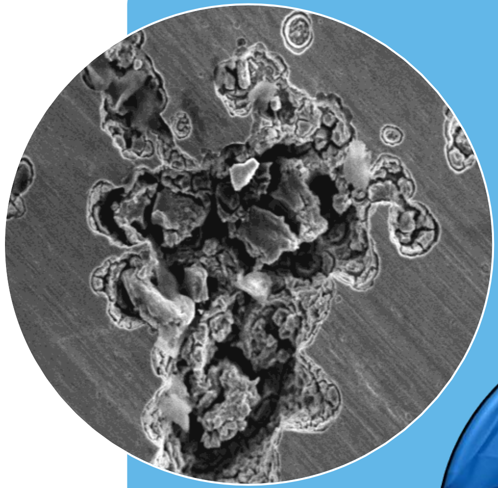
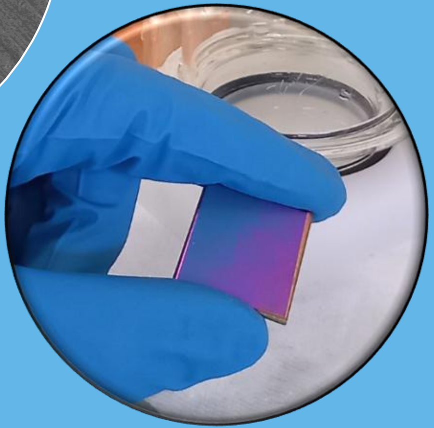
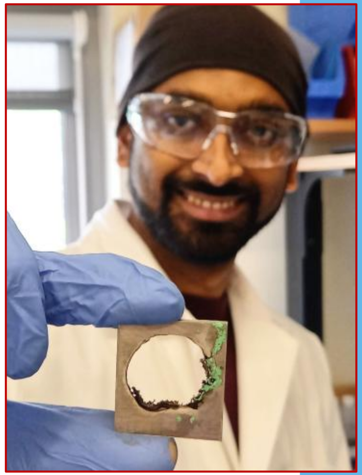
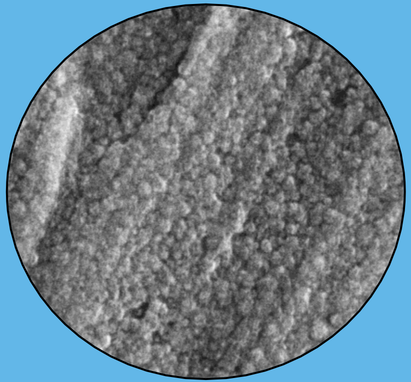
Projet Européen SWEETHY:
Électrolyse directe de l'eau de mer

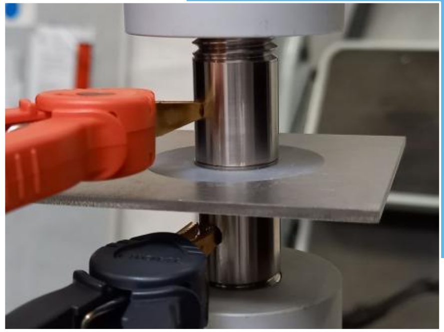
SWEETHY











Dr. Michel Prestat

Institut de la Corrosion (site de Brest)

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UNIRESEARCH

FRENCH CORROSION INSTITUTE

cidetec surface engineering

ProPuls

RI. SE

CEN mat

DLR Deutsches Zentrum für Luft- und Raumfahrt

SINTEF

ITAE Consiglio Nazionale delle Ricerche

Clean Hydrogen Partnership

Co-funded by the European Union

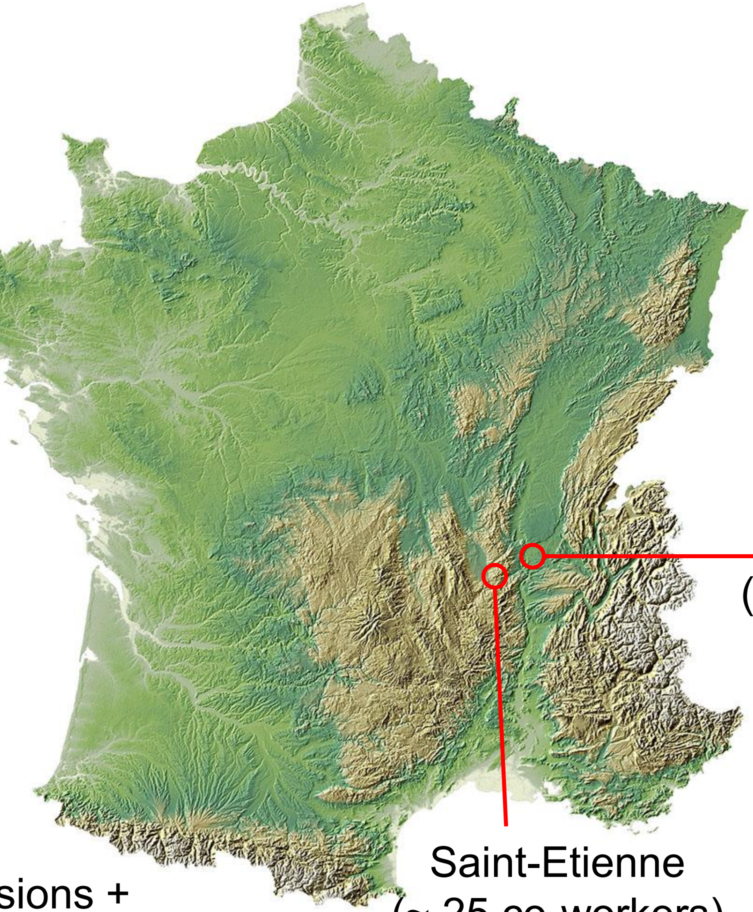
The French Corrosion Institute in a nutshell

FRENCH CORROSION INSTITUTE

Technopole of Brest
(headquarters, ~40 coworkers)

Institut de la Corrosion
French Corrosion Institute

- Non-profit R&D SME
- Founded in 2002
- Subsidiary of RISE
- Ca. 70 co-workers
- Mostly industrial R&D and commissions + low-TRL (academic) projects
- 85% funding from industry + 15% public funding (national/regional agencies, EU)



Lyon
(~ 5 coworkers)

Saint-Etienne
(~ 25 co-workers)

Active in many industrial fields: marine corrosion, aerospace, oil&gas, infrastructures, automotive industry, corrosion sensors, implants, hydrogen (**incl. water electrolysis**)…

Our ongoing publicly-funded electrolysis-related projects:

PEM: PROTIS unicorn

AEM, seawater: SWEETHY

This talk

SWEETHY project (TRL 2-4, 2025-2029)

SWEETHY

FRENCH CORROSION INSTITUTE

Consortium composition:

UNIRESEARCH

FRENCH CORROSION INSTITUTE

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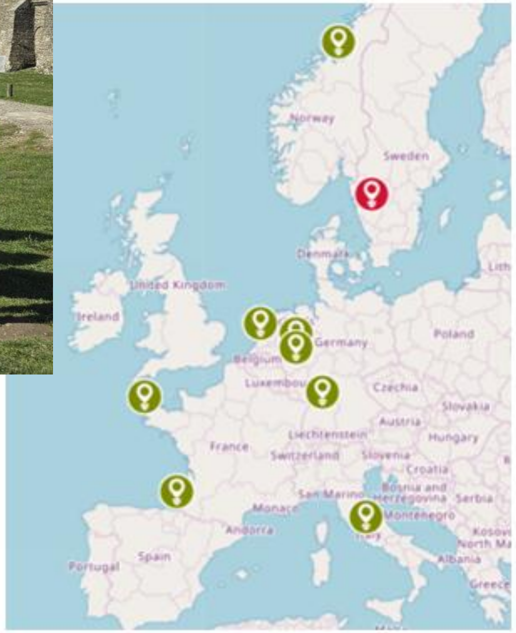

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Home > Funding > Calls for proposals > Development of innovative technologies for direct seawater electrolysis

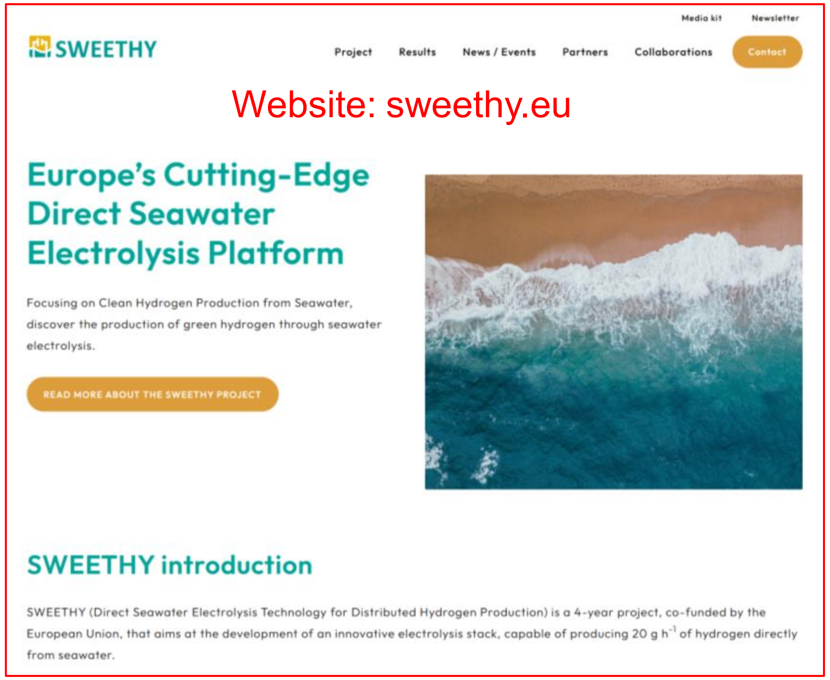
Development of innovative technologies for direct seawater electrolysis

HORIZON-JTI-CLEANH2-2024-01-03

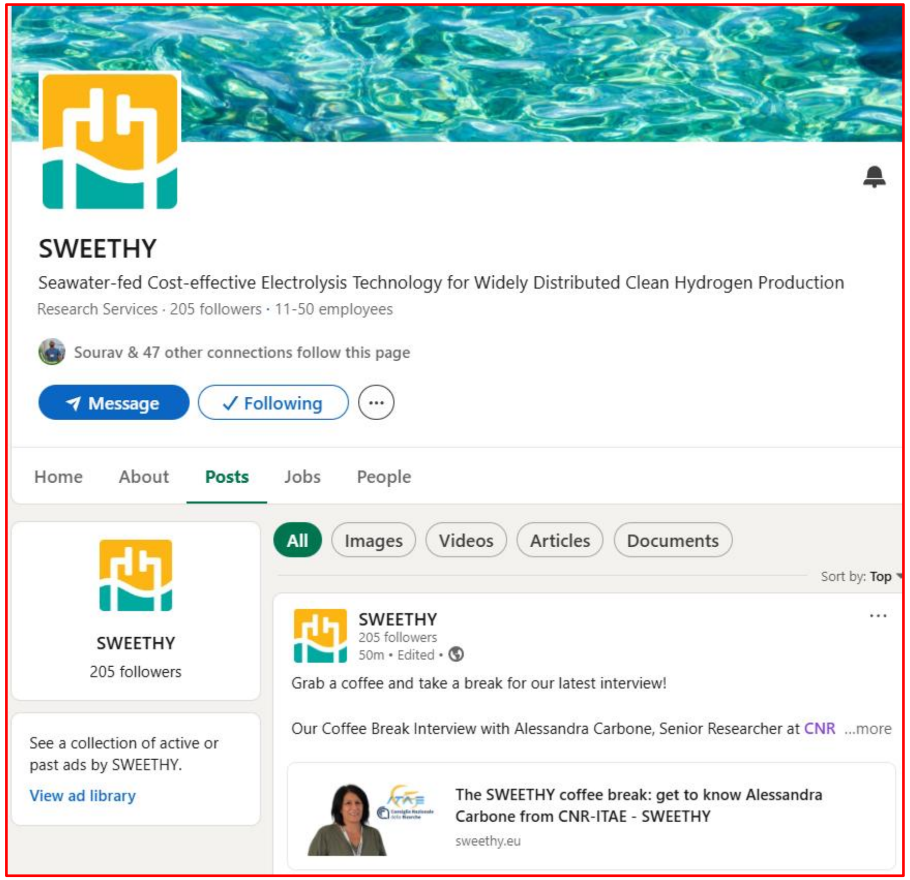
Clean Hydrogen Partnership

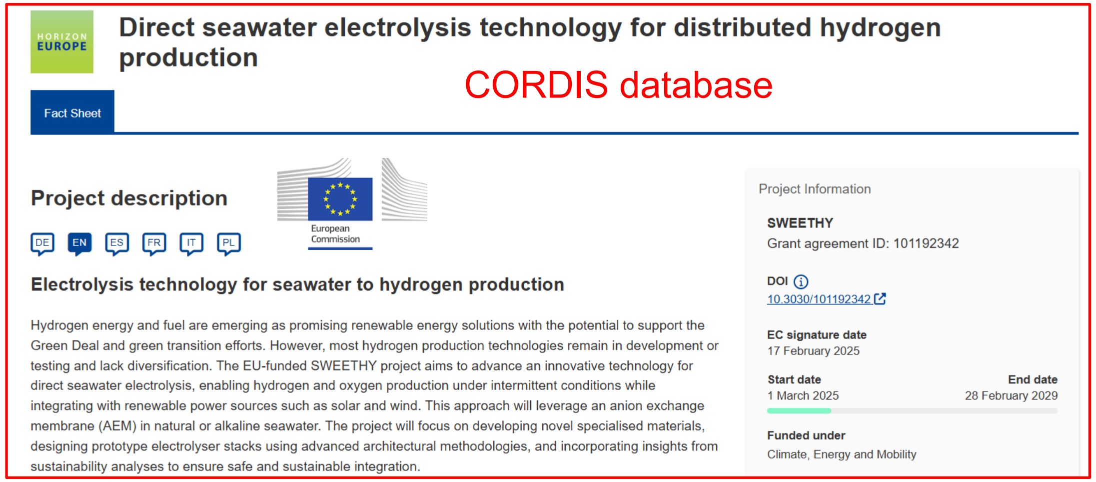
Co-funded by the European Union

SWEETHY project: online resources

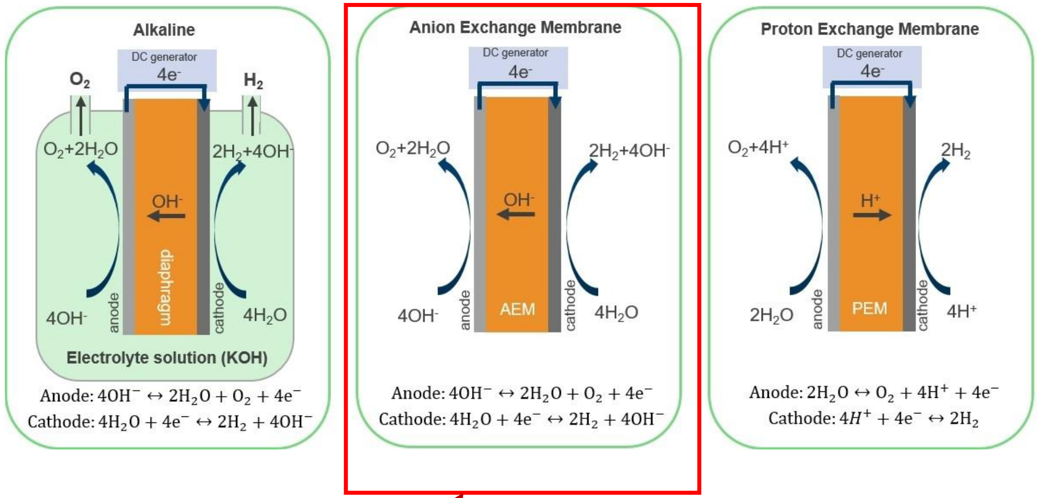


LinkedIn





Challenges of direct seawater electrolysis (without desalination)

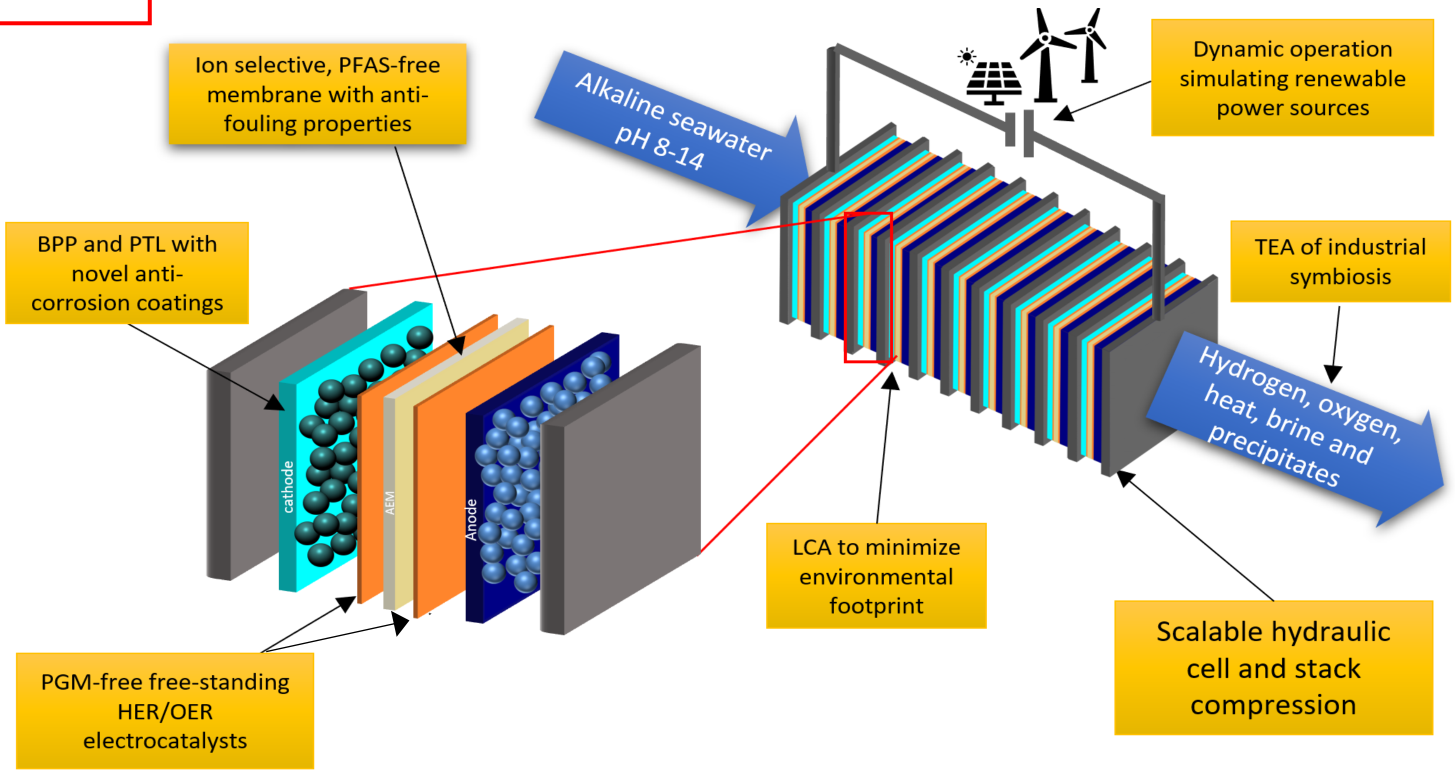


Technology based on **anion exchange membrane (AEM)**

Key-performance indicators (KPI):

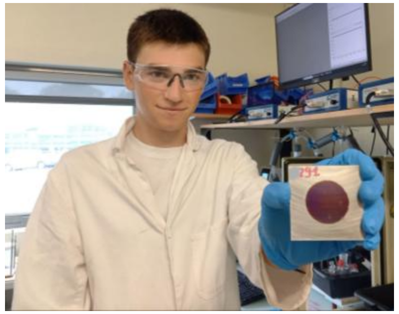
- 10 cells up to 120 cm^2 in pocket design
- Production pressure p_{H2} up to 20 bar
- $U_{Cell} \leqslant 2$ V, $i \geqslant 0.5$ A cm^{-2}
- Production rate $\geqslant 20$ g h^{-1}

Challenges addressed by SWEETHY:

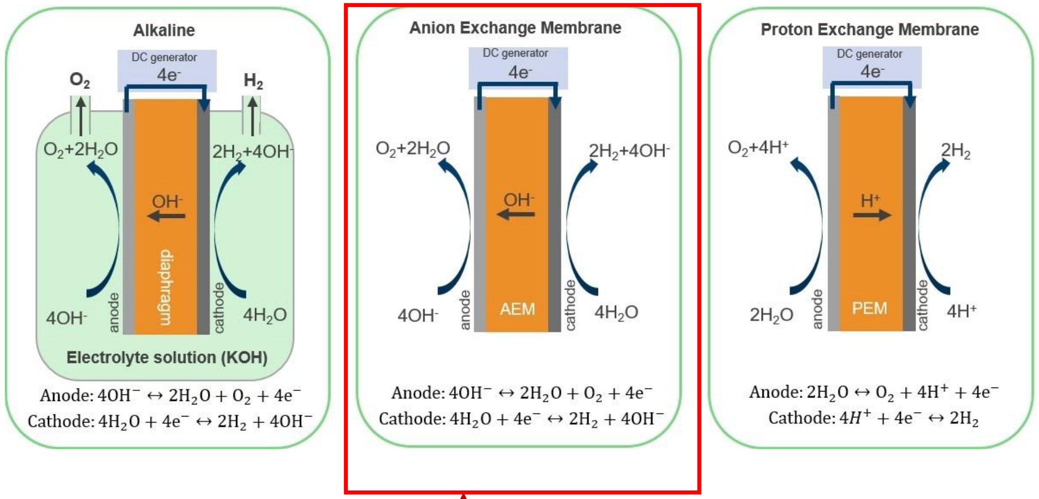


Corrosion problem…

… and anti-corrosion solutions



Anion exchange membrane (AEM) development

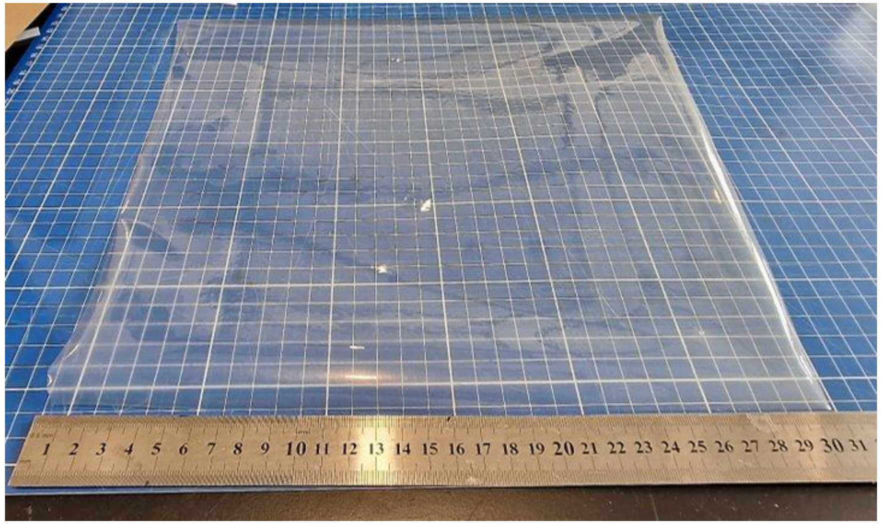


Technology based on **anion exchange membrane (AEM)**

CENmat's AionFLX™membrane:

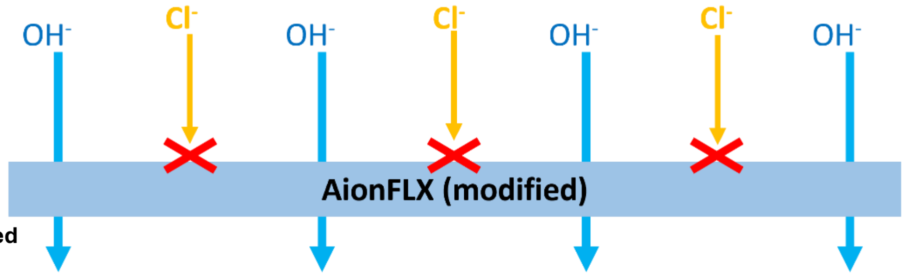
• Developed by CENmat; **PFAS-free**, partially recycled polymer backbone.
• **High OH⁻ conductivity** and **> 1,000 h durability** at 0.1 M and 1 M KOH without detectable degradation demonstrated.
• Manufactured up to 1000 cm² at once with batch-to-batch consistency for rapid scale-up.

Developed within the project HYScale (AEM, freshwater, hyscale.eu)



Objectives:

• Selectivity: high OH^- conductivity and low Cl^- ion conductivity
• Enhanced durability and stability in saline conditions (up to 2000 h)
• Anti-fouling properties (bacteria, bio-organisms…)



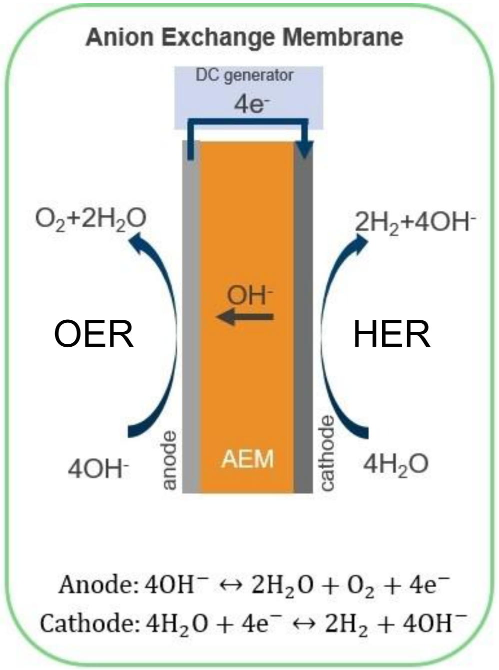
Development of HER and OER catalysts

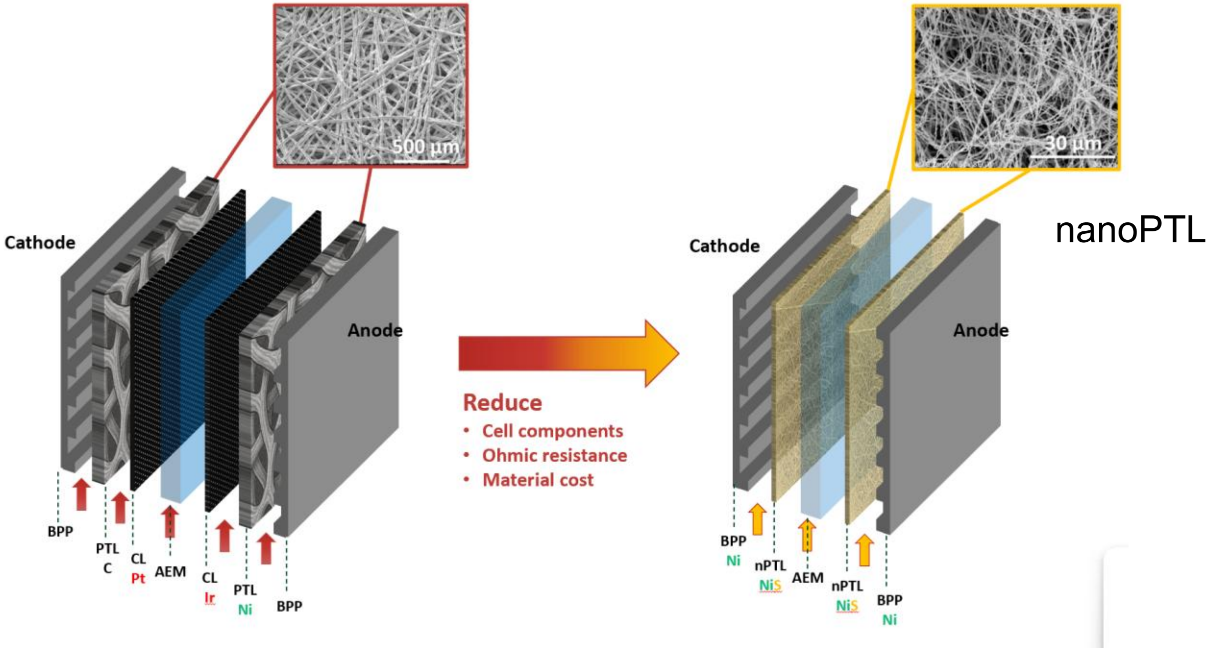
Objectives:

- Catalysts for hydrogen evolution reaction (HER, cathode) & oxygen evolution reaction (OER, anode)
- Earth-abundant (non-PGM, ideally non-CRM) materials:
- High activity, long-term durability, corrosion resistance and scalability
- Low overpotentials (<150 mV @ 0.5 A/cm^2) with high selectivity towards HER and OER.

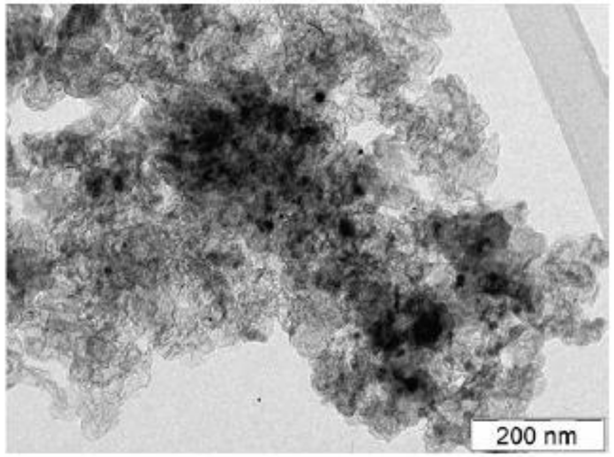
Strategy:

- Materials candidate (non-PGM ideally non-CRM): transition metals, oxides, sulfides, LDH…
- Two main approaches: **supported and free-standing catalysts**





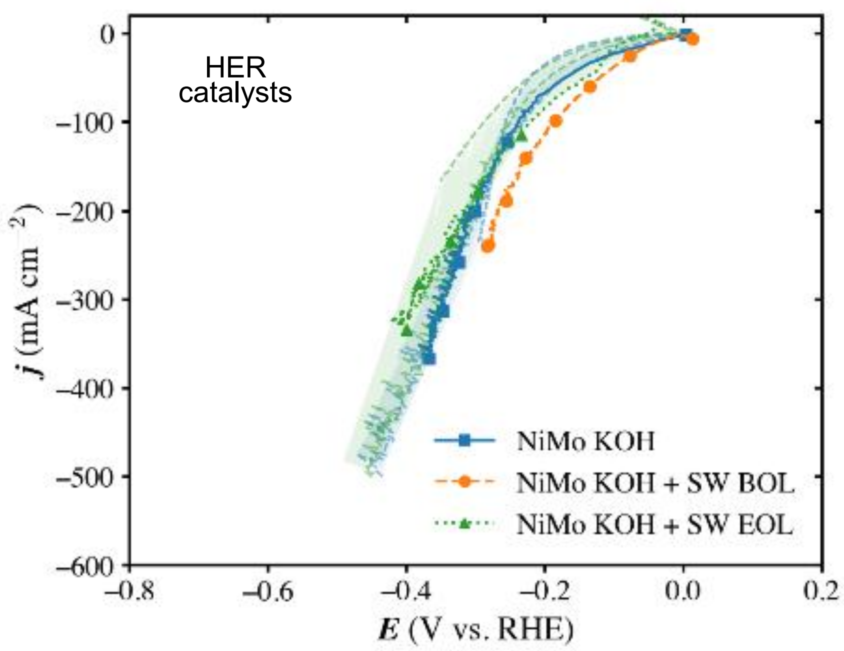
Free-standing catalysts: nanoPTL replaces "PTL + catalyst layer"

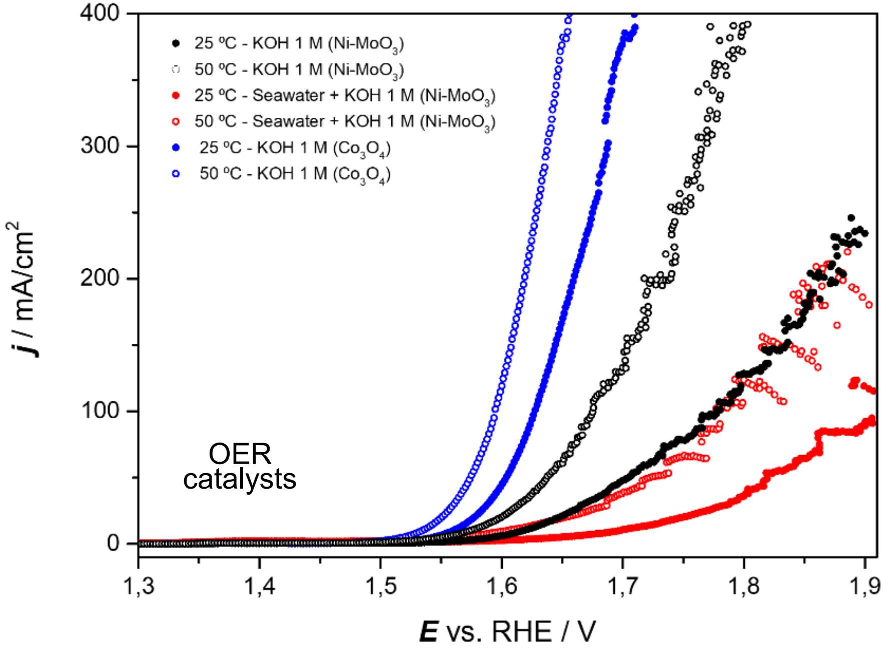


Supported catalysts: (top) Hull cell testing for screening electrodeposition conditions; (bottom) Nanostructured HER catalysts.

Assessment of catalysts performance

Catalysts	Synthesis method	Particle size (nm)	Structure
Co_3O_4	Commercial powder (Alfa Aesar)	35	Cubic spinel (Fd-3m)
Pt/C 40%	Commercial powder (Thermo Scientific)	3.8	Pt: face-centered cubic (fcc)
NiMo/KB (**CNR**)	Co-precipitation	22	Ni: fcc, Mo: bcc (nanocrystalline)
NiFe LDH (**CNR**)	Co-precipitation	4.6	Rhombohedral layered structure (LDH)
NanoPTL@Ni_3S_2 (**SINTEF**)	Magnetic field assisted chemical reduction followed by hydrothermal sulfidation	200-500 in wire thickness	Rhombohedral Ni3S2 shell on Ni core (fcc)
NanoPTL (**SINTEF**)	Magnetic field assisted chemical reduction	50-200 in wire thickness, decorated with 20 nm Ni cones	Face-centered cubic (fcc)
NiS_2 (**CIDETEC**)	Hydrothermal synthesis	15	Cubic
MoS_2 (**CIDETEC**)	Hydrothermal synthesis	5-6	Hexagonal
$NiMoS_2$ (**CIDETEC**)	Hydrothermal synthesis	5-6	Hexagonal MoS_2
Mo_2C (**CIDETEC**)	Solid-solid synthesis	21	Hexagonal
Ni-Mo (**CIDETEC**)	Electrodeposition	<5	Amorphous-like
Ni-Mo-S (**CIDETEC**)	Electrodeposition	<5	Amorphous-like
NiFe-LDH (**CIDETEC**)	Hydrothermal synthesis	5-7	Hexagonal LDH phase
NiMn-LDH (**CIDETEC**)	Hydrothermal synthesis	12	Hexagonal LDH phase
Ni-MoO_3 (**CIDETEC**)	Solid-solid synthesis	30-45	Orthorhombic MoO_3

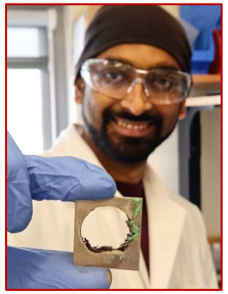




- → First catalysts results are reported in public deliverables (D3.1, D3.2).
- → Durability testing (several hundreds of hours) is in progress for the most promising catalysts

Corrosion behaviour of uncoated BPP and PTL materials

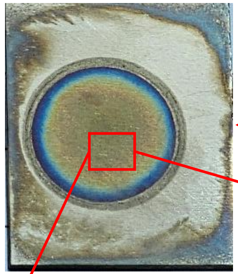
Nickel, state-of-the-art material for AEMWE (freshwater), corroded when anodically polarized in seawater.



← 1.6V/RHE, 60 °C, 2 days
Alkaline Seawater

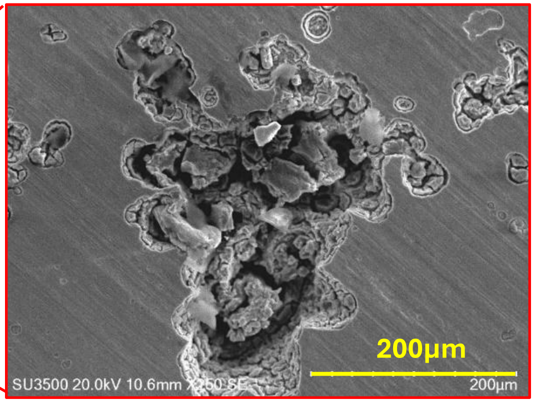
1.6V/RHE, 60 °C, 5h →
Alkaline Seawater

Titanium corrodes as well when anodically polarized in seawater.



← 1.6V/RHE, 60 °C, 7 days
1M KOH

1.6V/RHE, 60 °C, 7days →
Alkaline Seawater



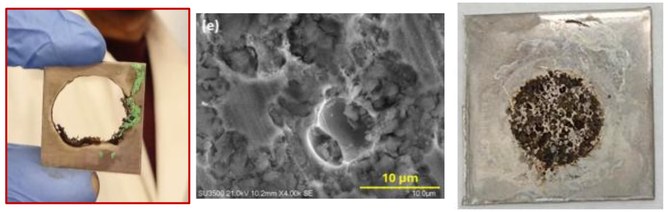
	C	O	Ti
Pristine	2.2		97.8
After 7 Days	3.8	19.2	70.2

→ Public deliverable (D5.1) on corrosion of uncoated substrates in KOH and in alkaline seawater published in June 2026.

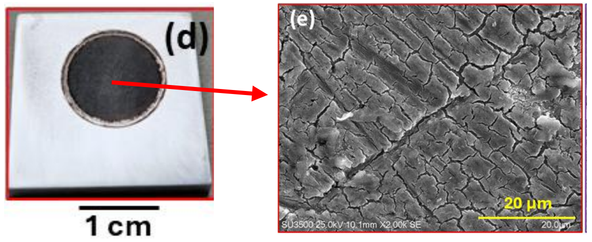
→ Coating necessary for protecting metallic elements (PTL, BPP) on the anode side.

Corrosion behaviour of uncoated substrates

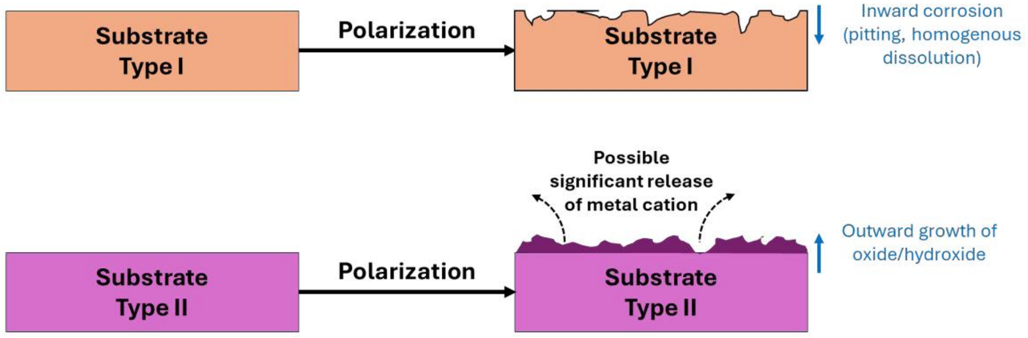
Type I: severe corrosion (pitting, dissolution)
Ni, 316L, Monel400



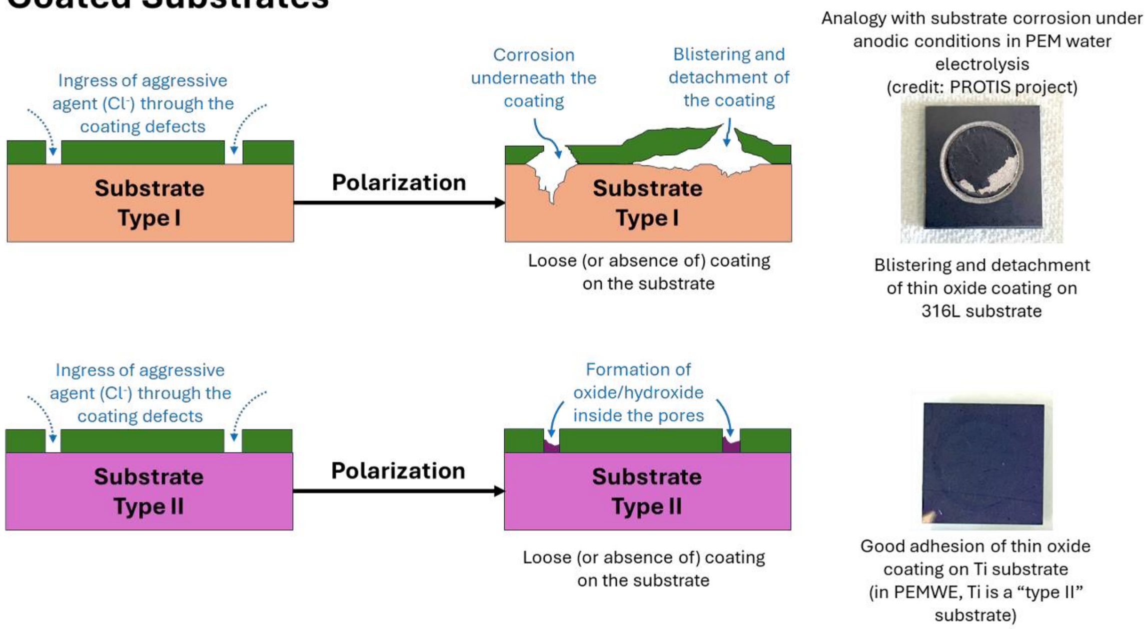
Type II: mild corrosion (surface oxidation/hydroxylation)
C22, Inconel 625



(a) Uncoated Substrates



(b) Coated Substrates



Substrates	Anodic Polarization (1.6V to 2.2V; 50 °C; 1hr to 7days)		Cathodic Polarization (–0.3V to –0.2V; 50 °C; 2 to 7days)
	In 1M KOH	In alkaline ASW	In alkaline ASW
Ni	✓ Stable	✗ Pitting corrosion	-
Ti	✗ Metal dissolution + Oxide/hydroxide Oxide/hydroxide layer formation	✗ Pitting corrosion + Oxide layer formation	✓ Oxide / hydroxide layer formation
316L	✗ Metal leaching	✗ Pitting corrosion*	✓ Stable
C22	✓ Stable	✗ Oxide / hydroxide layer formation*	-
Monel 400	✓ Stable (short-duration results only: 3 hours)	✗ Pitting corrosion*	✓ Stable
Inconel 600	✓ Stable	✗ Pitting corrosion	✓ Stable
Inconel 625	✓ Stable or Oxide / hydroxide Layer formation (depending on the applied potential)	✗ Oxide/hydroxide layer formation	✓ Stable

* Crevice corrosion was observed at the (peripheral) gasket area.

→ The oxide/hydroxide layer increases the ICR.

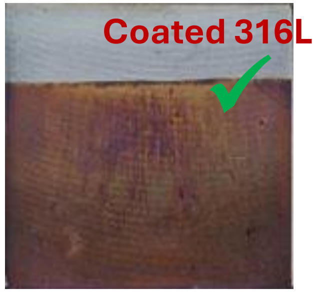
Development of non-PGM protective coatings

Two approaches are followed to protect metallic components: **electrodeposition and plasma spray**

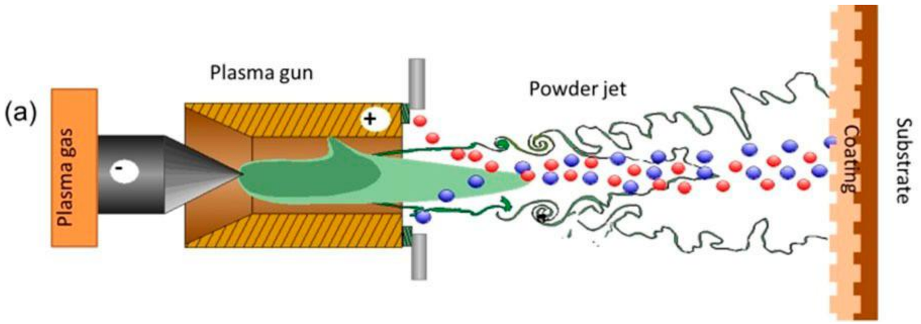
Electrodeposition (thin film approach < 1 µm):

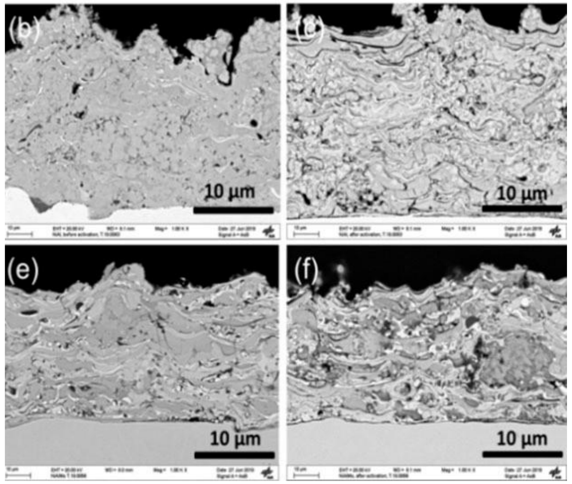
1.6V/RHE, 60 °C
Alkaline Seawater

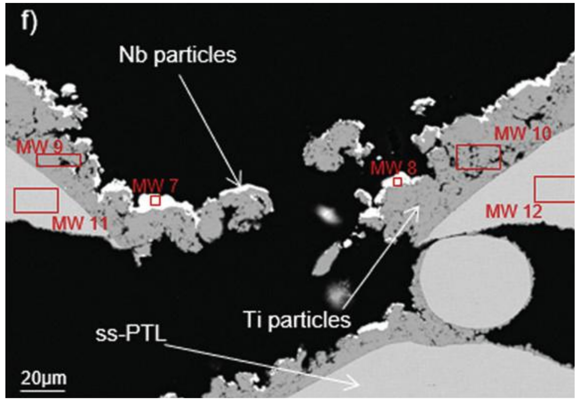
1.6V/RHE, 60 °C
Alkaline Seawater



Plasma spray (vacuum or atmospheric, thick film approach > 10 µm)



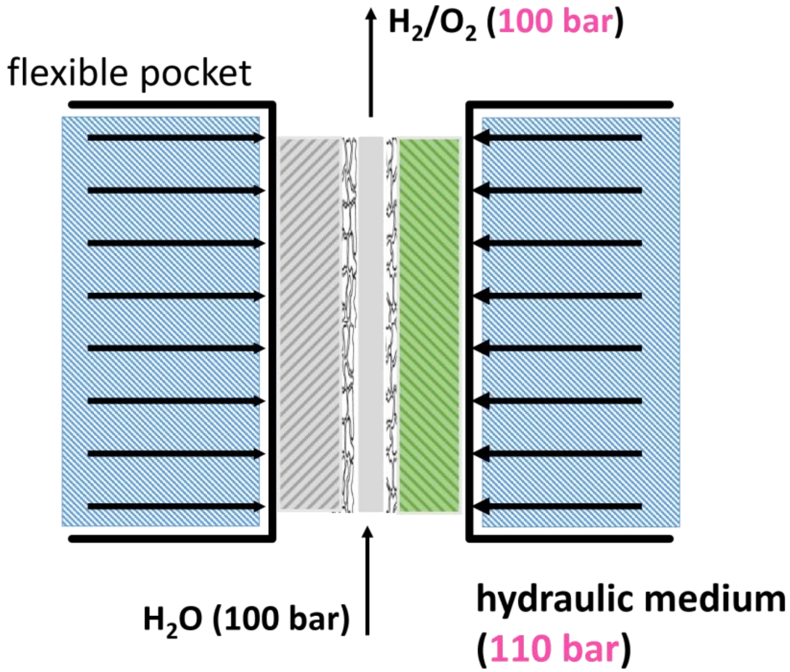




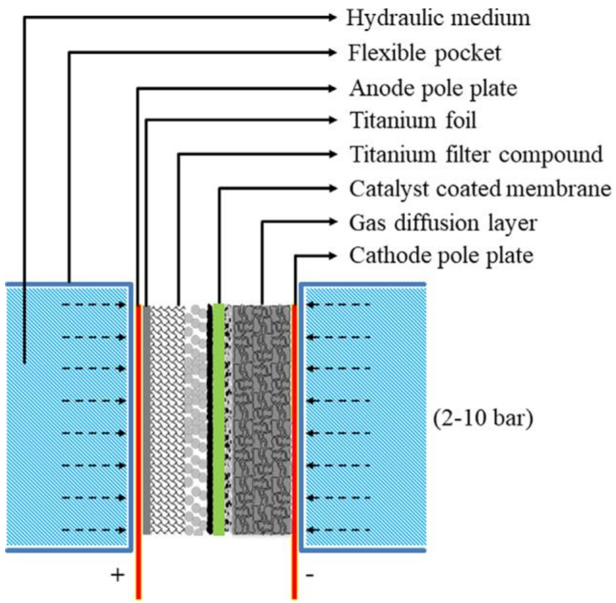
Stiber *et al.*, Energy Environ. Sci. 15 (2022) 109

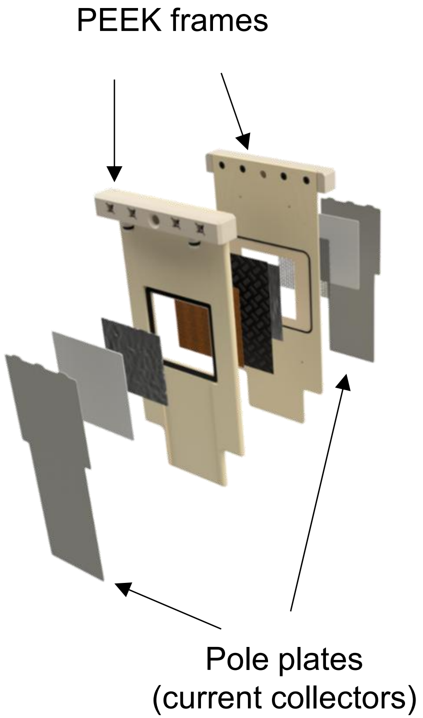
Single cell development and testing

ProPuls technology:

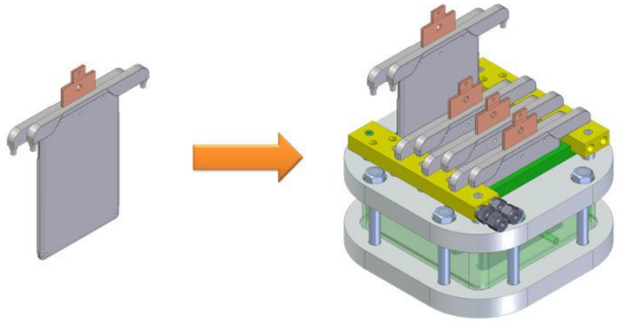


Rost *et al*., Fuel Cells 22 (2022) 284



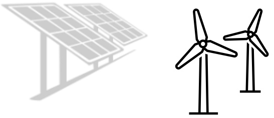


Hydraulic compression in “pocket design”:
- Homogeneous spatial pressure distribution
- Effective heat management (fast heating, waste heat removal)
- Modular design with interchangeable cells



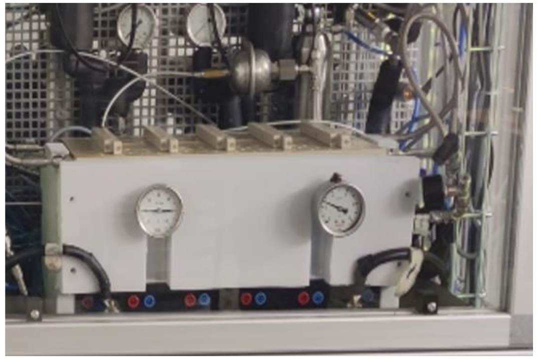
Patent: M. Brodmann *et al.*, Vorrichtung zur Energieumwandlung, insbesondere Brennstoffzelle oder Elektrolyseur, WO/2018/001543 (2018)

Stack development and prototype testing



alkaline seawater

pH 8-14



H_2, O_2, heat, brine

(precipitates)

Key-performance indicators (KPI):

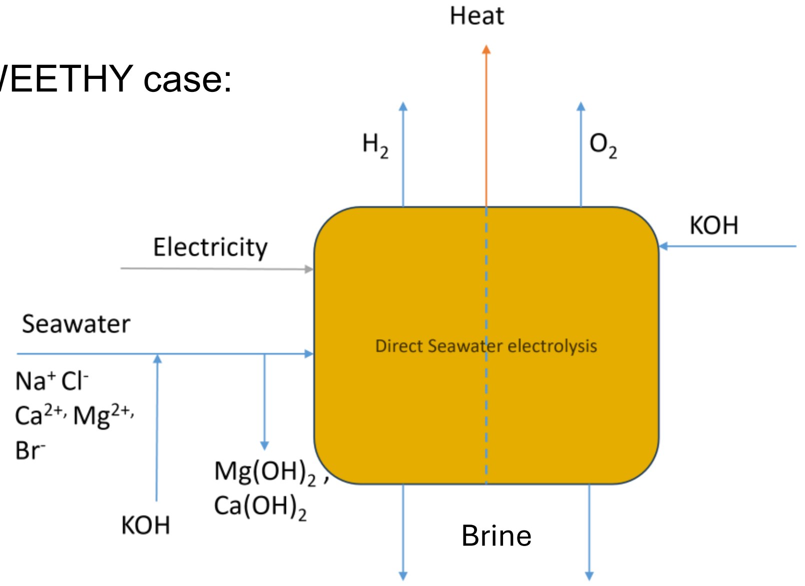
- 10 cells up to 120 cm^2 in pocket design
- Production pressure p_{H2} up to 20 bar
- $U_{Cell} \leqslant 2$ V, $i \geqslant 0.5$ A cm^{-2}
- Production rate $\geqslant 20$ g h^{-1}

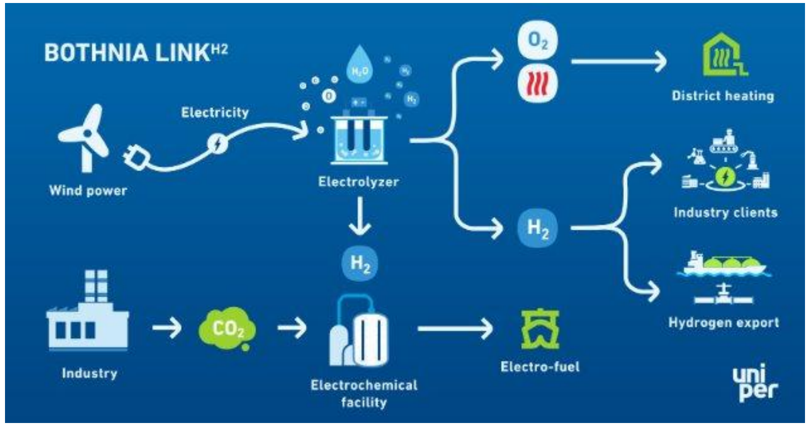
Stack prototype to be operated for 2000 hours under dynamic load in Messina, Italy.

Sustainability anlysis

Industrial symbiosis: integration of SWEETHY electrolyzer in industrial ecosystems

SWEETHY case:

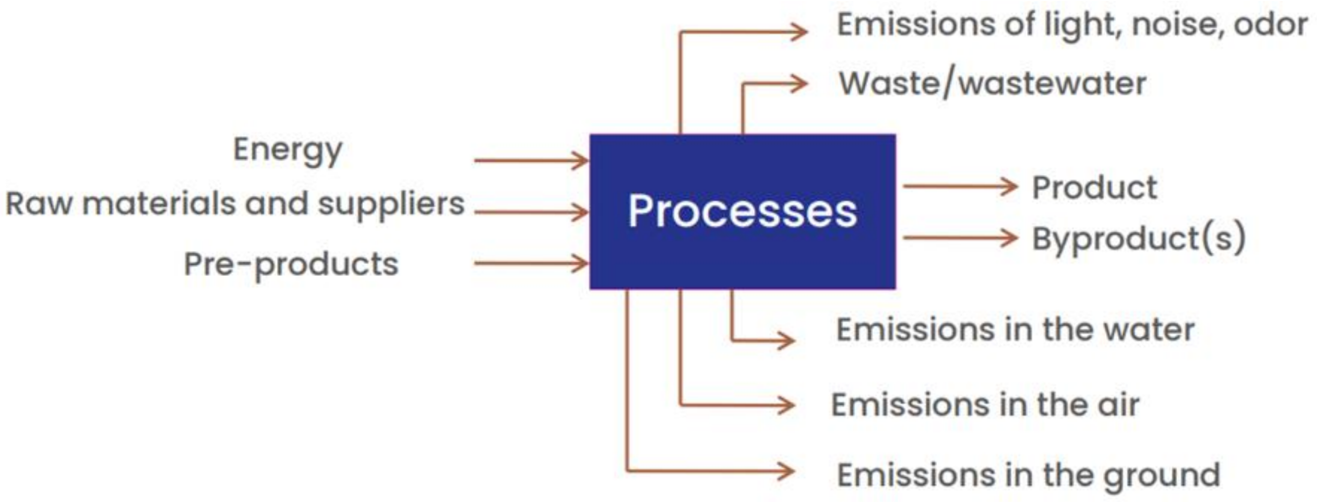




Example of BOTHNIA LINK^{H2} project (Sweden)

Life Cycle Assessment (LCA):

- Assessing environmental impact of product or service during its entire life cycle
- Standardized framework (ISO14040 and ISO14044)
- Multiple environmental indicators
- Potential uses in early process design:
    - Increased knowledge on environmental hotspots
    - Selection of materials and processes with less environmental impact
    - Avoiding sub-optimization over the life cycle



European Symposium on Durability Issues in Low-T Water Electrolysis

Join the European water electrolysis community this fall in Stockholm !

When: October 13-15, 2026

Where: Stockholm, Sweden

Organizers: IC, RISE, SINTEF, KTH, Uni. Galway

Contributions: oral presentations & posters

Abstract submission deadline: May 15, 2026 (posters accepted during summer).

Registration fee: 250 €

Sponsorship offer: available on demand (600 € / 1000 €)

Communication: through SWEETHY channels (website, LinkedIn)

Contact: symposium2026@ri.se, michel.prestat@institut-corrosion.fr

Scope:

- **Technologies:** alkaline, PEM, AEM, membrane-less, seawater, low-grade water electrolysis as well as photo-electrochemical water splitting.
- **Degradation and durability of components:** catalysts, electrolyte membranes, porous transport layers, bipolar plates, water feed pipes, and other balance-of-plant and stack components…
- **Degradation modes affecting electrolysis performance:** corrosion, hydrogen embrittlement, electrolyte membrane thinning, catalyst coarsening or dissolution, and impurities in the water feed…
- **Durability solutions:** anti-corrosion coatings, surface treatments, catalyst dissolution mitigation…
- **Fundamental aspects of degradation mechanisms:** electrochemical degradation mechanisms and kinetics, multiscale numerical modeling…
- **Methods to investigate degradation and durability:** in operando, in situ, and ex situ techniques, as well as accelerated stress tests…
- **Durability of materials for next-generation water electrolysis:** PFAS-free electrolyte membranes, non-critical raw materials, and non-platinum group materials…
- **Life-cycle and techno-economic analyses:** benefits of reducing critical raw materials and the potential for recycling…

Joint Initiative: SWEETHY PROTIS unicorn ANEMEL PUSH

Co-funded by
the European Union

Symposium

Merci de votre attention !

michel. prestat@institut-corrosion.fr