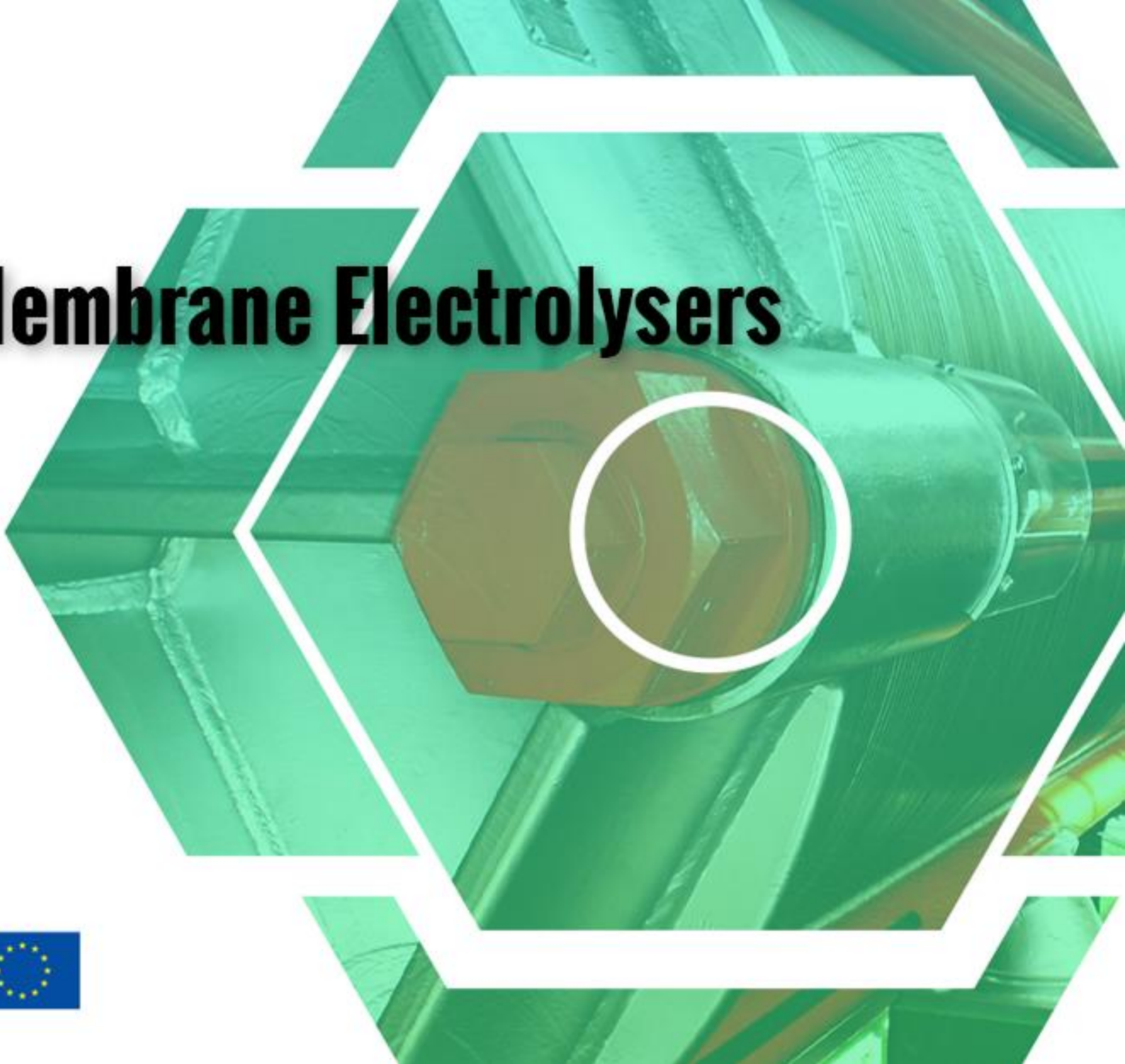
Webinar

Anion Exchange Membrane Electrolysers

6 July 2021

14:00 - 15:30 CEST



Hydrogen Europe
Research

Agend a

Webinar

Anione Exchange Membrane Electrolysers

14:00 - Opening remarks

Bart Biebuyck, Executive Director, FCH JU

Laurent Antoni, President of Hydrogen Europe Research

14:15 - Project presentations

ANIONE
Antonino Aricò, Institute of Advanced Energy Technologies

CHANNEL
Luis Colmenares-Rausseo, Research Scientist, SINTEF

NEWELY
Aldo Gago, Team Leader, German Aerospace Center (DLR)

15:15 - Round table discussion

moderated by Nikolaos Lymperopoulos, Project Officer, FCH JU

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Webinar

Anione Exchange Membrane Electrolysers

Practical information

- This event is being recorded
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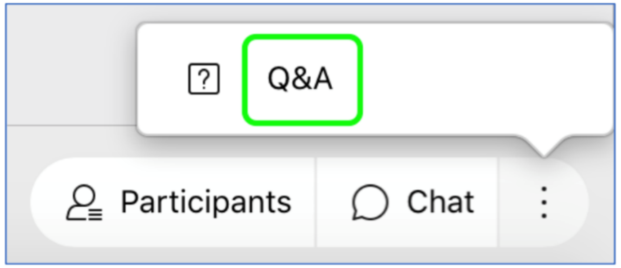

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FCH Hydrogen Europe Research

Anion Exchange Membrane Electrolysis for Renewable Hydrogen Production on a Wide-Scale

Antonino S. Aricò
CNR-ITAE

https://anione.eu/

PROJECT CONTEXT

ANIONE project is a research and innovation project (under the Fuel Cells and Hydrogen 2 Joint Undertaking) aiming at developing ***high-performance, cost-effective and durable anion exchange membrane (AEM) water electrolysis*** *technology.*

ANIONE technology combines the advantages of proton exchange membrane and liquid electrolyte alkaline electrolysis

Innovative reinforced anion exchange membranes are developed in conjunction with non-critical raw material electrocatalysts and membrane-electrode assemblies.

A cost-effective stack is designed to contribute decreasing capital costs of electrolysis systems

PROJECT OBJECTIVES

Overall objective:

To develop **high-performance** (energy consumption < 50 kWh/kg H_2), **cost-effective** (0.75 M€ / t/d H_2) and **durable** (degradation <5 µV/h at 1 A cm^{-2}) anion exchange membrane water electrolysis technology.

Approach:

Advanced CRM-free electrocatalysts, anion exchange membrane (AEM) and ionomer dispersion in the catalytic layers for hydroxide ion conduction in a system operating with diluted KOH.

ANIONE aims to validate, as proof-of-concept, a 2 kW AEM electrolyser with a hydrogen production rate of approximately 0.4 Nm^3 H_2/h .

Goal:

Allow a **scalable production of low-cost hydrogen** from renewable sources through a **reduction of capital costs**, while assuring **high conversion efficiency** and proper **life-time**.

ELECTROLYSIS TARGETS

- Achieving current density **> 1 A cm^{-2}** in AEM technology whilst maintaining the cell potential in a safe and efficient region (**E_{Cell}<1.8 V**) together with the exclusive use of non-critical raw materials

- Validate a **2 kW AEM electrolysis stack** with a hydrogen production rate of about **0.4 Nm^3/h** (TRL 4) operating at **30 bar** (>100 cm^2 cell area, > 10 cells).

- Energy consumption **< 50 kWh/kg** at stack level with a stack **efficiency** of about **80 % vs. HHV H_2**.

- Durability will be validated under steady and intermittent duty cycles conditions in time studies of at least **3,000 hours cumulative (2,000 h steady-state, 1,000 h cycled operation)** with targeted **degradation rate lower than 5 µV/h at a fixed current density of 1 A cm^{-2} and < 10 µV/h under cycled operation** →

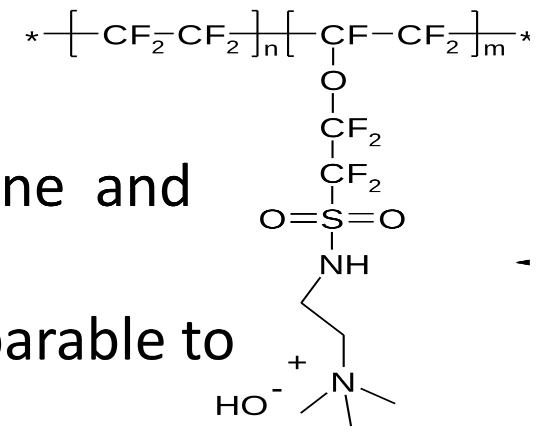
  → *limit to one the number of stack replacements in a typical 20 year life-span of the electrolyser*

- Perspective reduction of **capital costs, in large scale production, to less than 0.75 M€ / (t/d H_2)**

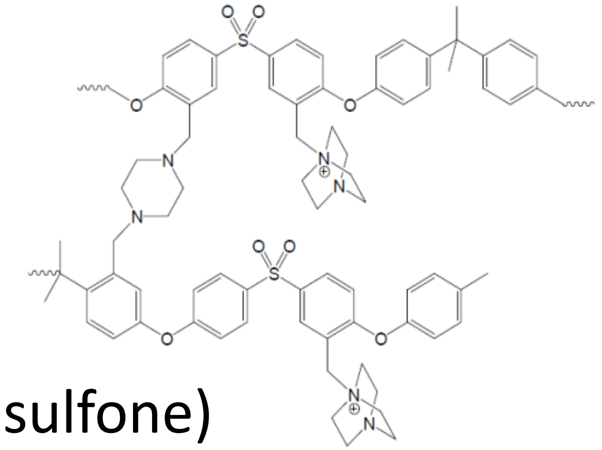
combined with a low renewable electricity cost ~0.04 €/kWh → reduction of the green hydrogen cost by electrolysis from ~10 to 2-3 €/kg **H_2**

PROJECT FOCUS

Focus on two parallel approaches for the anion exchange membrane:



- ✓ Short side chain **perfluorinated AEM** comprising a perfluorinated backbone and pendant chains, covalently bonded to the perfluorinated backbone, with quaternary ammonium groups to achieve conductivity and stability comparable to their protonic analogous (Nafion ®)
- ✓ **Hydrocarbon AEM membranes** consisting of either poly(arylene) or poly(olefin) backbone with quaternary ammonium hydroxide groups carried on tethers anchored on the polymeric backbone

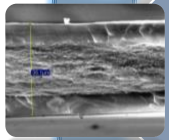


And a back-up solution:

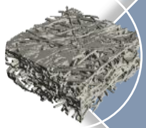
- ✓ Modify commercial hydrocarbon membranes and ionomers based on DABCO (1,4-diazabicyclo[2.2.2]octane $N_2(C_2H_4)_3$) cross-linked poly(sulfone) resins as alternative membranes (back-up solution).

Stack components optimization for AEM electrolysers

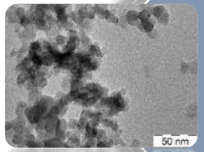
TRL 2



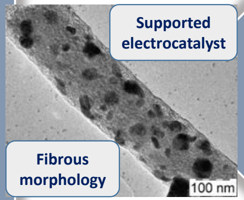
Reinforced AEM membrane with lower thickness to reduce ohmic drop and improve mechanical stability



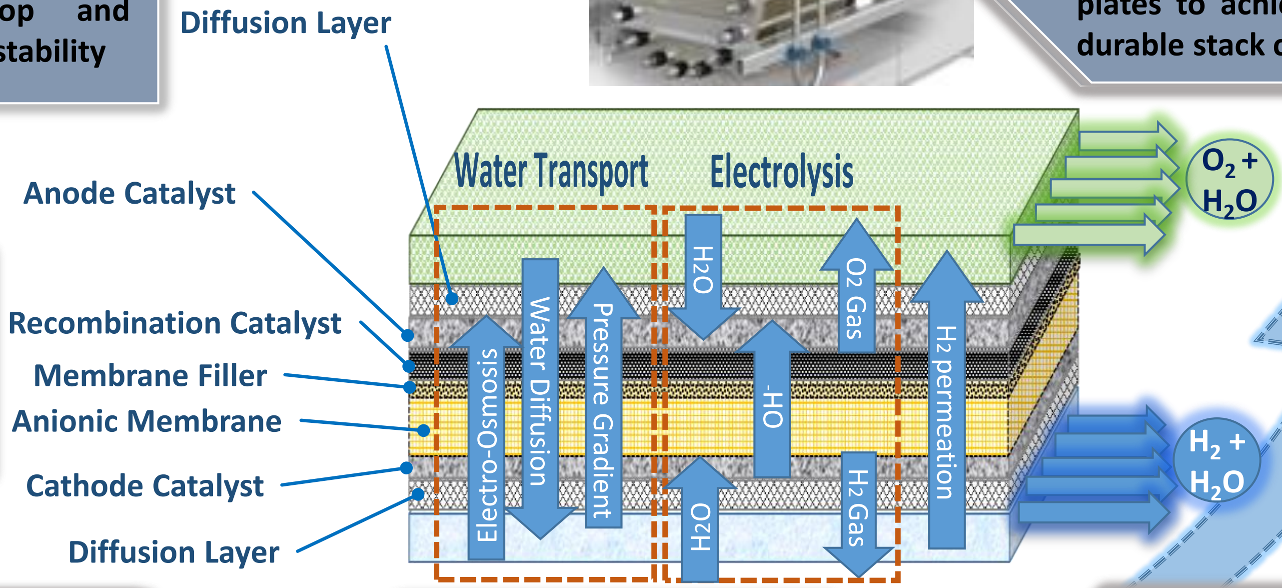
Redesign diffusion layers to improve gas diffusion and overcome reversible degradation



Cross-over management through recombination catalyst; Use of radical scavengers



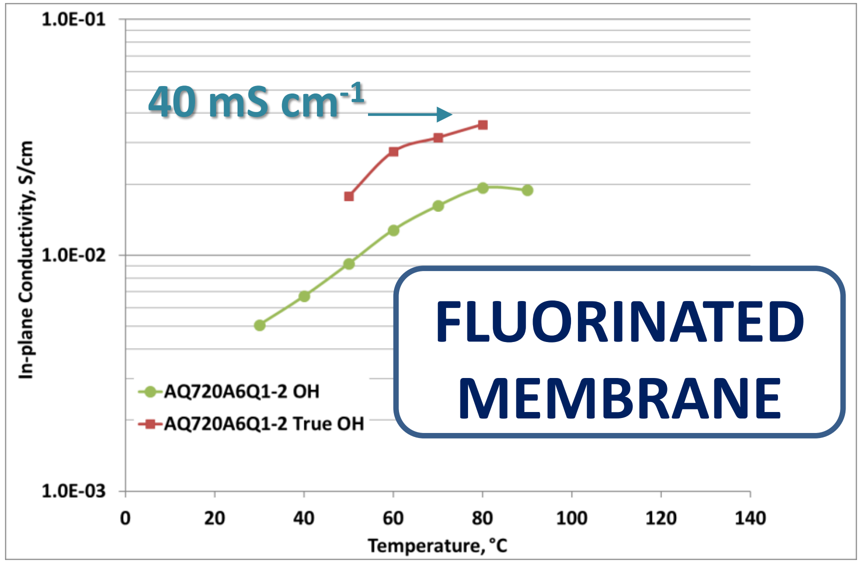
CRM-free nanostructured catalysts to increase intrinsic activity and stability, reducing mass transport



Flow-field free stack design amenable to scale up; protective coatings of steel plates to achieve low cost and durable stack components

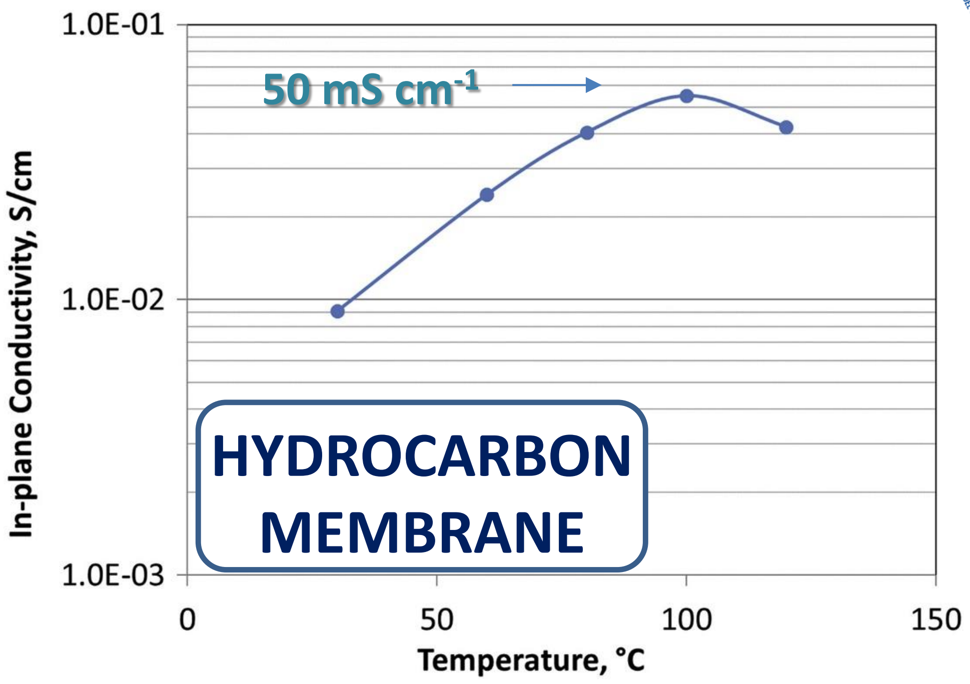
TRL 4

Increase current density to reduce capital costs, allow compact stack design and efficient use of materials



IEC, meq/g	λ	w.u.,%	ΔL/L, %	A, %	V_{wet}/V_{dry}
0.6	20.3	21.9	9	21.0	1.2

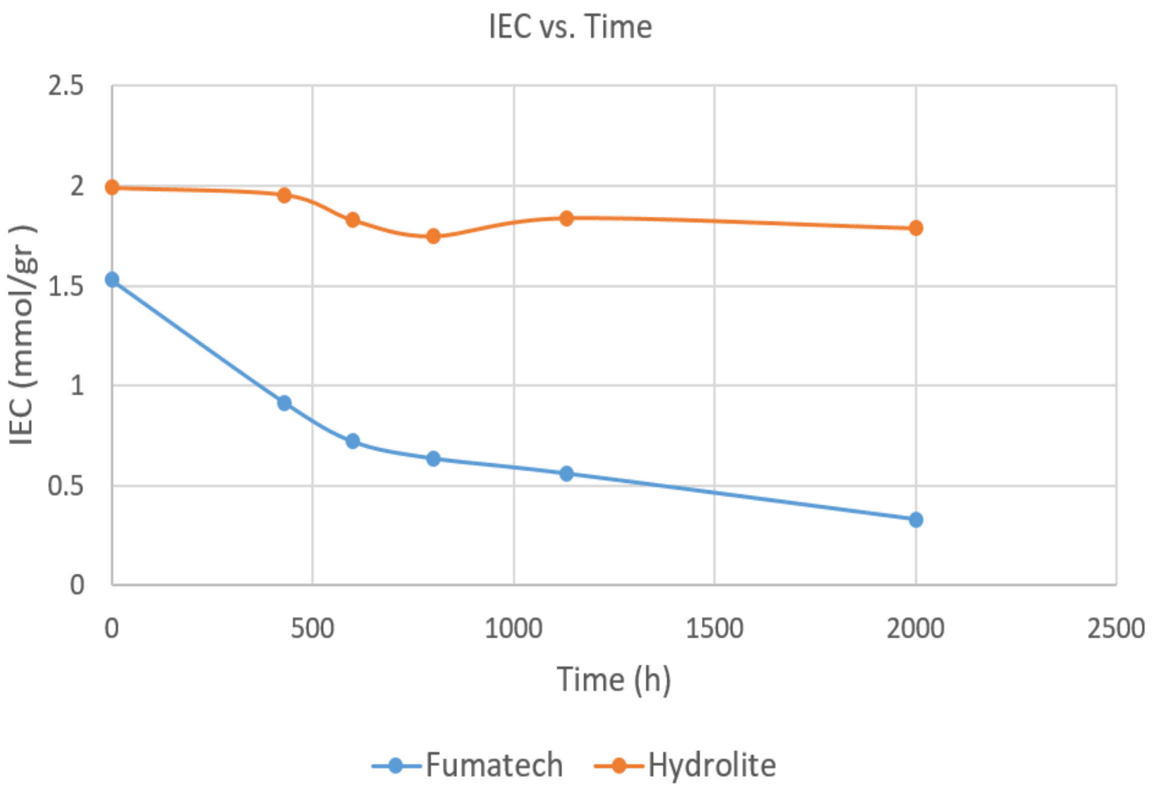
- Reduced swelling at 90°C
- "True OH^-" conductivity higher than raw OH^- conductivity
- Ion conductivity of ~40 mS/cm achieved despite the low IEC



IECexp.	IECnom.	% active groups
1.59	1.85	86
1.85	1.85	100

Wup, %	ΔL/L, %	λ	[ion], M	μ_{eff}, cm^2/Vs	D_σ, cm^2/s
17	9	6	1.5	$6.27\ 10^{-5}$	$1.63\ 10^{-6}$
70	19	25	1.1	$8.83\ 10^{-5}$	$7.17\ 10^{-6}$

HYDROLITE MEMBRANE VS. BENCHMARK MEMBRANE



IEC vs. Time (1 M KOH 80 °C)

Type of membrane/time in 1M KOH 80 °C (Hour)	0	430	600	800	1130	2000
IEC (mmol/gr) of FAA3-	1.53	0.915	0.72	0.635	0.56	0.33
IEC (mmol/gr) of Hydrolite	1.99	1.955	1.83	1.75	1.875	1.79

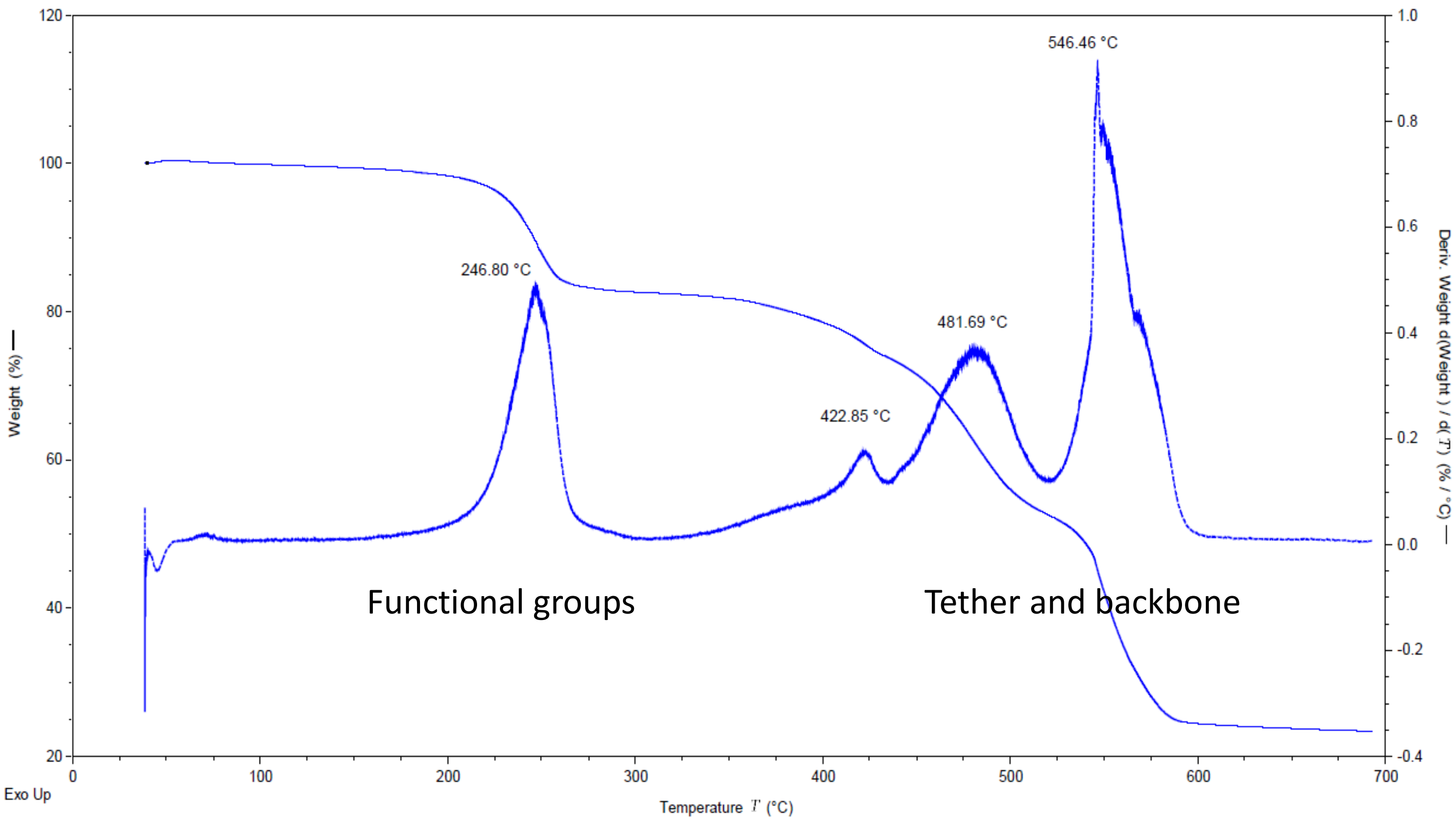
Excellent retention of the IEC for the Hydrolite membrane after prolonged immersion in KOH

- % of IEC remained after 2000h using Fumatech membrane is: 21.56
- % of IEC remained after 2000h using Hydrolite membrane is: 89.94

Hydrolite hydrocarbon membrane

Thermal Behavior

Thermal Stability-TGA



Description:

- TGA experiment was conducted, in the temperature range of 30-700 °C
- The rate was defined to 10 °C per min.
- N_2 environment.

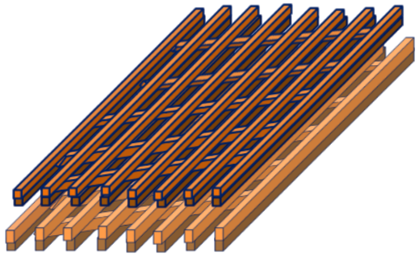
Observations:

- Loss of functional groups is observed at 246 °C.
- Loss of tether and backbone are seen at 422 °C and above .

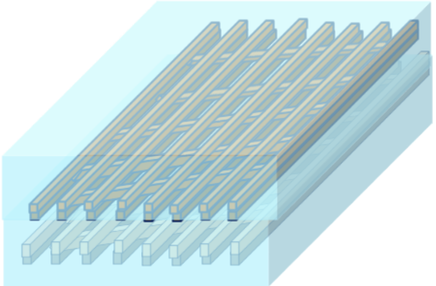
Reinforced composite membranes

Morphology

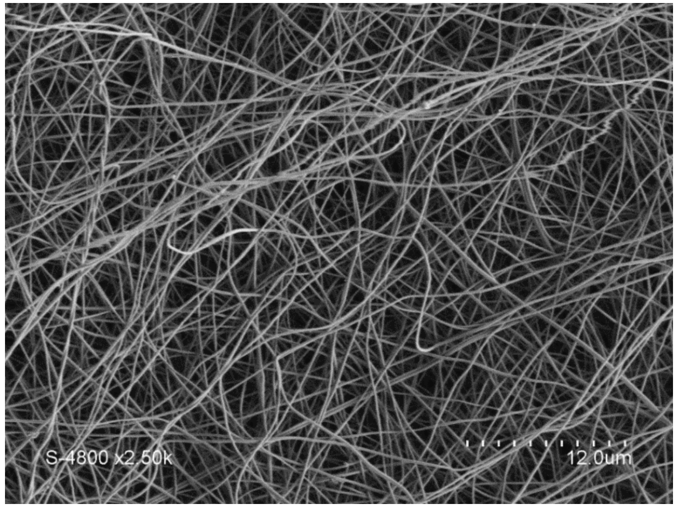
Membranes are reinforced by active polymer fibre webs prepared by electrospinning

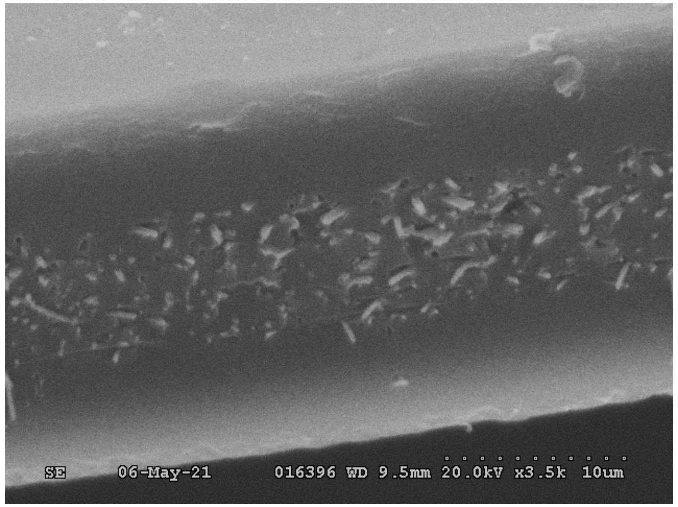


Electrospun fibre web



Reinforced membrane

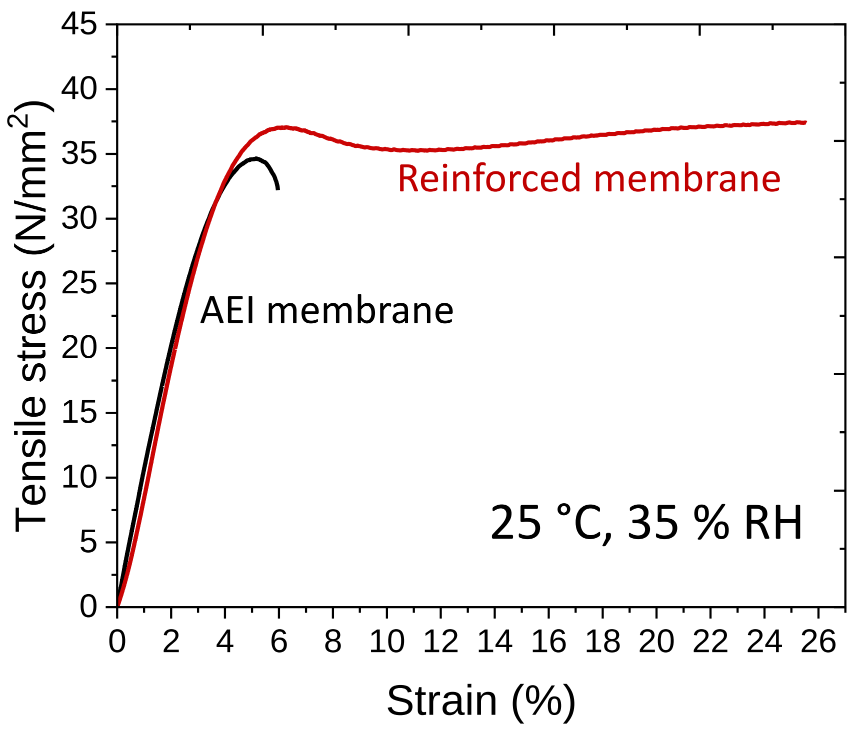




Composite membrane with nanofibre reinforcement

Reinforced composite membranes

Mechanical properties



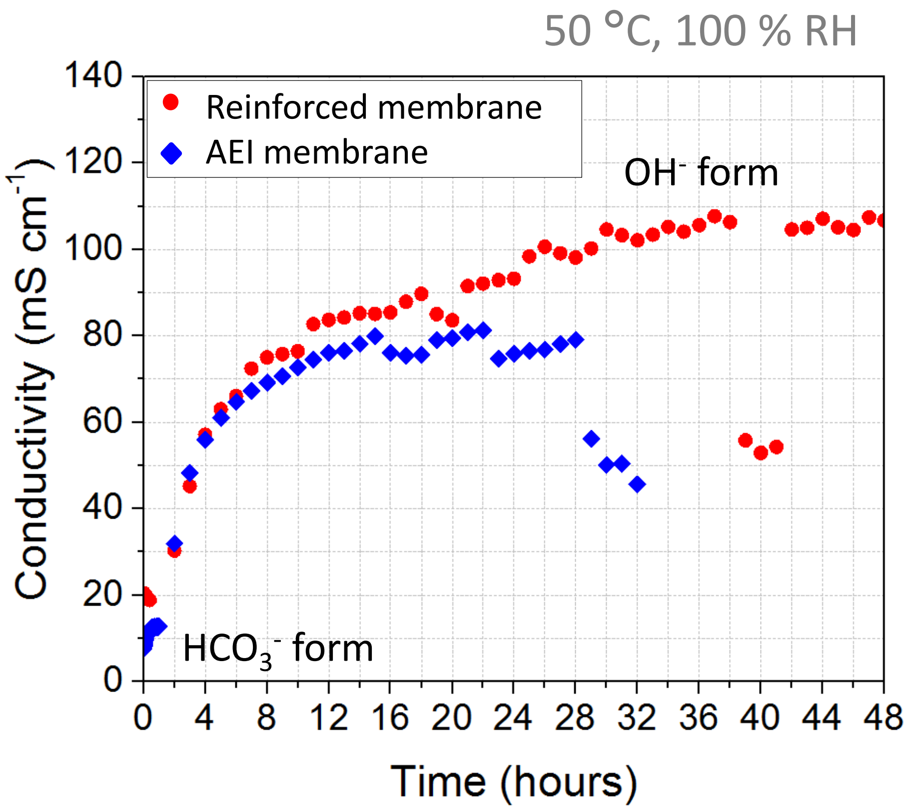
The used AEI is a stiff polymer, with low elongation at break but a high E-modulus

Composite reinforced membrane: similar E-modulus, but elongation at break is increased

Reinforced composite membranes

HCO_3^-/OH^- conductivity and stability determination

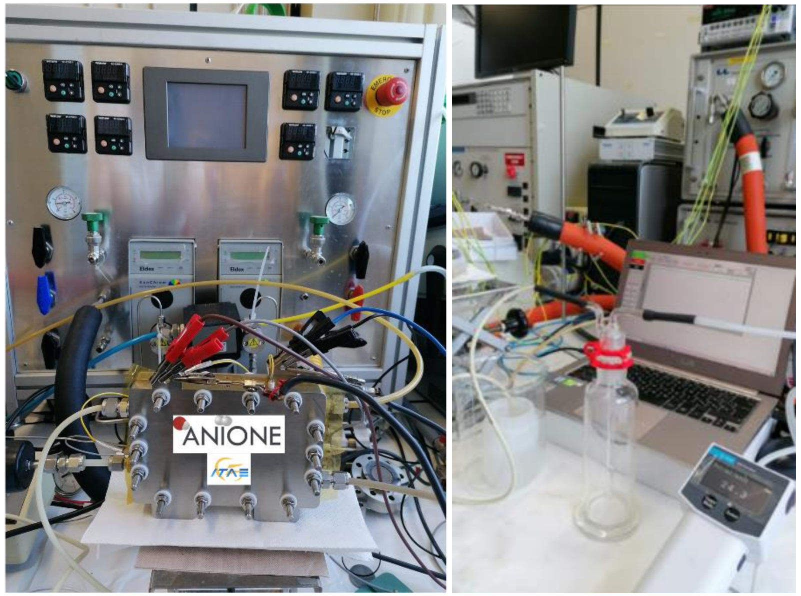
- Method allows not only "true" OH^- conductivity determination, but also to investigate the effect temperature and degree of hydration on membrane stability

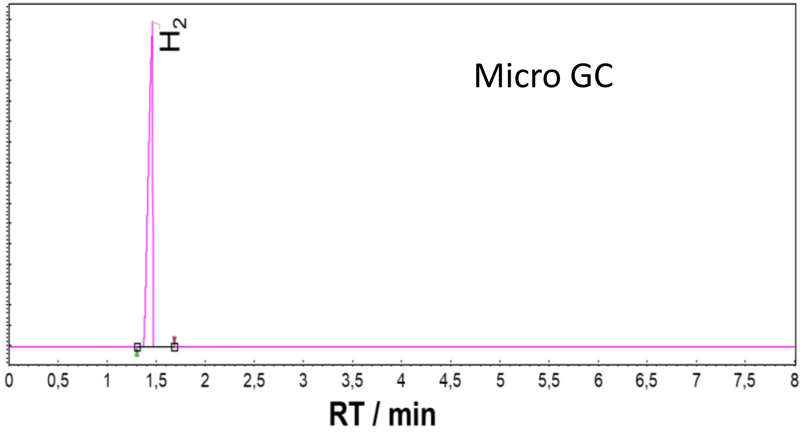


- Measurements show a factor 8 increase in conductivity between HCO_3^- form and OH^- form
- The stability increased with the reinforced membranes: full exchange achieved and conductivity of **105 mS cm^{-1}**

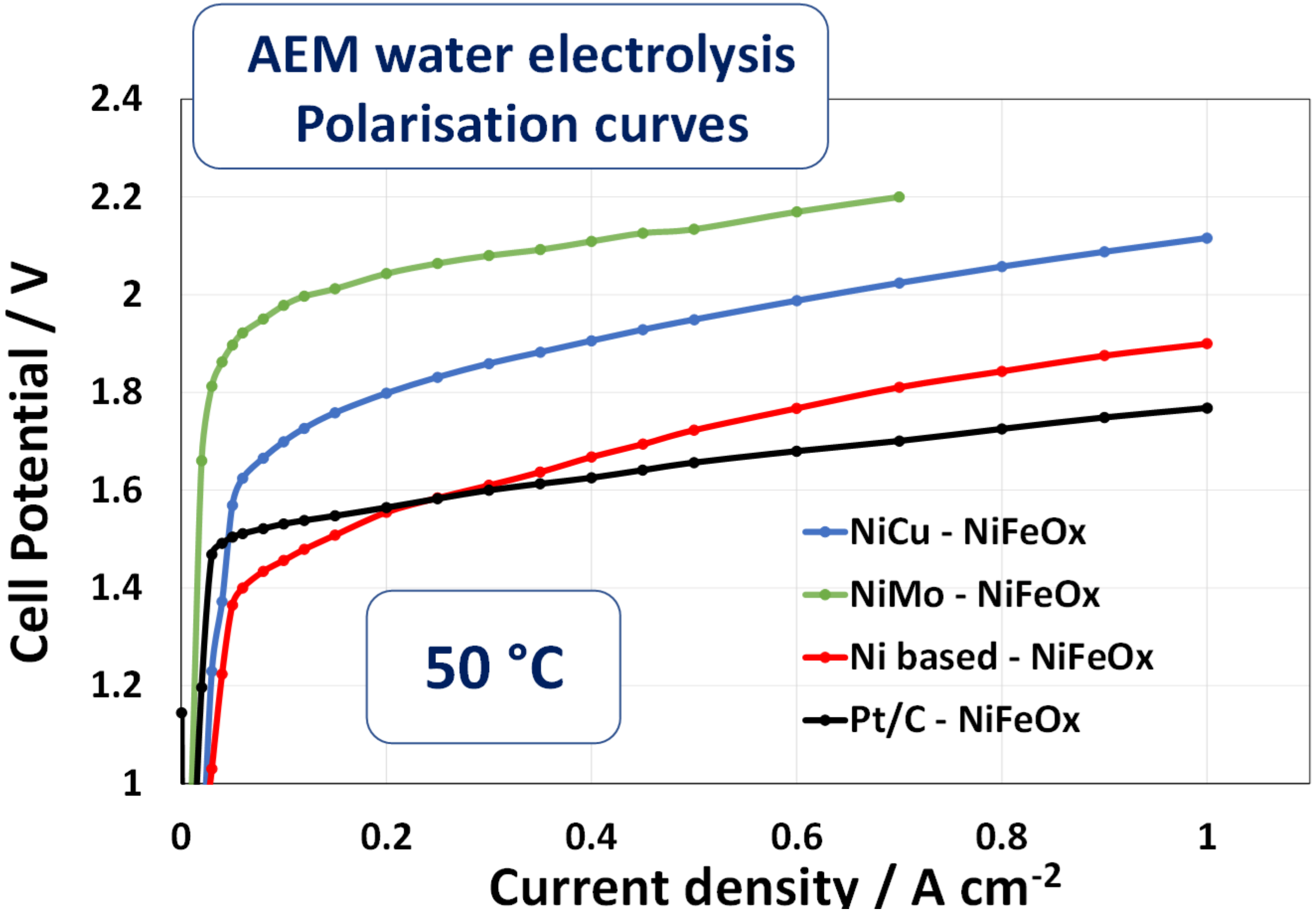
AEM Polarisation curves faradaic efficiency and hydrogen quality

AEM ELECTROLYSIS single cell testing in ANIONE



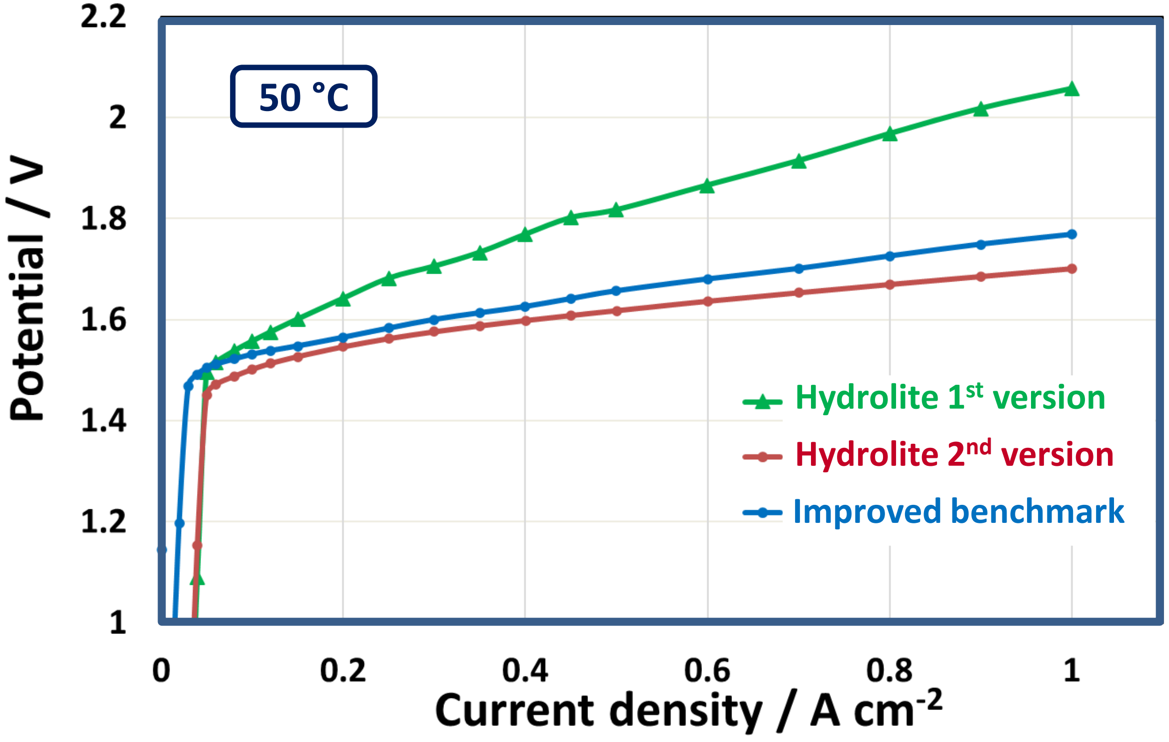


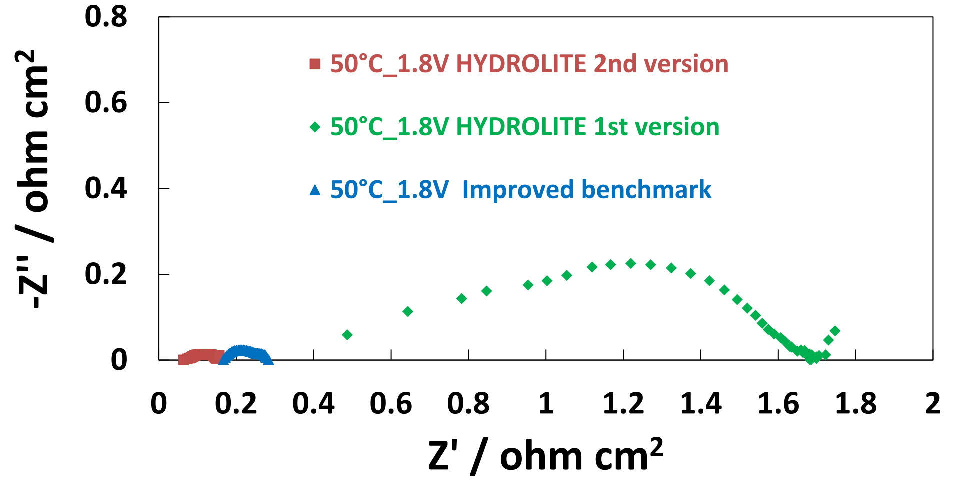
Effect of cathode catalyst composition

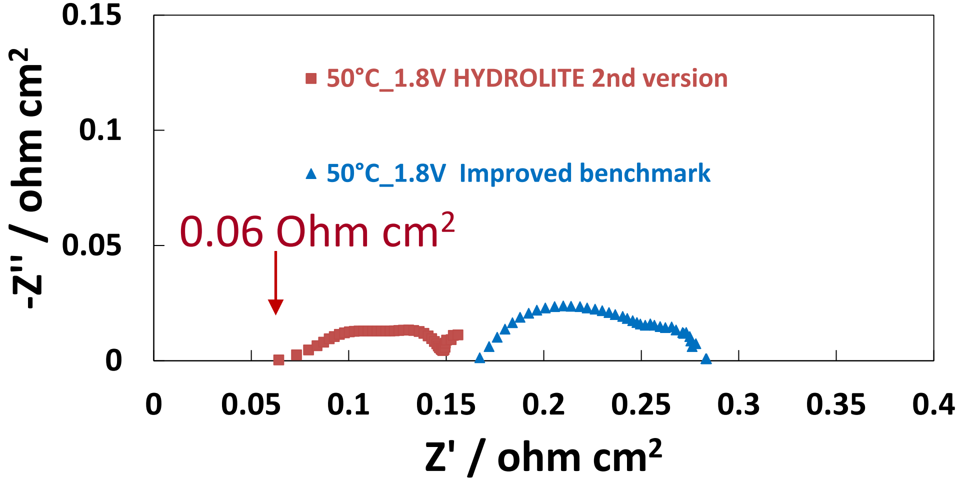


Hydrocarbon membrane development

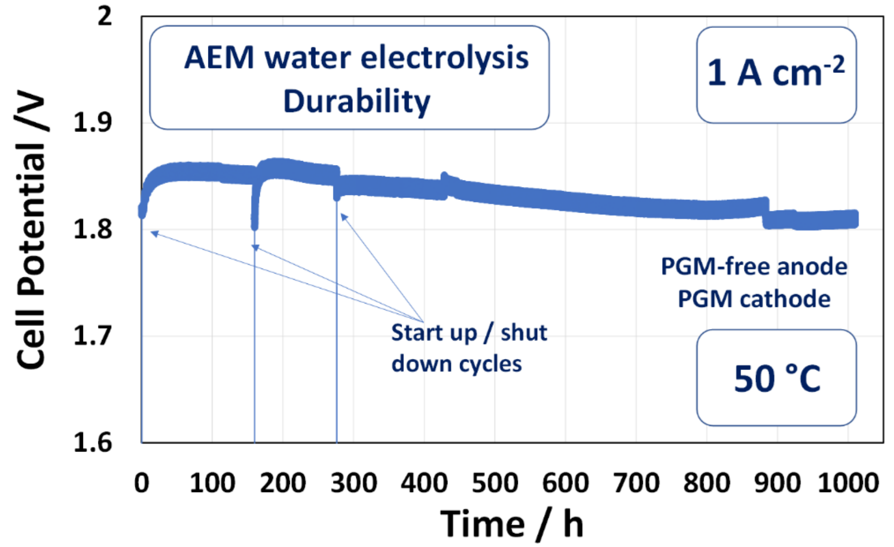
Performance of 1.7 V at 1 A cm^{-2} achieved

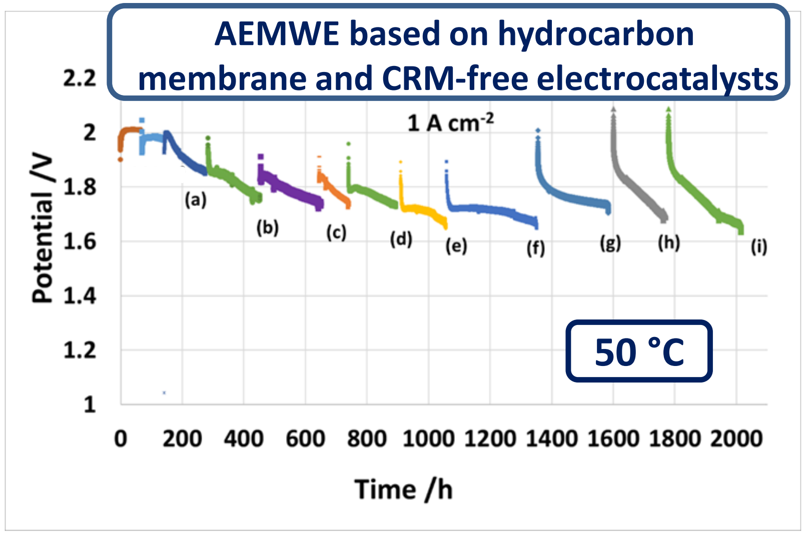




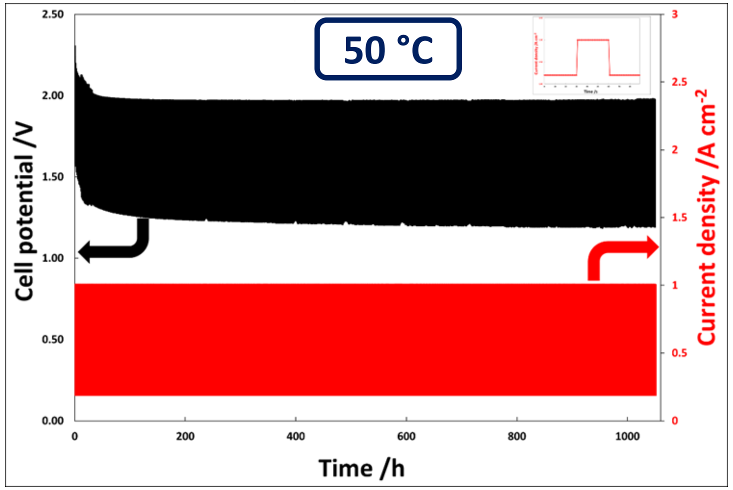


AEM durability



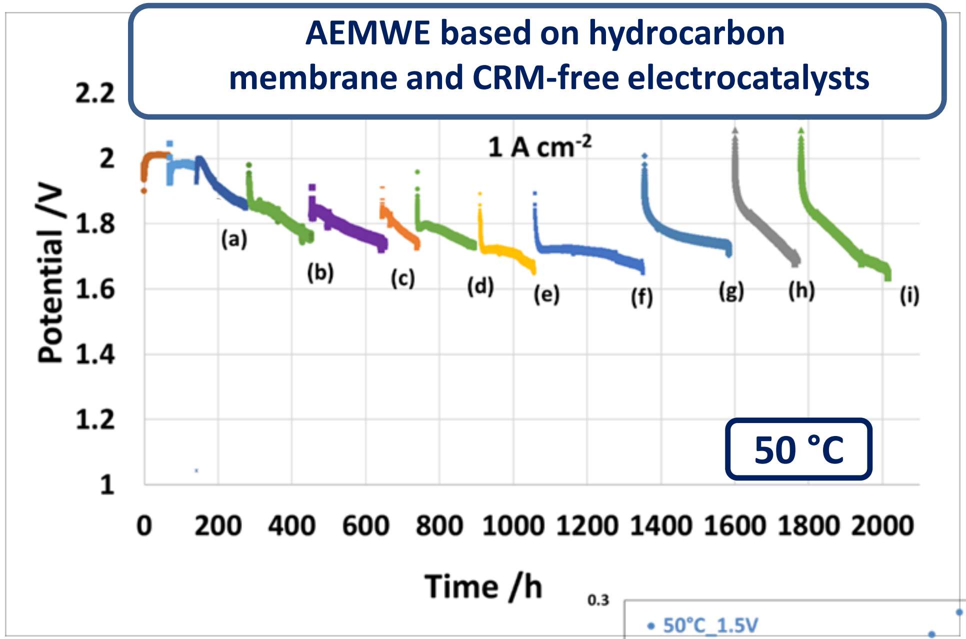


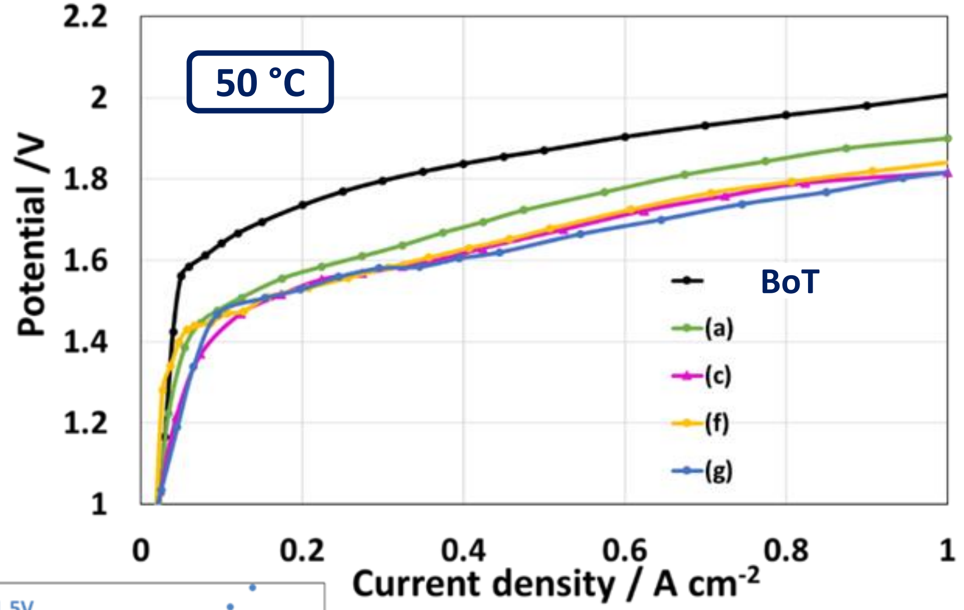
Steady-state operation at 1 A cm^{-2}

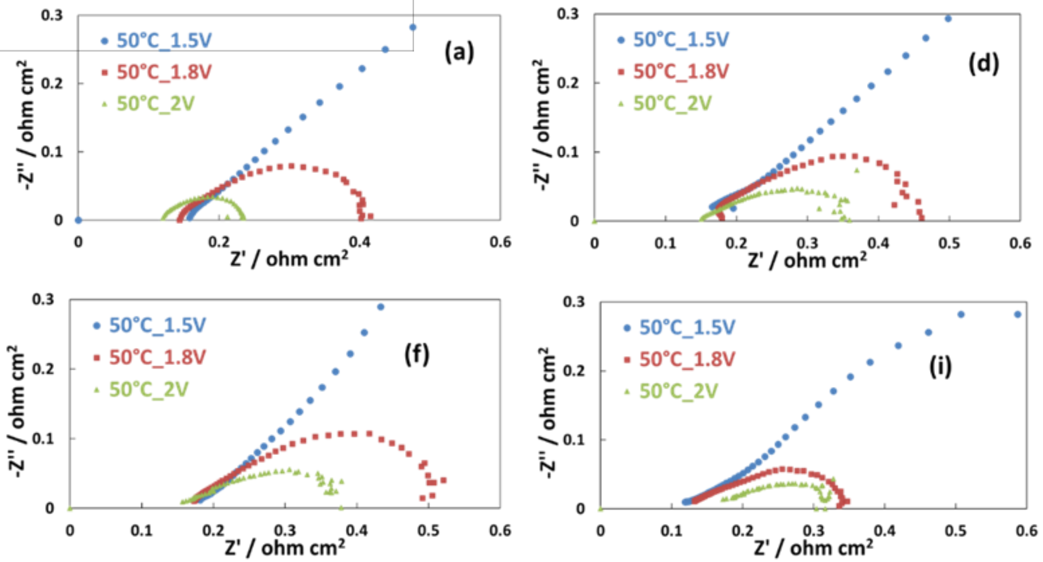


Cycled operation
Step cycles between 0.2 and 1 A cm^{-2}

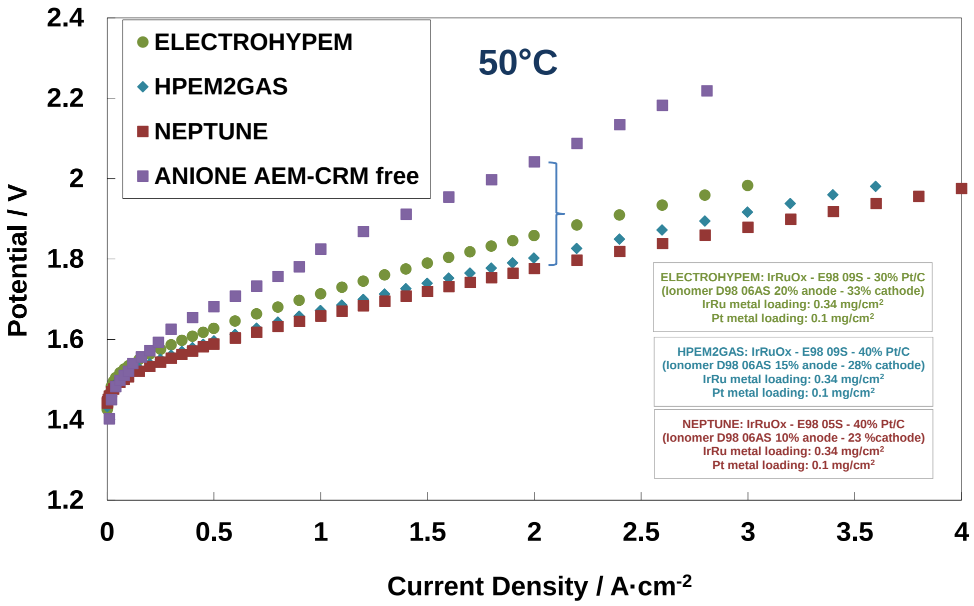
Steady-state operation at 1 A cm^{-2}







Comparison of PEMWE and AEMWE performance



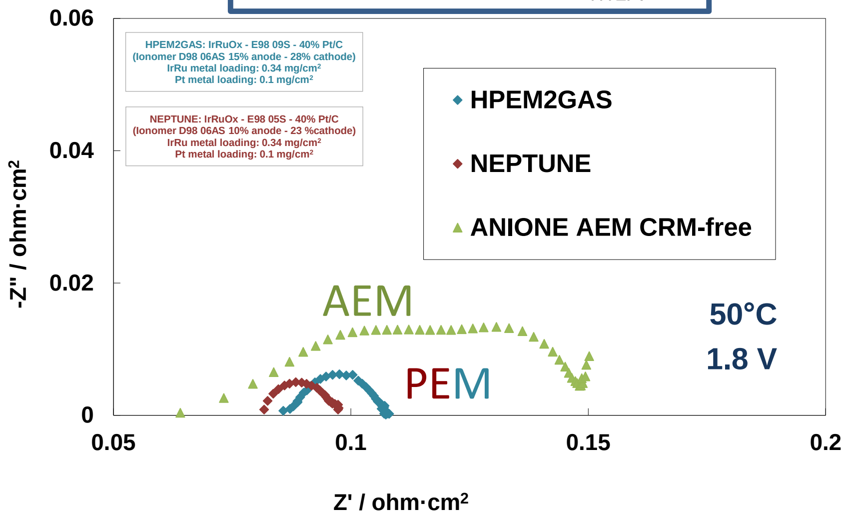
300 mV performance gap between AEM and PEM at 2 A cm^{-2}

ANIONE AEM technology:

- ✓ Non-PGM eletrocatalysts
- ✓ CRM-free materials,
- ✓ Hydrocarbon membrane
- ✓ Titanium-free

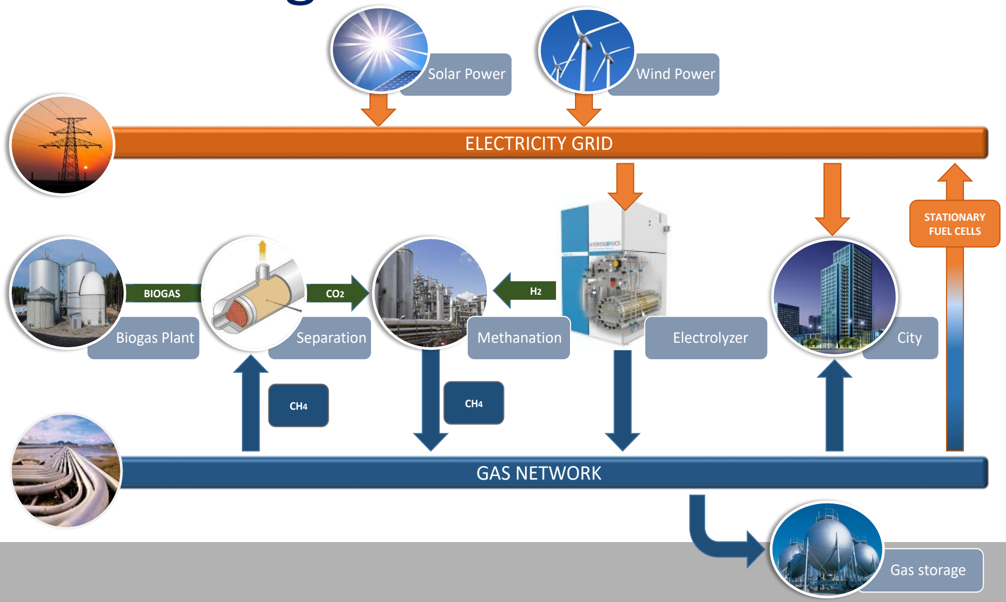
PGM content in PEMWE
<0.5 mg PGM cm^{-2} $_{MEA}$

Performance gap associated to larger polarisation resistance for AEM compared to PEM



CONCLUSIONS

- ✓ Achievement of a wide scale decentralised hydrogen production infrastructure using AEM technology with the long-term goal to reach net zero CO_2 emissions in EU by 2050
- ✓ Contribute significantly to reducing the AEM electrolyser CAPEX and OPEX costs while keeping the advantages of PEM electrolysers in terms of performance and dynamic behaviour
- ✓ Deliver a techno-economic analysis and an exploitation plan for successive developments with the aim to bring the innovations to market



Thank you!

- This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 875189. The information and views set out in this publication does not necessarily reflect the official opinion of the European Commission. Neither the European Union institutions and bodies nor any person acting on their behalf, may be held responsible for the use which may be made of the information contained therein.

CHANNEL

Thulile Khoza, AEM webinar, 6th July 2021

Development of the most Cost-efficient Hydrogen production unit based on ANioN exchange membrane ELectrolysis

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 875088. This Joint undertaking receives support from the European Union's Horizon 2020 research innovation programme and Hydrogen Europe and Hydrogen Europe Research

AEMWE an emerging electrolyser technology and has the potential to combine the best of both worlds…..

CHANNEL

PEM Electrolysis

- High currrent density ↑
- Compact design ↑
- Pressurized H_2 (e. g. 30 – 200 bar) ↑
- Rapid power-up/power-down rates ↑
- Expensive materials & catalysts ↓

High CAPEX, low OPEX

Alkaline Electrolysis (AEL)

- Lower current density ↓
- Large system size ↓
- No pressurized H_2 ↓
- Cheap materials & catalysts ↑

Low CAPEX, higher OPEX

Best of two worlds

AEM Electrolysis

- High current density ↑
- Compact design ↑
- Pressurized H_2 (up to 30bar) ↑
- Rapid power-up/power-down rates ↑
- Cheap materials & catalysts ↑

Low CAPEX & low OPEX

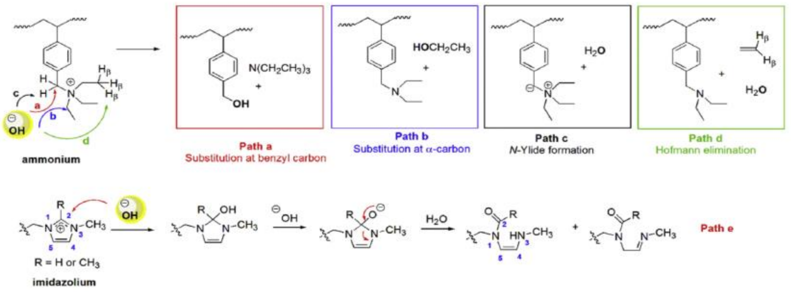
AEM: Anion exchange membrane | PEM: Proton exchange membrane | AEL: Alkaline exchange membrane | EL: electrolysis

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 875088. This Joint undertaking receives support from the European Union's Horizon 2020 research innovation programme and Hydrogen Europe and Hydrogen Europe Research

S. Gottesfeld, D. R. Dekel, M. Page, C. Bae, Y. Yan, P. Zelenay, Y. S. Kim, Journal of Power Sources 375 (2018) 170-184

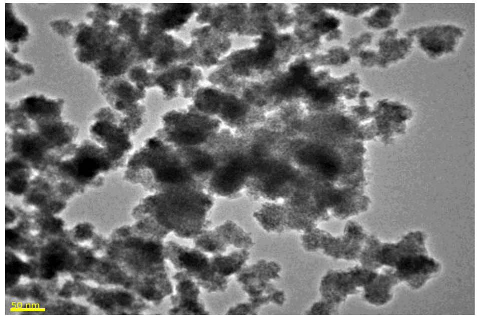
Challenges for AEMWE

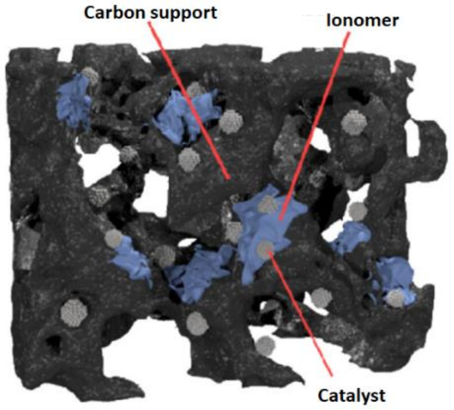
- Anion exchange membrane, conductivity, chemical and mechanical stability
- Active and durable PGM-free catalysts
- Electrode design and three phase boundary
- Current collector and BPP materials and design



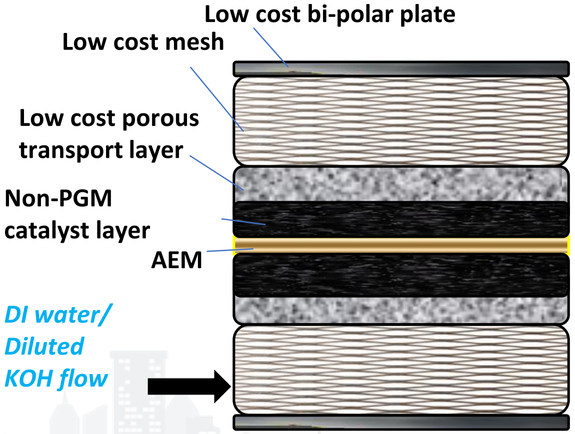
- *QA-based polymers cationic groups are susceptibility to hydroxide attack, leading to reduced IEC. Low KOH concentrations, DI water operation preferred.*

- *Ni and Ni based alloy nanostructures with high surface area may become unstable over time, loss of active area/dissolution*





- *AEI conductivity and stability, binding properties, catalyst poisoning and membrane interface*



- *CCM vs. CCS configuration, PTLs/GDLs structure, materials and coatings, the use of mesh or flow fields.*

CHANNEL

development of the most Cost-efficient Hydrogen production unit based on ANioN exchange membrane ELectrolysis

- Topic: FCH-02-4-2019: New Anion Exchange Membrane Electrolysers
- Duration: 2020-2022
- Total budget: 2 M€
- From TRL 2 to TRL3

The aim of CHANNEL is to design, construct and test a cost-efficient, 2 kW AEM water electrolyser stack and balance of plant able to operate at differential pressure.

The electrolyser will be based on low-cost materials, including non-PGM electrocatalysts, porous transport layers and bi-polar plates, performing at < 1.85 V per cell at 1 A cm^{-2}, using diluted KOH electrolyte at a system capital cost of < 600 €/kW

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 875088. This Joint undertaking receives support from the European Union's Horizon 2020 research innovation programme and Hydrogen Europe and Hydrogen Europe Research

CHANNEL

Specific Objectives

1. To further develop best-in-class EVONIK polymer materials and deliver > 40 units of large area AEM membranes > 500 cm^2 fulfilling the membrane and ionomer KPI's according to the FCHJU objective 2.4-2019;

2. To further optimise nanostructured Ni-based electrocatalysts with respect to activity and durability for the HER and OER;

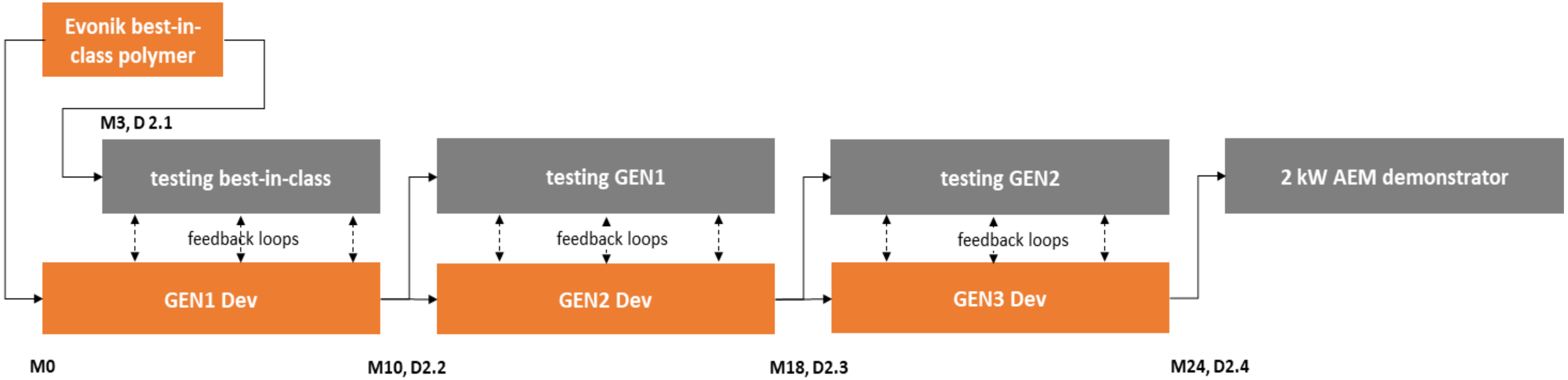
3. To optimise coating methods, catalyst loading, as well as ionomer type and loading in order to obtain the single cell performance of < 1,85 V per cell at 1 A cm^{-2} and outstanding durability, also including studies focused to understand the interaction between catalyst and ionomer, as well as the electrode-membrane interface;

4. To design and integrate the newly developed components in a 100 cm^2 active area, 10 cell, 2 kW stack platform, with cell voltages < 1,85 V per cell at 1 A cm^{-2} below 50°C, using diluted electrolytes (≤ 1 M KOH) and an operating differential pressure of 30 bar.

5. To develop a low-cost electrolyser unit with a CAPEX equal to or below current classical alkaline electrolyser.

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 875088. This Joint undertaking receives support from the European Union's Horizon 2020 research innovation programme and Hydrogen Europe and Hydrogen Europe Research

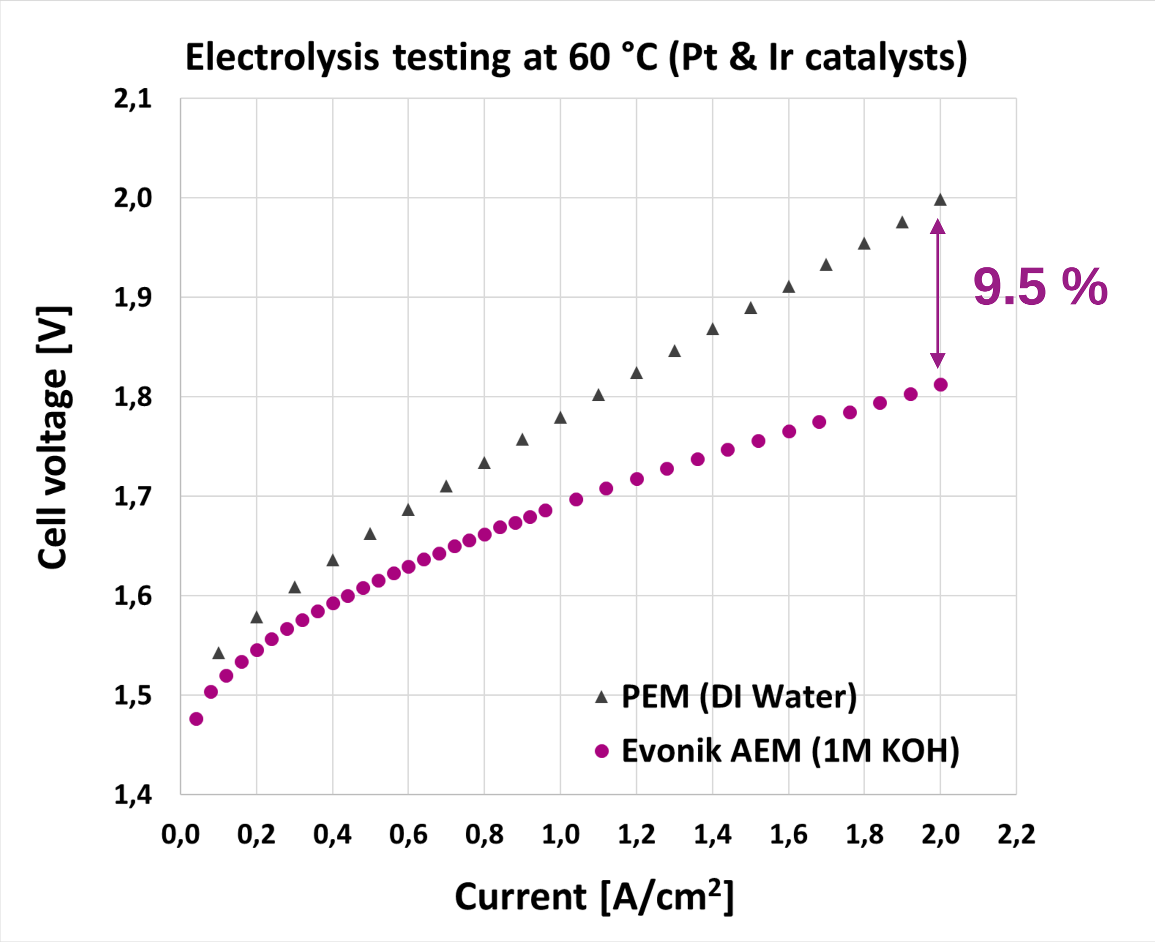
As part of the CHANNEL consortium, Evonik is working on the best-in-class polymer & membrane



KPI	UNIT	OBJECTIVE FCHJU 2.4-2019	OBJECTIVE CHANNEL
Area specifc resitance ASR, T = RT	Ωcm²	< 0,07	< 0,06
OH conductivity, T = RT	mS/cm	50	> 50
OH conductivity, T = 60°C	mS/cm	not specified	> 90
Ex-situ stability (AST protocol, 1 M KOH, T = 60 °C, 600 hr)	mS/cm	not specified	> 80
hydrogen crossover (T = 60°C)	[mol/m.s.Pa]x10^{-15}	not specified	< 15
water uptake, T = RT	w-%	not specified	< 10
Dry/wet swelling machine Direction (MD)	%	< 1	< 1
Dry/wet swelling traverse Direction (TD)	%	< 4	< 4
Mechanical strength (in dry conditions, T = RT, RH = 50%)	MPa	15	15
Elongation at break (in dry conditions, T = RT, RH = 50%)	%	100	100
Mechanical strength (DMTA, in fully hydrated, swollen conditions, T = 30°C)	MPa	not specified	> 0,1
Mechanical strength (DMTA, in fully hydrated, swollen conditions, T = 60°C)	MPa	not specified	> 0,1
Ionomer OH conductivity, T = 60°C	mS/cm	20	> 60
In-situ stability ASR remains	h	2000	> 5000

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 875088. This Joint undertaking receives support from the European Union's Horizon 2020 research innovation programme and Hydrogen Europe and Hydrogen Europe Research

Evonik AEM outperforms PEM benchmark Nafion N-115



- Evonik AEM outperforms in 1M KOH electrolyte benchmark PEM membrane Nafion N-115 in DI-H_2O @ 60°C by 0.186 V @ 2 A/cm^2 (lab scale, single cell, 25 cm^2 active area)

- **Application of Evonik AEM in 1M KOH electrolyte @ 60°C & @ 2 A/cm^2 can enable reduction of operational costs up to 9.5% in comparison to PEM water electrolysis**

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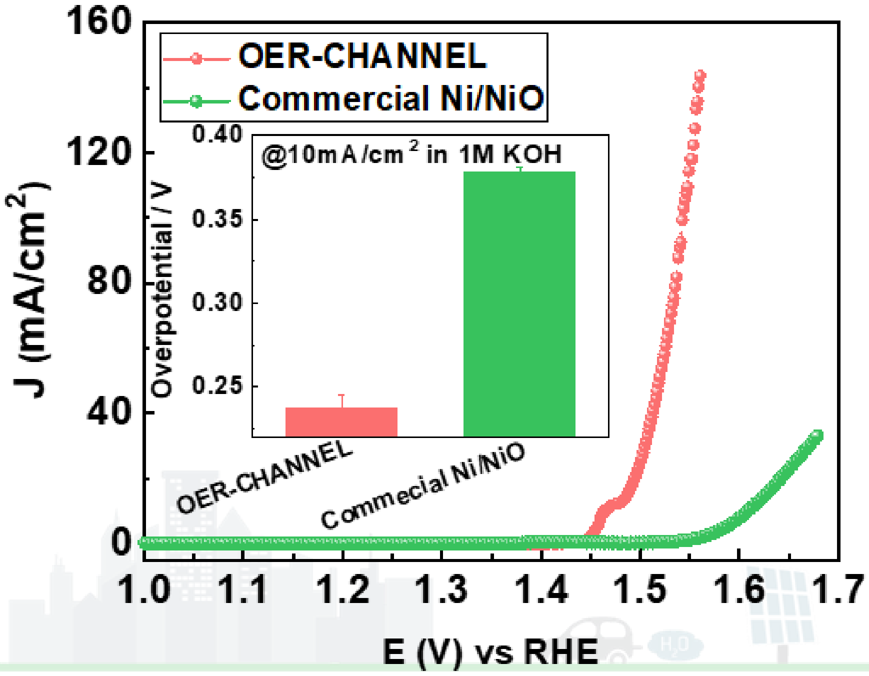
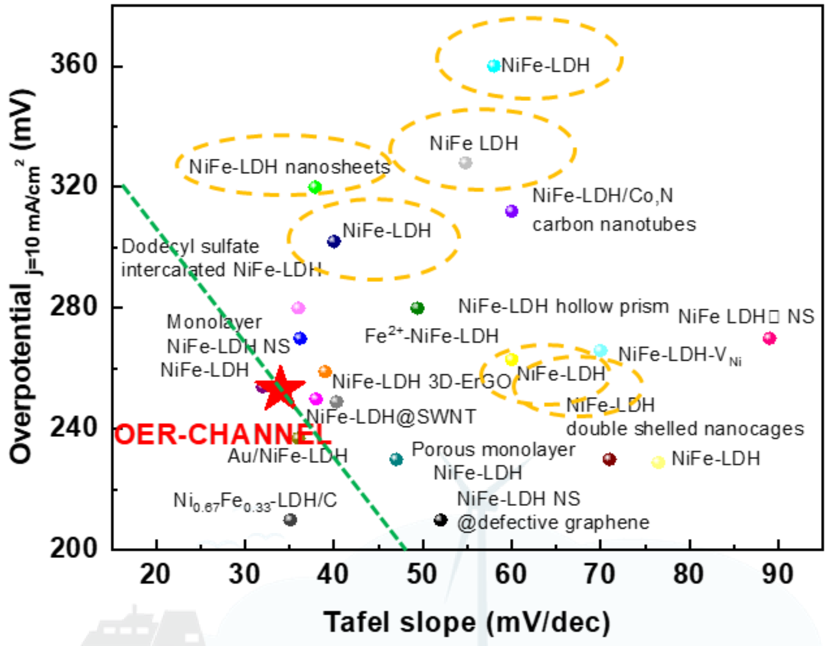
OER Development
Electrochemical performance

***Ex situ* testing- RDE**

- OER-CHANNEL catalyst present an overpotential＜300 mV at 10 mA/cm$^2_{geo}$



- OER-CHANNEL catalyst is stable for more than 500 hours at 1.6 V – degradation of less than 20 mV
- OER-CHANNEL catalyst showed higher performance compared to Ni-based catalysts presented in the literature.



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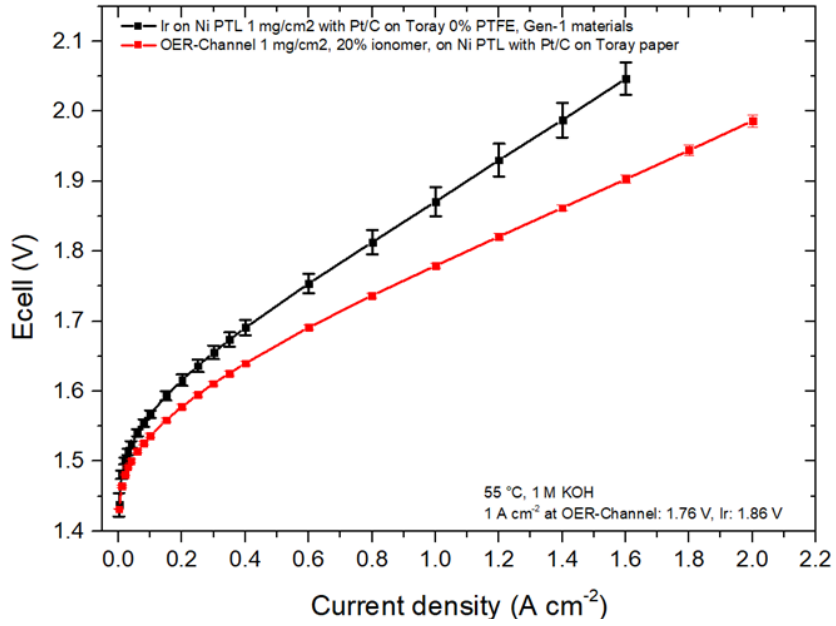
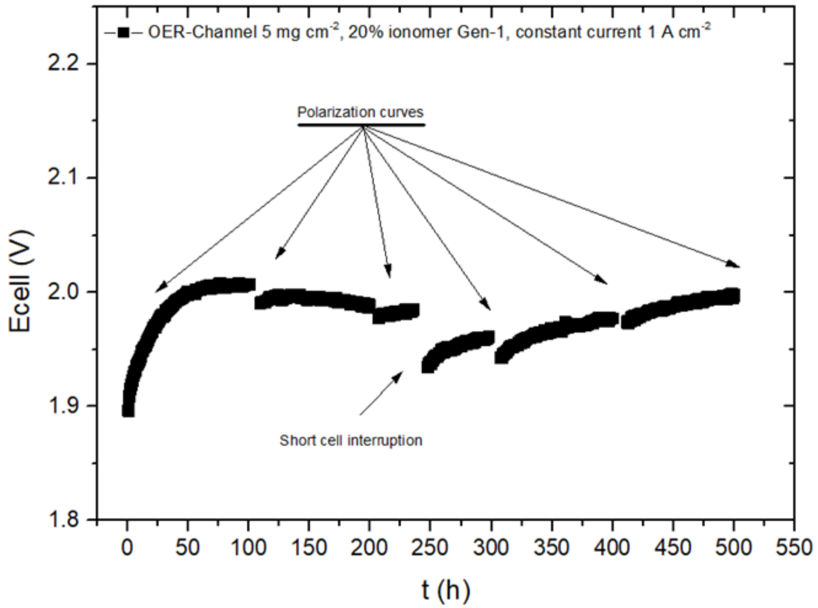
OER catalysts development
Electrochemical performance

***In situ* testing- single cell performance**

- OER- CHANNEL catalyst loading: 5mg cm^{-2}
- OER-CHANNEL catalyst present cell voltage of < 1.8 V at 1 A cm^{-2}
- 500h cell testing present stable and robust catalyst and electrode structure with insignificant degradation rates

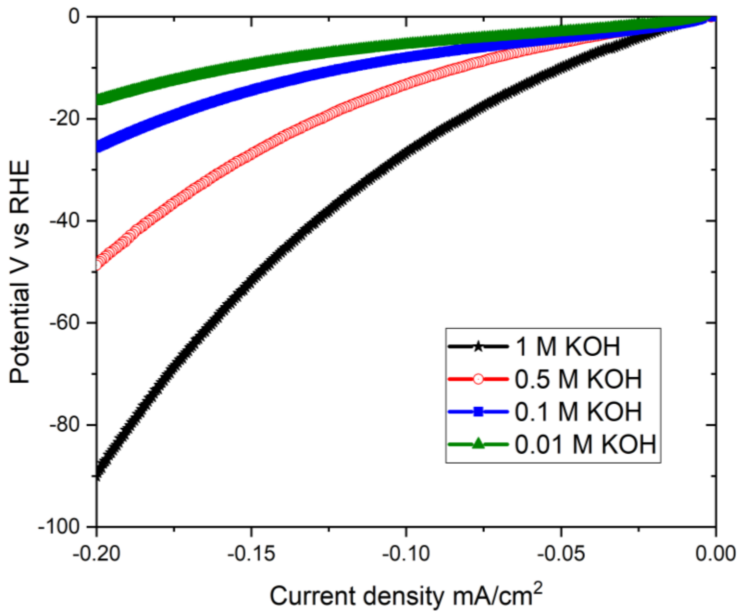


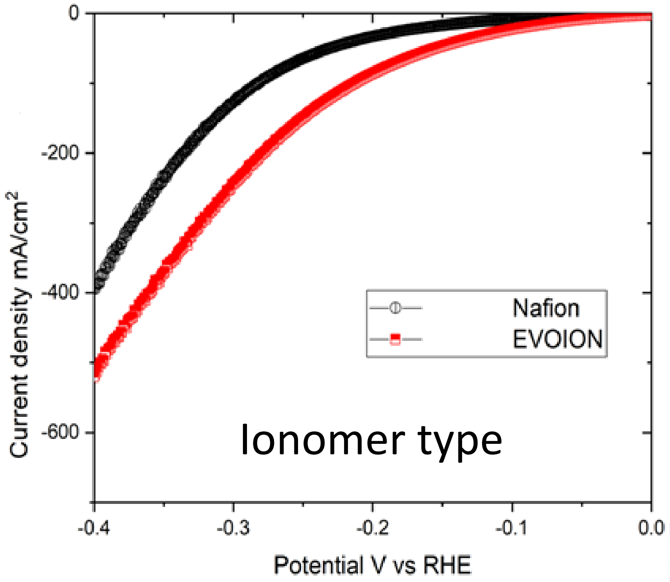


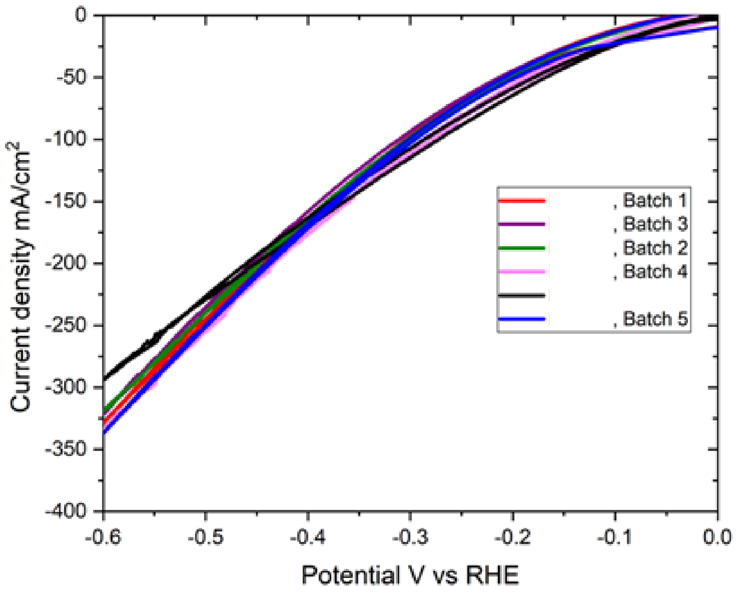
This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 875088. This Joint undertaking receives support from the European Union's Horizon 2020 research innovation programme and Hydrogen Europe and Hydrogen Europe Research

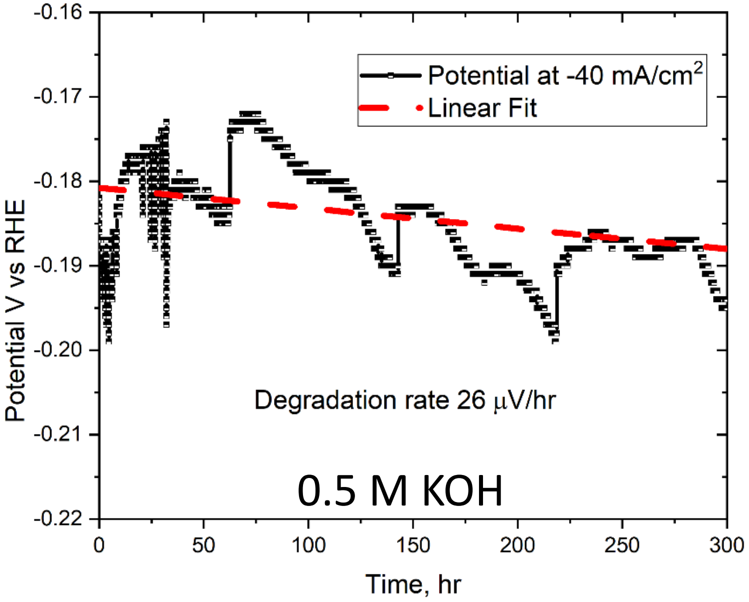
HER catalyst development

- HER-CHANNEL catalyst achieves <150 mV overpotential at 10 mA cm^{-2}_{geo} in <1 MKOH.
- The catalyst shows only 26 µV/hr degradation rate.
- HER catalysts achieve performance comparable to Pt/C in alkaline



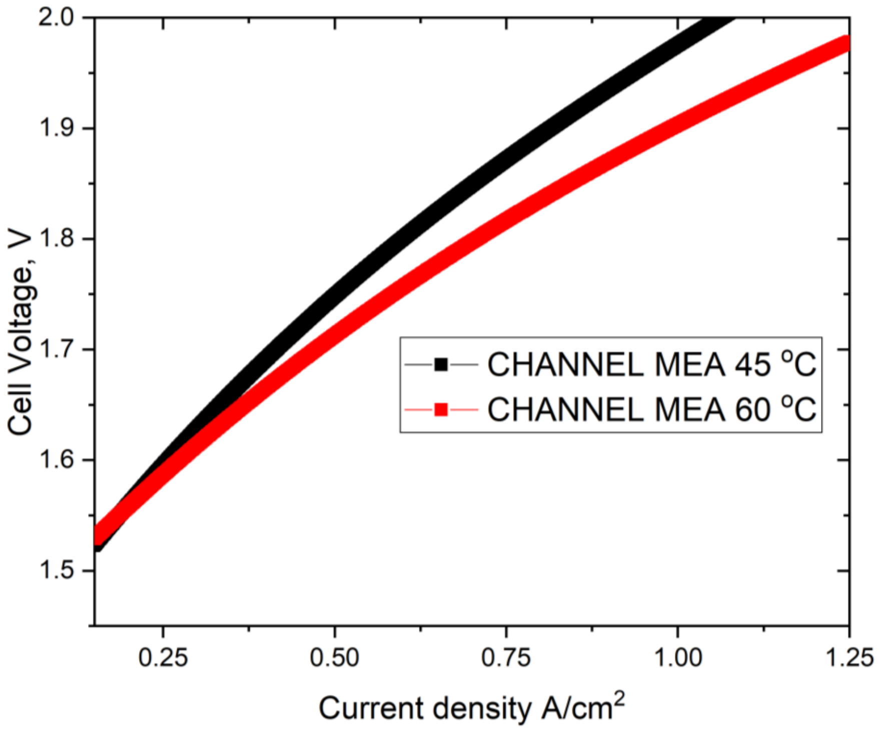


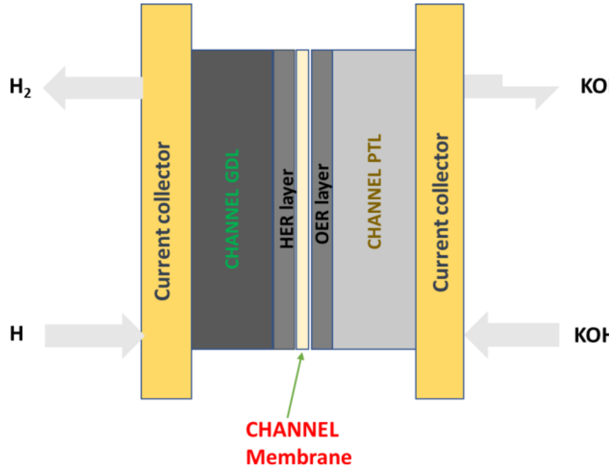


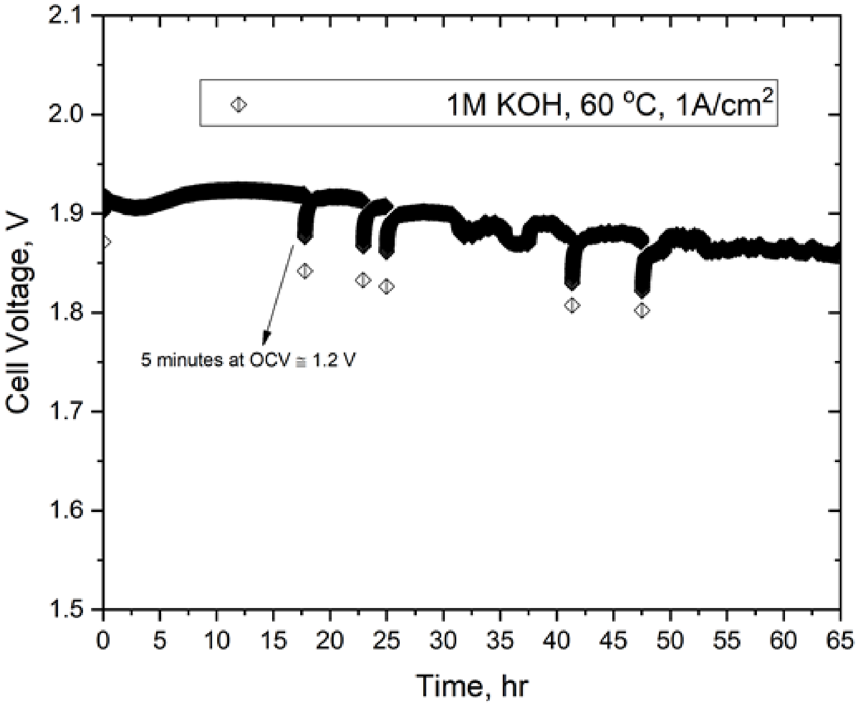


CHANNEL Full non-PGM electrolyzer

Performance of 1 A cm^{-2} at 1.9 V with good stability.







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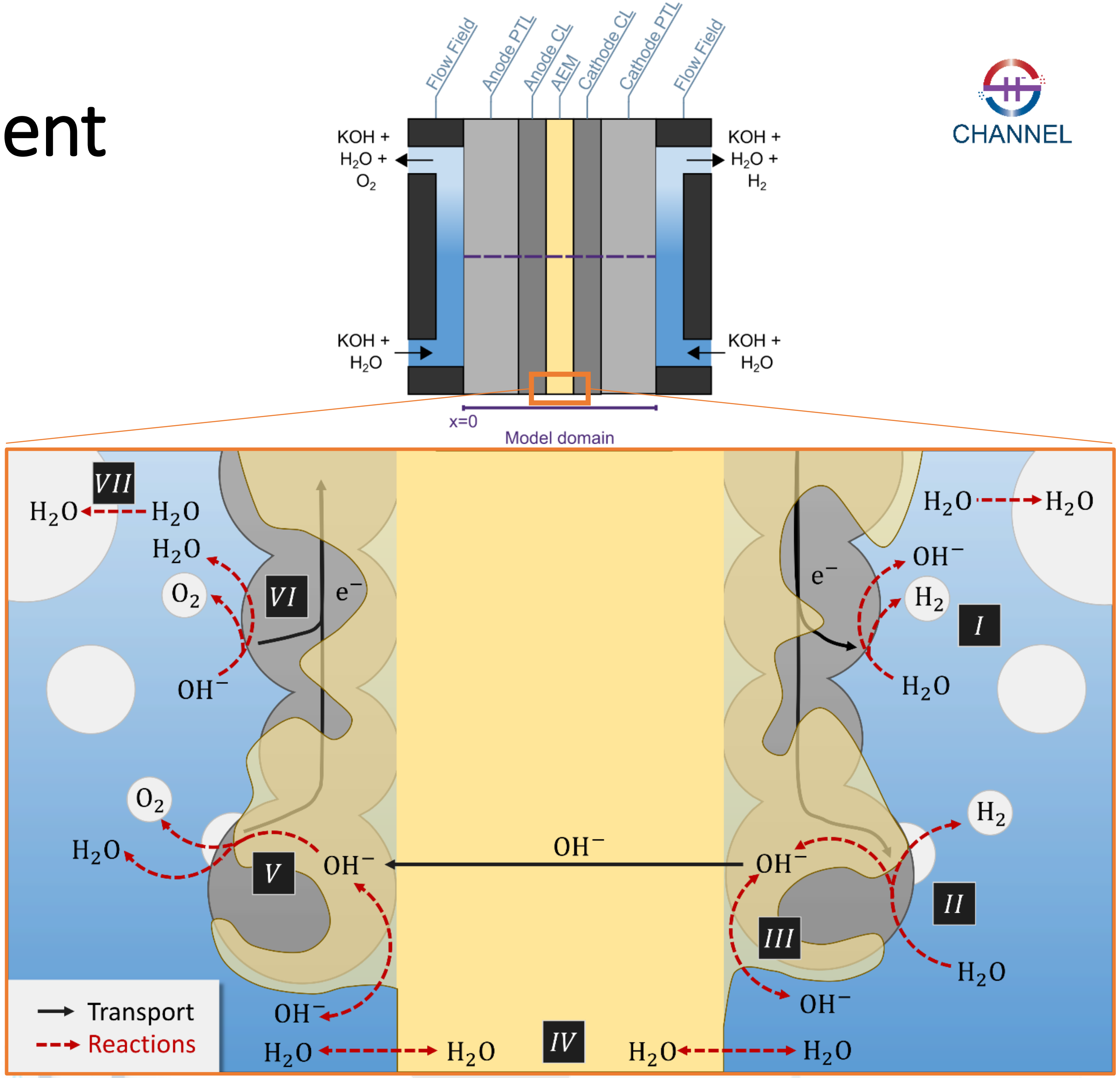
Development of 1-D transient AEM electrolyzer model

- Unique challenges for AEM electrolysis include:
  - Parallel ion conduction pathways
    - Liquid electrolyte (I, VI)
    - Solid ionomer (II, V)
    - Ion exchange (III)
  - Water absorption, desorption, and transport in AEM (IV)
  - Evaporation and condensation (VII)
- Coupled equations are solved using custom MATLAB scripts



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Stack development

- 100 cm^2 active area stack

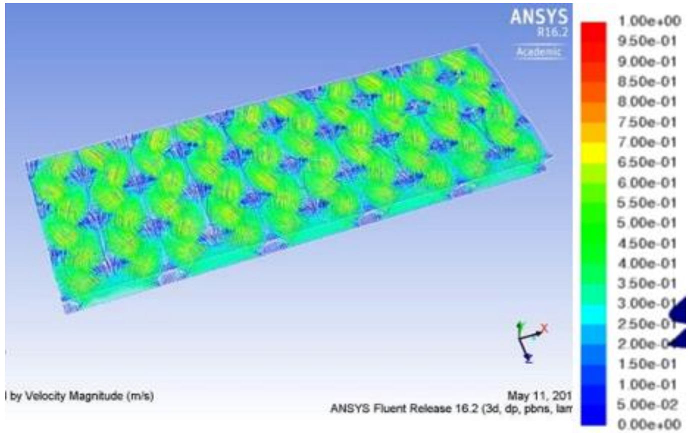
- *Cell voltages of <1.85 V per cell at 1 A cm^{-2} below 50°C, using diluted electrolytes (≤ 1 M KOH)*

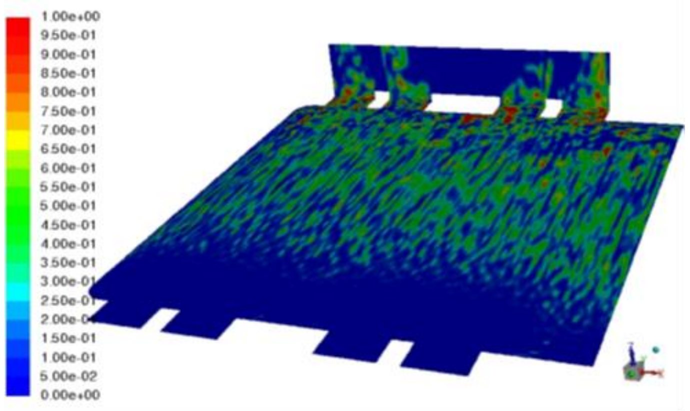
- *Operating differential pressure 30 bar*

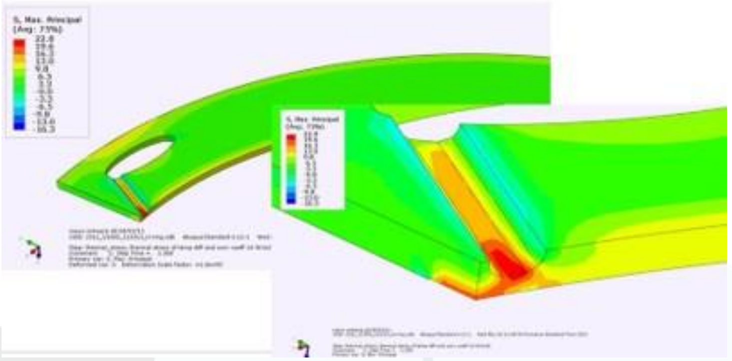
- *Maintain stable performance for 2,000 h with a degradation gap of less than 50 mV*

In addition, all electronic conductive components, PTLs, foams, mesh and BPPs, must maintain low ICR

- *< 20 mΩ cm^2 after ex-situ AST test in KOH and validated in 25 cm^2 AEM single cell*







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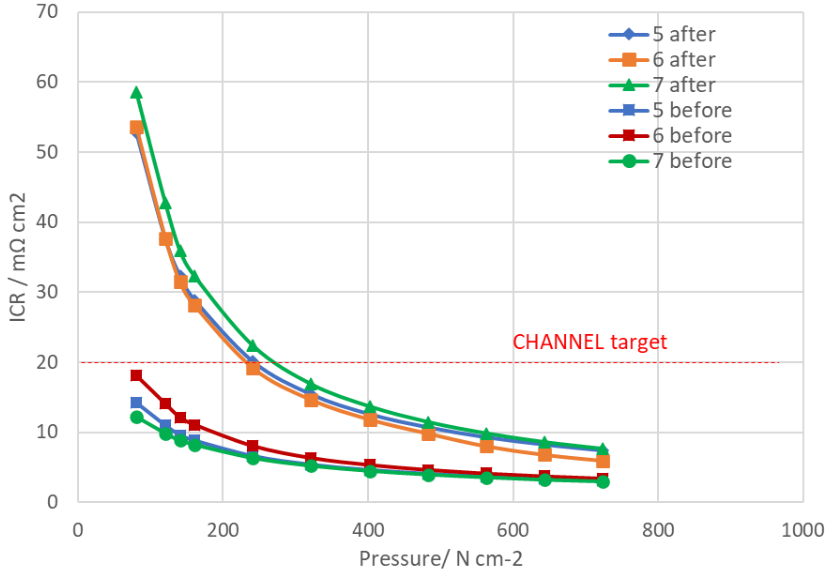
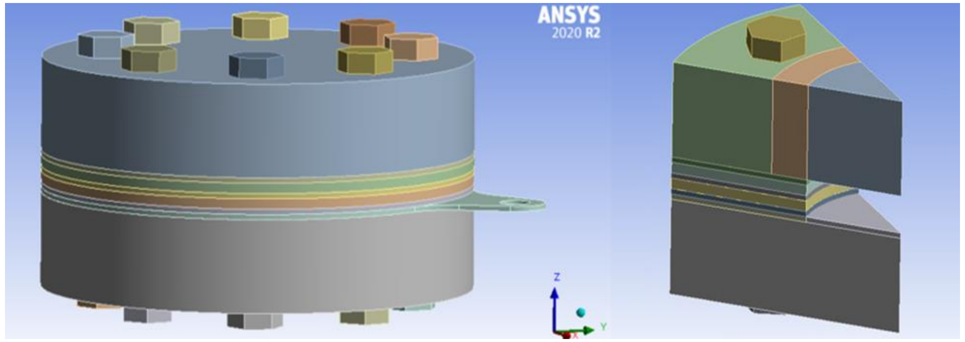
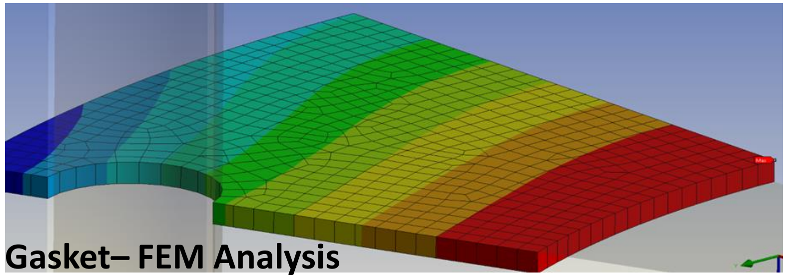
Bipolar plates / PTLs / Flow field

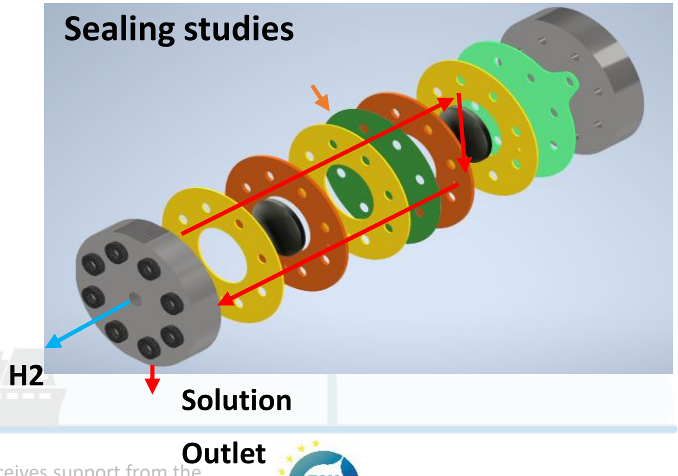
- Bipolar materials
  - Ti
  - SS AISI 304L
  - Inconel 625
  - SS AISI 316L
  - Nickel
- PTL materials
  - SS AISI 316L
  - Nickel
  - Titanium

Interfacial contact resistance









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Summary

- OER and HER CHANNEL catalysts exhibit excellent performance in *ex situ* and in *in situ* electrochemical testing
- Production of both electrocatalysts is cost efficient and simple
- Development of 1-D transient model to predict durability of catalyst layers over time, and probing local effects
- Preliminary stack design concluded and validation of PTLs and Bipolar plate materials, including sealings
- Construct prelimanary stack underway

The CHANNEL project has received funding from the European Union's Horizon 2020 research and innovation programme under GA No. 875088. The information in this presentation reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein

CHANNEL

Future work

- Further optimisation of membranes and ionomers to reach the KPIs
- Further optimization of non-PGM electrocatalysts and catalyst layers to achieve the performance of < 1,85 V per cell at 1 A cm^{-2} , while testing with non-PGMs.
- Scaling-up of synthesis batches to larger quantities without compromising electrocatalytic performance
- Understanding catalyst and ionomer interaction to reach better chemical compatibilities
- Testing of the preliminary short stack before end of 2021, and finalising the final 2kW stack design
- *Develop a beyond the state-of-the-art AEM electrolyser system including power supply, system control, gas drying unit achieving:*
    - *An electrolyser cost < 600 €/kW at 500 kW system level*
    - *An energy consumption < 4.7 kWh/Nm³ at a system level*
    - *A 100% EU supply chain and increased EU competitiveness in production of green hydrogen from renewable energy sources.*
- Explore the upscale and commercialisation of the newly developed technology.

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Acknowledgements

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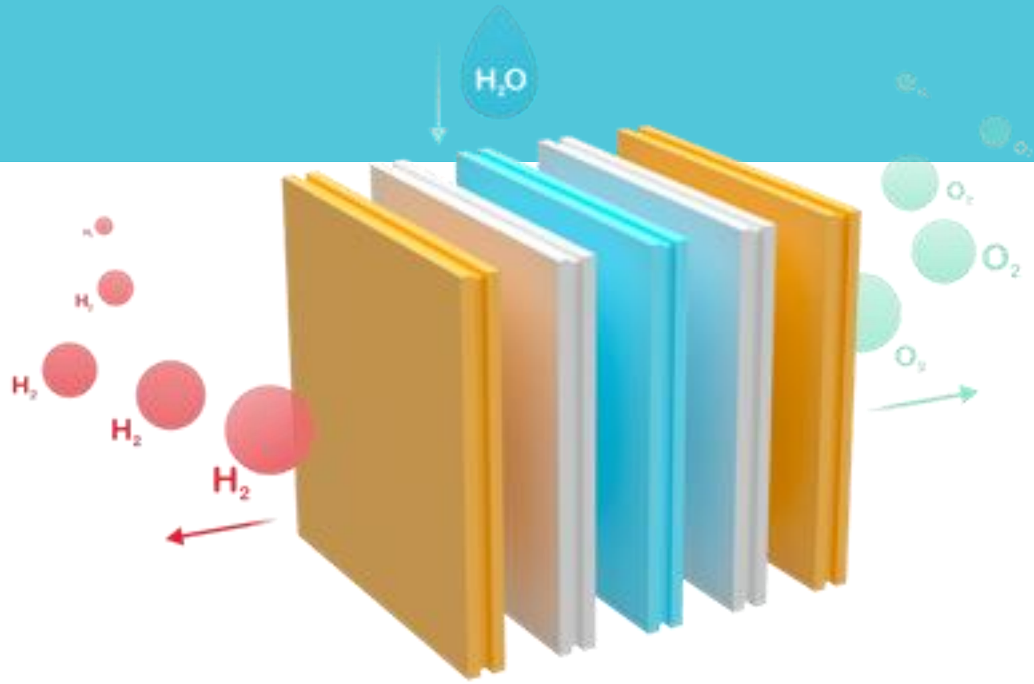
NEWELY

Next Generation Water Electrolyser

Next Generation Alkaline Membrane Water Electrolysers with Improved Components and Materials



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Contents

- Short summary about NEWELY
- Objectives of the project
- Partners and their roles
- Concept of NEWELY
- Preliminary results
- Video

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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

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.

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.

Partners and their roles in the project

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

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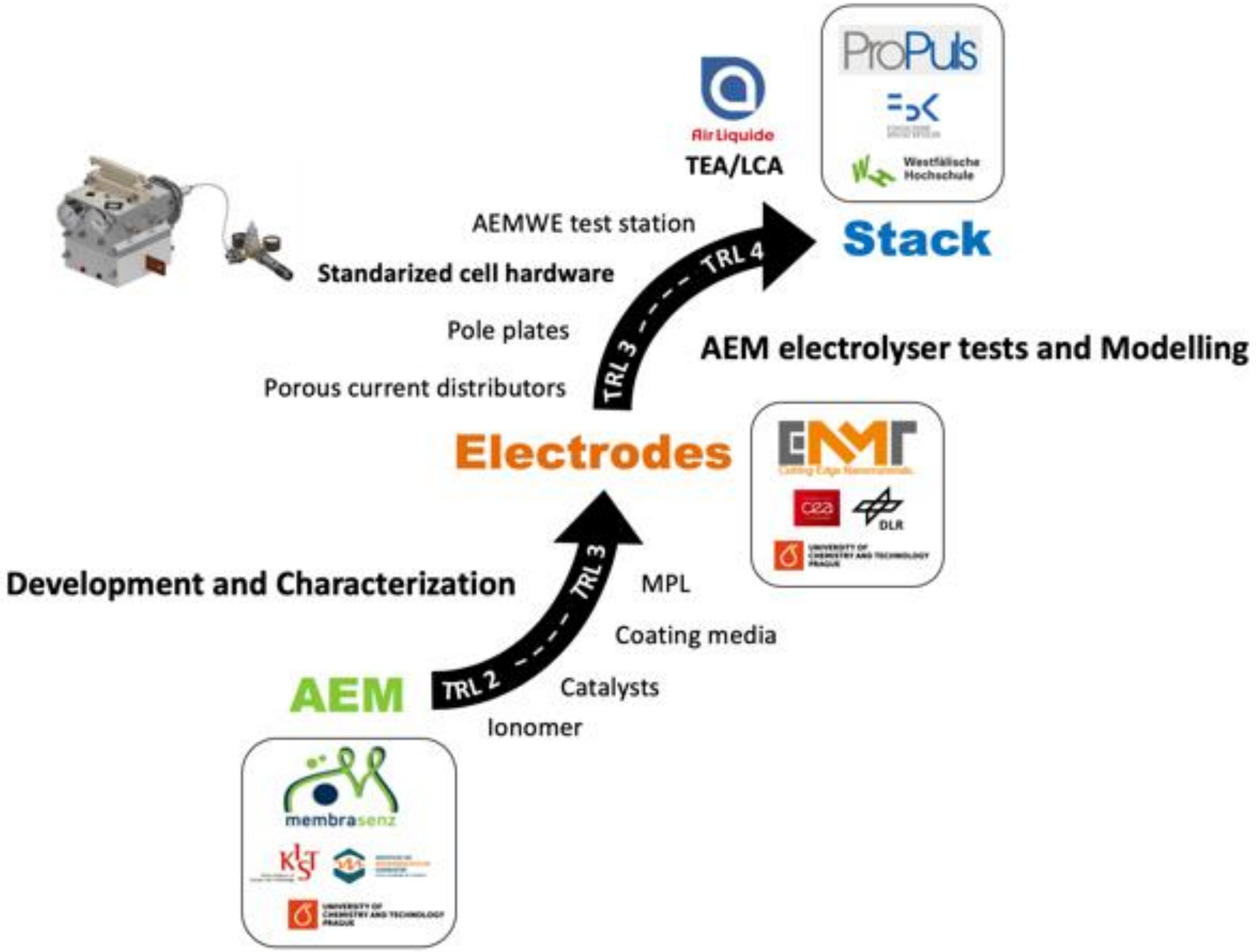
NEWELY
Next Generation Water Electrolyser

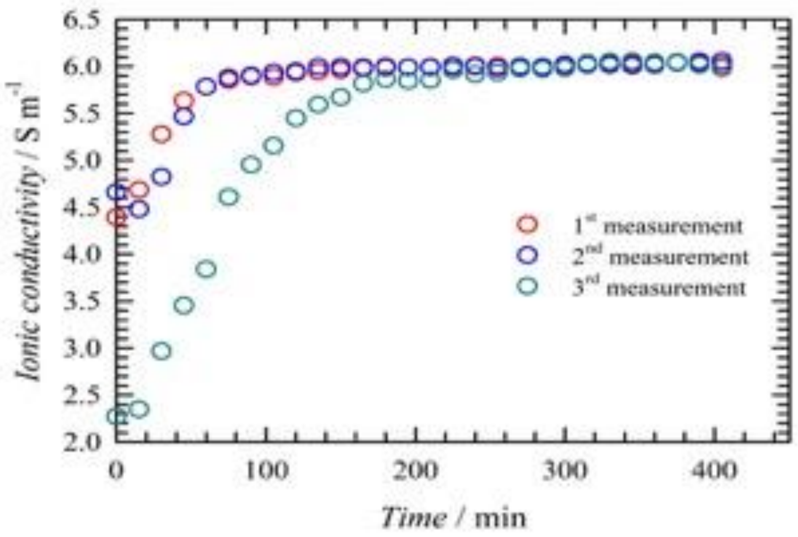
Concept of NEWELY



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

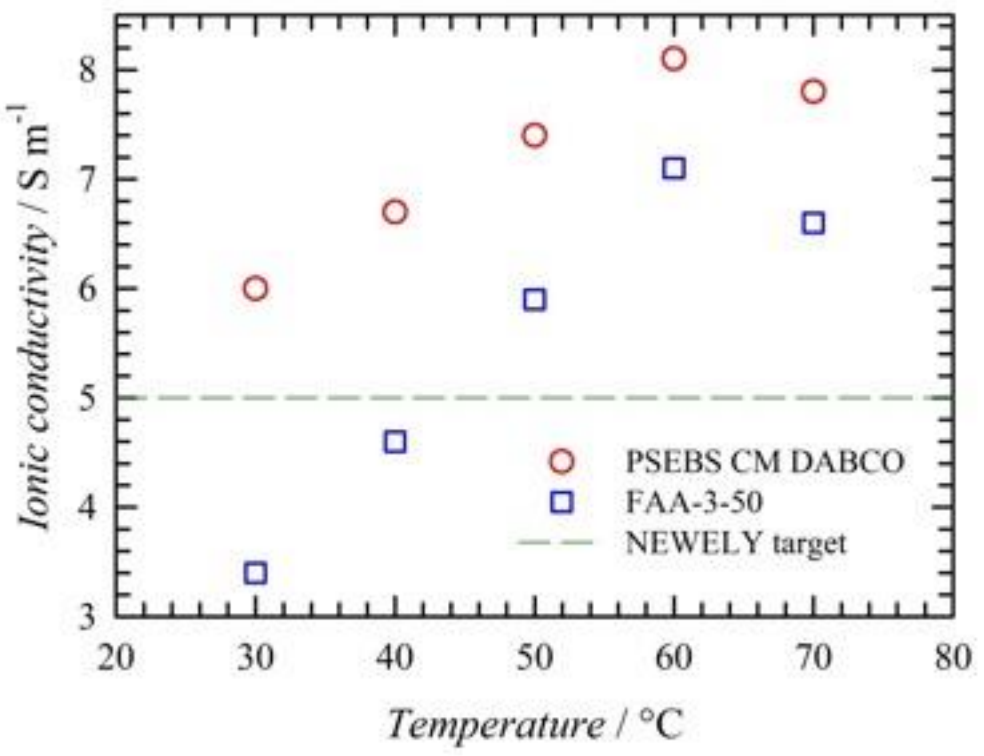


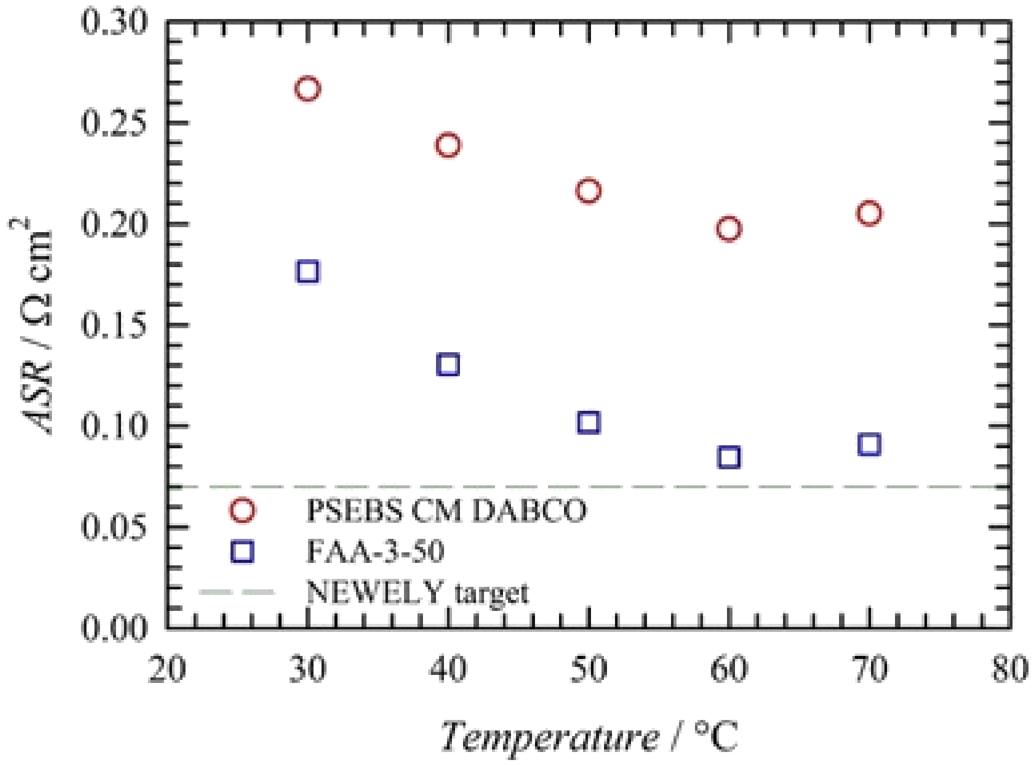
PSEBS-CM-DBC membrane properties

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, $\Omega\ cm^2$	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):

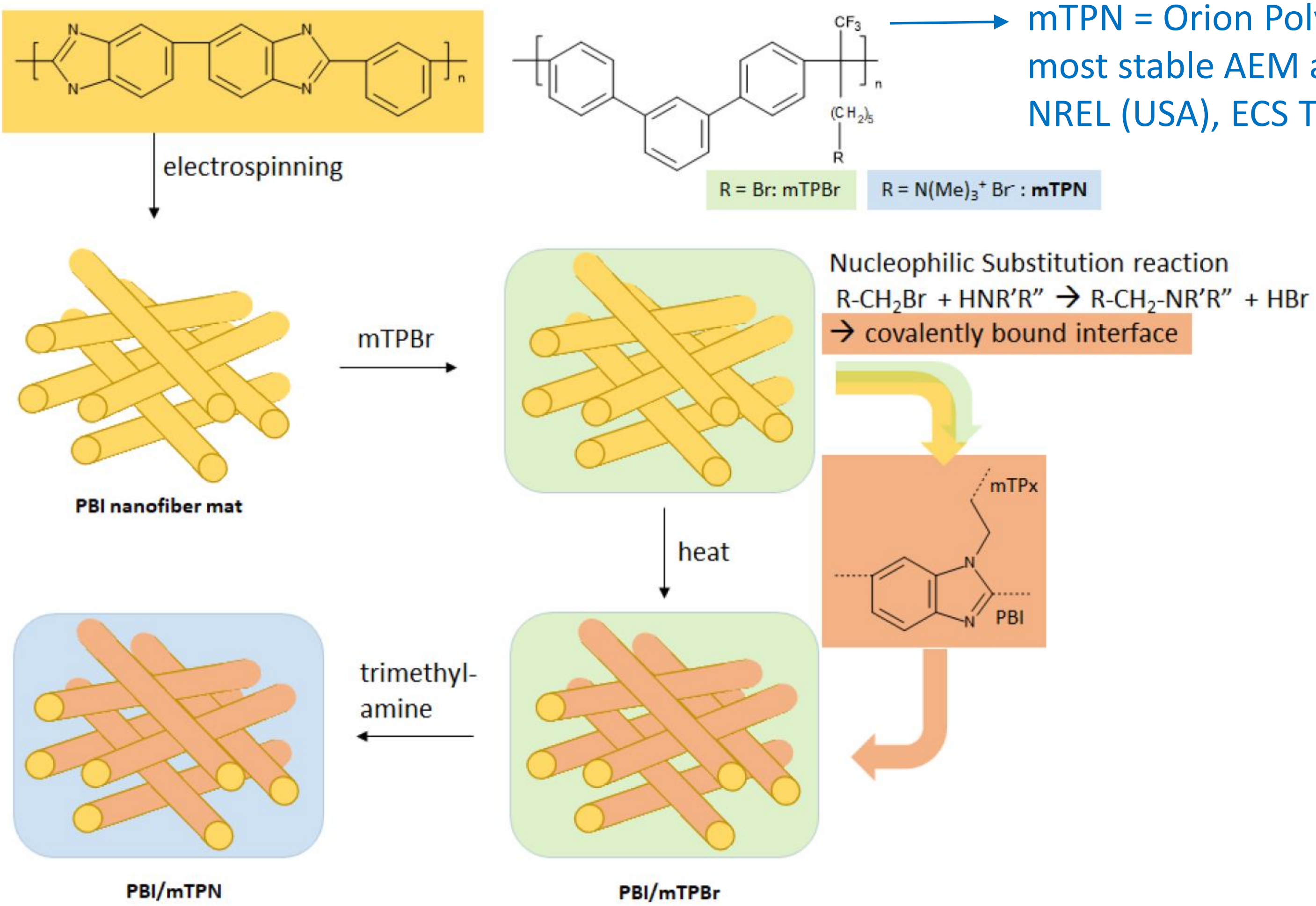
- calculated from measured ionic conductivity

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

NEWELY
Next Generation Water Electrolyser

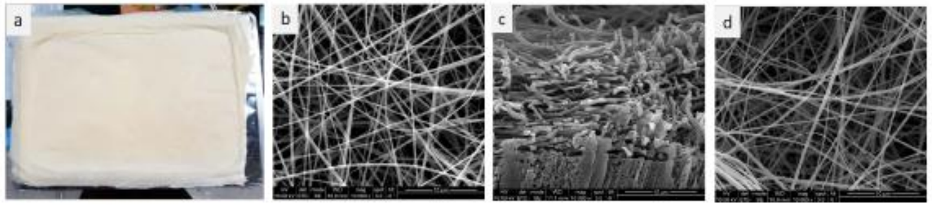
Membrane and binder Type 2 – based on Orion Polymer TM1

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

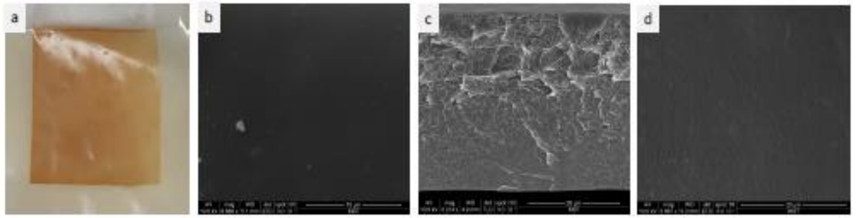


mTPN = Orion Polymer TM1
most stable AEM among 50 membranes tested by NREL (USA), ECS Trans. 2019 (92) 723

PBI nanofiber mat made by electrospinning



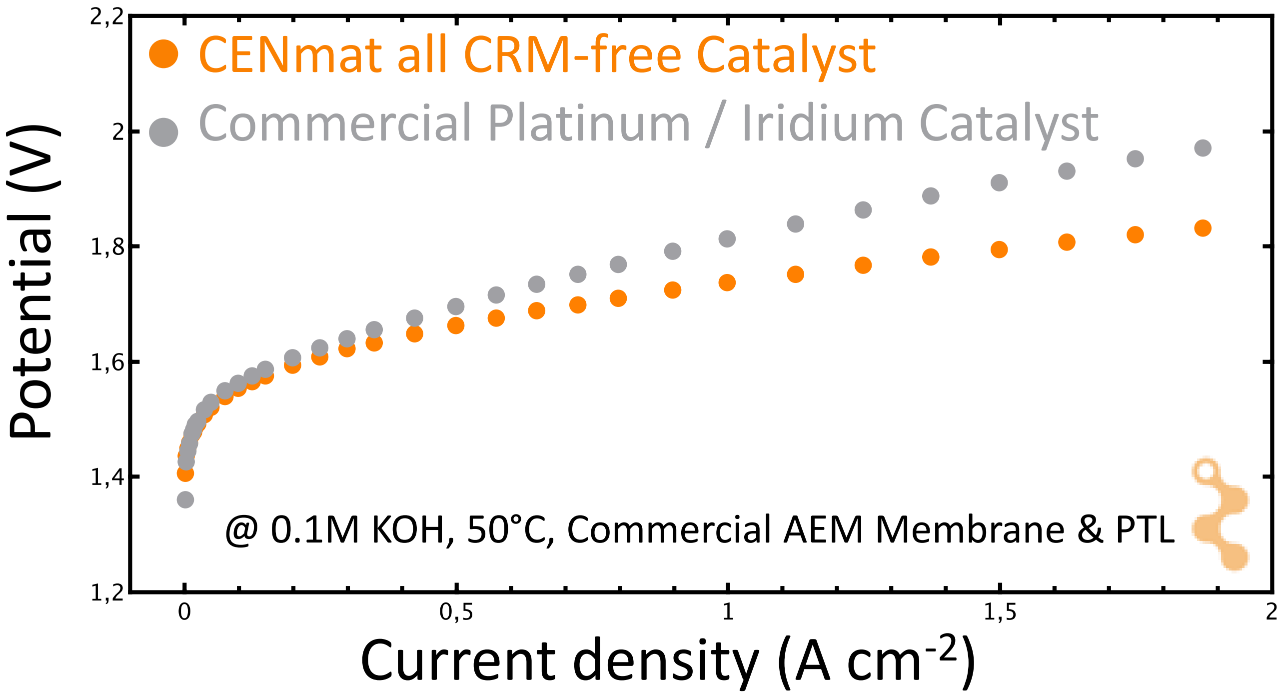
After pore filling with mTPBr

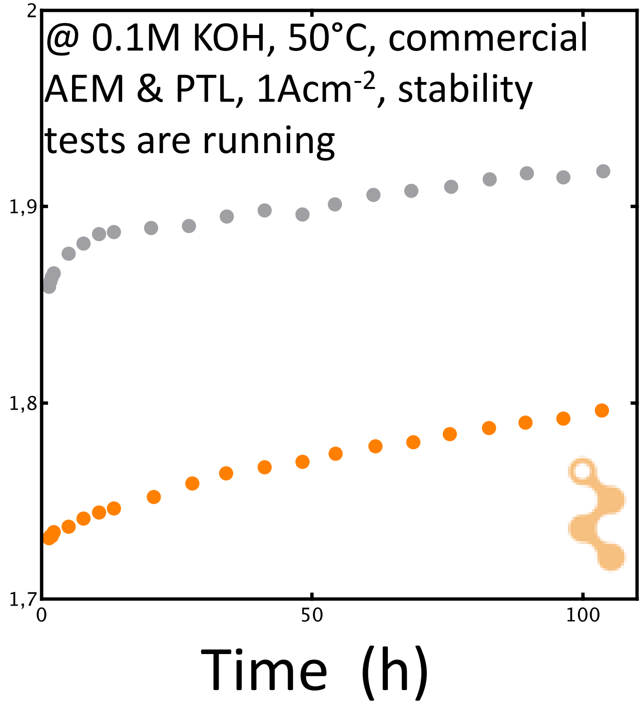


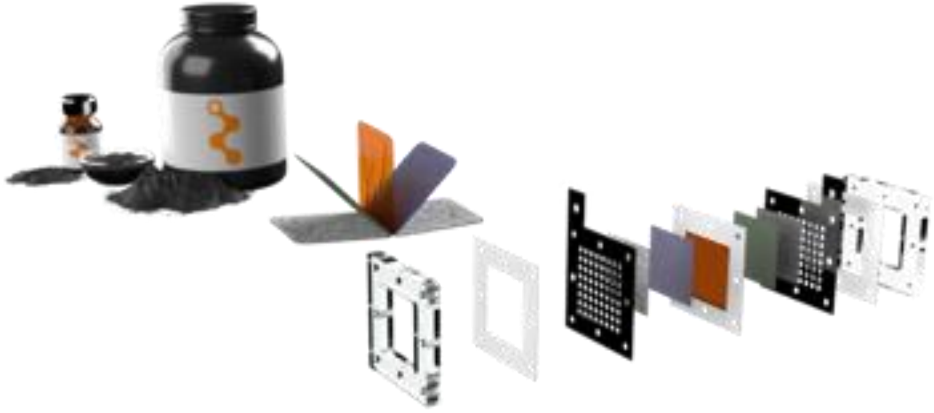
Conductivity in DI water: 62 mS/cm

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

Catalysts - CENmat







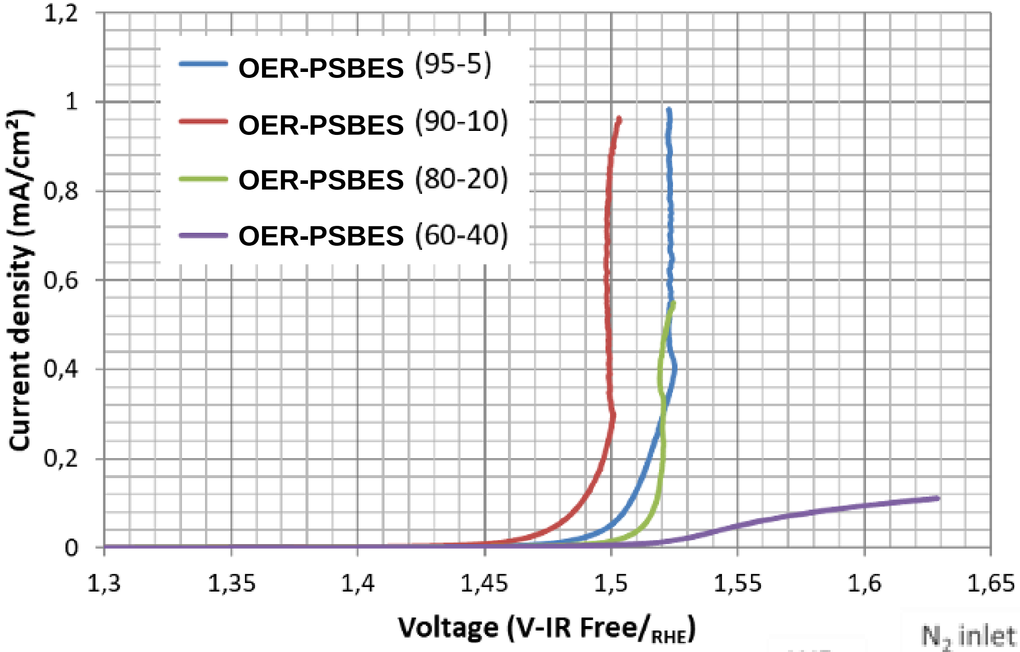
CENmat's proprietary:

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

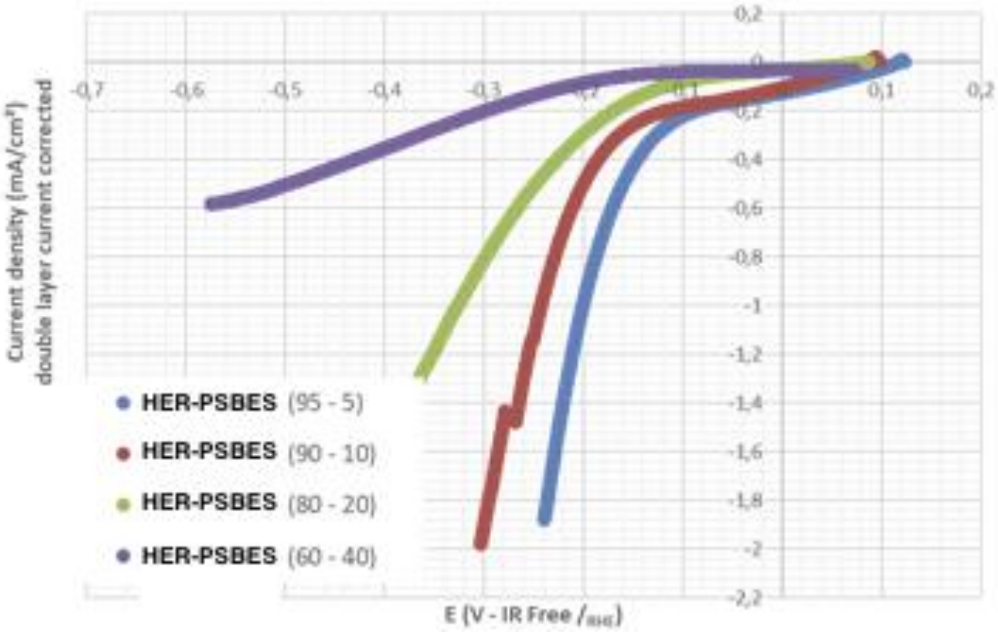
-> Allows to reduce the costs of the AEM electrolysis to CAPEX 400-500€/kW (system level) and LCOH to 3€/kg already after 3000h hours of operation

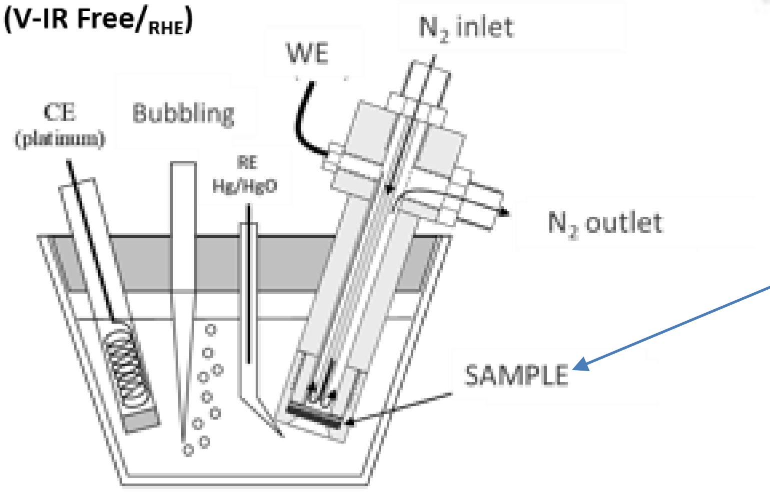
Catalysts - CEA

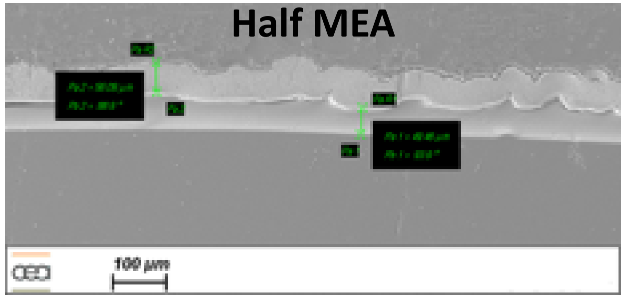
Influence of the ionomer content in the anode catalyst layer (OER)



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



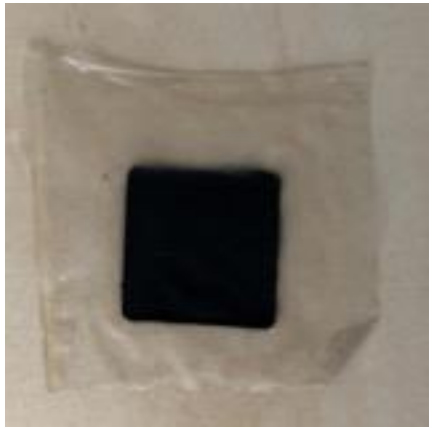


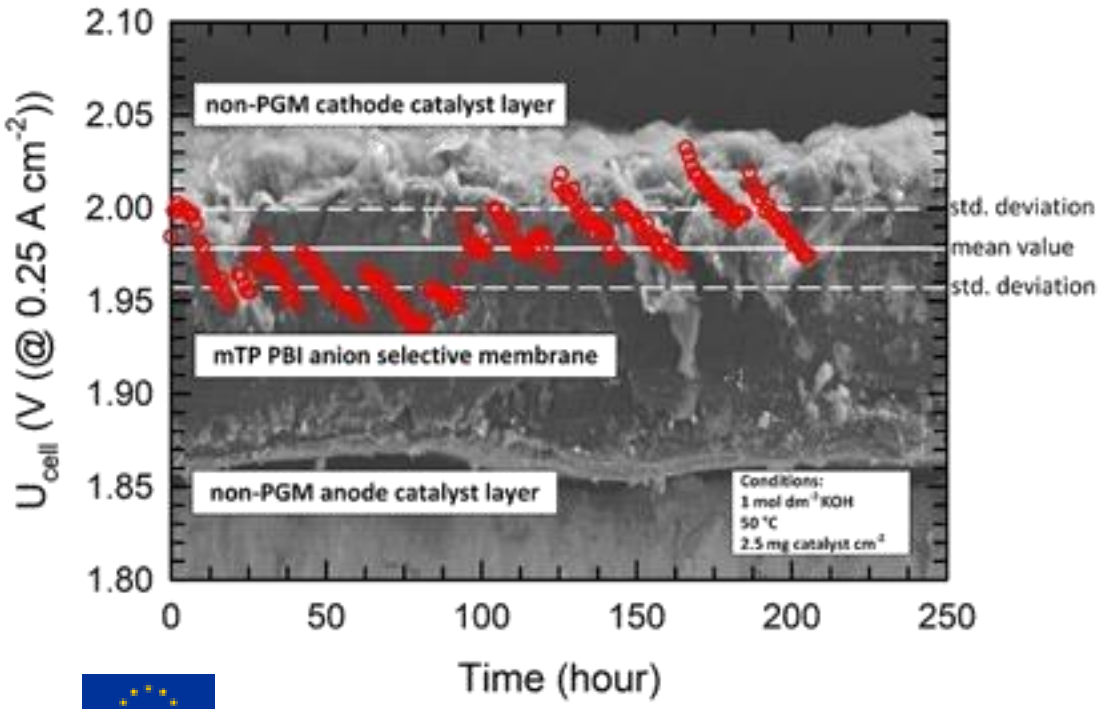


CCM & MEA – UCPT + DLR

MEA @ UCPT

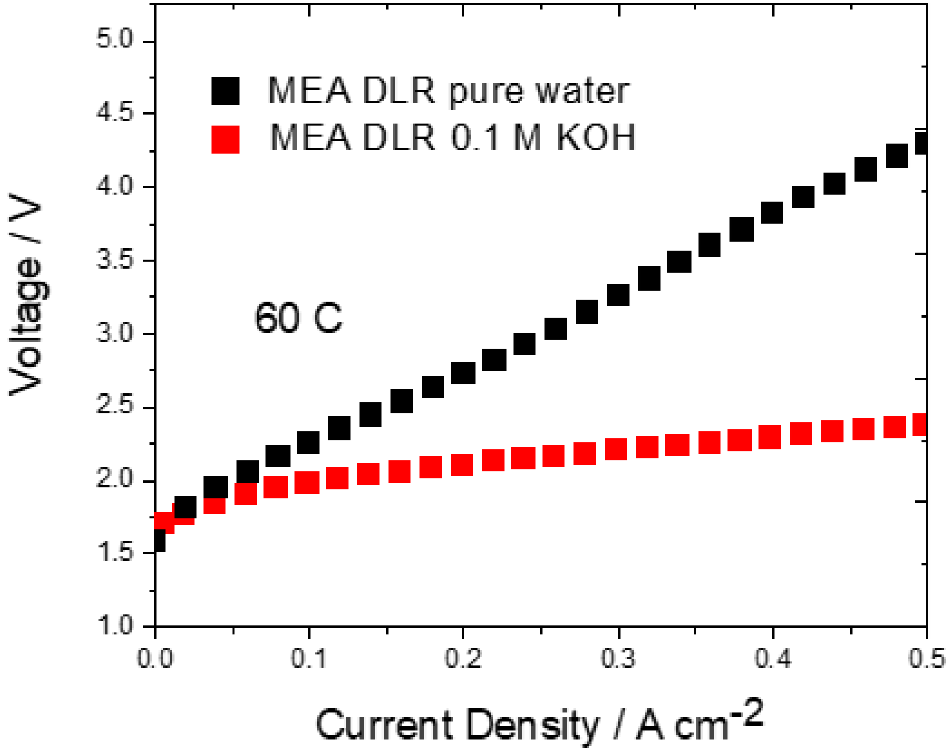
- Exclusively the project materials were used
- Average cell voltage of (1.98 ± 0.02) V at 0.25 A cm^{-2} over 200 hours experiment





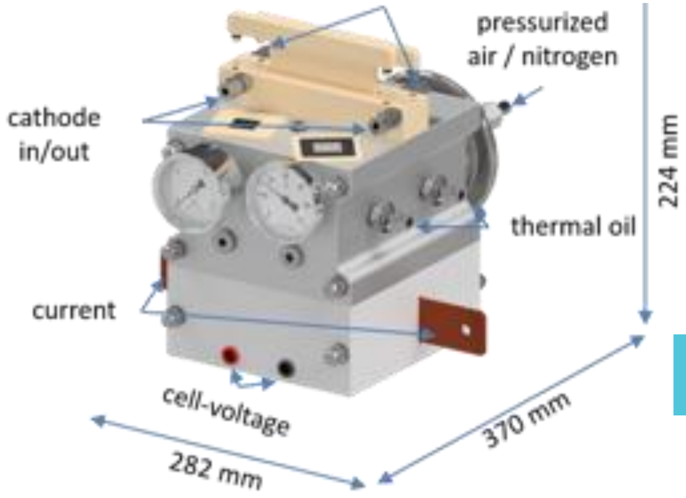
MEA @ DLR

- Exclusively the project materials were used



NEWELY
Next Generation Water Electrolyser

Stack concept and test station



New design

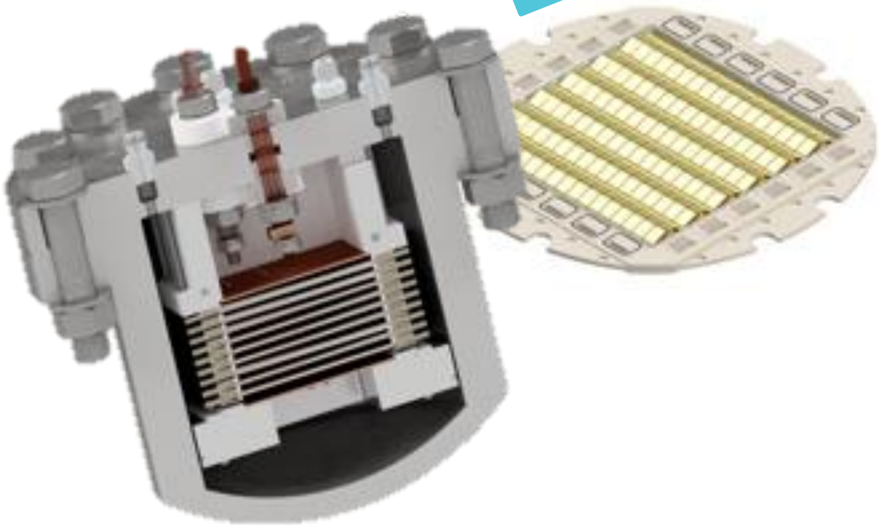
Test station for AEMWE

- 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

TEA of AEMWE

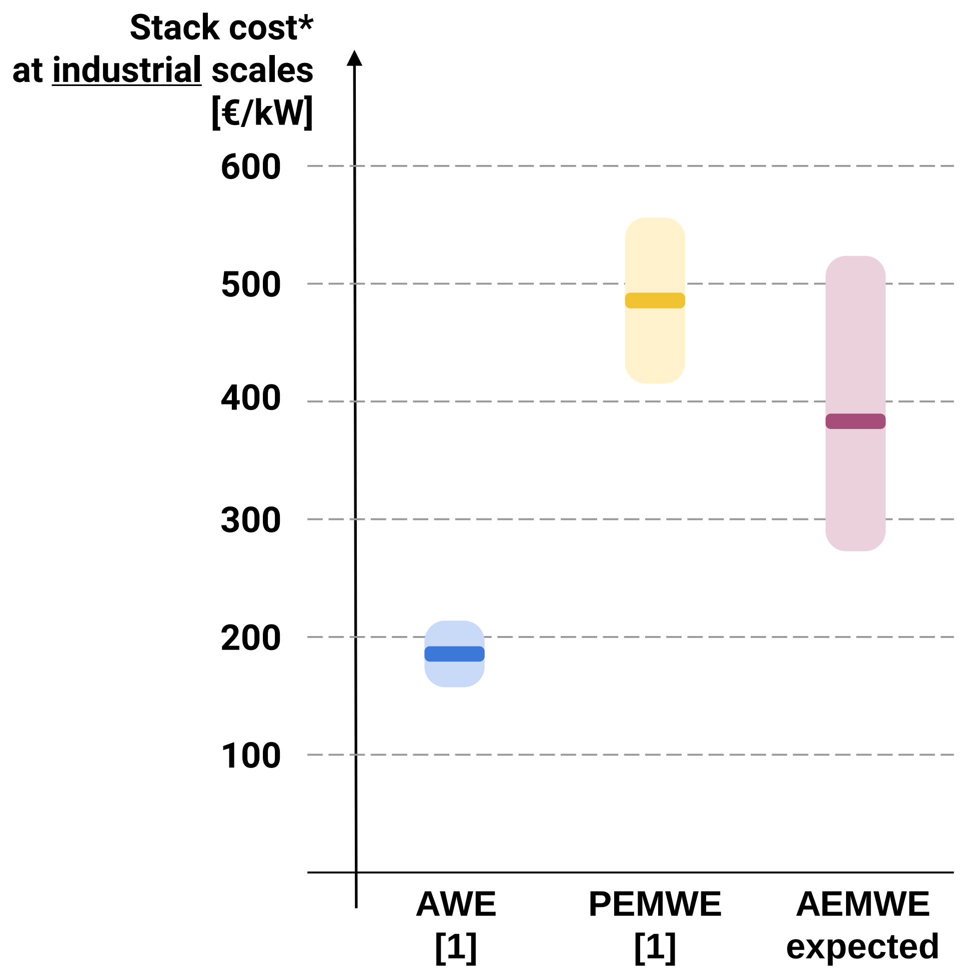
A **Techno-Economic Analysis (TEA)** will be performed

- 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**.

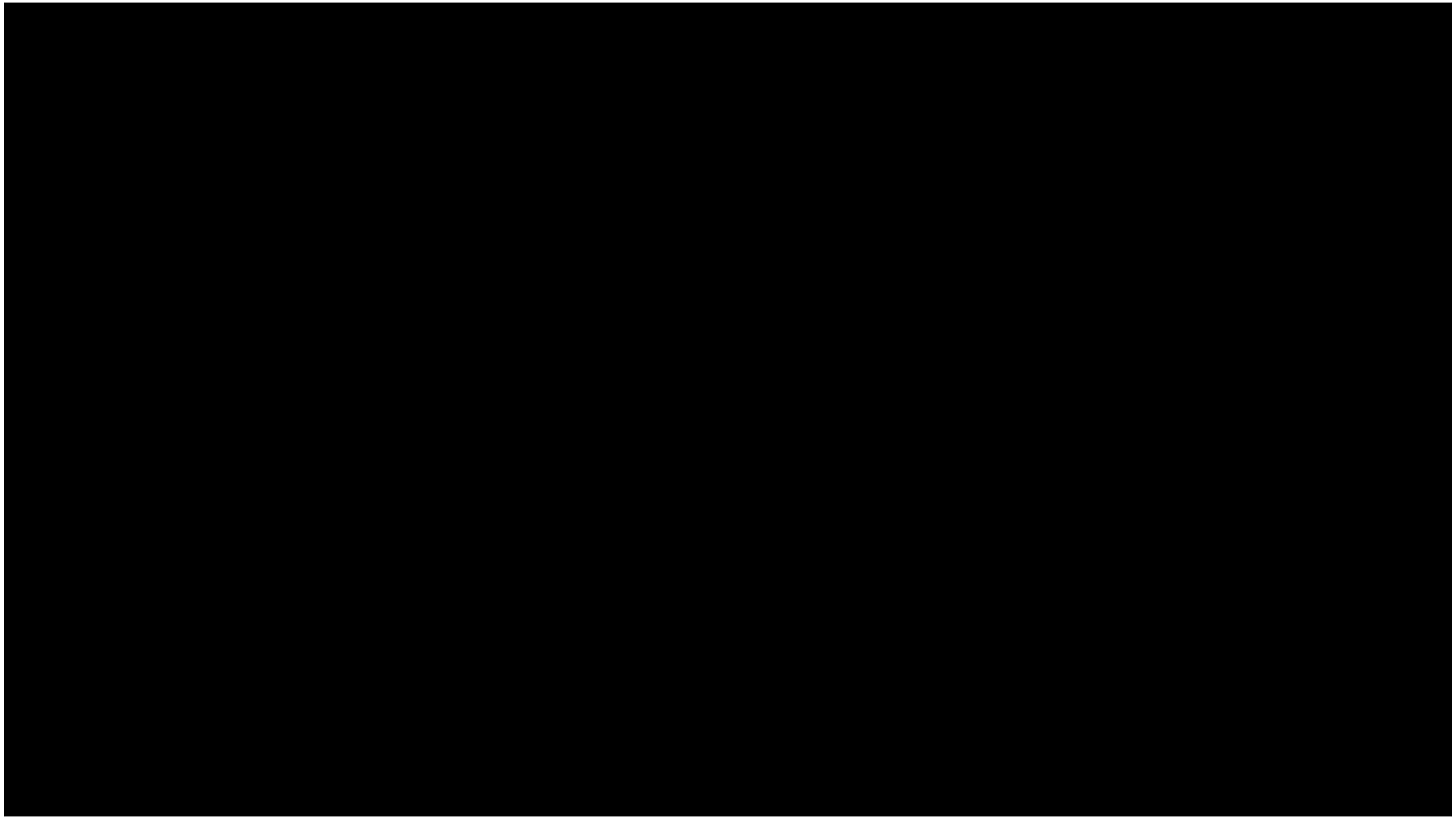
* Cost excluding construction and contingencies

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



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.

Video for general public on AEMWE



Video can be watched here: www.newely.eu

Thank you for your attention!

www.newely.eu

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The AEM-HUB Cluster

ANIONE

NEWELY
Next Generation Water Electrolyser
H_2

CHANNEL

AEM
HUB
Reshaping green hydrogen production

The projects in the **AEM-Hub** aim at **developing solutions** for efficient and sustainable storage of renewable energy by converting electricity into **hydrogen** via advanced anion exchange membrane (**AEM**) water electrolysis (**WE**).

AEM HUB

Reshaping green hydrogen production

Website coming soon to be implemented into Projects' webpages

Objectives

- To develop standardised test protocols and terminology for AEM electrolysis research
- To develop innovative AEMs with high performances
- To optimise non-PGM electrocatalysts for AEM WE systems
- To demonstrate 2 kW AEM WE stack prototypes operating at high pressure

Impacts

The AEM-HUB projects will push the development of AEM water electrolysis systems towards lower costs, higher efficiency, and increased sustainability. This will pave the way for larger-scale implementation of the technology and make Europe a global leader in green hydrogen production.

Learn more on how we are pursuing our mission of a green and sustainable world!

NEWELY
- www.newely.eu
- NewelyProject/
- company/newely-project/

CHANNEL
- www.channel-fch.eu
- CHANNEL_FCH
- company/channel-fch/

ANIONE
- www.anione.eu

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HORIZON RESULTS BOOSTER

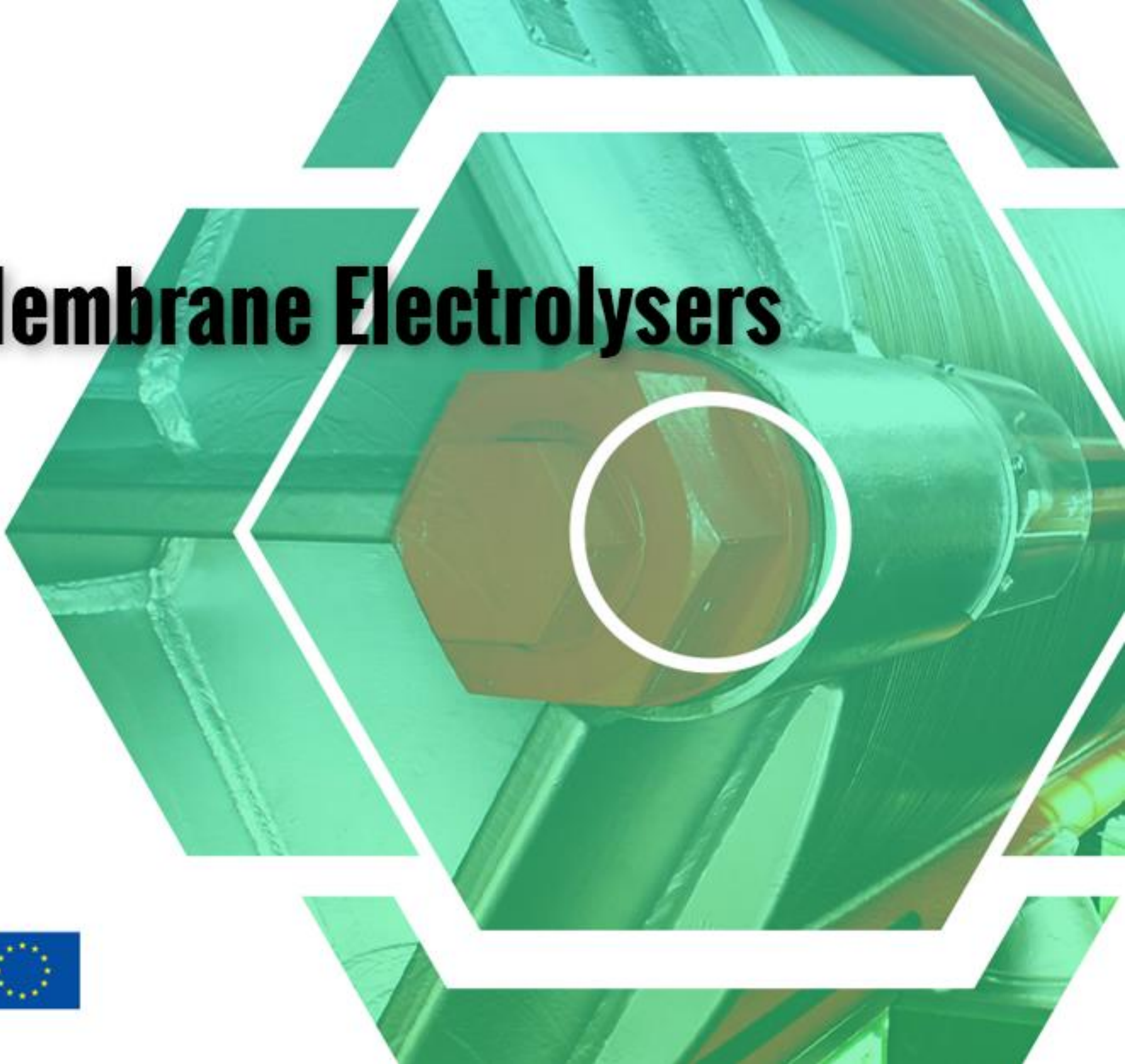
An initiative of the European Commission

Webinar

Anion Exchange Membrane Electrolysers

6 July 2021

14:00 - 15:30 CEST



FCH

Hydrogen Europe Research