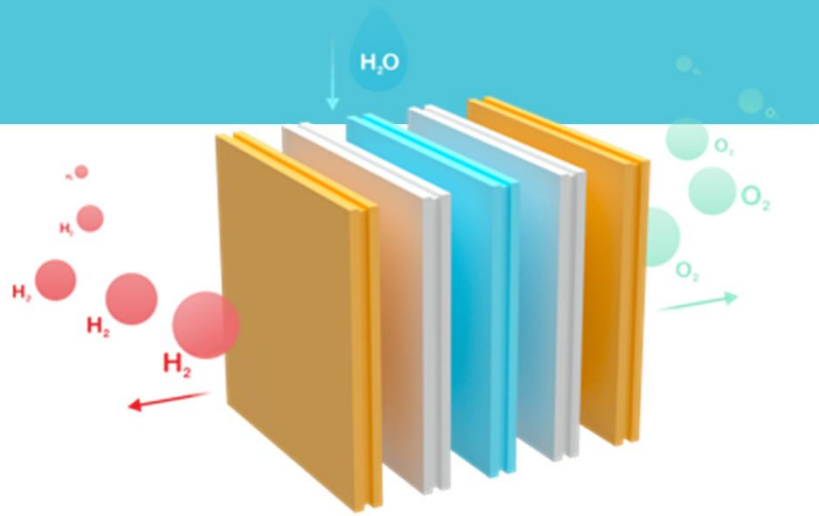
NEWELY

Next Generation Water Electrolyser

Next Generation Alkaline Membrane Water Electrolysers with Improved Components and Materials



This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 875118. This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme, Hydrogen Europe and Hydrogen Europe Research.

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Short summary about NEWELY

- Starting date: 1st January 2020
- Duration: 36 months
- Budget: 2,597,414 €
- FCH-JU contribution: 2,204,846 €
- Call topic: FCH-02-4-2019 New Anion Exchange Membrane Electrolysers

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Objectives

- NEWELY project aims to redefine AEMWE, surpassing the current state of AWE and bringing it one step closer to PEMWE in terms of efficiency but at lower cost. The main developments include:
  - Stable AEMs and ionomers with ionic conductivity of at least 50 mS cm^{-1} in pure water
  - Highly active on-PGM nanostructured oxygen evolution reaction (OER) and hydrogen evolution reaction (HER) catalysts
  - MEAs based with pore-gradient catalytic layers with open structure
  - Thermal sprayed pore-graded macroporous layers (MPL) on low-cost mesh-type stainless steel PTLs, to decreae cell overpotential
  - 200 cm^2 active area AEMWE 5-cell stack with hydraulic compression technology and output hydrogen pressure up to 40 bar.
- The stack will reach 2 V @ 1 A cm^{-2} with pure water feedstock only. The targeted performance of the NEWELY prototype will be validated in a 2,000 hours endurance test with < 50 mV degradation.

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Partners and their roles in the project

Participant	Participant organisation name	Country	Role
	Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)	Germany	Coordinator, PTL, MEA
	Westfälische Hochschule Gelsenkirchen, Bocholt, Recklinghausen (WHS)	Germany	Stack testing, stack development
	Commissariat à l'énergie atomique et aux énergies alternatives (CEA)	France	MEA, testing
	ProPuls GmbH (ProPuls)	Germany	Stack, test cell
	Air Liquide (Air Liquide)	France	TEA, LCA
	Fondazione Bruno Kessler (FBK)	Italy	Testing, communication, dissemination and exploitation
	Cutting-Edge Nanomaterials UG (CENmat)	Germany	Catalysts
	MEMBRASENZ GmbH Sàrl (Membrasenz)	Switzerland	Membrane
	Vysoká škola chemicko-technologická (UCTP)	Czech republic	Membrane testing, analytics
	Ústav makromolekulární chemie AV ČR v.v.i. (IMC-CAS)	Czech republic	Ionomer, membrane
	Korea Institute of Science and Technology (KIST)	South Korea	Membrane

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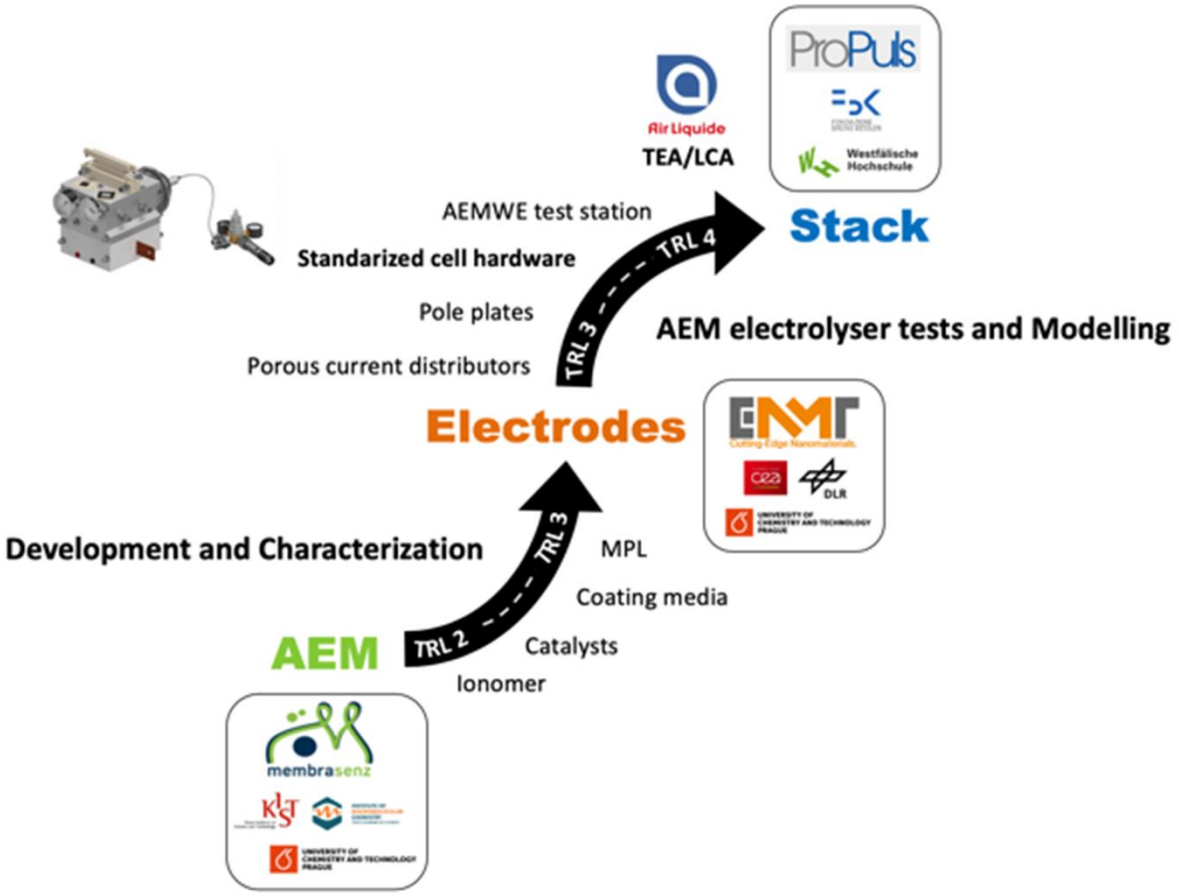
Concept of NEWELY



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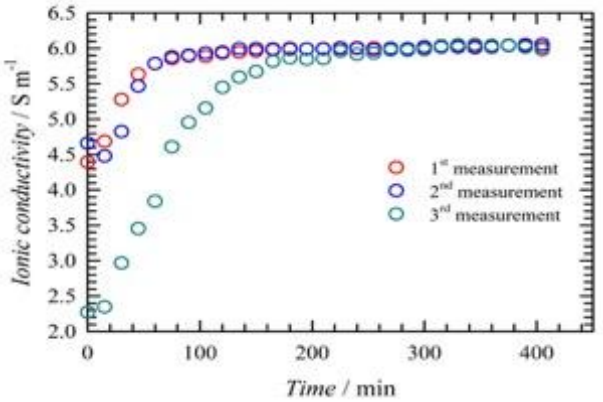
Membrane and binder
Type 1 - based on hydrocarbon backbone with DABCO functional group

- High OH^- conductivity,
- good mechanical stability (60 µm thickness)
- Stability of functional group in KOH
- Developed active binder based on same chemistry

IC vs time at 30 °C in demineralised water, bubbled nitrogen
EIS frequency range 30 kHz – 10 Hz, max. amplitude 20 mV

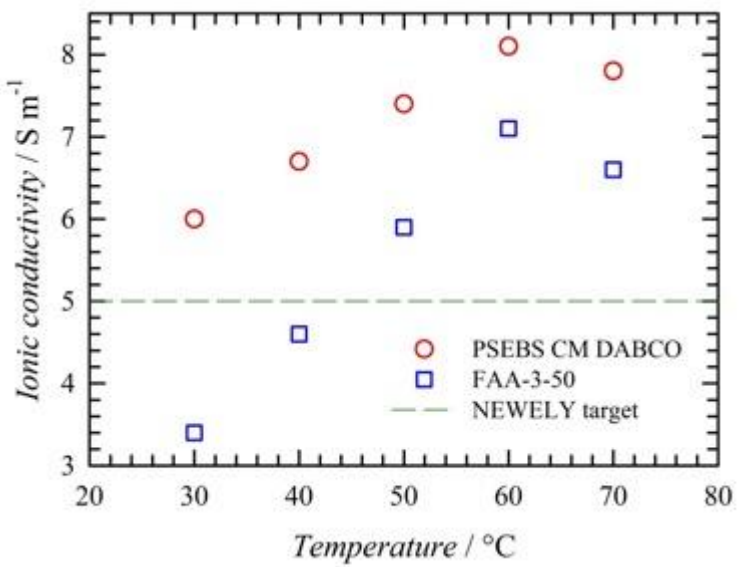


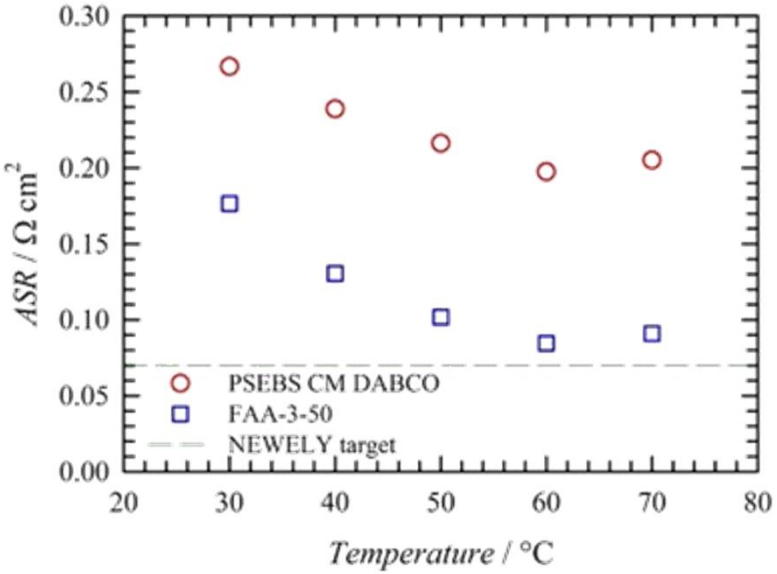
PSEBS-CM-DBC membrane properties

Fully hydroxide form, demineralised water, 30 °C

Membrane parameter	PSEBS CM DABCO	NEWELY target	Comment on the next optimisation steps
Tensile stress at break, MPa	3.4	15	Crosslinking; Reinforcement textile
Tensile strain at break, %	436	100	Target was met
IC, S m^{-1}	6.0[a]	5.0[a]	Target was met
ASR, Ω cm^2	0.27	0.07	Increased degree of chloromethylation; Thickness reduction

Membrane and binder Type 1 – transport properties





Ionic conductivity (IC):

- fully hydroxide form, demineralised water, 30 °C
- 4-electrode arrangement
- electrochemical impedance spectroscopy
- applied constant voltage 2 V
- in-plane conductivity

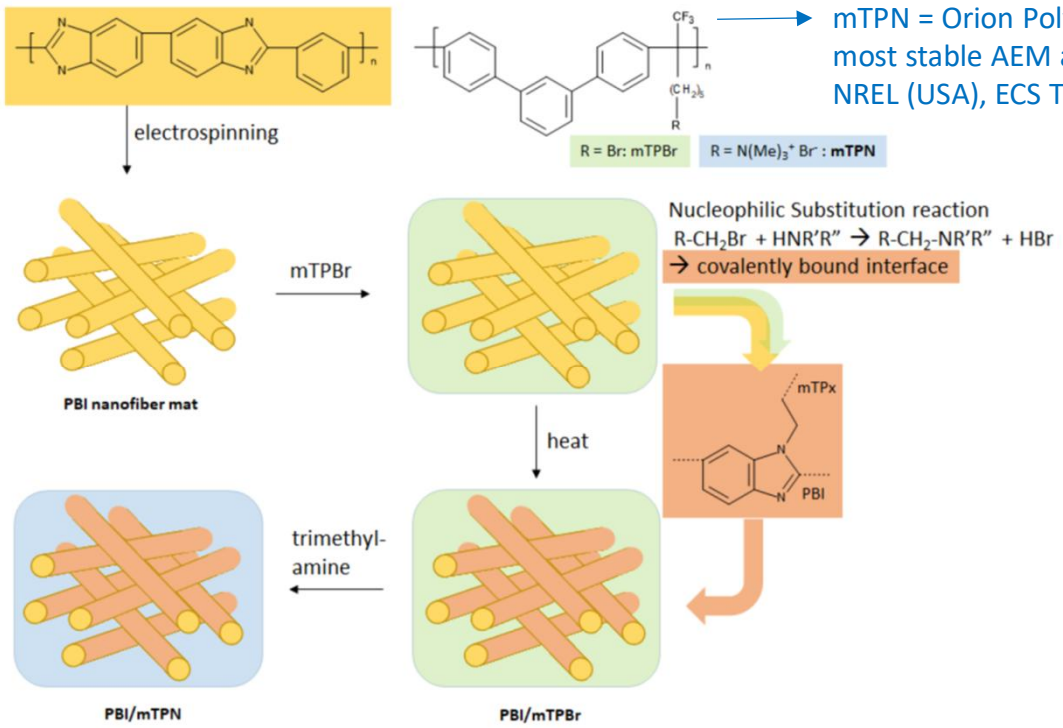
Area specific resistance (ASR):

- calculated from measured ionic conductivity

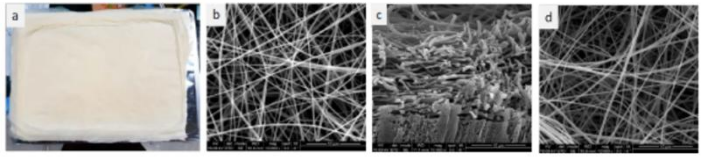
$$ASR = \frac{membrane\ thickness}{ionic\ conductivity}$$

Membrane and binder Type 2 – based on Orion Polymer TM1

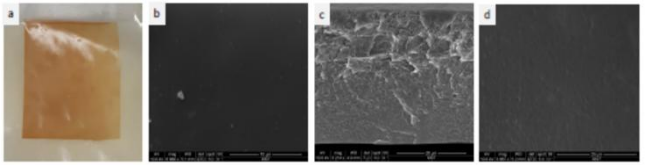
Common strategy to control swelling: membranes reinforced by porous support
Problem: Different swelling of support and ion conductive matrix can lead to voids along the support
Solution: Enhanced interface by covalent bonds between support and ion conductive matrix



PBI nanofiber mat made by electrospinning



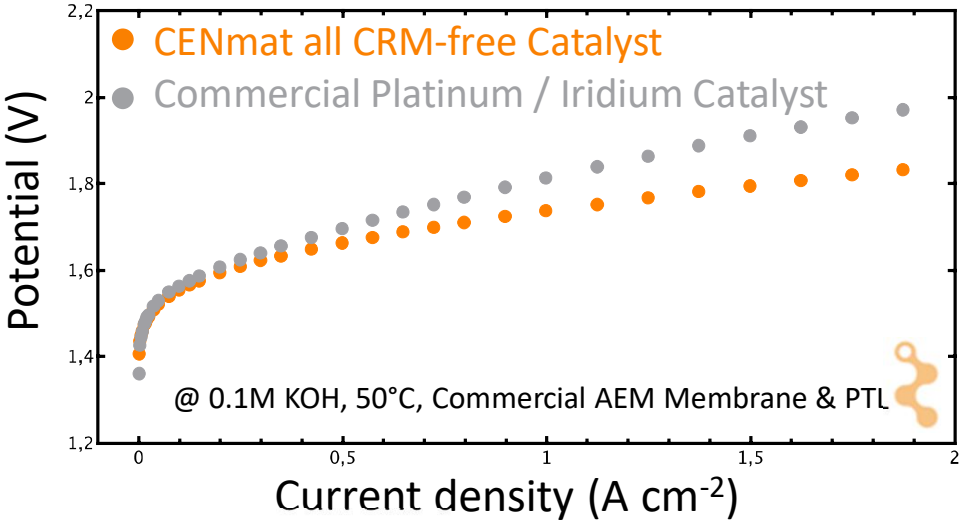
After pore filling with mTPBr

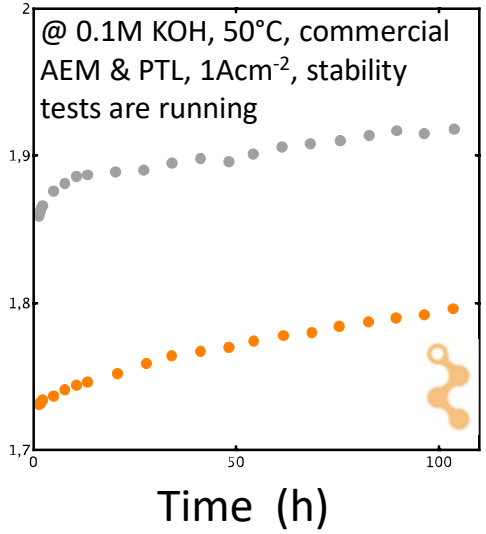


Conductivity in DI water: 62 mS/cm

Patent application (KIST): KR2020-0070694, EU 21152812.0; Paper submitted (KIST, UCTP, DLR)

Catalysts - CENmat





CENmat's proprietary:

- Highly active and durable CRM-Free catalyst (OER & HER) &
- Low cost component and cell design

-> **Allows to reduce the costs of the AEM electrolysis to CAPEX 400-500€/kW (system level) and LCOH to 3€/kg already after 3000h hours of operation**

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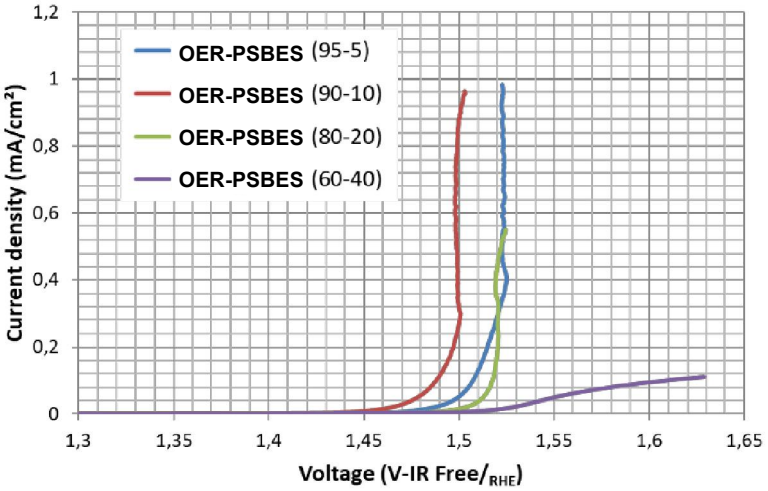
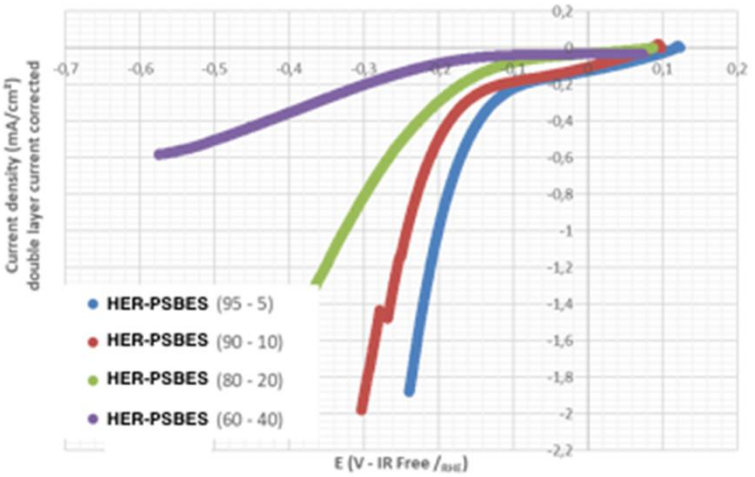
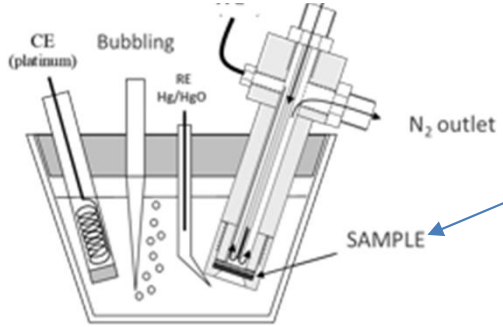
Catalysts - CEA

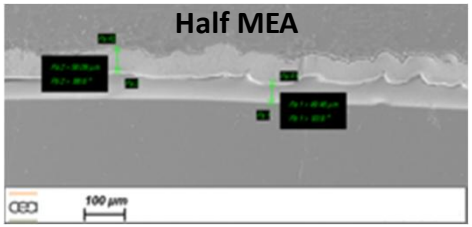
Influence of the ionomer content in the anode catalyst layer (OER)



Influence of the ionomer content in the cathode catalyst layer (HER)



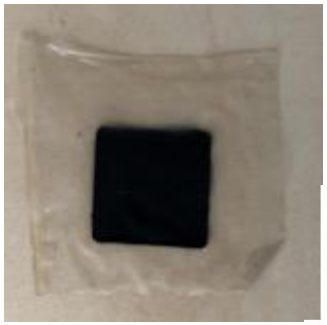


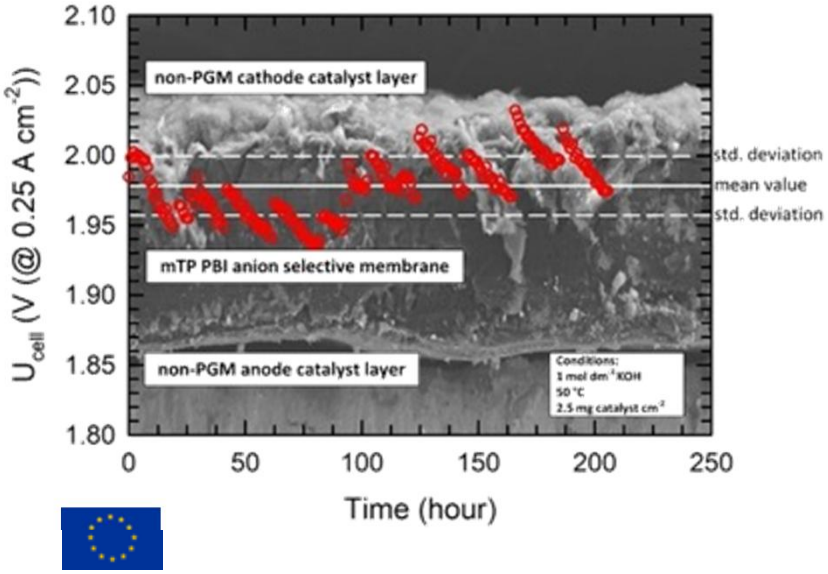


CCM & MEA – UCPT + DLR

MEA @ UCPT

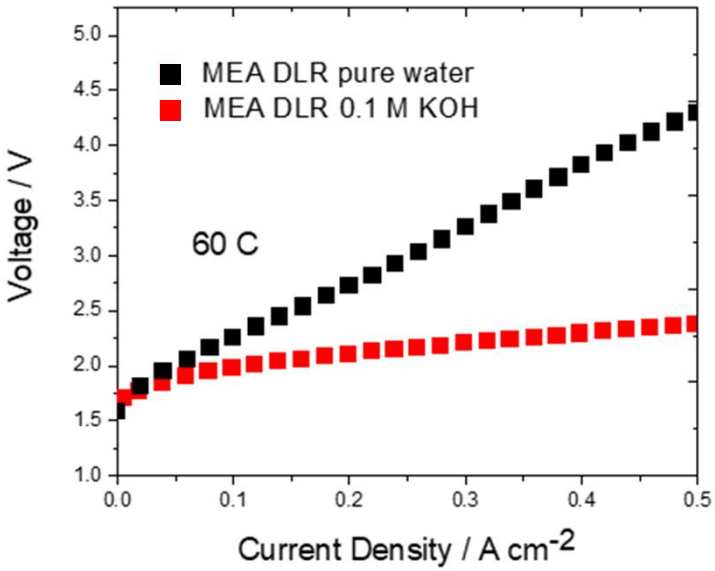
- Exclusively the project materials were used
- Average cell voltage of (1.98 ± 0.02) V at 0.25 A cm^{-2} over 200 hours experiment





MEA @ DLR

- Exclusively the project materials were used



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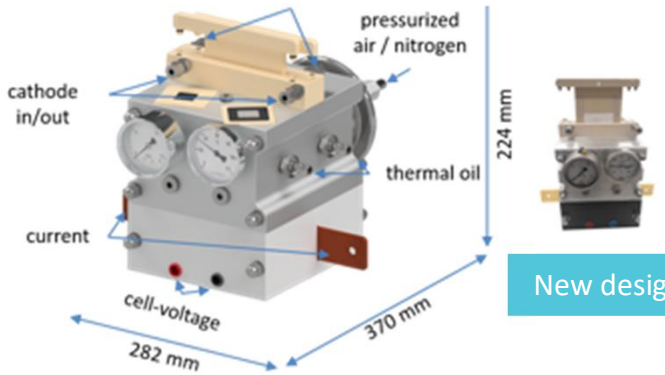
Stack concept and test station



New design

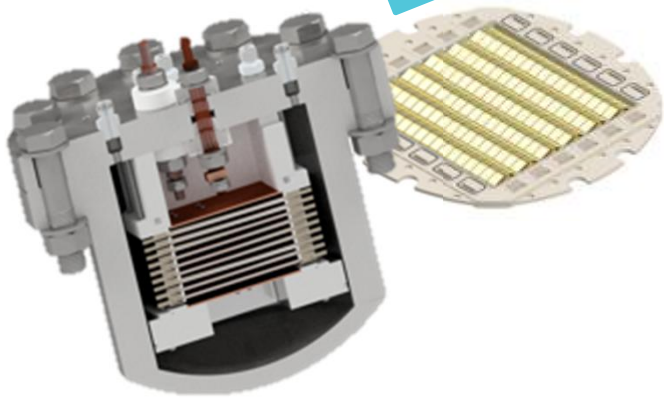
Test station for AEMWE

- 25 cm² / 200 cm²
- resin water / KOH
- option for NEWELY Stack

results

Single cell test system

- 25 cm² cell size
- ambient pressure
- up to 150 A @ 3 V
- useable for PEM/AEM



New AEMWE stack

- 5 cells
- 200 cm²
- 1 A/cm² @ 2 V
- Up to 2 kW
- 40 bar

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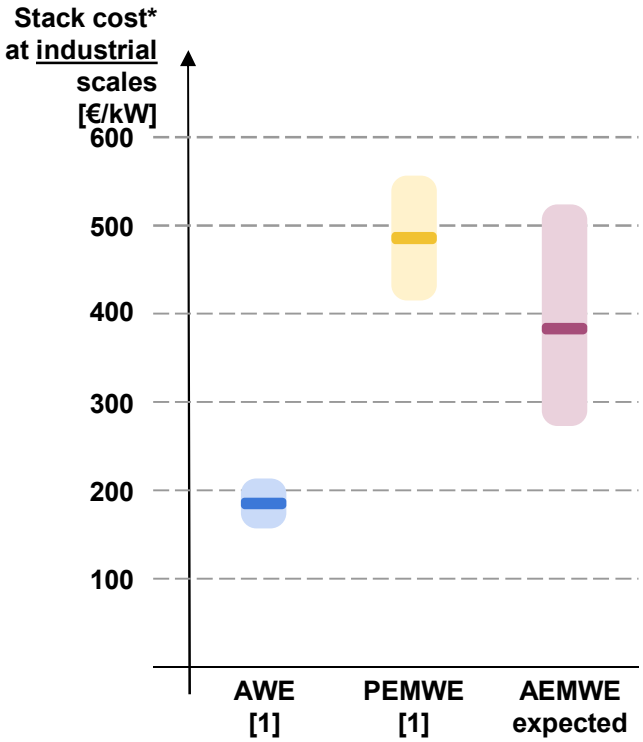
TEA of AEMWE

A **Techno-Economic Analysis (TEA)** will be performed

- proving the competitiveness of AEMWE compared to AWE and PEMWE
- indicating the development focus for future research

AEMWE target cost at short-term: **intermediate** between AWE and PEMWE.
The current **costs** (R&D level) are expected to **reduce importantly** once the production reaches **industrial scales**.



* Cost excluding construction and contingencies

[1] Gigawatt green hydrogen plant, state-of-the-art design and total installed capital costs, Hydrohub Innovation Program, 2020

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Video for general public on AEMWE

Video can be watched here: www.newely.eu

Thank you for your attention!

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www.newely.eu

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