European Hydrogen Week

NEPTUNE

NEPTUNE: Next Generation PEM Electrolysers under New Extremes

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ITM Power
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IRD Fuel Cells

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Aims and Objectives

AWP 2017 – Topic 02-1-2017 Game changer Water Electrolysers

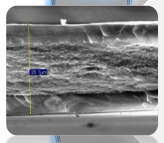
Challenge	Scope	Impact
• Higher pressure • Rapid response • Increased current density • Reduced critical raw materials • Elevated temperature	• P ≥ 100 bar, • I ≥ 4 A/cm^2, • T ≥ 80°C • 10-50 kW, • ≥ 2,000 Hours of operation	• Develop and validate prototype game-changer electrolyser • Knowledge on designing and operating such an electrolyser • Assessment of commercial opportunities

TRL 3 → TRL 5

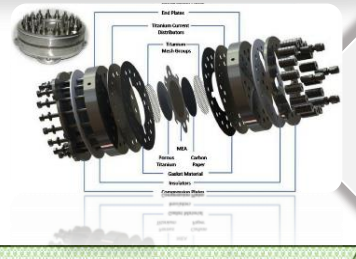
Concept and Approach

Development of MEA and Stack Components

TRL 3

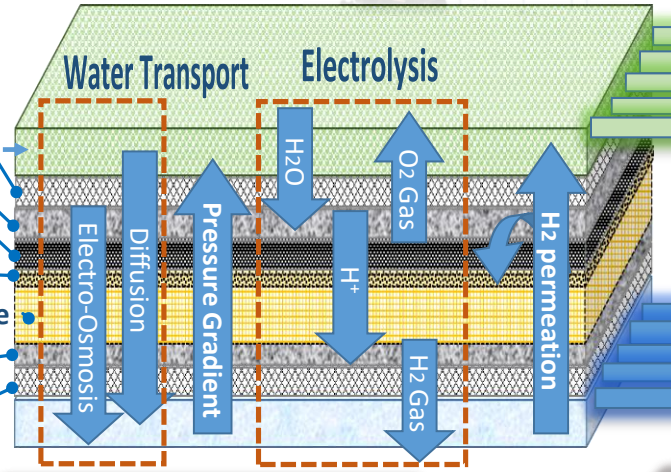


Reinforced membrane with lower thickness to reduce ohmic drop and improve mechanical stability

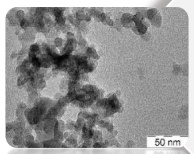


Hydraulic compression (high P), flow-field free design and protective coatings of Ti plates to achieve low cost and durable stacks

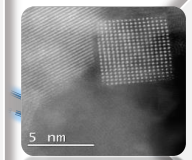
Redesign diffusion layers to improve gas diffusion and overcome reversible degradation



TRL 4



Cross-over management through dual recombination catalysts (membrane filler and integrated in the anode)



Nanostructured catalysts to increase intrinsic activity and stability, lower precious metal content; reducing mass transport

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

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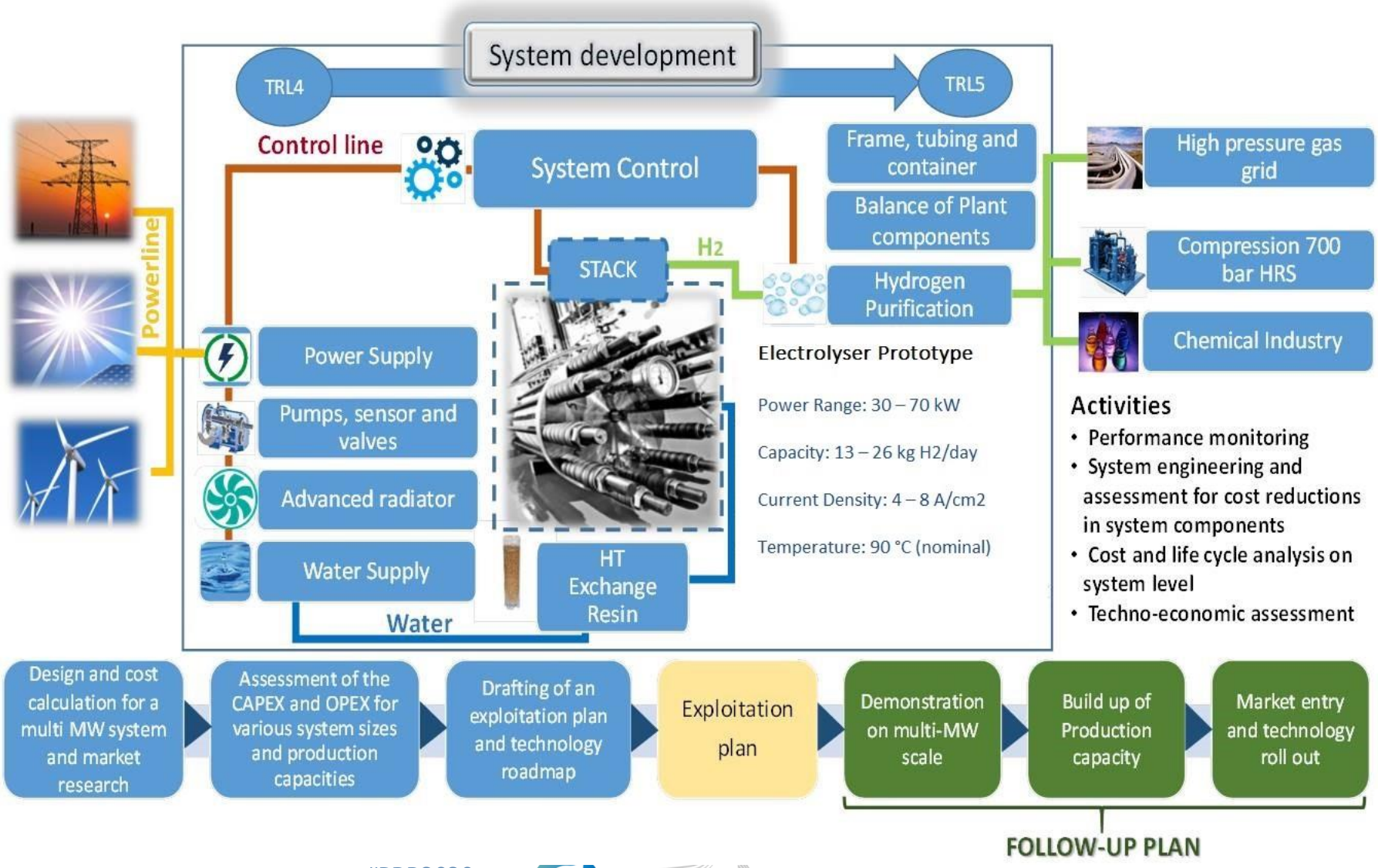
Concept and Approach



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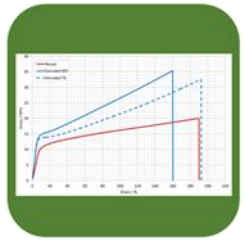
Results Highlights - Membranes

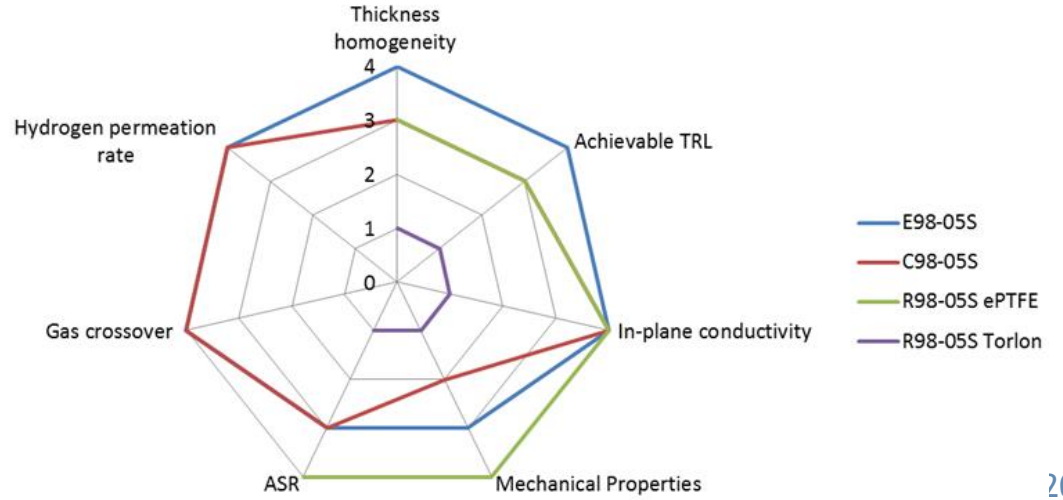
EXTRUDED MEMBRANE



CAST MEMBRANE

TORLON REINFORCED MEMBRANE

ePTFE REINFORCED MEMBRANE



Several Aquivion-based membranes were evaluated for Neptune and selection for the final product was based on

- Performance (i.e. electrochemical, mechanical and mass transport properties)
- Achievable quality
- Achievable Technology Readiness Level (TRL)

Required quantity of membrane has been produced and shipped to the partner responsible for MEA fabrication

Aquivion E98-05S Membrane

Membrane type: Extruded

Equivalent Weight (EW): 961 g/mol

Thickness: 55 µm

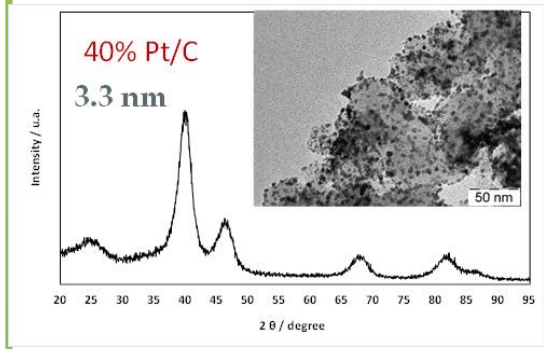
Chemically stabilized

- Siracusano, S.; Oldani, C.; Navarra, M.A.; Tonella, S.; Mazzapioda, L.; Briguglio, N.; Aricò, A.S. J. Memb. Sci. 2019, 578, 136-148.
- Gatto, I.; Carbone, A.; Saccà, A.; Passalacqua, E.; Oldani, C.; Merlo, L.; Sebastiàn, D.; Aricò, A.S.; Baglio, V. J. Electroanal. Chem. 2019, 842, 59-65.

Results Highlights - Catalysts

Cathode

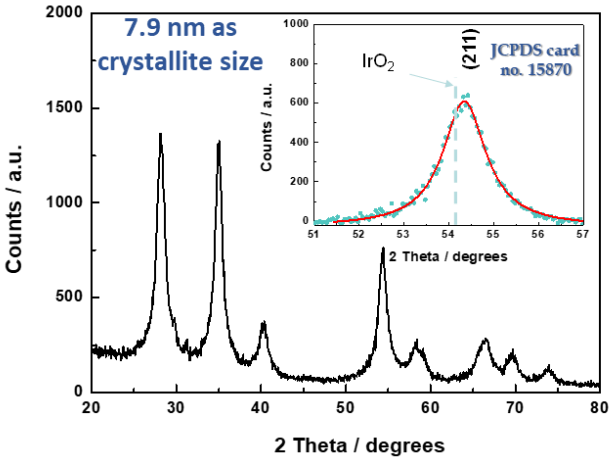
40% Pt/C: Sulphite complex route

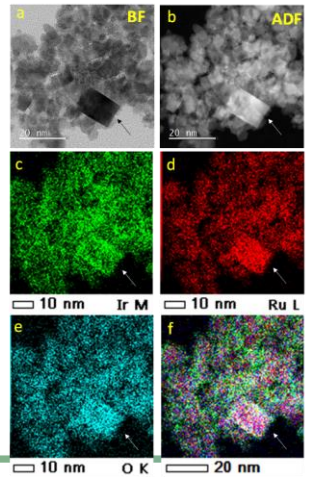


XRD: Pt cubic and Carbon support hexagonal crystallographic structures

Anode

IrRuOx: Modified Adams Synthesis

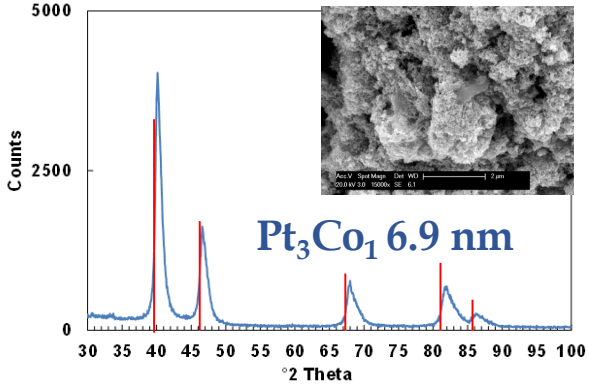




Evidence of solid solution with some enrichment of Ir on the surface and Ru in the bulk

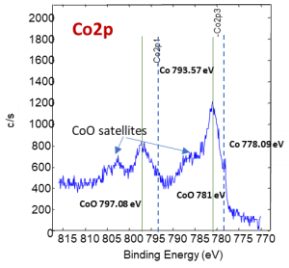
Recombination

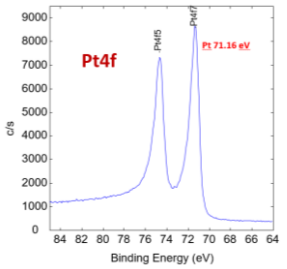
Anode integrated recombination catalyst: PtCo



PtCo alloy obtained

Pt_3Co_1 is characterised by a lower fraction of Cobalt on the surface





At.%	Pt	Co
Surface	90	10
Bulk	75	25

- S. Siracusano, N. Hodnik, P. Jovanovic, F. Ruiz-Zepeda, M. Šala, V. Baglio, A. S. Aricò. Nano Energy 40 (2017) 618-632.
- N. Briguglio, S. Siracusano, G. Bonura, D. Sebastián, A. S. Aricò. Applied Catalysis B: Environmental 246 (2019) 254-265

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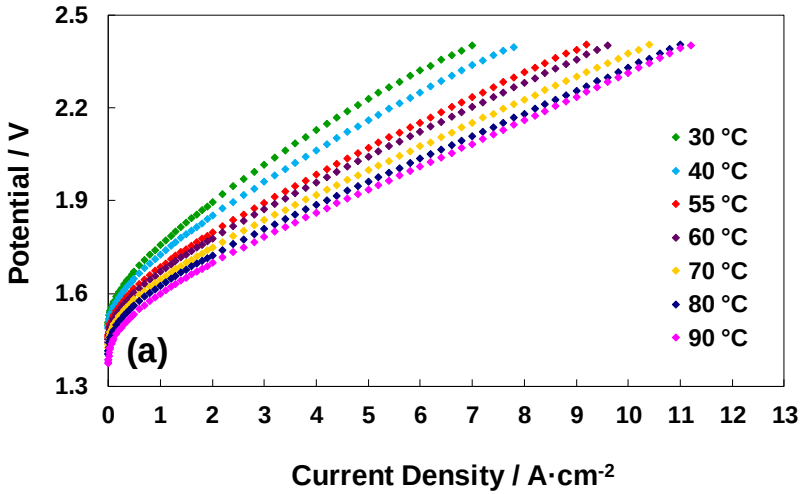
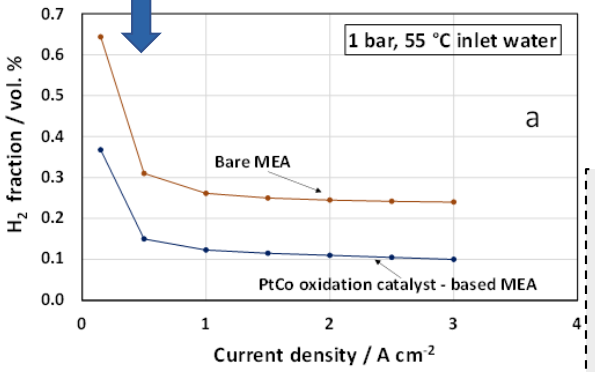
Results Highlights - MEAs

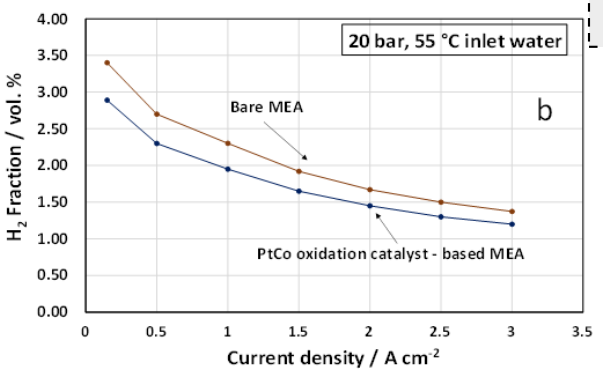
IrRuOx (15% D98 06AS) 0.3 mg·cm^{-2}
PtCo 0.2 mg·cm^{-2}
E98 05S
40% Pt/C (28% D98 06AS) 0.1 mg·cm^{-2}

Single Cell Performance



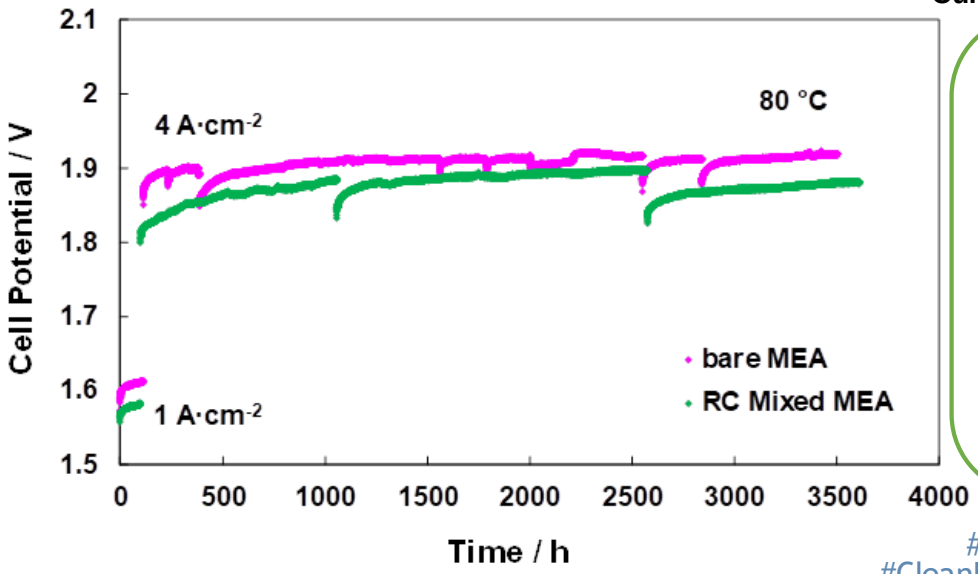
Almost 50% reduction of the H_2 concentration in O_2 in a wide range of current densities





IrRuOx (15% D98 06AS) 0.34 mg·cm^{-2}
E98 09S
40% Pt/C (28% D98 06AS) 0.1 mg·cm^{-2}

RC: PtCo (10% D98 06AS) 0.2 mg·cm^{-2}



MEA with recombination catalyst shows good stability with a voltage efficiency of ~ 80 % vs. the high heating value (HHV) of hydrogen at a high current density of 4 A cm^{-2}.

- N. Briguglio, S. Siracusano, G. Bonura, D. Sebastián, A. S. Aricò. Applied Catalysis B: Environmental 246 (2019) 254-265
- F.Pantò, S.Siracusano, N.Briguglio, A.S.Aricò. Applied Energy 279 (2020) 115809

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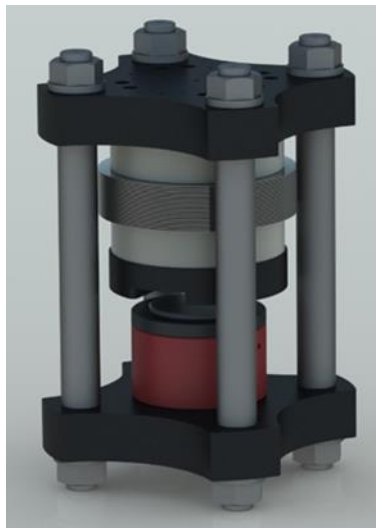
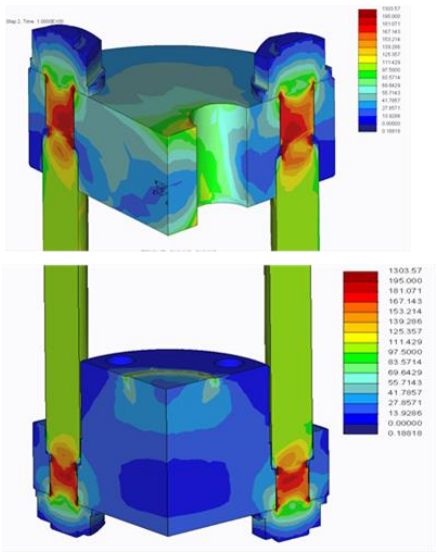
Results Highlights – Stack





New PEMWE stack module designed at ITM acts as a pressure vessel - self-pressurizing to save energy and cost in compression of gases. Low-cost, single acting hydraulic cylinder provides compression for the stack module.

Stack module consists of:

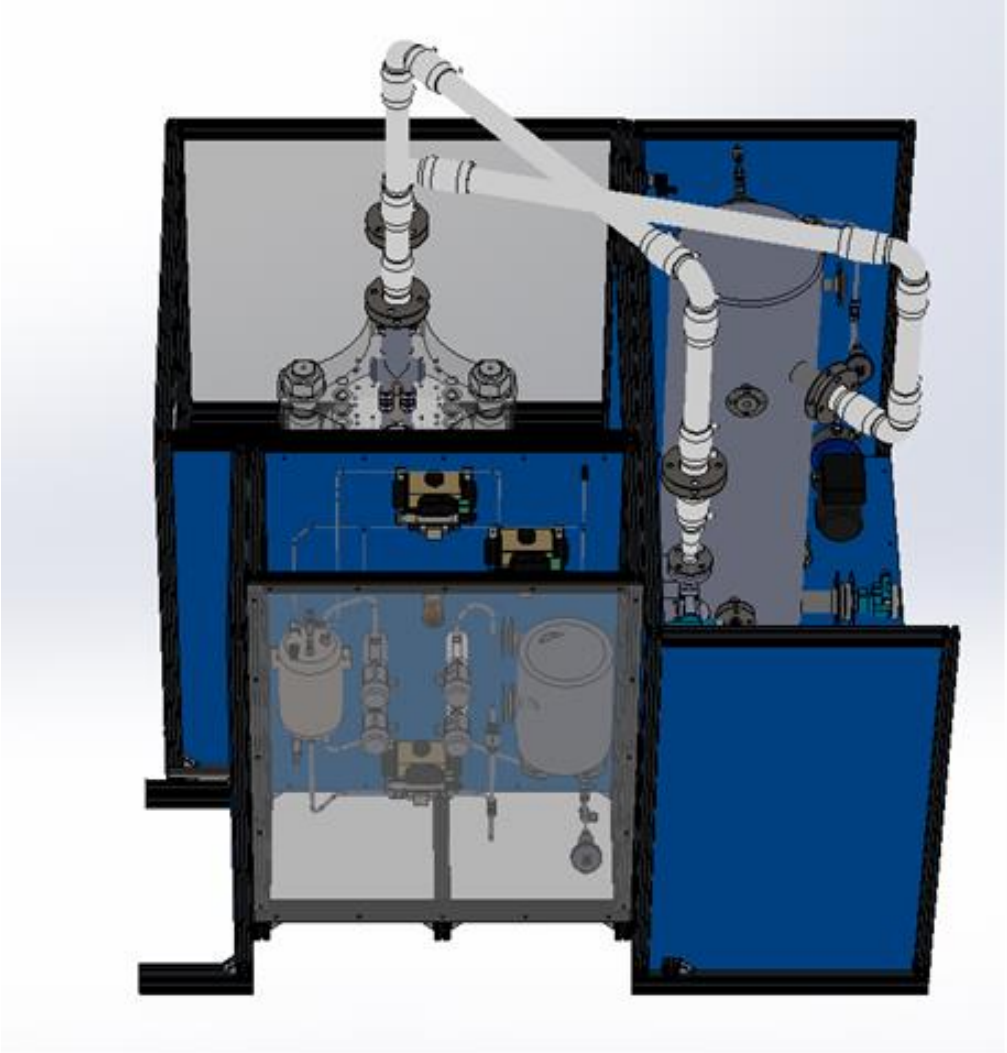
- composite cell-plate assemblies
- end-plates
- retention structure

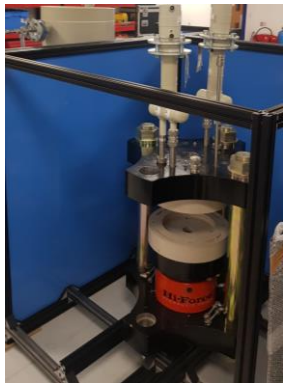
Stack design based on:

- ‘filter press assembly’, in a bipolar arrangement
- injection-moulded parts
- flow-field free architecture to eliminate expensive machining costs
- efficient, compact design for lean manufacture

Results Highlights - System

- Prototype stack operating at high temperature, pressure and current density integrated into an single, compact unit with advanced balance of plant.
- All sub-systems and components have been evaluated in a design review.
- Engineering calculations and computer simulations carried out to aid selection of correct materials of construction.
- Build of balance of plant and installation of electrical systems nearing completion.





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Acknowledgements

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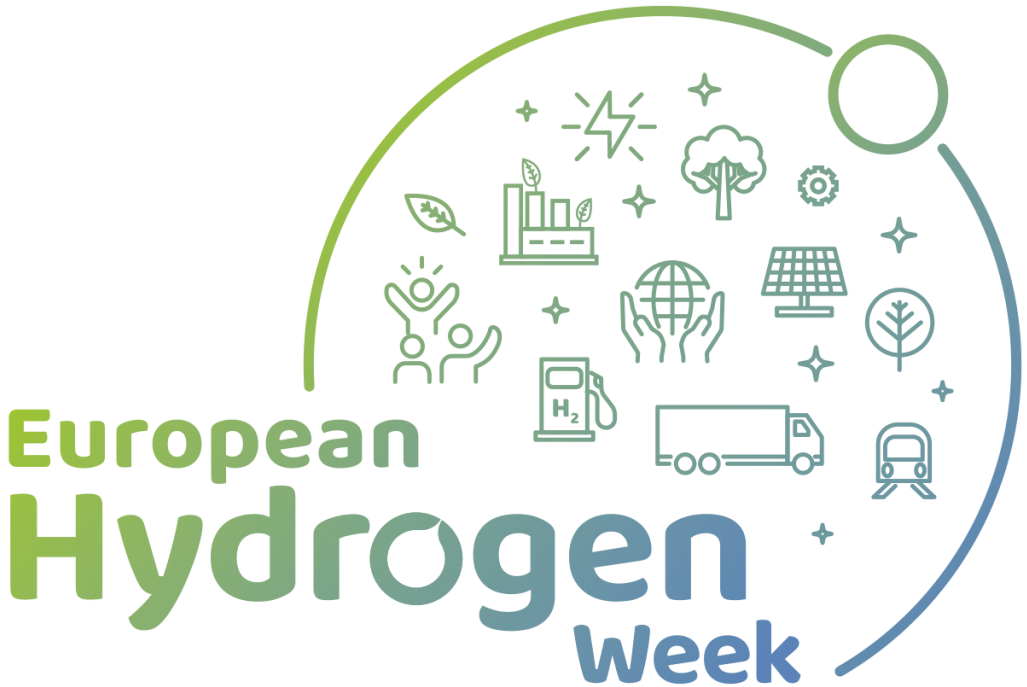
Further Information

www.neptune-pem.eu



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