane endurance in complex matrices
 - **Operationally:** use of X-AI and virtual sensors
 - **Economically:** prove fast ROI to end-users

2026
Pilots assembly and operation

2027
Techno-economic validation + DPA full deployment

Post-project
Pilots upscaling from TRL 7 to TRL 9 + Commercial exploitation





Thank you!



ThreadingCO2

Captured carbon as an alternative feedstock for polyester: closing the carbon loop in the textile value chain



Bruno MARENGO

Fairbrics

The Innovation

Turning CO₂ waste streams into feedstock for polyester textiles.



CO₂-derived MEG is combined with PTA to make PET.



One European value chain linking conversion, catalysis, purification, polymerisation and spinning.



Scale-up ambition: pilot validation to TRL 7 demonstration, using renewable energy.



The Results and Impact

Technical progress is building the basis for industrial demonstration and textile qualification.



1

Conversion & catalysis

Catalysts prepared and assessed for carbonylation and hydrogenation.

2

Textile proof points

Pilot-scale yarns produced; CO₂-based PET evaluated by end-users.

3

Engineering progress

Process models, flow diagrams and reactor specifications developed.

-70%

Environmental ambition

GHG emissions vs conventional PET manufacturing (project target)

Industrial Relevance & Next Steps

Pilot validated, end-use qualification underway

Industrial fit

Designed for existing PET polymerisation and textile conversion value chains.



Project progress





Thank you!



P4Planet Projects Results

Workshop 4

Closing loops through
enabling technologies





17:40 – 18:00

Wrap up and closure
Join us in Room Albert Hall!



P4Planet Projects Results

Workshop 5

H4Cs: Shaping the
Circular Ecosystems of
Industrial-Urban
Symbiosis



REDOL

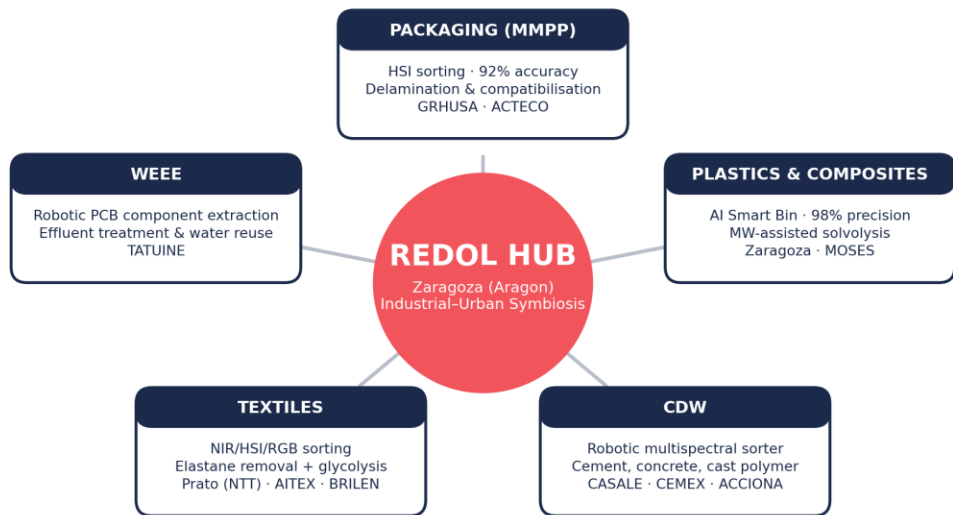
Aragón's **RE**gional Hub for circularity: **Demonstration Of**
Local industrial urban symbiosis initiatives



Andrés YÁÑEZ

CIRCE Research Centre

The Innovation



TRL: from TRL 5 (start) → target TRL 6-7 (demonstration in real environment)

Where demonstrated

Zaragoza, in Spain, as the center of the Aragon Hub. Replicators in Prato (Italy), Amsterdam (The Netherlands) and Bornholm (Denmark).

Challenge addressed

- Complex urban waste (multilayer packaging, composites, CDW, PET/elastane textiles, PCBs) still ends up in landfill or incineration.
- Mixed waste accounts for 68% of Zaragoza's total. Its recycling rate is 40%, compared with around 70% for separated waste.

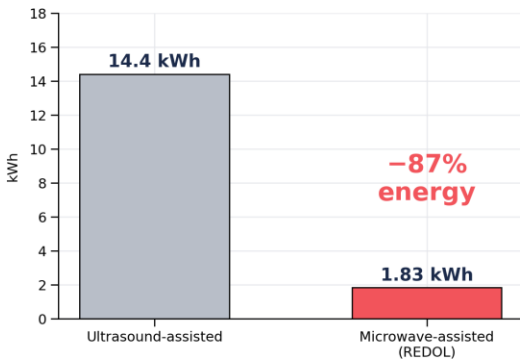
Technology / solution

- **Sorting**: AI smart bin, HSI for multilayer packaging, robotic sorter for CDW and paper, NIR/HSI/RGB textile sorter, robotic PCB component.
- **Recycling**: composites μwave-assisted solvolysis, delamination of multilayer packaging, CDW into cement and cast polymer, PET glycolysis
- **Circular products**: cement, cast polymers, concrete blocks, rigid plastics, automotive parts, reinforced table boards, recycled yarn, etc.

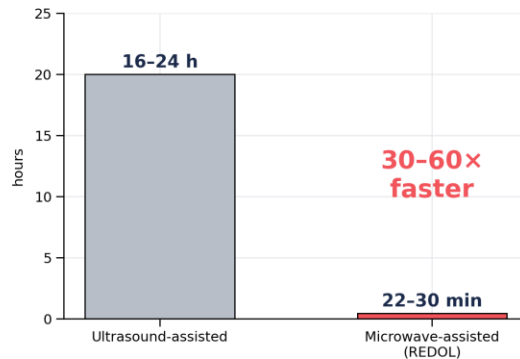
The Results and Impact

Composite recycling: green solvolysis comparison

Energy consumption per batch



Reaction time



1

AI smart bin: ~98% classification precision and ~96% end-to-end sorting success.

2

Composite recycling: microwave solvolysis takes 22–30 min vs 16–24 h with ultrasound. It uses ~1.83 kWh vs ~14.4 kWh (about 87% less energy) and recovers more than 90% of the fibre.

3

Textile to textile: 450 kg of chemically recycled PET from BHET with >99% purity. BRILEN produced 180 kg of high-tenacity yarn (75.5 cN/tex), comparable to conventional polyester.

4

CDW: 500 kg of cement produced with 10–15% substitution of natural raw materials.

5

Aragon Circular Economy Cluster: participation in the foundation

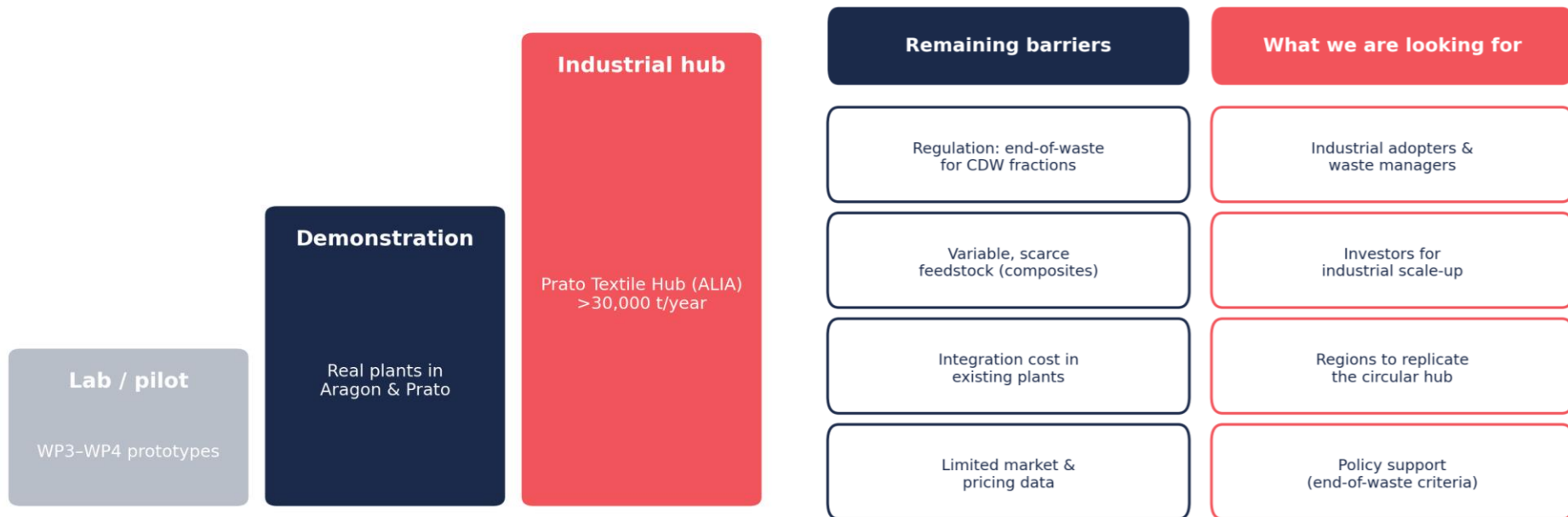


Virgin-equivalent recycled polyester → high-tenacity yarn for geotextiles

Industrial Relevance & Next Steps

From pilot to industrial hub

Replication: D7.1 Circular Hub Guidelines · D7.3 Roadmap





Thank you!



tExtended

Developing the Framework for Extended Textile Circulation



Claudia ESPOSITO

Carr Communications



The Innovation

- Systemic approach to reduction of textile waste
- Practical solution on how to build the system
- A series of items for the digitalization of the system

The Results and Impact

tExtended results have been obtained through a high level of collaboration between the partners, which have used only their already existing factories and structures to realize the project work



1

Theoretical basis of circularity of textiles

2

Real scale demonstrators

3

Social innovation spin-off

Industrial Relevance & Next Steps

What is next?

- Many of the results obtained are already in use by tExtended industrial partners
- Many Key Exploitable Results set at the start of the project have been obtained or are close to be realized
- Plans for future exploitation use





Thank you!



THESEUS

From Data to Decisions: Modelling and Policy
Support for Circular Industrial Transition in THESEUS



Dr. Charalampos MANOUSIADIS

ICCS, I-SENSE Research Group

The Innovation

A regional Hub for Circularity

Materials

Sorting & recycling

Water

Reuse & recovery

Energy

Solar & hydrogen

**Attica H4C
and connected regions**

Digitalisation and robotics
Collaboration and governance

Fragmented resources, connected solutions

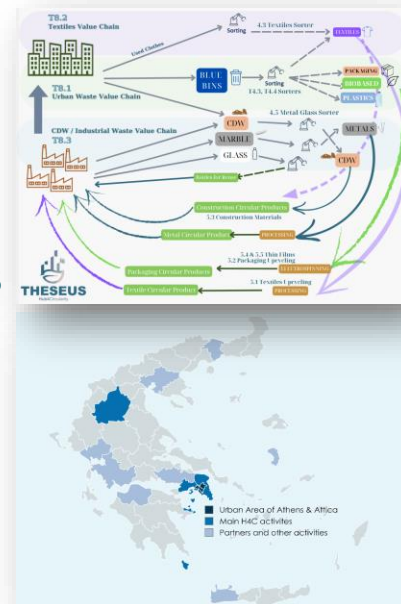
One hub links technologies, industrial partners and regional governance

Demonstration locations

Attica and connected Greek regions
Energy pilot in Ptolemaida

Planned maturity pathway

Most technologies: TRL 5 to 7



From Data to Decision Evidence



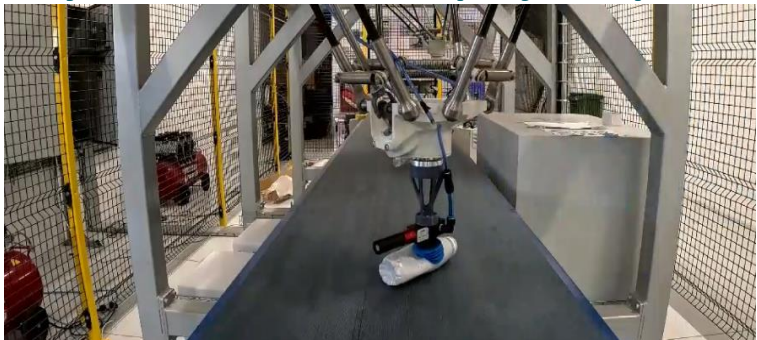
Implementation and monitoring update the evidence

Policy · Market · Community

Regional roadmap

The Results and Impact

Early results from 2026 project updates



Robotic sorter in laboratory testing

Can the exchange work?

Which opportunities matter most here?

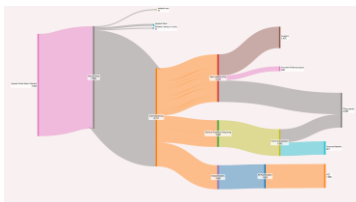
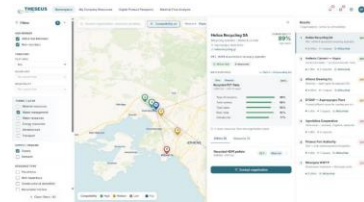
Technical feasibility



Regional prioritisation

Quality and quantity
Distance and capacity

Resource pressures and infrastructure
Environmental, social and economic value



1

≈90% sorting success

Laboratory tests on plastics ≈0.9 s per test cycle

2

Circular material trials

Recycled plastics incorporated into new formulations

3

4.5 m³ rainwater storage

Three 1.5 m³ tanks installed at an Athens school

4

Marketplace mockup

Integration framework for shared digital functions

+30%

More recovered resources
used in value chains

50%

Less freshwater consumption
for urban green irrigation

26,852

t CO₂e/year less GHG emissions
Long-term Attica projection

≥15%

Lower transportation costs

Industrial Relevance & Next Steps

Consortium industries

Textiles

COMO

Packaging and films

TSIMIS, ThracePoly, Panchart

Construction and minerals

KEBE, FIBRAN, ThraceMarble

Metals and glass reuse

HALCOR, AB

Resource and utility operators

WATT, RECYCOM, EYDAP, DHCP

Next: validate performance, business cases and local fit for scale-up

Replication and scale-up

Malmö and Mo i Rana

Adapted models, Marketplace and local business cases

Further European hubs

Replication tool and H4C guidelines through A.SPIRE's networks



Thank you!

Shared evidence for regional decisions

c.manousiadis@iccs.gr · theseus-h4c.eu

UNITED CIRCLES

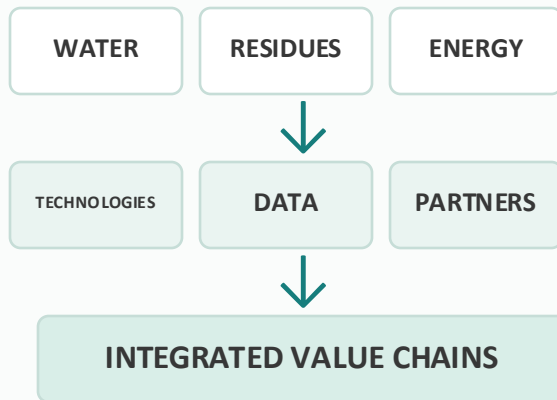
Networked industrial-urban symbiosis value chain demonstrators for biomaterials, C&DW, circular water loops & WWTPs, driven by Hubs 4 Circularity



Francisco CORONA

Fundación Cartif

H4C INTEGRATION MODEL



The Innovation

WHAT HAVE YOU DEVELOPED?

CHALLENGE

Industrial and urban resource flows are often managed separately, limiting cross-sector synergies and circular value chains.

SOLUTION

An integrated H4C approach linking recovery technologies, resource-flow mapping, stakeholders and governance.

DEMONSTRATION

Three demonstration hubs: Ankara, Veneto and Salamanca; complemented by four replication hubs.

MATURITY

Hub baselines and integration planning established. Technologies have different TRLs; integrated demonstration and validation are the next steps.

The Results and Impact

WHAT HAVE YOU ACHIEVED? | PROGRESS TO M24

1

3 H4C baselines and resource mapping

Characterisation of industrial and urban resource streams, infrastructure and symbiosis opportunities across the demonstration hubs.

2

Technology integration and demonstration readiness

Definition of technology roadmaps, integration requirements, monitoring parameters and technological gaps.

3

H4C cooperation and governance

Development of cooperation frameworks to support stakeholder engagement, resource exchanges and long-term hub operation. Social Impact Assessment framework and GRETA sustainability assessment.

4

4 replication hubs in the project

Extension of the H4C approach to four replication hubs, supported by common methodologies for assessing circularity and industrial applicability.

LESSON: Successful industrial symbiosis requires coordinated technology integration, reliable resource data and committed industrial stakeholders.

VERIFIABLE SCALE

3

demonstration
hubs

4

replication
hubs

**7 interconnected H4C
contexts (circular
ecosystems)**

CO₂, energy and resource savings: to be quantified from demonstration data.

Industrial Relevance & Next Steps

WHAT DOES THIS MEAN FOR INDUSTRY?

INDUSTRIAL APPLICABILITY

Water reuse, recovery of materials and nutrients, and valorisation of side streams through cross-sector partnerships.

REPLICATION AND SCALE-UP

Transfer the H4C methodology from Ankara, Veneto and Salamanca to four additional contexts, adapting it to local flows and demand.

BARRIERS AND NEEDS

Reliable stream-quality data, technical interfaces, bankable business cases, regulatory compliance and stable off-take agreements.

NEXT STEPS / PARTNERS

Complete integration and demonstration; monitor performance and impacts; engage industrial users, technology providers and potential replicators.

From
demonstration

Validated circular
value chains

Replication and
industrial uptake

P4Planet Projects Results

Workshop 5

H4Cs: Shaping the
Circular Ecosystems of
Industrial-Urban
Symbiosis





15:40 – 16:10

**Networking coffee
Project posters session**



2DPLOY

2DPLOY Final Event 22 October 2026



Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.



Picture: Evonik
Industries AG

AGENDA

> WELCOME & INTRODUCTION

16:10 – 16:15

Edoardo Pagnelli, ASPIRE (2DPLOY Consortium Partner)

> THE 2DPLOY PROJECT: FROM R&I RESULTS TO INNOVATION FUND DEPLOYMENT

16:15 – 16:30

Kristian Aas, SINTER – 2DPLOY Coordinator

- Overview of the 2DPLOY project and its objectives
- The 2DPLOY innovation pipeline and methodology
- From project screening and qualification to Innovation Fund proposal preparation
- Key achievements and results of the project
- Outlook: how the 2DPLOY approach can support future deployment projects

> FROM CAPACITY BUILDING TO PROPOSAL READINESS: LESSONS FROM THE 2DPLOY ADVANCED MASTERCLASSES

16:30 – 16:45

Miet Van Dael, VITO (2DPLOY Consortium Partner)

- The role of the Advanced Masterclasses within the 2DPLOY innovation pipeline
- Key topics and Innovation Fund requirements addressed
- Experience from working with the pilot projects
- Key lessons for innovation owners preparing Innovation Fund proposals

> FROM QUALIFICATION TO DEPLOYMENT: LESSONS LEARNED FROM THE 2DPLOY METHODOLOGY

16:45 – 17:00

Simona Pace, RINA-CSM (2DPLOY Consortium Partner)

- Lessons learned from applying the 2DPLOY methodology
- Experience from project qualification and validation
- Key gaps and challenges identified through the process
- How lessons learned have contributed to refining the methodology for future projects

> FROM R&I TO INDUSTRIAL DEPLOYMENT: THE CEMENT INDUSTRY PERSPECTIVE

17:00 – 17:15

Nikos Nikolakakos, CEMENT EUROPE

- Challenges in moving decarbonisation technologies from R&I to industrial-scale deployment
- Technical and investment readiness, scalability and business case
- Infrastructure and the role of funding instruments such as the Innovation Fund

> Q&A DISCUSSION : WHAT CAN WE LEARN FROM 2DPLOY FOR FUTURE INDUSTRIAL DEPLOYMENT?

17:15 – 17:30

Edoardo Pagnelli, ASPIRE (2DPLOY Consortium Partner)

2DPLOY

LOGO

WELCOME & INTRODUCTION

Welcome to the 2DPLOY Final Event within A.SPIRE Industrial Innovation Days 2026

Our mission: Bridging the gap between industrial R&I results and deployment

The 2DPLOY journey: From project qualification to investment and proposal readiness

Today's focus: Key results, lessons learned and the industrial perspective

Looking ahead: How can we accelerate the deployment of industrial innovation?



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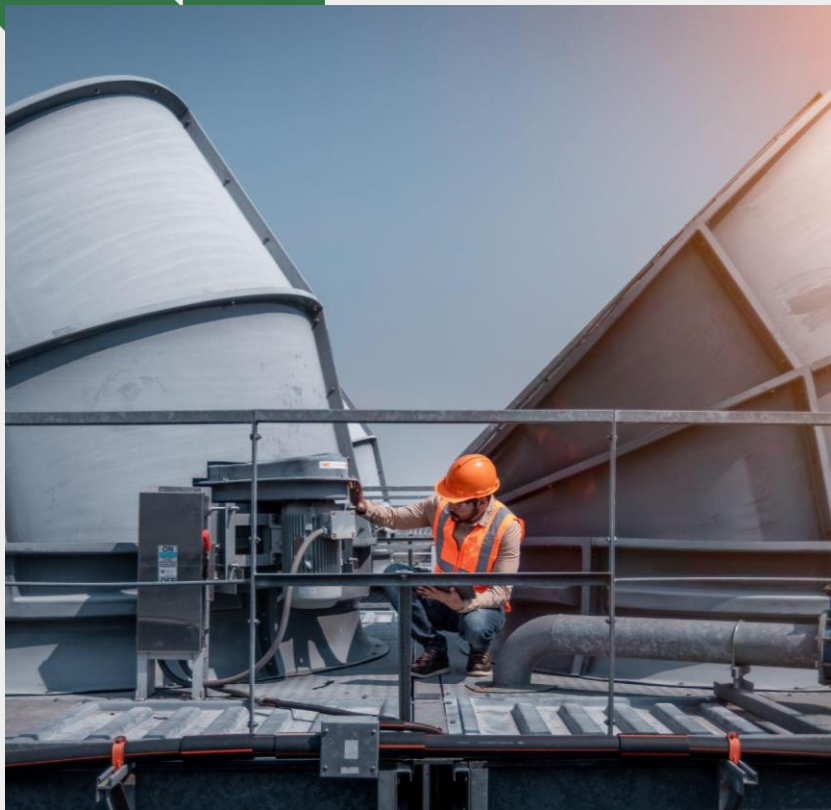
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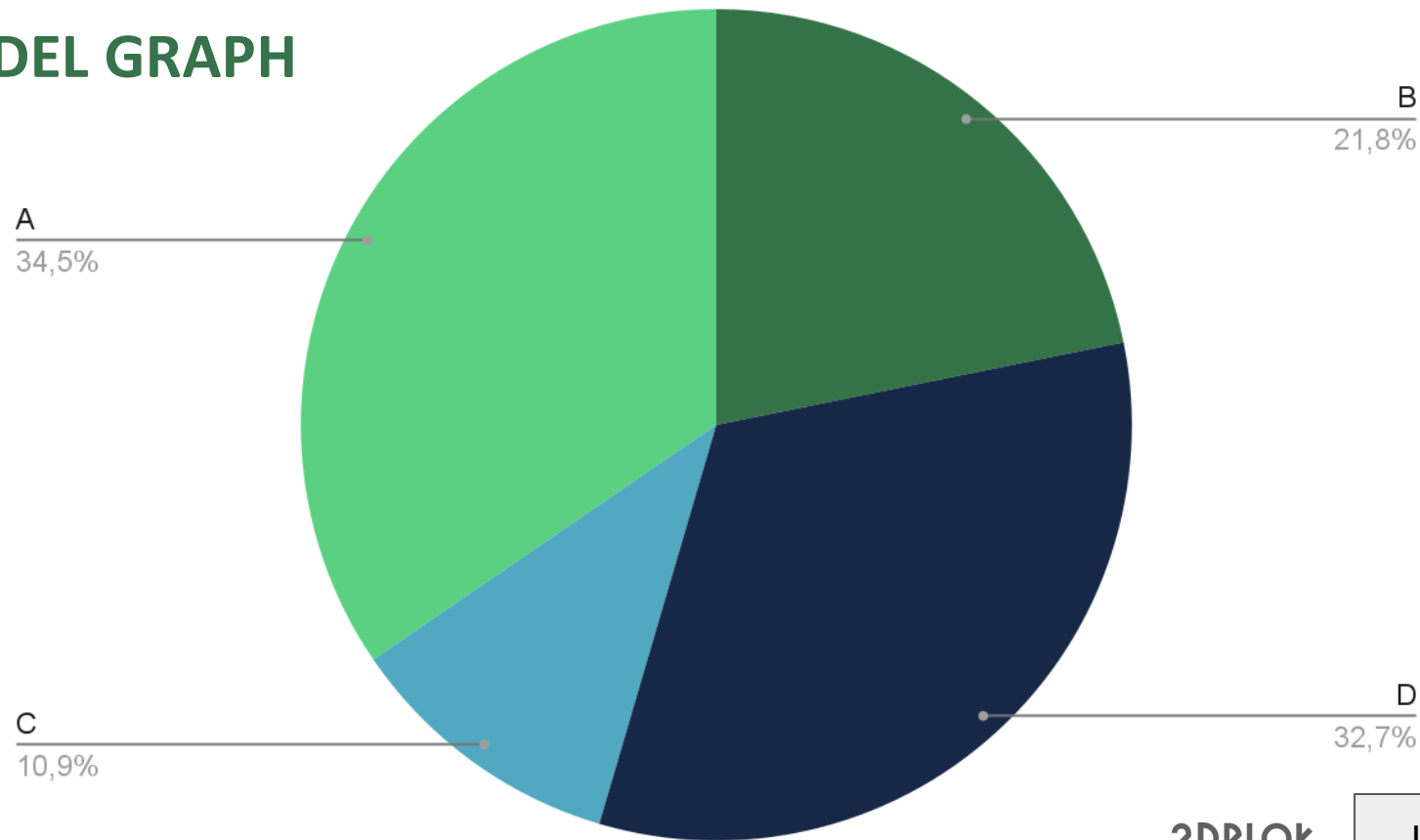
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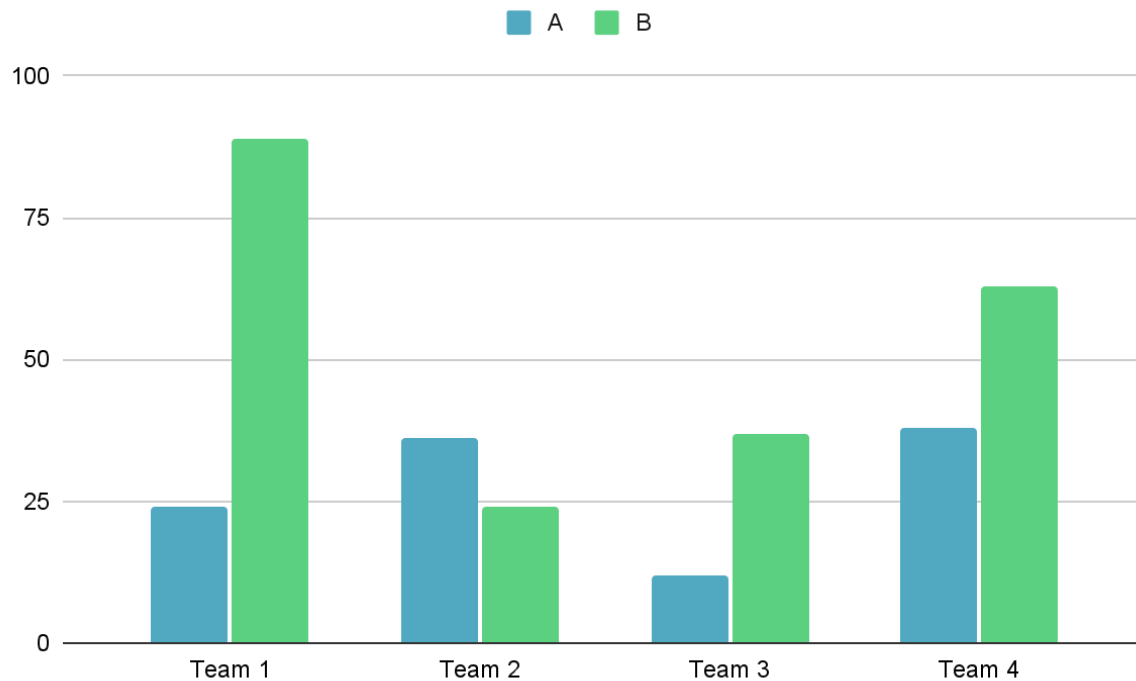
CIRCULAR MODEL GRAPH



2DPLOT

LOGO

MODEL GRAPH



BOARDS

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TIMELINE



20XX

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Next steps



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magna aliqua.



Q&A DISCUSSION

**How can 2DPLOY's
lessons help accelerate
industrial deployment?**





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