CHANNEL

Development of the most cost-efficient hydrogen production unit based on anion exchange membrane electrolysis

European Hydrogen Week

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on behalf of

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European Commission

Project Overview

- Call topic: FCH-02-4-2019: New Anion Exchange Membrane Electrolysers
- Project dates: 2020-2022
- Total project budget: 2M €
- TRL: 2-3
- Coordinator: SINTEF

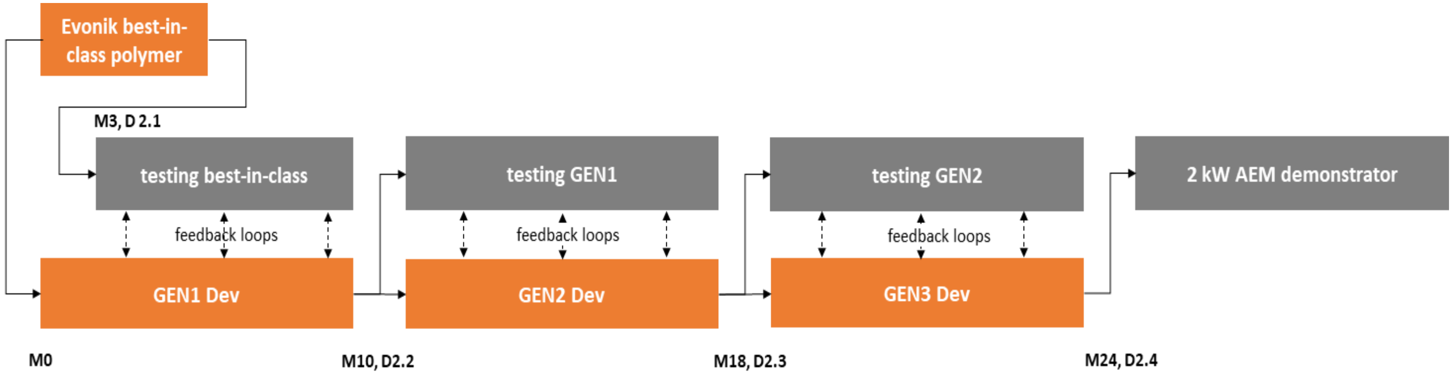
The aim of CHANNEL is to design, construct and test a cost-efficient, 2 kW AEM water electrolyser stack and balance of plant able to operate at differential pressure.

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

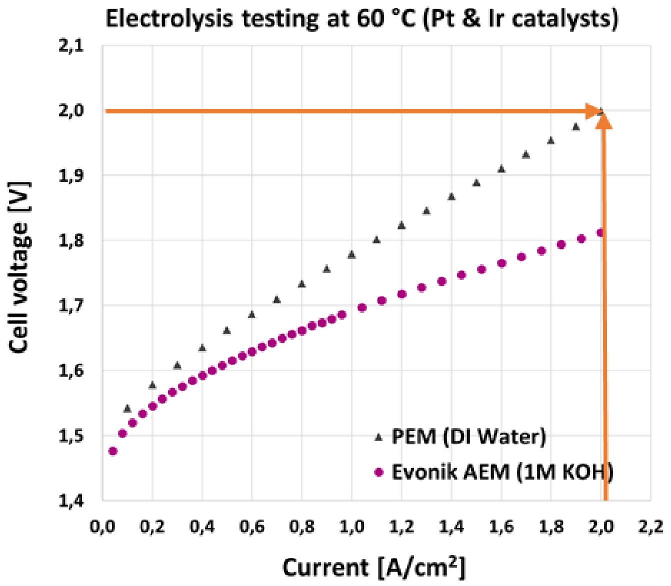
CHANNEL Specific Objectives

- To further develop best-in-class EVONIK **polymer materials** to fulfil the **membrane** and **ionomer** KPI's according to the FCHJU objective 2.4-2019
- Optimize nanostructured Ni-based **electrocatalysts** with respect to activity and durability for the **HER** and **OER**
- Optimize 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
- 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 , 30 bar differential pressure
- To develop a **low-cost electrolyser** unit with a CAPEX equal to or below current classical alkaline electrolyser

Progress: membrane and ionomer



KPI	UNIT	OBJECTIVE FCHJU 2.4-2019	OBJECTIVE CHANNEL
Area specifc resitance ASR, T = RT	Ω cm²	< 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]x 10^{-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



- Evonik AEM outperforms by 0.186 V (@ 60°C @ 2 A/cm^2 1M KOH) benchmark PEM membrane Nafion N-115 (60°C @ 2 A/cm^2 DI-H_2O)
- ***Implementing Evonik AEM can enable reduction of operational costs up to 9.5% in comparison to PEM water electrolysis***

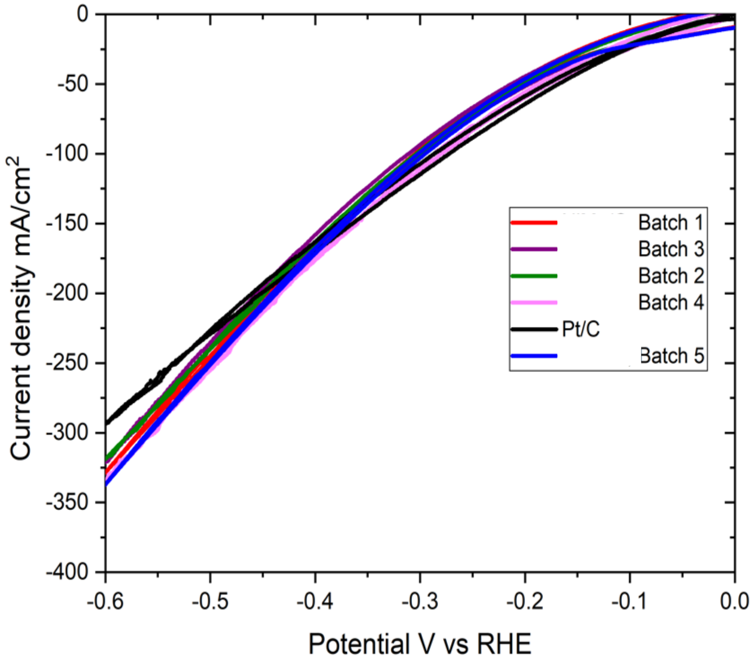
Single cell, 25 cm^2 active area

Progress: catalyst development

Overpotential at 10 mA cm^{-2}_{geo} in <1 M KOH

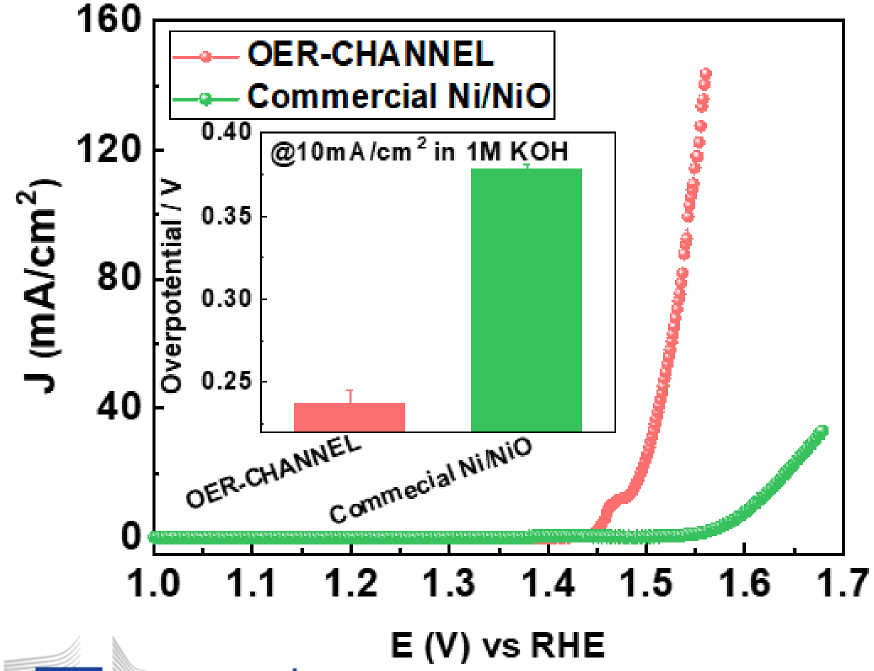
Hydrogen Evolution Reaction (HER)

- HER-CHANNEL catalyst: <150 mV overpotential
- Performance comparable to Pt/C in alkaline electrolyte.

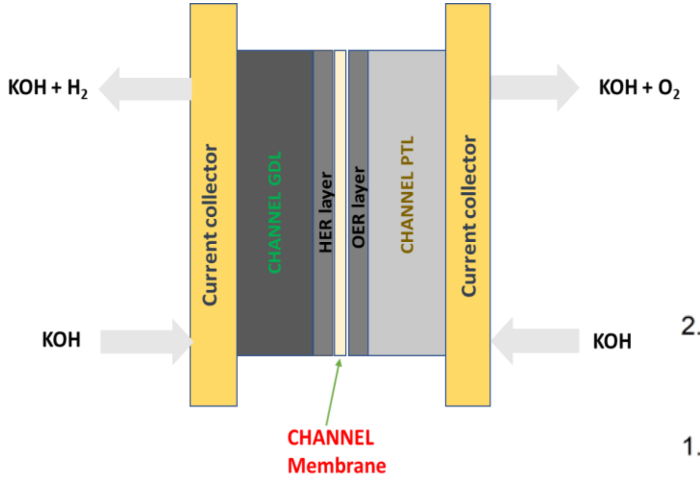


Oxygen Evolution Reaction (OER)

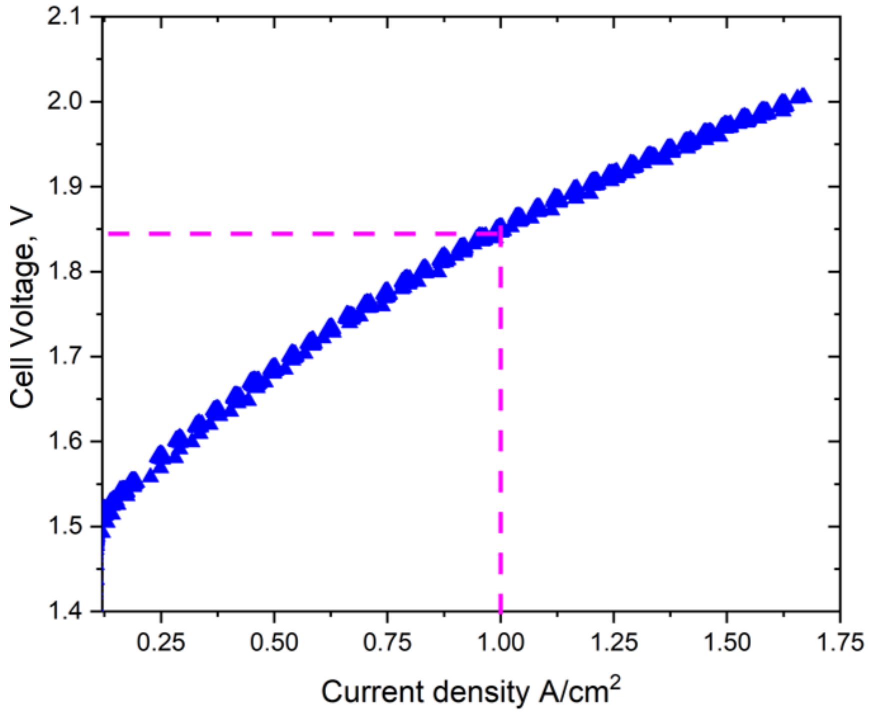
- OER-CHANNEL catalyst: <250 mV overpotential



Progress: Electrolyser performance



1.85 V at 1 A cm^{-2}



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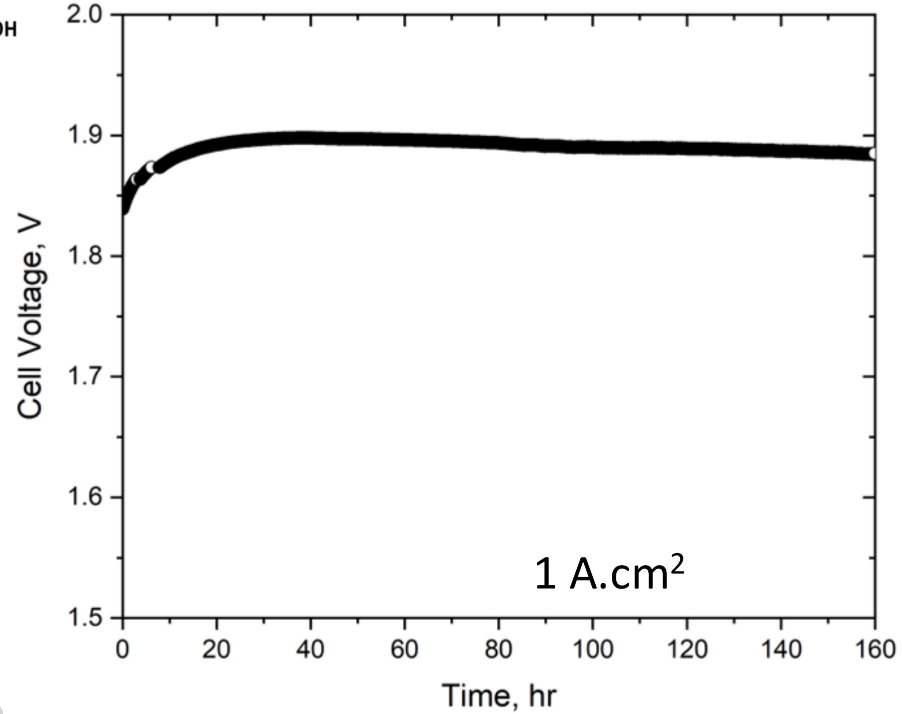
non-PGM electrolyser

Outstanding stability

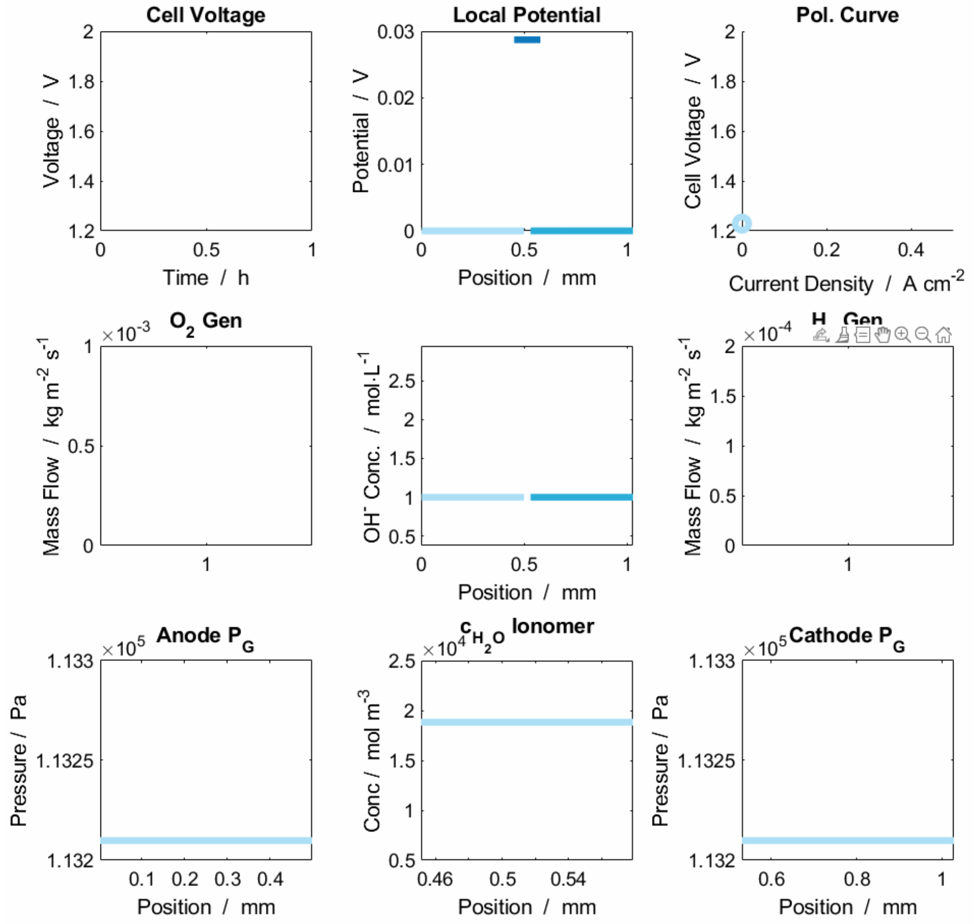


Development of 1-D transient AEM electrolyser model

- Model captures local effects
  - pH changes within catalyst layers
  - Water concentration gradient within AEM

- Model predicts degradation over time
  - catalyst dissolution

- CHANNEL initiative:
  - release of code on GitHub



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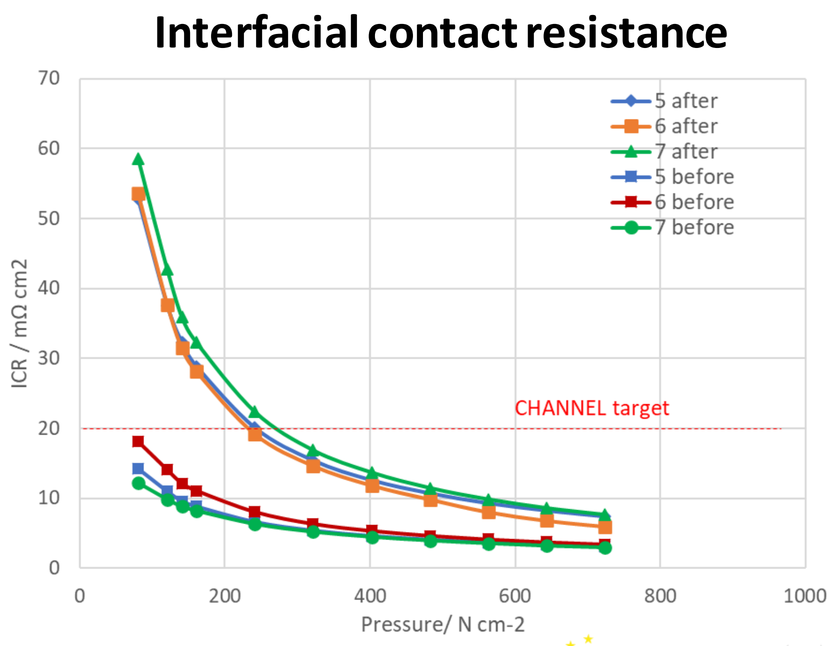
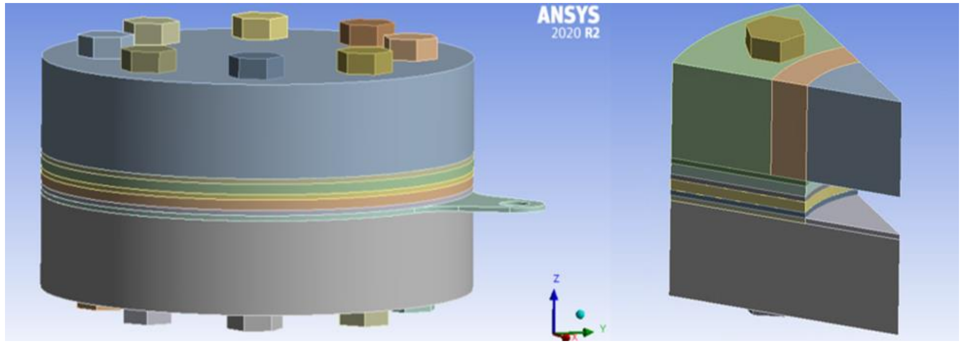
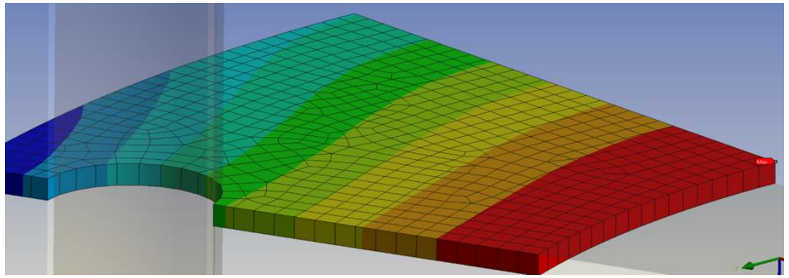
Progress: Stack development

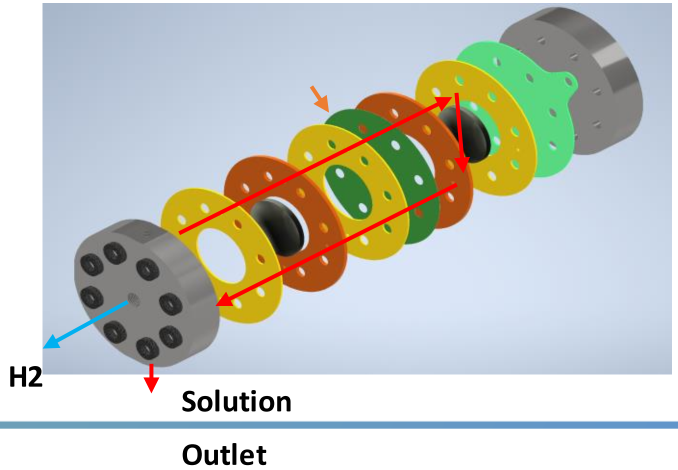
Bipolar plates / PTLs / Flow field

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



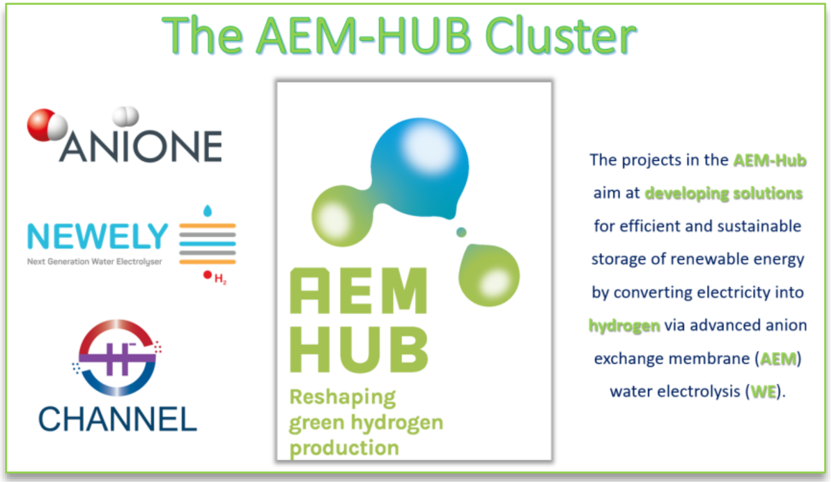






Progress: Dissemination and communication

- Project Website and three social media accounts have been established.
- CHANNEL promotional video has been created
- One per-review publication and six contributions to conferences/webinar; organizing two-days workshop on AEM.
- Creation of the AEM Hub for promoting the AEM technology in cooperation with the other EU granted AEM projects.



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horizonresultsbooster.eu

Summary

- OER and HER CHANNEL catalysts exhibit excellent performance, comparable or better than SoA catalysts
- Membranes and ionomers with excellent chemical/mechanical properties and good compatibility with CHANNEL electrocatalysts
- Development of 1-D transient model to predict durability of catalyst layers and probing local effects
- Preliminary stack design concluded and PTLs and BPP materials validated, including sealings
- Communication and dissemination progressing as expected

Future work

- Testing of the preliminary stack and finalize the design of the 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.*

- Assess the upscale and commercialisation of the newly developed technology

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