

ADVANCEPEM

ADVANCED HIGH PRESSURE AND COST-EFFECTIVE PEM WATER ELECTROLYSIS TECHNOLOGY



Project ID	101101318
PRR 2025	Pillar 1 - H ₂ Production
Call Topic	HORIZON-JTI-CLEANH ₂ -2022-01-03
Project Total Costs	1 631 066.56
Clean H ₂ JU Max. Contribution	1 607 330.00
Project Period	01-02-2023 - 31-01-2027
Coordinator Beneficiary	CONSIGLIO NAZIONALE DELLE RICERCHE, IT
Beneficiaries	RHODIA OPERATIONS, SPECIALTY OPERATIONS FRANCE, HSSMI TRADING LIMITED, OORT ENERGY LTD, RWE GENERATION SE, IRD FUEL CELLS A/S, Rhodia Laboratoire du Futur, SOLVAY SPECIALTY POLYMERS ITALY SPA, RWE POWER AKTIENGESELLSCHAFT

<https://advancepem.eu/>

PROJECT AND GENERAL OBJECTIVES

Direct production of highly pressurised hydrogen from electrolytic water splitting can allow significant amounts of energy to be saved compared with down-stream gas compression. ADVANCEPEM aims to develop a set of breakthrough solutions at materials, stack and system levels to increase hydrogen pressure and current density, while keeping the nominal energy consumption at < 50 kWh/kg H₂. Reinforced Aquivion® polymer membranes that have enhanced conductivity, a high glass transition temperature and increased crystallinity, and are able to withstand high differential pressure, have been developed for this application. To mitigate hydrogen permeation to the anode and related safety issues, efficient recombination catalysts are integrated in both the membrane and the anode structure. The new technology has been validated by demonstrating a high-pressure electrolyser of 50 kW nominal capacity in an industrial environment. The consortium comprises an electrolyser manufacturer, a membrane and catalyst supplier, a membrane electrode assembly developer and an end-user for demonstrating the system.

NON-QUANTITATIVE OBJECTIVES

- Develop a novel polymer electrolyte membrane (PEM) electrolyser able to produce hydrogen at very high pressure thus reducing the post-compression energy consumption.

- Develop a cost-effective technology allowing to achieve large-scale application of PEM electrolyzers.
- Achieve a significant reduction of capital costs by minimising use of critical raw materials, developing cheap coated bipolar plates and operating the electrolyser at a high production rate while assuring high efficiency and safe operation.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

- Development of functional components and stack with the following initial results:
 - (i) Thin (90 µm) Aquivion membranes containing radical scavengers showing conductivities of about 200 mS cm⁻¹.
 - (ii) IR-free O₂ and H₂ evolution overpotentials 120 mV cumulative vs. thermoneutral potential at 5 A cm⁻² with PGM loading 1.2 mg cm⁻² with an IrRu-oxide solid solution anode and Pt/C cathode catalyst.
 - (iii) Performance of 5 A cm⁻² at 1.83 V/cell, 90 °C, with a total PGM loading per MEA 1.2 mg cm⁻² combining Aquivion membrane/ionomer and advanced PGM catalysts.
- Design for the validation of the PEM electrolyser.



- Definition of the most important technical, health, safety and environmental standards, technical parameters and boundary conditions with regard to installation, commissioning and testing of the new developed technology.
- Set up of the project website and identity.
- Publication of a paper on an international open access journal.
- The Data Management plan and the Communication, Dissemination and Exploitation plan were submitted and delivered.

FUTURE STEPS AND PLANS

- Development of the life cycle analysis process.
- Development of the most promising reinforced membrane based on large-scale manufacturing potential.
- Scale-up to larger batches of the oxygen evolution reaction (OER) and hydrogen evolution reaction (HER) catalysts and recombination catalyst for membrane electrode assembly (MEA) manufacturing.
- Production of large area MEAs for the stack.
- Procurement of components.
- Kick off meeting for construction site.
- Delivery of the ADVANCEPEM demonstrator.
- Trials operation phase.
- Continuation of dissemination activities.

PROJECT TARGETS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SoA result achieved to date (by others)	Year for reported SoA result
Project's own objectives	CAPEX referred to input power	€/kW	500			900	2020
	CAPEX referred to capacity	€/(kg/d)	1 000			2 100	
	Hydrogen output pressure	bar	200	30		30	
	Hot idle ramp time	sec	1				
	Cold start ramp time	sec	10			30	
	Electricity consumption @ nominal capacity	kWh/kg	50	48.6 (at cell level)		55	
	Low Electrode Overpotentials	mV vs. E _{tn} @ 5 A cm ⁻²	200	120	✓	N/A	N/A
	Cell performance	V@ 5 A cm ⁻²	1.85	1.83		2.2	
	Degradation	%/1 000 h	0.25	0.1		0.19	2020
	Nominal Current Density	A/cm ²	5	5		2.2	
	Cell/Stack operating temperature	°C	90	90		90	2021
	Membrane conductivity	mS cm ⁻¹	200	> 200		200	2024