HERAQCLES

NEW MANUFACTURING APPROACHES FOR HYDROGEN ELECTROLYSERS TO PROVIDE RELIABLE AEM TECHNOLOGY BASED SOLUTIONS WHILE ACHIEVING QUALITY, CIRCULARITY, LOW LCOH, HIGH EFFICIENCY AND SCALABILITY

Project ID	101111784
PRR 2024	Pillar 1 – Renewable hydrogen production
Call topic	HORIZON-JTI-CLEANH2-2022-01-04: Design for advanced and scalable manufacturing of electrolysers
Project total costs	EUR 2 342 385.00
Clean H_2 JU max. contribution	EUR 1 999 622.50
Project period	1.6.2023–31.5.2027
Coordinator	Schaeffler Technologies AG & Co. KG, Germany
Beneficiaries	Consiglio Nazionale delle Ricerche, Exentis Technology GmbH, HyGear BV, HyGear Fuel Cell Systems BV, HyGear Hydrogen Plant BV, HyGear Operations BV, HyGear Technology and Services BV, John Cockerill Hydrogen Belgium, Manufacture Française des Pneumatiques Michelin, Monolithos Katalites Ke Anakiklosi Etaireia Periorismenis Evthinis, Vlaamse Instelling voor Technologisch Onderzoek NV

https://www.schaeffler.com/en/technology-innovation/culture-of-innovation/funded-projects/

PROJECT AND GENERAL OBJECTIVES

The project aims are as follows.

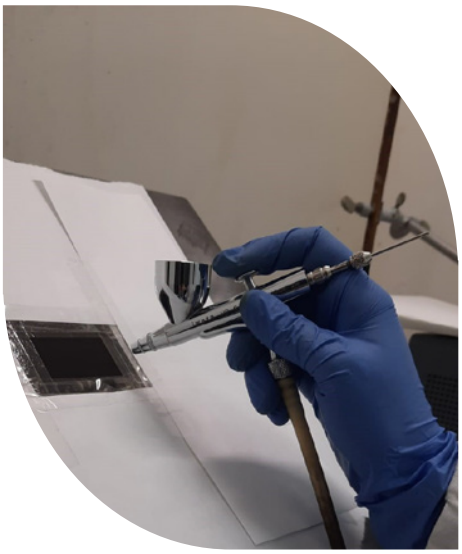
- Heraqcles will develop automated manufacturing processes for anion-exchange membrane (AEM) water electrolysers and validate a proof-of-concept 25 kW system operating at 30–50 bar with a hydrogen production rate of about 12.5 kg H_2/day (manufacturing readiness level 5) with detailed design and cost calculation for a 100 MW electrolysis plant.
- The project will produce a marked increase in operating current density (1 A/cm^2 nominal at 1.8 V/cell and 2 A/cm^2 at 2.2 V) while keeping energy consumption to < 48 kWh/kg at 1 A/cm^2 with a stack efficiency of ~ 80 % in respect of the higher heating value (~ 70 % in respect of the lower heating value). This will bring an efficiency improvement of at least 2–4 % in respect of the lower heating value compared with the present state of the art in the field of liquid alkaline electrolysers while enabling operation at a much higher current density.
- It will also reduce the capital costs in large-scale production (100 MW production volume) to less than EUR 0.6 million/(t/day H_2). This corresponds to EUR 300/kW for a production volume of 100 MW. The development of an automated manufacturing process for a novel stack architecture, the use of non-critical raw materials (cheap Ni-based electrocatalysts; hydrocarbon membranes; and cost-effective, Ni-coated, stainless steel bipolar plates), the minimisation of material use, a simplified balance of plant for differential pressure operation and the increased current density (according to Faraday's law) will bring a new perspective.
- Heraqcles aims to validate the durability under steady and intermittent duty cycle conditions in time studies of at least 2 000 hours cumulative (1 000 hours of steady-state and 1 000 hours of cycled operation) with a targeted degradation rate of less than 5–7 µV/h at a fixed current density of 1 A/cm^2, corresponding to about 0.2–0.4 %/1 000 h.
- The system will operate for 10 years without stack replacement and 20 years with a single stack replacement (cut-off voltage: 2.4 V).
- The project will achieve a significant reduction in the levelised cost of hydrogen to less than EUR 2–3/kg H_2, with EUR 0.6 million/(t/day H_2) in capital expenditure, and operation and maintenance costs of less than EUR 20/(kg/day)/year, assuming a EUR 40/MWh renewable electricity cost and 4 000 h/year of uptime.
- It will also achieve market competitiveness for green hydrogen.

NON-QUANTITATIVE OBJECTIVES

The Heraqcles project aims to address new manufacturing approaches for AEM electrolysers to provide reliable AEM-technology-based solutions, directly fulfilling targets for the large-scale deployment of cheap green hydrogen. The project will thus contribute to EU policy in terms of limiting the environmental impact of current hydrogen technology applications, minimising material usage, avoiding critical raw materials (CRMs), improving the cost-effectiveness of clean hydrogen solutions and reinforcing the EU's scientific and industrial ecosystem.

PROGRESS AND MAIN ACHIEVEMENTS

- Project management procedures have been installed, such as an administrative toolset, a data management plan and a detailed risk management plan.
- Monolithos has received spent AEM and proton-exchange membrane water electrolyser membrane electrode assemblies – with CRM (Pt and Ir) and non-CRM (Ni, Fe and Mo) electrodes – from Schaeffler and Consiglio Nazionale delle Ricerche. In addition, life-cycle analysis studies have been undertaken



to evaluate the environmental impact of the process, identify areas of high environmental impact and explore alternative options for reducing energy consumption, CO_2 emissions and waste generation.

- State of the art from scientific and technical sources enables the selection of the best protocols for AEM materials and membrane testing. In terms of experimental work, equipment tool build-up is in progress. Regarding AEM material, formulations have been selected using an experimental design approach and the preliminary test casting of liquid formulations has started.
- The project has developed NiFe layered double hydroxide anode electrocatalysts (BET, 116 m^2/g; XRF, 85:15 at. %; XRD, PS = 5 nm), developed 40 % Ni0.8Mo0.2/C cathode electrocatalysts (XRF, 80:20 at. %; XRD, PS = 10 nm), developed printing pastes (316L) with pore-forming agents, designed printing screens according to a defined geometry co-designed with Schaeffler and printed the first samples (316L), tested the debinding of the developed pastes and completed the first sintering trial. Samples are now being studied in terms of the achieved material properties, such as porosity, and successful debinding of all carbon.
- Heraqcles has designed loops to adapt the existing polymer electrolyte membrane platform to AEM technology, aligned the components and tested the rig design according to the stack specification.
- The development of a system for protype stack testing is in the early stages of the engineering phase. The process flow diagram has been created, and a start has been made on the mass and energy balance.
- The project identity, logo, flyer and website have been finished for communication activities. A communication, exploitation and dissemination plan has been made and uploaded.

FUTURE STEPS AND PLANS

Heraqcles will complete the assembly and testing of the loop 1 stack.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives and SRIA (2021–2027)	CAPEX	€/kW	300	
SRIA (2021–2027)	Degradation	%/1 000 h	0.4	
	Electricity consumption @ nominal capacity	kWh/kg	48 kWh/kg @ 1 A/cm^2	
	Current density	A/cm^2	1	
	O&M cost	€/(kg/day)/year	20	
	Voltage	V	1.8 V/cell at 1 A/cm^2 current density	
	Hydrogen cost	€/kg	2–3	
	Capital cost	€/(kg/day)	600	
	Use of CRMs as catalysts	mg/W	0	

Clean Hydrogen Partnership
Co-funded by the European Union