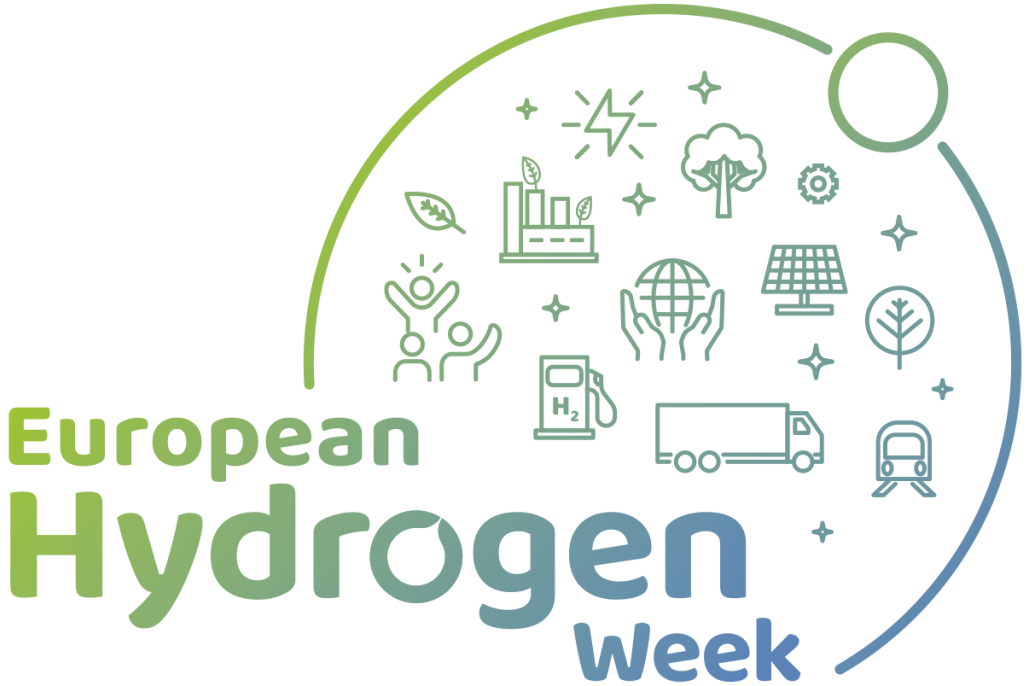
ANIONE

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



Antonino S. Aricò

CNR-ITAE

www.anione.eu

arico@itae.cnr.it

#PRD2021
#CleanHydrogen

FCH

European Commission

Project Overview

- Call year: **2019**
- Call topic: **FCH-02-4-2019 New Anion Exchange Membrane Electrolysers**
- Project dates: **01-01-2020 - 31-12-2022**
- % stage of implementation 01/11/2019: **60%**
- Total project budget: **1 999 995.00 €**
- FCH JU max. contribution: **1 999 995.00 €**
- Other financial contribution: **0 €**
- Partners: CNR-ITAE, CNRS, HYDROLITE (formerly POCELLTECH), TFP (formerly PV3), IRD, HYDROGENICS, UNIRESEARCH BV

#PRD2021
#CleanHydrogen

Project Summary

ANIONE aims at developing high-performance, cost-effective and durable anion exchange membrane (AEM) water electrolysis technology combining 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.

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:

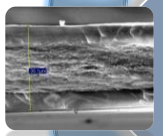
Allow a **scalable production of low-cost hydrogen** from renewable sources through a **reduction of capital costs,** while assuring **high conversion efficiency** and proper life-time.

Project Summary

European Hydrogen Week

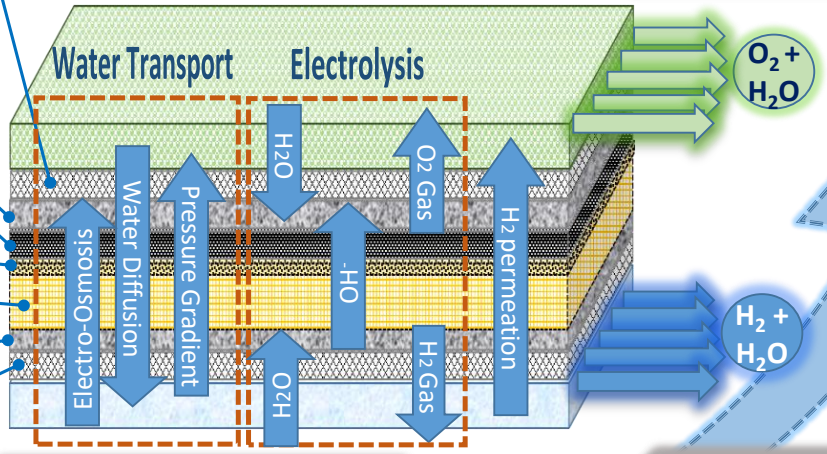
Stack components optimization for AEM electrolysers

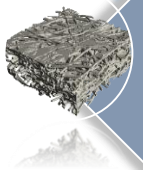
TRL 2



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

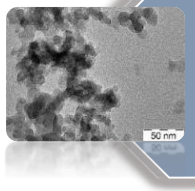
Flow-field free stack design amenable to scale up; protective coatings of steel plates to achieve low cost and durable stack components



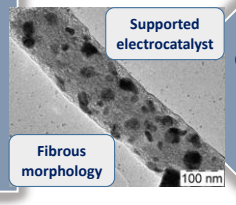


Redesign diffusion layers to improve gas diffusion and overcome reversible degradation

TRL 4



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



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

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

#PRD2021
#CleanHydrogen

FCH

European Commission

Project Progress/Actions:
Cell performance and faradaic efficiency

Project start value

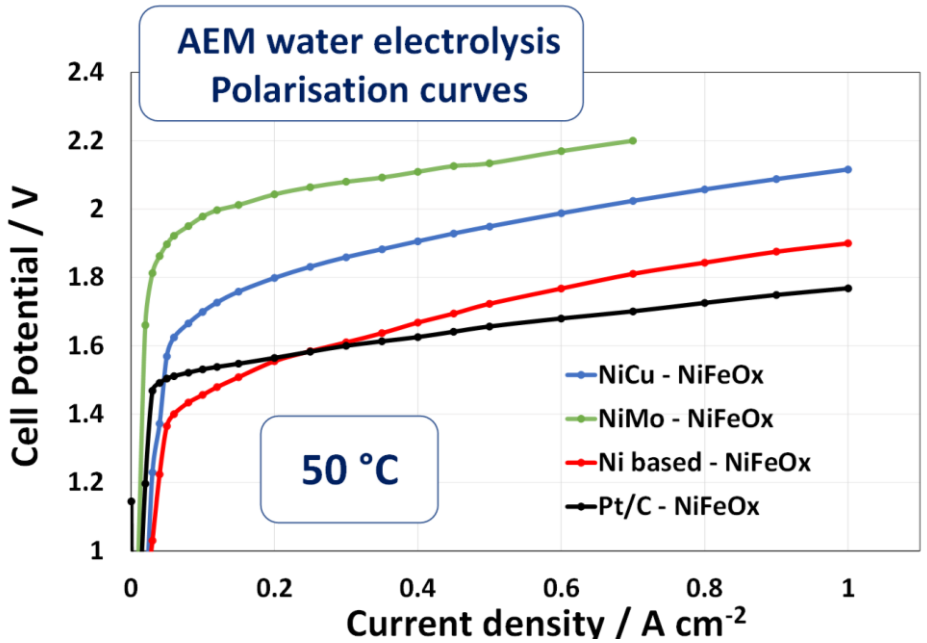
Achievement to-date

0.3 A cm^{-2} at 1.8 V /cell

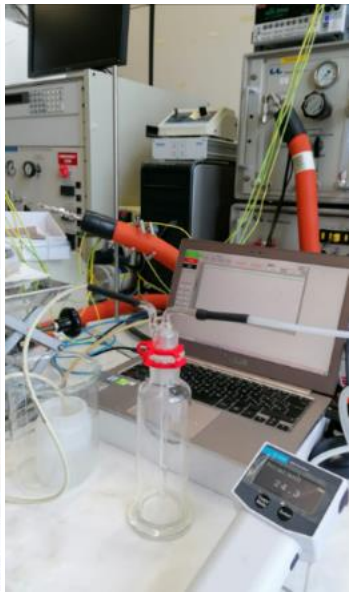
25% 50% 75%

Project end value

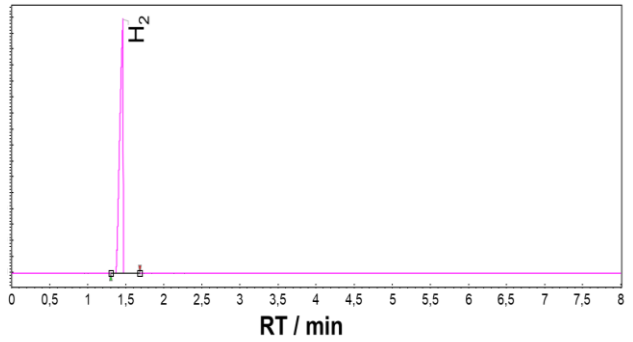
1 A cm^{-2} at 1.8 V /cell 99% faradaic efficiency



AEM ELECTROLYSIS single cell testing in ANIONE



1 A cm^{-2} @ 1.8 V /cell
Faradaic efficiecny of >99%



#PRD2021
#CleanHydrogen

European Commission

Project Progress/Actions: Durability

Degradation >20 µV/h at 1 A cm^{-2}

Project start value

Project end value

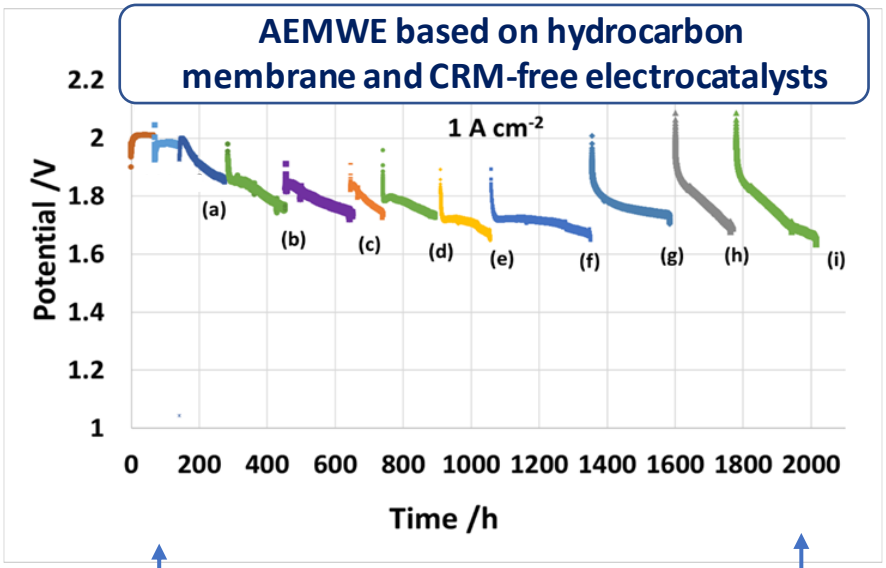
Achievement to-date

Degradation >20 µV/h at 1 A cm^{-2}

25% 50% 75%

Degradation <5 µV/h at 1 A cm^{-2}

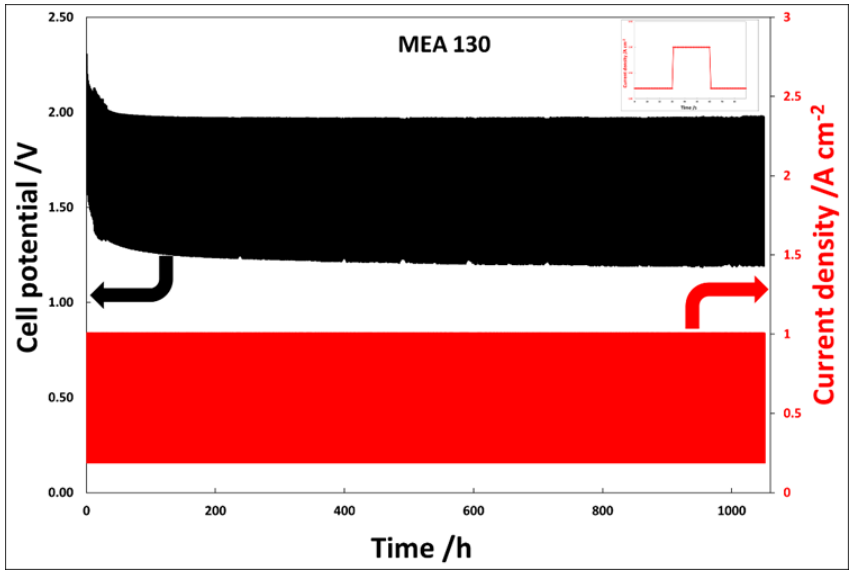
AEMWE based on hydrocarbon membrane and CRM-free electrocatalysts



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

Reversible losses recorded during shut down and start-up cycles

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



Faradaic efficiency >99%

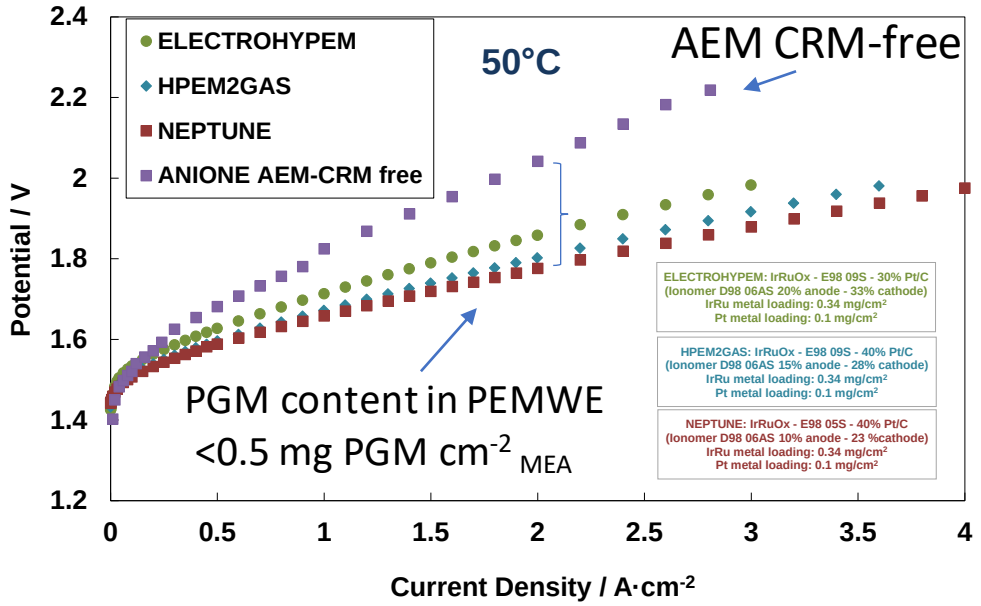
Faradaic efficiency >96%

#PRD2021
#CleanHydrogen

European Commission

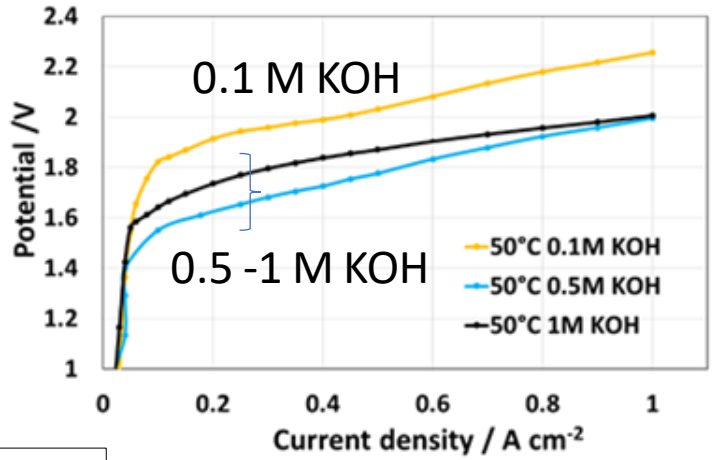
Project Progress/Actions:

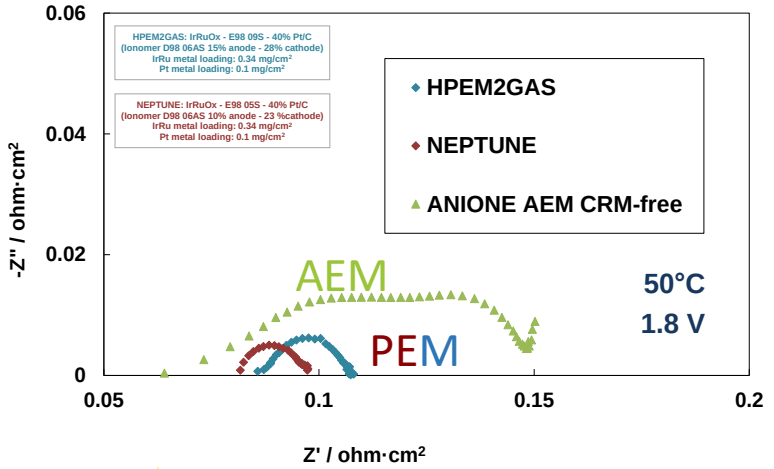
Comperison of AEM and PEM performance and operation with diluted KOH



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

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





Operation with diluted KOH suitable performance for KOH > 0.5 M

ANIONE AEM technology:

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

#PRD2021
#CleanHydrogen

Risks, Challenges and Lessons Learned

- Gas cross-over management for thin anionic membranes in the presence of high differential pressure - ***Mitigation strategies: membrane and MEA engineering to include a recombination catalyst integrated in the anode layer and membrane reinforcement increasing the tortuosity path for gas permeation.***
- Demonstrating the capability of advanced membrane-electrode assemblies and related components to operate in a wider operating temperature and pressure ranges. ***MEA performance and durability has been assessed in the first phase at ambient pressure and 50°C. Investigation of operation at high pressure just started. It seems that operation above 50°C can compromise stability of AEM ionomers; however, the performance targets have been already achieved at 50°C.***
- Implementation of the innovative solutions for AEM electrolysis, into a 2 kW stack operating at high pressure. ***This task has started in the first period. However, there have been specific delays due to the pandemic and the hiring of personnel. The task will be fully implemented.***

Synergies With Other Projects And Programmes

The AEM-HUB webpage is available via each of the project websites.

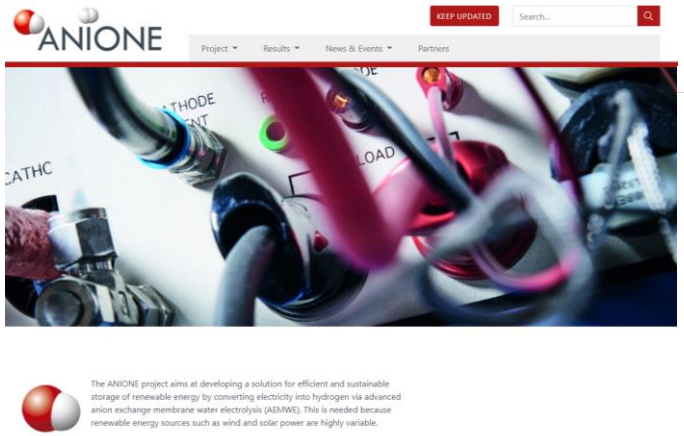
- Ongoing collaboration with other FCH JU AEM projects: NEWELY, CHANNEL
- Horizon Booster activities with Project Group:
  - Completed Module A - Identification of R&I results and creation of portfolio → report available on METT
  - April – Nov 2021: Module B - Portfolio dissemination plan and execution

- Activities with Project Group:
  - Visual identity → logo + colour scheme
  - AEM Hub Webpage
  - Flyer
  - Video
  - Joint webinar (sometime in 2022):
    - Latest development in AEM field
    - Definition of common vocabulary for the field
    - Possible interactions with industry on technology adaptation and future partnerships

#PRD2021
#CleanHydrogen

Communications and Dissemination Activities

Project website and Newsletters



The ANIONE project aims at developing a solution for efficient and sustainable storage of renewable energy by converting electricity into hydrogen via advanced anion exchange membrane water electrolysis (AEMWE). This is needed because renewable energy sources such as wind and solar power are highly variable.

www.anione.eu

Conferences and workshops

Conferences and Exhibitions	Date/Year	Partner responsible / involved
ESOF 2020 - The role of Hydrogen for sustainable global transport and trade	04 Sep 2020	Antonino S. Aricò (CNR-ITAE)
SMCyTM Congress	22nd Oct 2020	Antonino S. Aricò (CNR-ITAE)
Tech Share Day Conference (TSD 2021) - Session on Environmentally Sound Technologies (EST)	07 May 2021	Antonino S. Aricò (CNR-ITAE)
4th International Workshop on Degradation - Issues of Fuel Cells and Electrolysers	5th May 2021	Deborah Jones (CNRS)
4th International Workshop on Degradation - Issues of Fuel Cells and Electrolysers	5th May 2021	Antonino S. Aricò (CNR-ITAE)
9th World Hydrogen Technologies Convention (WHTC 2021)	20-24 June 2021	Sabrina C. Zignani (CNR-ITAE)
EFCF 2021 on Low-Temperature FUEL CELL, ELECTROLYSER & H2 Processing. Lucerne – on line event	30 June 2021	Antonino S. Aricò (CNR-ITAE)
FCH Webinar on Anion Exchange Membrane electrolysers	6 July 2021	Antonino S. Aricò (CNR-ITAE)

Publications

- A. S. Aricò et al. Fuel Cells & H2 Processing, Proceedings of EFCF 2021 Conference, Pages 123-127, A0401 (Special Talk)
- A. Ashdot et al. Membranes 2021, 11, 686

#PRD2021
#CleanHydrogen

Exploitation Plan/Expected Impact

Exploitation

The exploitation plan includes a technology roadmap and a market introduction scheme for the exploitation of the knowhow/results of the project.

ANIONE project offers an excellent opportunity to several partners to develop and validate their components and devices in AEM water electrolysis at a prototype scale.

CNR-ITAE and CNRS: new patents for AEM membranes and catalysts; Hydrolite: production of new anionic membrane; TFP: non-CRM catalyst production and coatings; IRD: fabrication of large area AEM MEAs; HYE new patents and knowledge on AEM stack design and manufacturing; UNR exploitation of specific communication tools and potential new workshops.

Impact

- ❑ **New knowledge with respect to the design and operation of AEMWE components and stacks;**
- ❑ **Stable and cost-effective components for AEM water electrolysis based on non CRMs;**
- ❑ **Reduce substantially the risk to incur in supply bottlenecks;**
- ❑ **Reducing the electrolyser CAPEX and OPEX costs and thus the total €/kg H_2;**
- ❑ **Increased EU competitiveness in production of green hydrogen from renewable sources at large scale.**

Thank you for your kind attention!

ANIONE

European Hydrogen Week

Antonino S. Aricò
CNR-ITAE
www.anione.eu
arico@itae.cnr.it

#PRD2021
#CleanHydrogen

FCH

European Commission