Ammonia cracking in H2SITE membrane reactors:

Producing fuel cell-purity hydrogen in Birmingham, UK

WEBINAR

Jon Meléndez Rey
Technical Director,
Membrane Engineering
H2SITE

Jose Antonio Medrano Jimenez
Technical Director,
Process Engineering
H2SITE

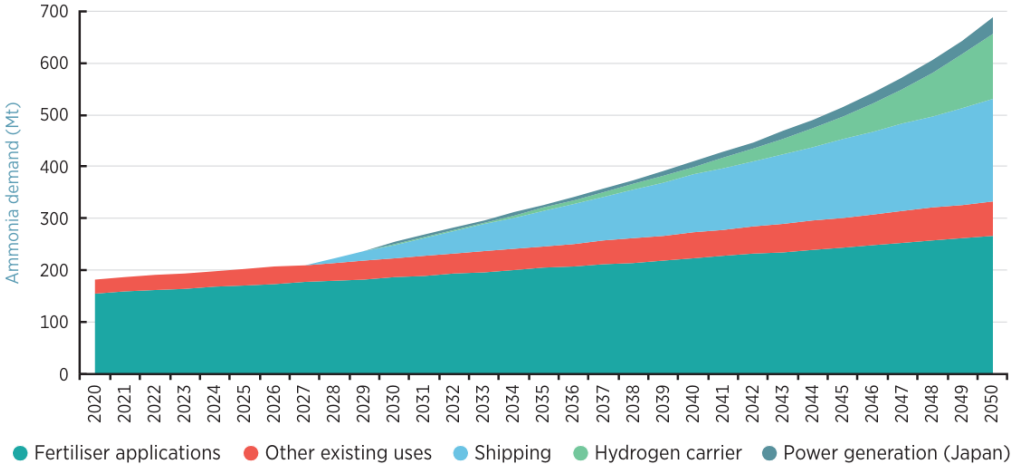
Join in the conversation with AEA Technology Manager Kevin Rouwenhorst.
Register now, and submit your questions in advance.

AMMONIA ENERGY ASSOCIATION

Thursday, May 23, 2024
3PM CET (9AM ET)

Ammonia as hydrogen carrier

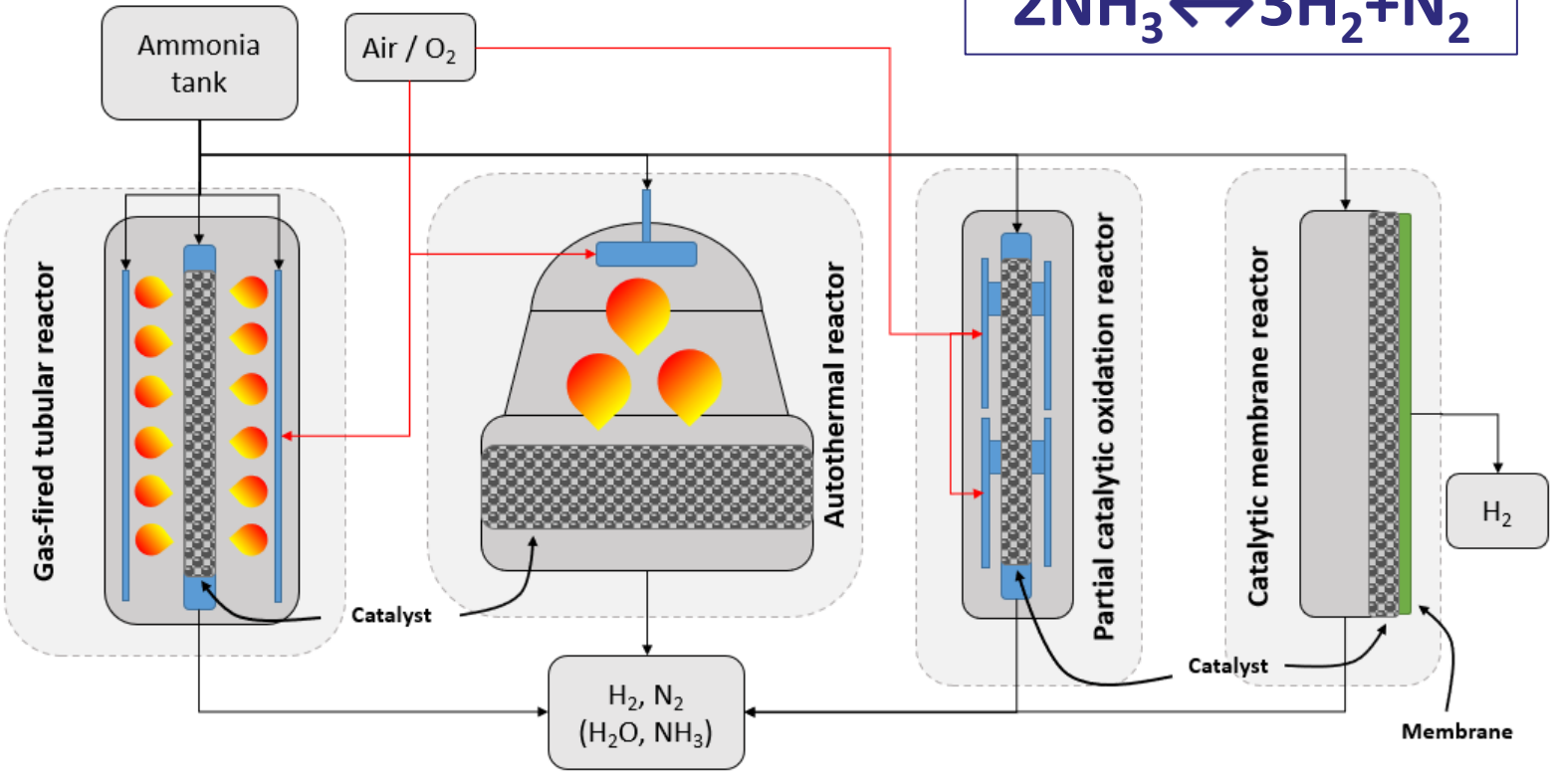
- Ammonia (NH_3) is currently used for its Nitrogen content, e.g. for fertilizer applications
- Ammonia is also a zero-carbon fuel and Hydrogen carrier



Link: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/May/IRENA_Innovation_Outlook_Ammonia_2022.pdf

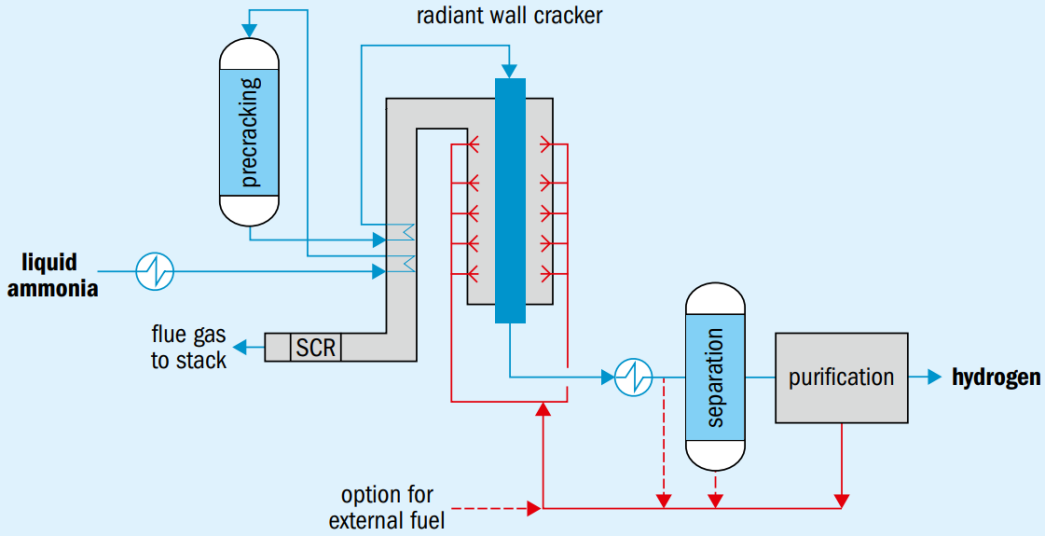
Ammonia cracking

$$2NH_3 \leftrightarrow 3H_2 + N_2$$



Technology Spotlight: Ammonia cracking. Ammonia Energy Association. (Forthcoming)

Large-scale ammonia cracking



2400 TPD-NH_3 ammonia cracker for heavy water production (Topsoe)

"Efficient and proven ammonia cracking at scale". Topsoe. Nitrogen+Syngas 385 (September-October 2023).

Membrane reactor demonstration

The ammonia-to-hydrogen demonstration, Brisbane, Australia, August 8, 2018. Photograph courtesy of CSIRO.

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H2SITE

Ammonia Cracking in membrane reactors for high purity hydrogen production

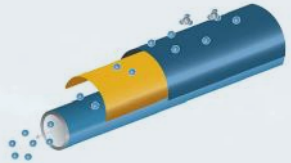
Low carbon hydrogen production areas and points of use are often disconnected

Lack of efficient long distance hydrogen transportation solutions

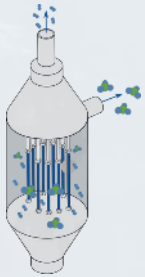
When available, transportation solutions add 80 to 300% to hydrogen generation cost

THE TECHNOLOGY
KEY COLLABORATION

tecnalia TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY



Integrated membrane reactors



DEVELOPMENT AND SCALING UP

RE4CELL · Fluid CELL · DEMCAMER Catalytic Membrane Reactors · FERRET · BIONICO · HyGrid

- Fluidized/Packbed configuration
- Scaling up of reactor capacity
- Different feedstocks
- Boost Pd membrane properties
- Authothermal reforming
- Separation from the grid
- …

H2SITE IS BORN
FOUNDERS AND INVESTORS

2019

Seed round

ENGIE New Ventures

Round A (2022)

Breakthrough Energy

equinor

Bizkaia seed capital

CURRENT PROJECTS AND FUTURE CHALLANGES

MACBETH · yield · INNOMEM

H2OCEAN · areNH3a · ammogen ammonia to hydrogen conversion project · APOLO

H2sarea

GREENH2PIPES

H2SITE's founding team

Deep-tech passionate, highly committed, focused on industrialization

Andrés Galnares

CEO

General management, strategy and business development

Startup founder and board member

Extensive corporate experience in the energy segment

+10y in distributed renewables and Renewable gases project development

Gorka Hermoso, MBA

CFO

Responsible for finance and internal structuring

Extensive startup experience both as board member and CFO

8y in global strategic consulting (BCG) on industrial goods and energy industry

Jon Meléndez, PhD

Technical Director Membrane development

Industrialization and membrane R&D

PhD Cum Laude on Pd-based supported membranes as a H2 separation technology

Built +1000 of Pd membranes during the last 12 years

He has led the design of the industrial production process

José A. Medrano, PhD

Technical Director Reactor Engineering

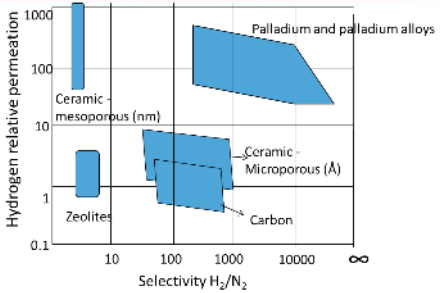
Design, construction, commissioning and monitoring.

Leads engineering and operations teams,

PhD Cum Laude on development of membrane reactors for H2 generation

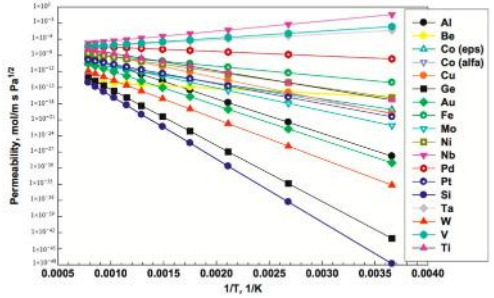
+15y experience on integrated membrane reactors (ammonia, methanol, syngas...) and separators

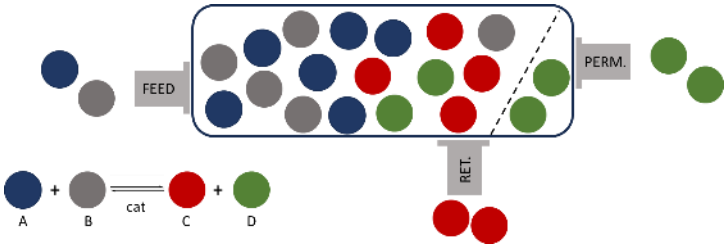
Our dream is to create a unique Deep-tech European Industry, that contributes strongly to the Energy Transition and enables the hydrogen value chain.



- Dense selective layer
- Solution-diffusion model
- Best balance between hydrogen permeation and selectivity compared with other type of membranes (organic, ceramic…)

- Palladium's permeability on top 4 among metals and it avoids surface resistance compared with G.V metals (V, Ta, Nb)
- Metal alloys (Ag, Au, Cu) enhance permeation properites or contaminants resistance





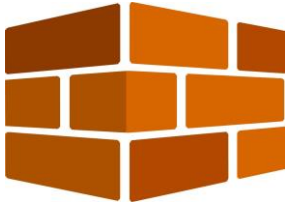
- Pd-membranes integrated in Hydrogen generation processes (working at > 300°C) lead to:
  - Higher conversion
  - Lower working temperatures
  - More compact units

Palladium – Silver alloy

Higher H2 permeability
Protection against embrittlement

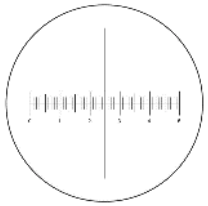
Patented double-skin layer

Protection against catalyst
Level of defects decreases



Supported membranes

High pressure gauge resistance (100 bar)
Ammonia on-board cracking proved (H2OCEAN video)



Thin selective layer

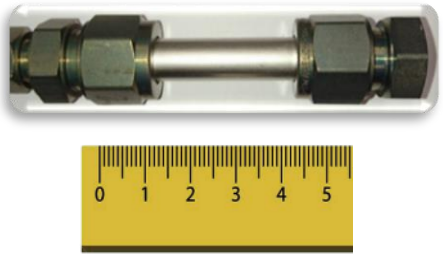
Higher %H2 recovery
Cost reduction

Palladium recycling

Patented technology on
100 % palladium recovery

Leak tigth configuration

Higher H2 purities



2009 - 2016

From first supported membranes to lab scale production optimization

Development and validation

2017-2020

Scaling up and first pilot integrated membrane reactor testing

Scaling up

2022

First palladium membrane Manufacturing line Officially launched

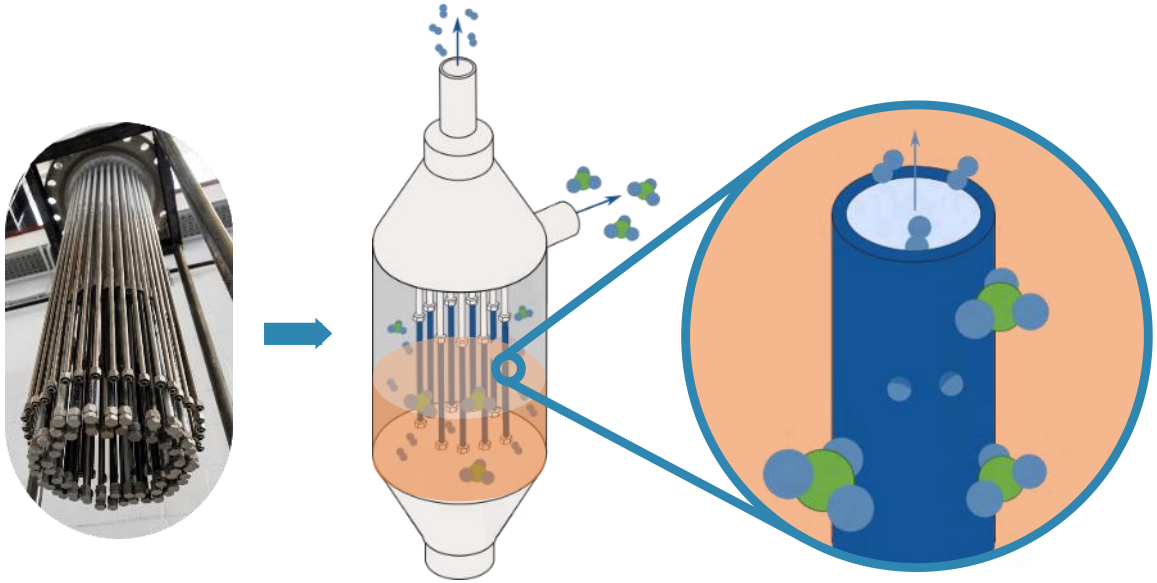
Industrialization

2022 - …

Quality and reproducible process. Thousands of membranes since

Reproducible process

We enable two solutions to transport hydrogen:
H2-infrastructure management solutions
H2-carriers with well-known supply chains



We separate pure hydrogen from gas blends:

- Gas network management (Salt caverns, aquifers, deblending)
- Natural hydrogen

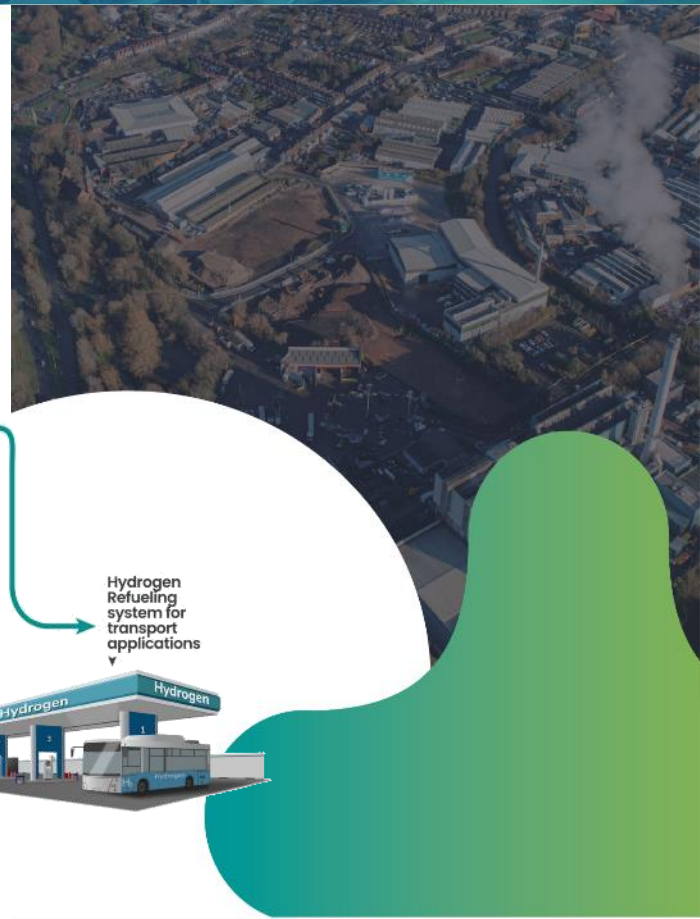
We transform carriers into pure hydrogen

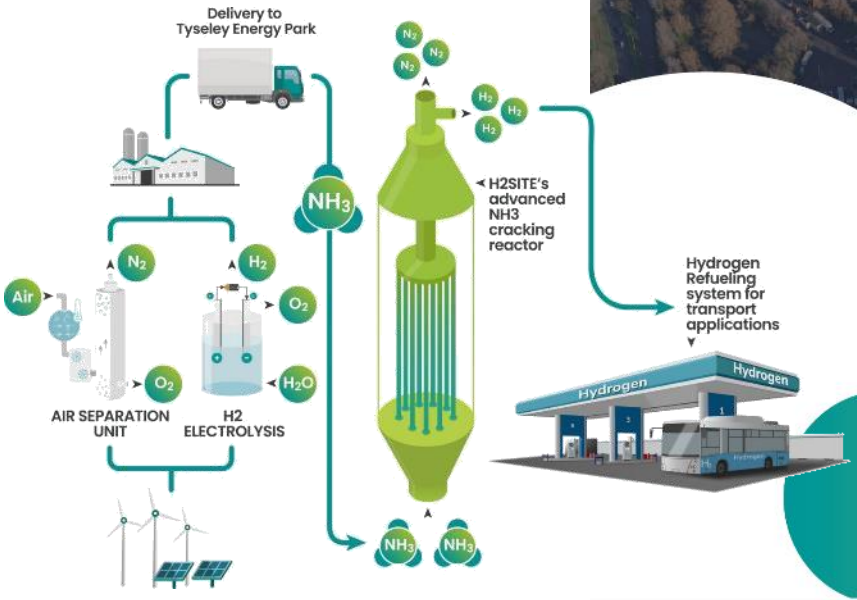
- Ammonia cracking
- Methanol reforming
- Waste to hydrogen

Department for Energy Security & Net Zero

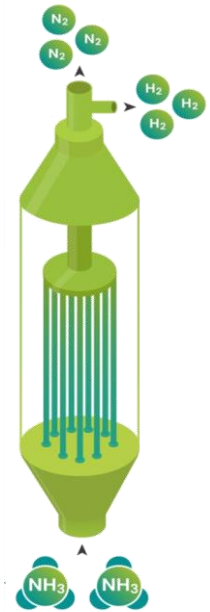
Project objectives:

- 200 kg/d Hydrogen
- Fuel cell purity grade





H2SITE´s core is in the membranes and how they are integrated in reactors & separators

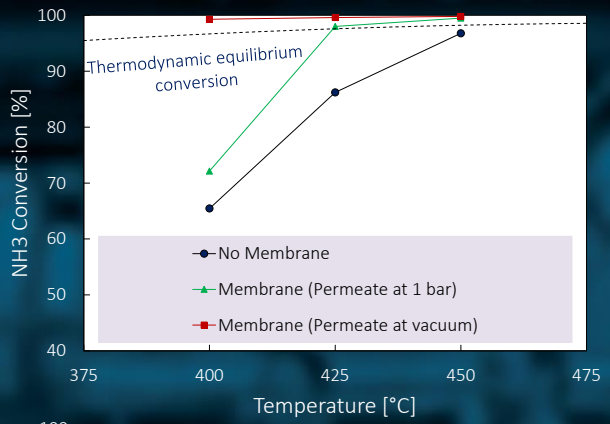


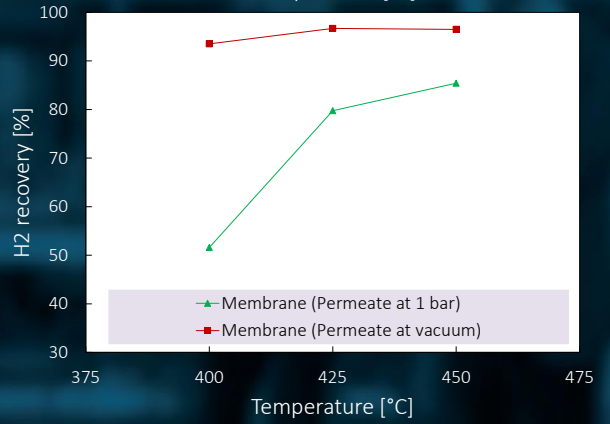
Why a membrane reactor?

Processes with thermodynamic restrictions get favored when chemical equilibrium is disturbed

$$2NH_3 \rightleftharpoons N_2 + 3H_2$$

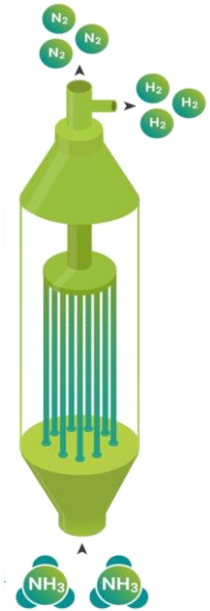
- Virtual full conversion achieved
- No H_2 downstream separation required
- Lower footprint
- Reduced OPEX
- Pure H_2 to the Fuel Cell





H_2 production via ammonia decomposition in a catalytic membrane reactor, Fuel Process Technology, 2021

H2SITE´s core is in the membranes and how they are integrated in reactors & separators



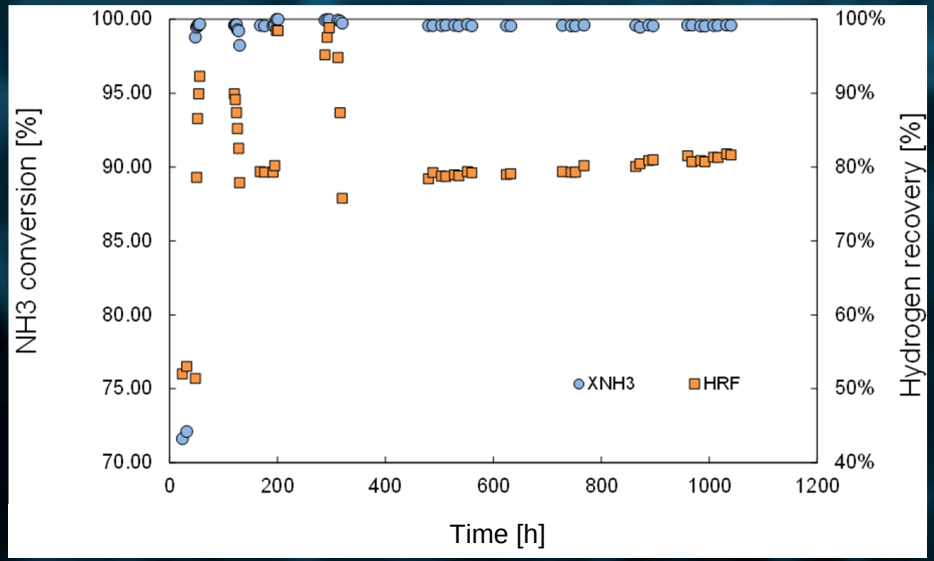
Cracking unit running in continuous operation

T: 425-450 ºC

Feed pressure: 4 – 14 bar(g)

H_2 output pressure: Vacuum – 4 bar(g)

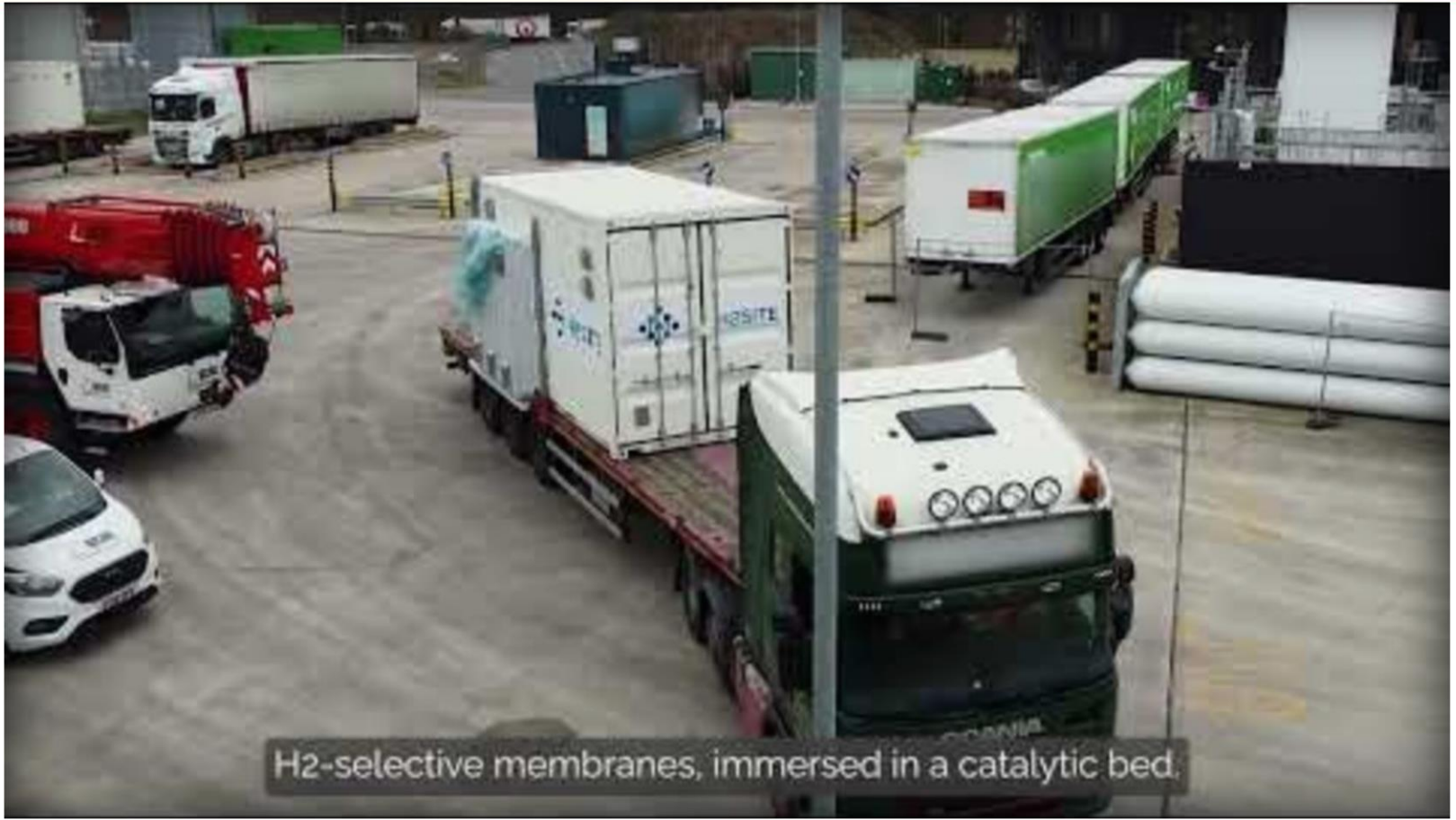
Proven quality > 99.98%



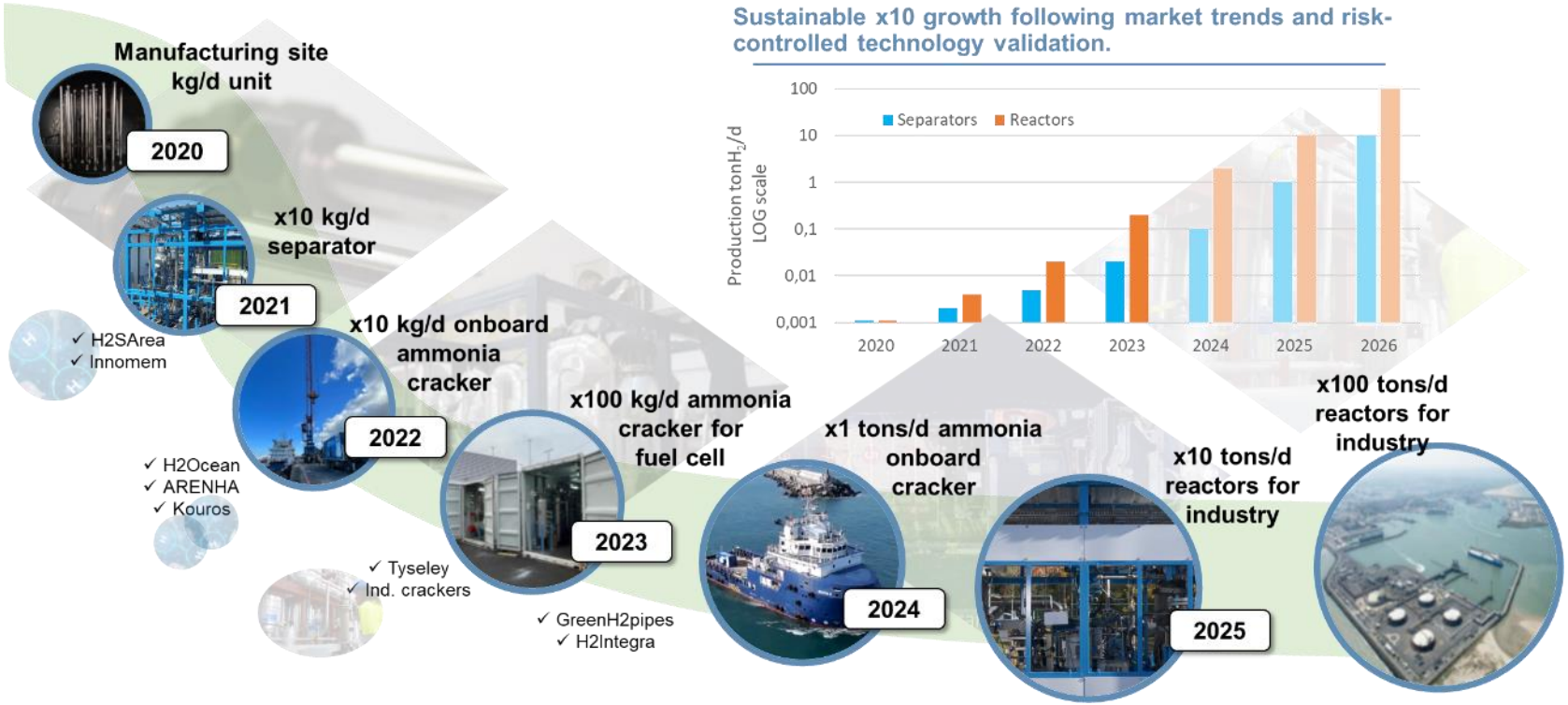
Ammogen project – Construction phase

Ammogen Project gathered at Tyseley Energy Park

Already available in Youtube

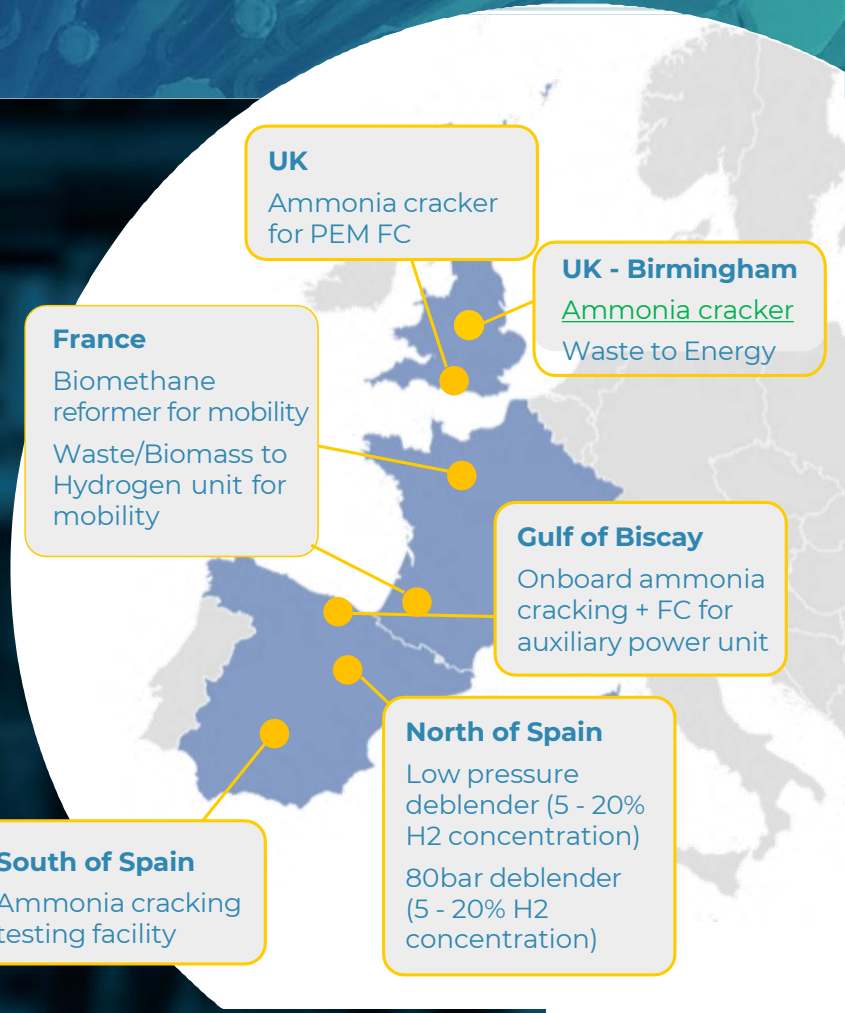


Scaling up-technology x10 every year since 2020 to limit risks



H2SITE

We are commissioning +10 reactors/separators in Western Europe and producing thousands of membranes



Enabling low carbon hydrogen transport solutions

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