Hydrogen Research & Innovation Days
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NEXT GENERATION ELECTROLYSERS

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STATE OF THE ART – ALKALINE ELECTROLYSIS

Alkaline electrolysers (AELs) are the **most mature and commercially available technology for large-scale hydrogen production**, with multi-megawatt capacities already deployed. There are 571 MWel of operational water electrolysis plants in the EU in 2025, with 2.8 GWel under construction. Based on EU Hydrogen Observator, Alkaline technologies account for approx 39% of total operational water electrolyser manufacturing capacity in Europe.

Strengths

- Reliable and safe operation
- Mature technology
- Cost-effective at large scale
- Tolerates lower-purity water
- Robust for industrial use

Challenges

- Low current density limits production
- Slow start-up and ramping reduce flexibility
- Gas crossover lowers purity and efficiency
- Limited durability under variable operation
- High capital and operational costs

ENDURE

Alkaline Electrolysers with enhanced durability

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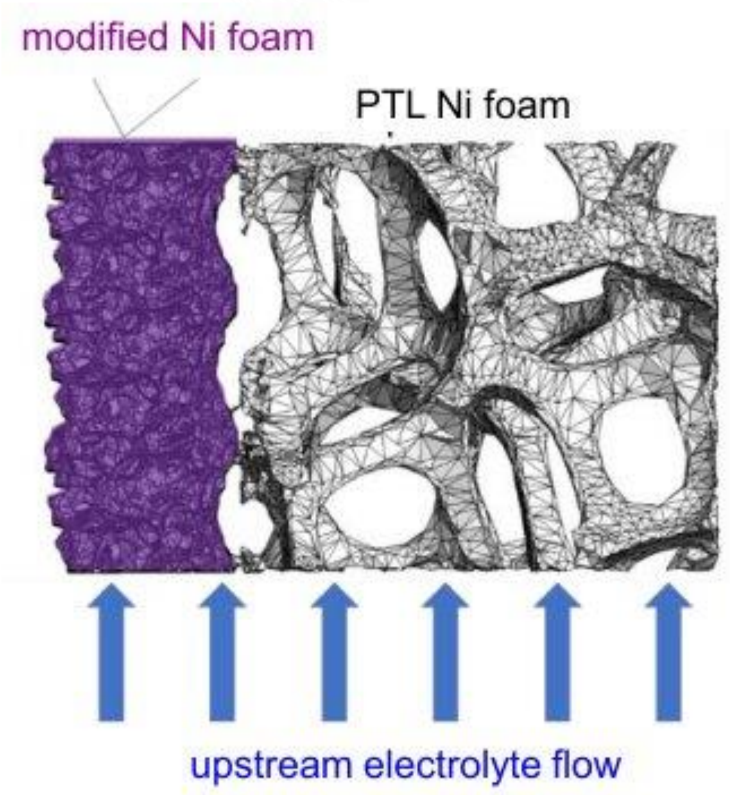
Alkaline Electrolysers with enhanced durability

Scope:
A PGM-free alkaline electrolyser stack with PEM-like performance and low degradation rate will be developed.

Innovations involve:
- Monolithic porous transport electrodes
- Multi-level computational fluid dynamics modelling
- Novel PGM-free high performance electrocatalysts
- Stack-level improvements and performance validation (100 and 1000 cm^2) stack platforms
- Benchmarking with state-of-the-art and accelerate tests



KPIs	Progress made
A prototype stack of ≥5 cells with an electrode footprint of ≥1000 cm² tested for ≥500 hours at a current density of 1 A/cm², demonstrating the baseline degradation profile, current-voltage characteristics and product gas purity of a stack using pre-commercial Ni foam electrodes.	➢ 7-cell baseline stack developed by Stargate and integrated at FHa test bench; first baseline tests are completed; testing protocol has been created and shared with JRC
An electrolysis single cell employing **monolithic Porous Transport Electrodes,** demonstrating high-efficiency operation (47 kWh/kg @ 1 A/cm², 80°C) for 100 hours and high-current density operation (≥1.25 A/cm² @ ≤ 1.95V/cell)	➢ First hierarchically structured Porous Transport Electrode have been fabricated by UCLouvain; Screen-printed foams show record performance (2.2 V @ 2 A/cm²)
Overpotential for the **HER** below 150 mV and for the **OER** below 250 mV at current density of ± 1 A/cm² after 100 h of testing on electrode level.	➢ $Ni_{10}Mo/MoO_2$ catalyst achieved HER target; OER catalysts close to target (269–286 mV) with promising stability after nitridation
A **Porous Transport Electrode upscaled to a footprint of ≥1000 cm²** while maintaining electrochemical performance	➢ 24 Porous Transport Electrodes (100 cm²) manufactured; routes for ≥1000 cm² electrodes under evaluation by Permascand
A prototype stack of ≥5 cells with an electrode footprint of ≥1000 cm², incorporating PTEs from WP2.	➢ Stack design started; stack will be assembled in spring 2026
A **laboratory stack of ≥10 cells** with an electrode footprint of ≥100 cm² demonstrating 48 kWh/kg @ 1 A/cm².	➢ 12-cell lab stack tested 200 h; baseline Porous Transport Layers limited current to 500 mA/cm²; best cells reached ~1.80 V (~47.9 kWh/kg @ 800 mA/cm²); further testing planned
Demonstrating degradation rate of 0.1%/1000h, based on **at least 500 hours of testing.**	➢ Testing will start in summer 2026

EXSOTHYC

Exsolution-Based Nanoparticles for lowest cost green hydrogen via electrolysis

Clean Hydrogen Partnership

Co-funded by the European Union

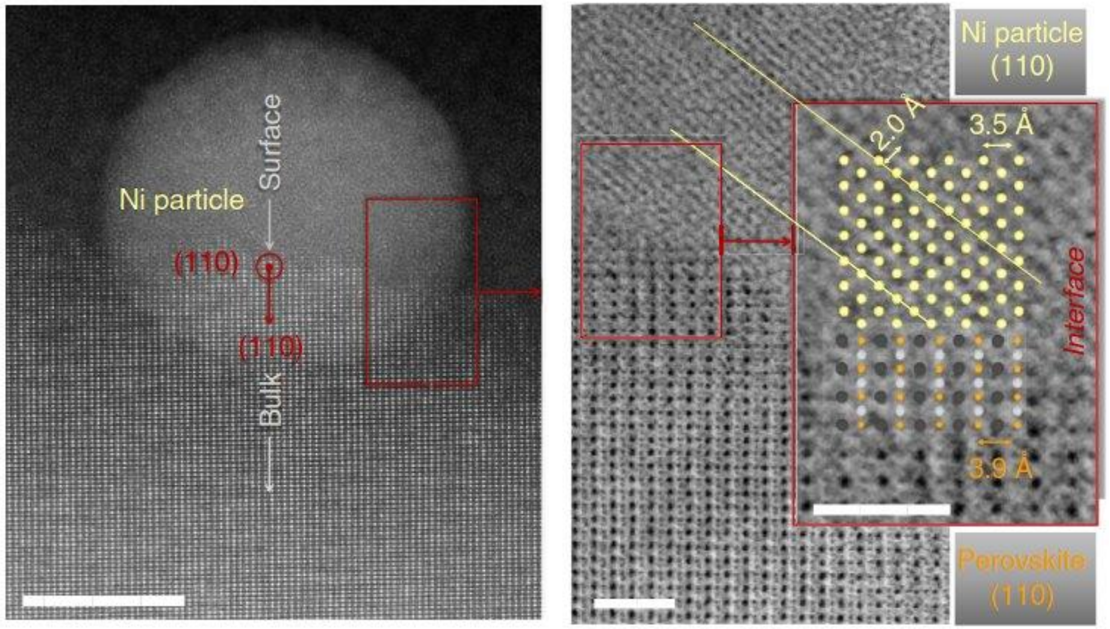
EXSOTHyC

Exsolution-Based Nanoparticles for lowest cost green hydrogen via electrolysis

Scope: The main objective of the EXSOTHyC is to develop and validate a next generation alkaline electrolyser short-stack prototype with a novel cell design containing disruptive sub-components and breakthrough materials.

Innovations involve:

- Uniform 3D coating of substrates with a catalyst
- Electrode structure based on ceramic catalyst particles bonded to the high porosity metallic substrates
- Integration of electrochemically active exsolution materials into electrode structures



KPIs	Progress made
Overpotential towards **OER** below 250 mV and **HER** below 100 mV at a current density of 10 mA/cm^2 achieved in RRDE measurement (1500 rpm, 0.1 M KOH, 25°C)	Novel phosphorus-, Co-, Fe-, and Pt-doped perovskites are being synthesized and tested; Pt-doped variants showed improved hydrogen evolution reaction (HER) activity
An **electrode** demonstrating overpotential towards HER < 100 mV @0.5 A/cm^2 and overpotential towards OER < 250 mV @ 0.5 A/cm^2 and high stability, measured at 80°C, 30% KOH, 3-electrode setup	High-quality electrodes have been produced; exsolved catalysts tested; performance encouraging
A **diaphragm** which results in HTO of 0.4% @ 50 mA/cm^2 demonstrated on >5 cm^2 scale.	Optimised pore structure has reduced permeability by 50–60%, but only modest hydrogen-in-oxygen reduction observed in cell tests.
Catalyst Coated Diaphragm demonstrating cell potential decrease by ≥0.3 V compared to the corresponding CCS while maintaining HTO ≤ 0.4%, when measured in a single cell setup @0.5 A/cm^2 at 80°C, 30% KOH	Achieved 0.33 V lower cell potential; binder-coated Zirfon reduced HTO without loss of performance; KPI met!
A **degradation rate** of <0.0033% / cycle on cell level and <0.0016% / cycle on electrode level in the accelerated stress test.	Shunt current model is developed; Reverse current models are being developed; first accelerated tests have been completed
The electrodes (WP1), the improved Zirfon membrane (WP2) and catalyst-coated diaphragms (WP3) manufactured at a **scale** that allows a prototype stack to be assembled.	First scaled powders have been produced and delivered; methods have been validated for larger-scale production; full upscaling is in progress.
A short stack prototype of 15 cells and a cell active area of 1000 cm^2 demonstrating: 1) electricity consumption at stack level below 48 kWh/kg at a current density of 1 A/cm^2, 2) use of critical raw materials < 0.3 mg/W (as defined in the SRIA roadmap), 3) operation at 5% load (0.05 A/cm^2) without exceeding 0.4% of H_2 concentration in O_2.	Baseline and modified membranes have been tested; stack design concepts have been defined; fabrication phase is ahead in the first half of 2026.

POTENTIAL SYNERGIES WITH OTHER PROJECTS

- “Sister projects meeting” led by ENDURE is happening online. In total 9 project representatives are attending the meeting and introducing their projects: SEAL-HYDROGEN, EXSOTHyC, X-SEED, AEMELIA, REDHY, ENDURE, ELECTROLIFE, HYPREAL and PEACE
- EXSOTHyC will be organising two on-site workshops in 2026
- We are considering organising a final event for both projects in the end of 2026
- We plan to pursue an exploitation route through proposal(s) funded under the HORIZON-JU-CLEANH2-2025-01-01 call, as the call specifically requests synergies with ENDURE and EXSOTHyC

THANK YOU!

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