



HYIELD: Building Europe's first world-scale biogenic waste to H₂ plant



POWERED BY THE **MOST ADVANCED**
PALADIUM MEMBRANE TECHNOLOGY

» The Waste Challenge

**Landfill restrictions tightening
(EU 2030–2035)**

**<10% municipal waste to landfill
by 2035**

**Economic pressure on disposal
(e.g. Spain Law 7/2022)**



**Multiple waste
valorization technologies
already exist**

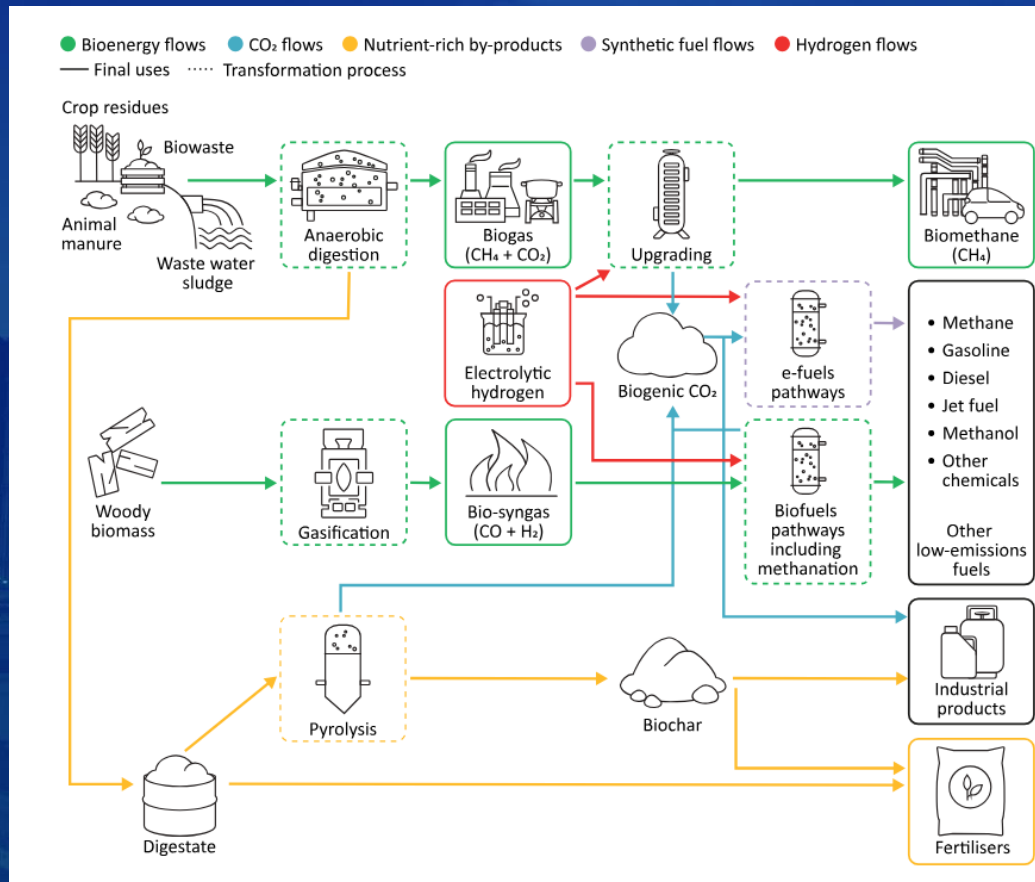
**Many are proven and
industrially deployed**

**Technology must match
the waste stream**

Start from the waste — not from the technology

Technology Choice Depends on Policy, Feedstock, and Project Ecosystem

Multiple conversion pathways

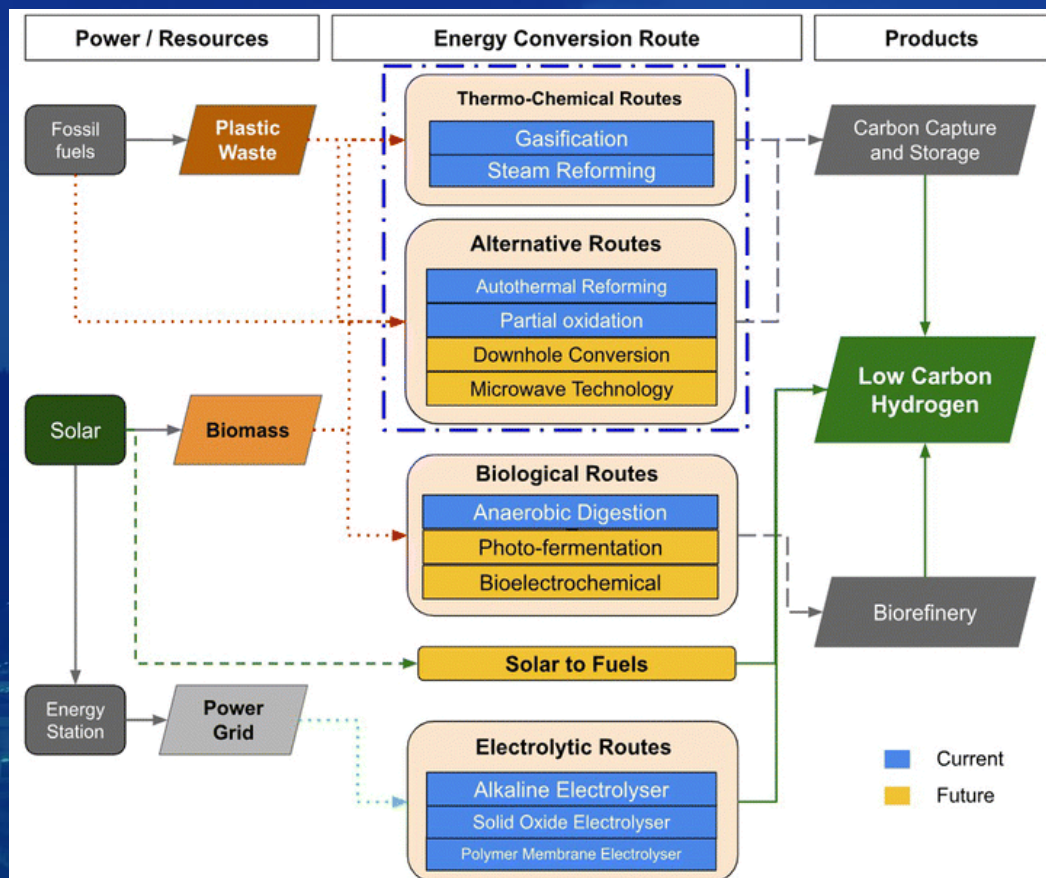


Multiple pathways from waste to molecules

Technology selection is context-driven

» From Waste to Hydrogen

Low carbon hydrogen routes



Multiple pathways to hydrogen

The best option depends on:

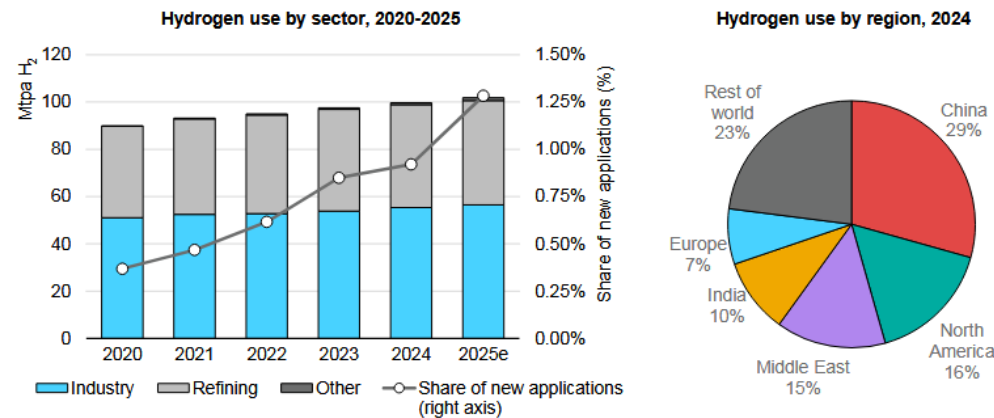
- ❖ Legislation
- ❖ Feedstock availability
- ❖ Local demand/offtake

No single route dominates

Fig. 2 Potential routes of the low-carbon hydrogen production (adapted from ref. 25 Reprinted with permission from the royal society (CC-BY 4)).

Hydrogen Demand Is Growing

Figure 2.1 Hydrogen demand by sector and by region, 2020-2025



Cost remains the main barrier for adoption of low-emissions hydrogen

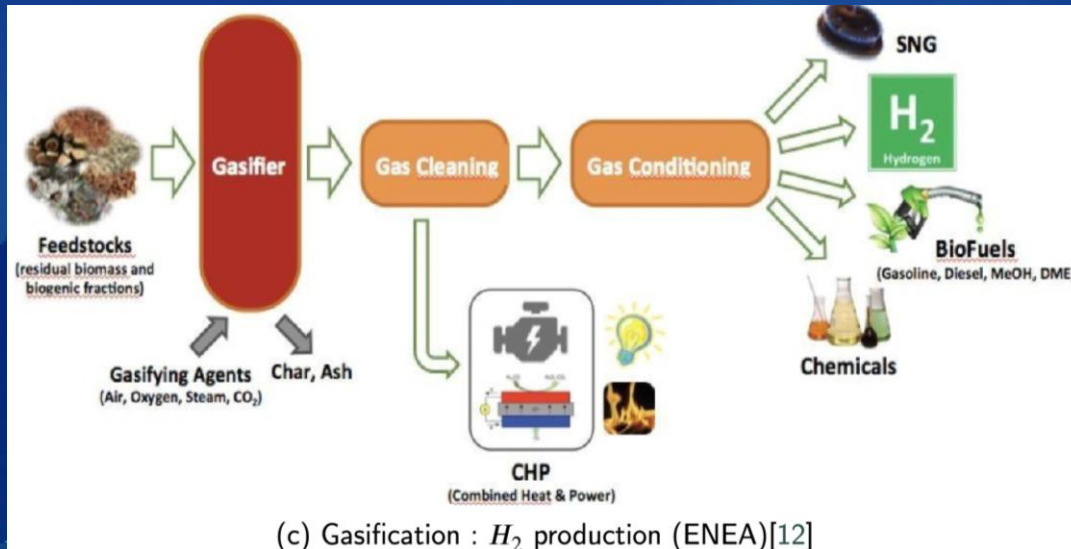
Waste-to-hydrogen pathways embed the cost of waste management

Waste-Based Pathways Have a Structural Advantage:

- ❖ Waste must be managed anyway
- ❖ Disposal cost is unavoidable
- ❖ Conversion → value creation instead of cost

» Enhancing the Economics of Waste-to-Hydrogen

Further Improvements Across the Value Chain



A review on machine learning applications in hydrogen energy systems

Zaid Allal ^a, Hassan N. Noura ^b, Ola Salman ^c, Flavien Vernier ^a, Khaled Chahine ^d  

Performance depends on the integration of these steps

Significant performance gains can be achieved through process intensification

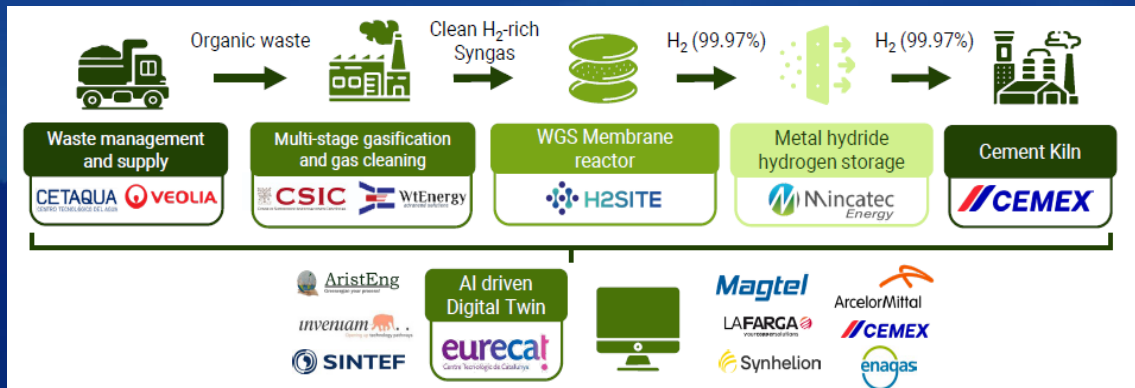
- ❖ Reaction + separation integration
- ❖ Higher conversion per stage
- ❖ Reduced number of unit operations
- ❖ Improved energy efficiency

Integration & intensification can significantly improve overall performance

» HYIELD Project Overview



Industrial Demonstration of Waste-to-Hydrogen

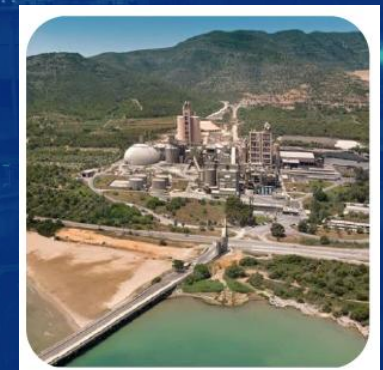


- ❖ Commissioning in 2027
- ❖ Location: Cataluña (Spain)



Demonstrating process intensification in waste-to-hydrogen

- ❖ Industrial-scale demonstration project: **2,2 t/ day H₂ production**
- ❖ Integrated gasification and membrane reactor system
- ❖ **High-purity hydrogen production (99.97%)**
- ❖ Deployment in a real industrial site (CEMEX)



» HYIELD Project objectives



FLEXIBILITY & SCALABILITY

- ❖ Wide feedstock flexibility (waste, biomass)
- ❖ Scalable, industrial design

PERFORMANCE & EFFICIENCY

- ❖ High H₂ yield (>0.16 kg/kg biomass)
- ❖ Heat integration & energy recovery
- ❖ Optimized H₂/C conversion

COST & COMPETITIVENESS

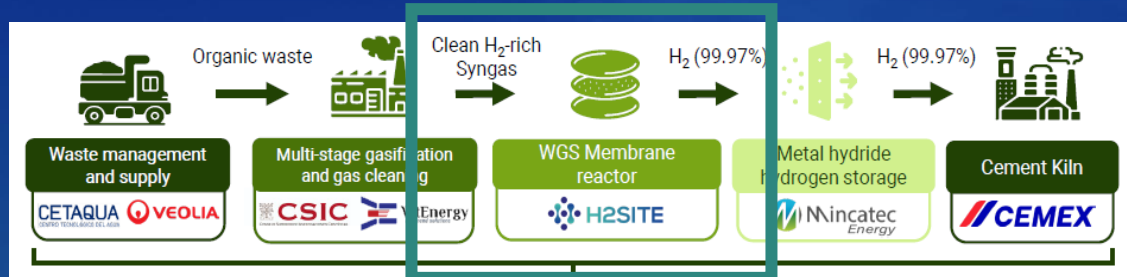
- ❖ LCOH < 3 €/kg
- ❖ Competitive vs alternative

PRODUCT QUALITY

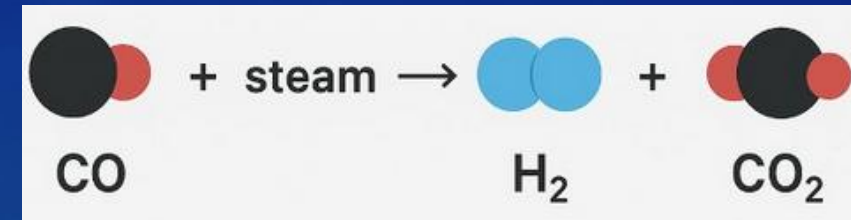
- ❖ >99.97% H₂ purity
- ❖ Industrial-grade hydrogen

Combining flexibility, efficiency and cost competitiveness in waste-to-hydrogen

» H2SITE: Enabling Efficient Syngas Conversion

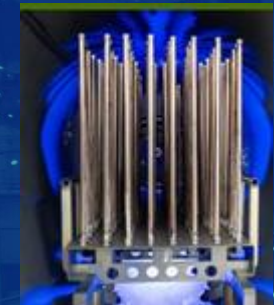


WGS converts CO into hydrogen



Integrated WGS reaction and hydrogen separation in a single unit

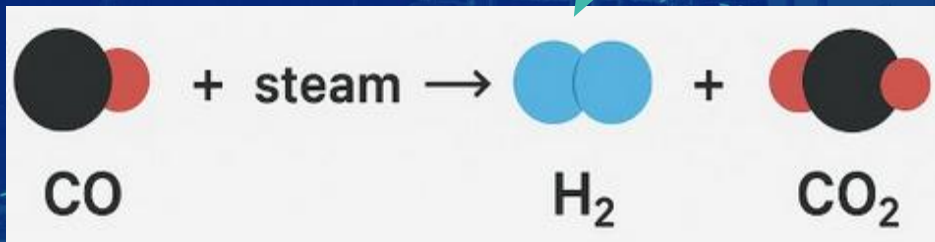
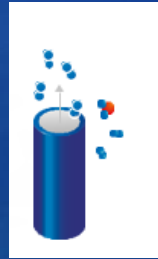
» **Pd membranes selectively separate hydrogen**



Innovation via Reaction and separation combined in a single step

» Breaking Equilibrium to Increase Hydrogen Yield

WGS reaction: Equilibrium-limited



Breaking reaction equilibrium:

Enhanced conversion

Removing hydrogen reduces its partial pressure → increases the reaction driving force

Equilibrium shift

The reaction shifts towards hydrogen production (Le Chatelier principle)

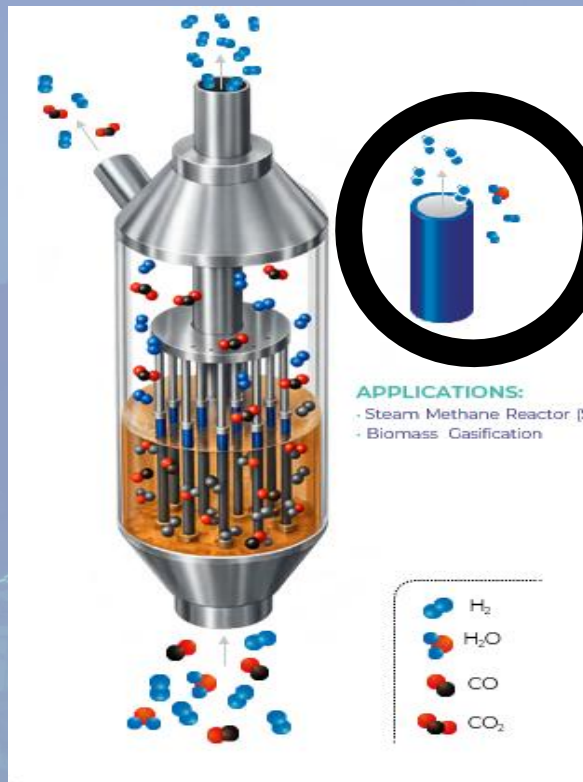
Higher yields & purity

Higher CO conversion → direct high-purity H₂

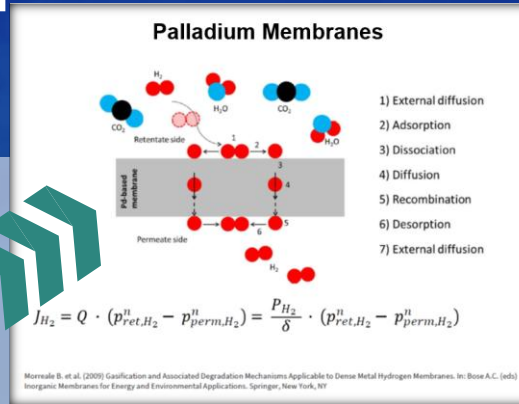
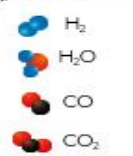
Hydrogen extraction drives higher conversion and yield

» How it works?

Pd Membrane integrated reactor



APPLICATIONS:
- Steam Methane Reactor (SMR)
- Biomass Gasification



Breaking equilibrium limitations

Selective hydrogen transport

Only hydrogen permeates through the Pd membrane

Driven by partial pressure

Flux driven by partial pressure difference

Continuous extraction

Continuous hydrogen removal during reaction

Continuous hydrogen permeation increases conversion and yield

» Key Performance Benefits



>90% CO conversion



+98% recovery



Higher hydrogen yield (+12% vs conventional technologies)



High-purity hydrogen (>99.9%)
Stable across operating conditions



Integration in high-temperature and high-pressure processes



Low maintenance (no moving parts, no regeneration)

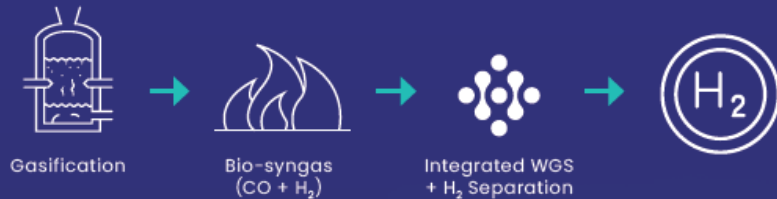
» **Higher conversion → higher yield → lower hydrogen cost**



» Additional Applications

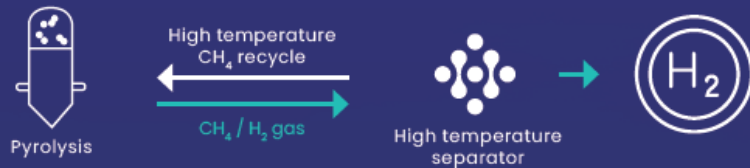
Turning Process Streams into high purity Hydrogen

WASTE TO H₂ GASIFICATION



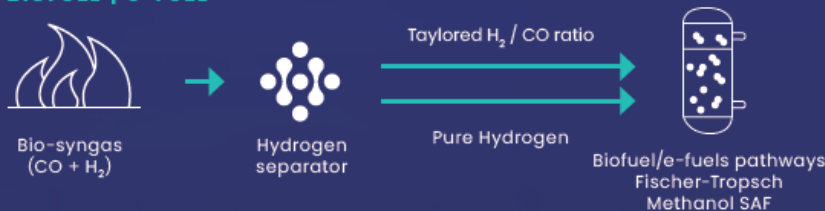
- ❖ Biomass and waste gasification →
Maximizing hydrogen recovery

METHANE GASIFICATION



- ❖ H₂/CH₄ separation and recirculation →
Maintaining process temperature

BIOFUEL | e-FUEL



- ❖ CO/H₂ ratio adjustment →
Downstream processes (methanol, fuels)

Applicable across multiple hydrogen production pathways

»» What Comes Next for Waste-to-Hydrogen

Waste-to-hydrogen will not scale without process intensification

Integration across process steps is key to improving economics

Achieving double-digit performance gains requires new process technologies



Process intensification will define the next generation of hydrogen production

» Industrial-Scale Palladium Membrane Manufacturing



Full supply chain control and lifecycle management



Proprietary membrane manufacturing



Module design & system engineering



Installation, commissioning & start-up



Monitoring, service & bundle replacement



End-of-life palladium recovery



Full value-chain control

Ensuring performance stability, supply security and long-term operability.

Thank You!



Jorge Roman
Product Manager
+34 604 203 815

jorge.roman@h2site.com