ELECTROHYPEM
(Contract number 300081)

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http://www.electrohypem.eu

PROJECT OVERVIEW

- Enhanced performance and cost-effective materials for long-term operation of PEM water electrolysers coupled to renewable power sources
- Call topic: SP1-JTI-FCH.2011.2.7
- Start date and end date: 01-07-2012 / 30-06-2015
- Budget: € 2,842,312 FCH JU contribution € 1,352,771
- Consortium overview:

- Overall purpose of the project: develop cost-effective components for proton conducting membrane electrolysers with enhanced activity and stability in order to reduce stack costs and to improve efficiency, performance and durability.
- Stage of implementation: 70% project duration passed

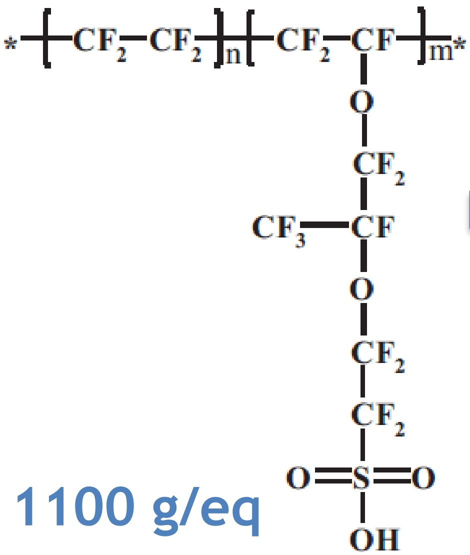
PROJECT TARGETS AND ACHIEVEMENTS

Status before project	AIP target (2011)	Project Target	Current status/ achievements	Expected final achievement
Capacity range for PEM electrolysers (0.2-30 Nm^3/h)	Hydrogen production capacity > 1 Nm^3/h	Novel materials: Rated capacity > 1 Nm^3/h	Materials validated at rated capacity ~0.2 -0.3 Nm^3/h	Rated capacity > 1 Nm^3/h
Energy consumption 4.8-5.6 kWh/Nm^3 H_2 (Efficiency 52- 62% LHV)	Efficiency of 75% (LHV)	Energy Efficiency > 75% (LHV); < 4 kWh/Nm^3 H_2	Energy consumption < 4 kWh/Nm^3 H_2 at current density of 1 A cm^{-2}	Energy consumption < 4 kWh/Nm^3 H_2 at current density of 1 A cm^{-2}
PEM Water electrolyser Perfomance	n.a.	Performance 1 A cm^{-2} at 1.6 V 2 A cm^{-2} at 1.8 V	Performance 1.3 A cm^{-2} at 1.6 V 3 A cm^{-2} at 1.8 V at 90 ° C	Performance 1.3 A cm^{-2} at 1.6 V 3 A cm^{-2} at 1.8 V

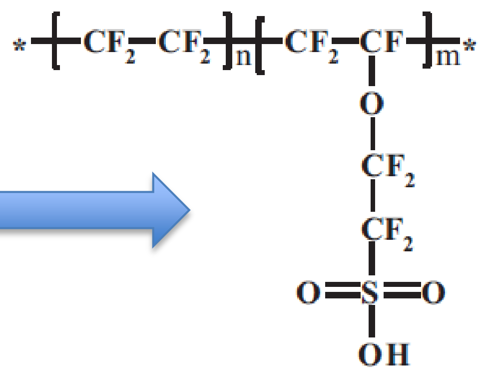
PROJECT TARGETS AND ACHIEVEMENTS

Status before project	AIP target	Project Target	Current status/ achievements	Expected final achievement
Cell Voltage increase < 20-30 μV/h at constant load	Cell Voltage increase < 15 μV/h at constant load	Cell Voltage increase < 15 μV/h at 1 A cm^{-2}	Cell Voltage increase ~8 μV/h (1200 hrs) at 1 A cm^{-2}	Cell Voltage increase ~8 μV/h (1200 hrs) at 1 A cm^{-2}
System cost~ 8 k€/Nm^3 H_2/h (including power and gas conditioning); Stack cost ~5k€/$Nm^3$$H_2$/h	Stack cost <2.5 k€/Nm^3 H_2/h in series production;	Stack cost <<2.500 €/Nm^3 H_2/h	PGM from 4 mg cm^{-2} (300 €) to 1-0.5 mg cm^{-2} (80-40 € per Nm^3/h) Hydrocarbon Membrane cost<100 €/kg, density of 100 g/m^2 will result in 10 €/m^2	Stack cost <<2.500 €/Nm^3 H_2/h with cost-effective bipolar plates

PROGRESS ACHIEVED IN THE PROJECT



1100 g/eq



870 g/eq

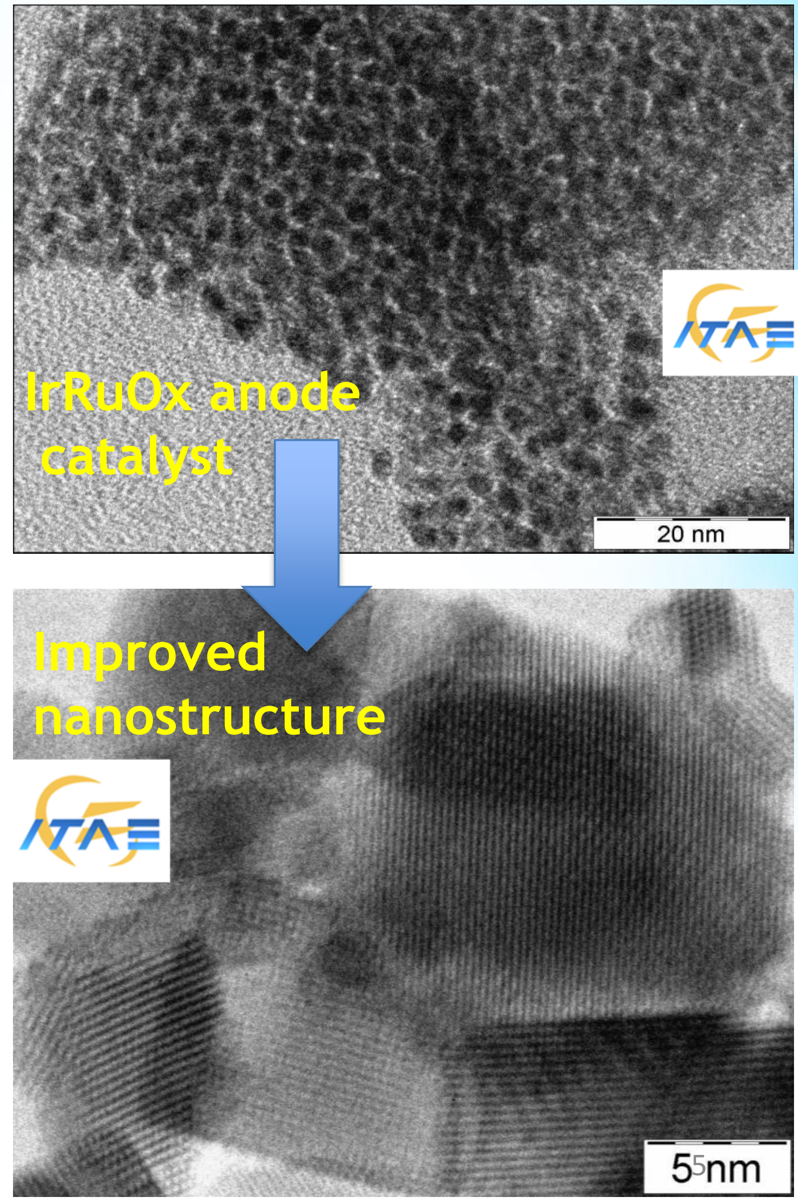
Nafion ®

Long side-chain ionomers

Aquivion ®

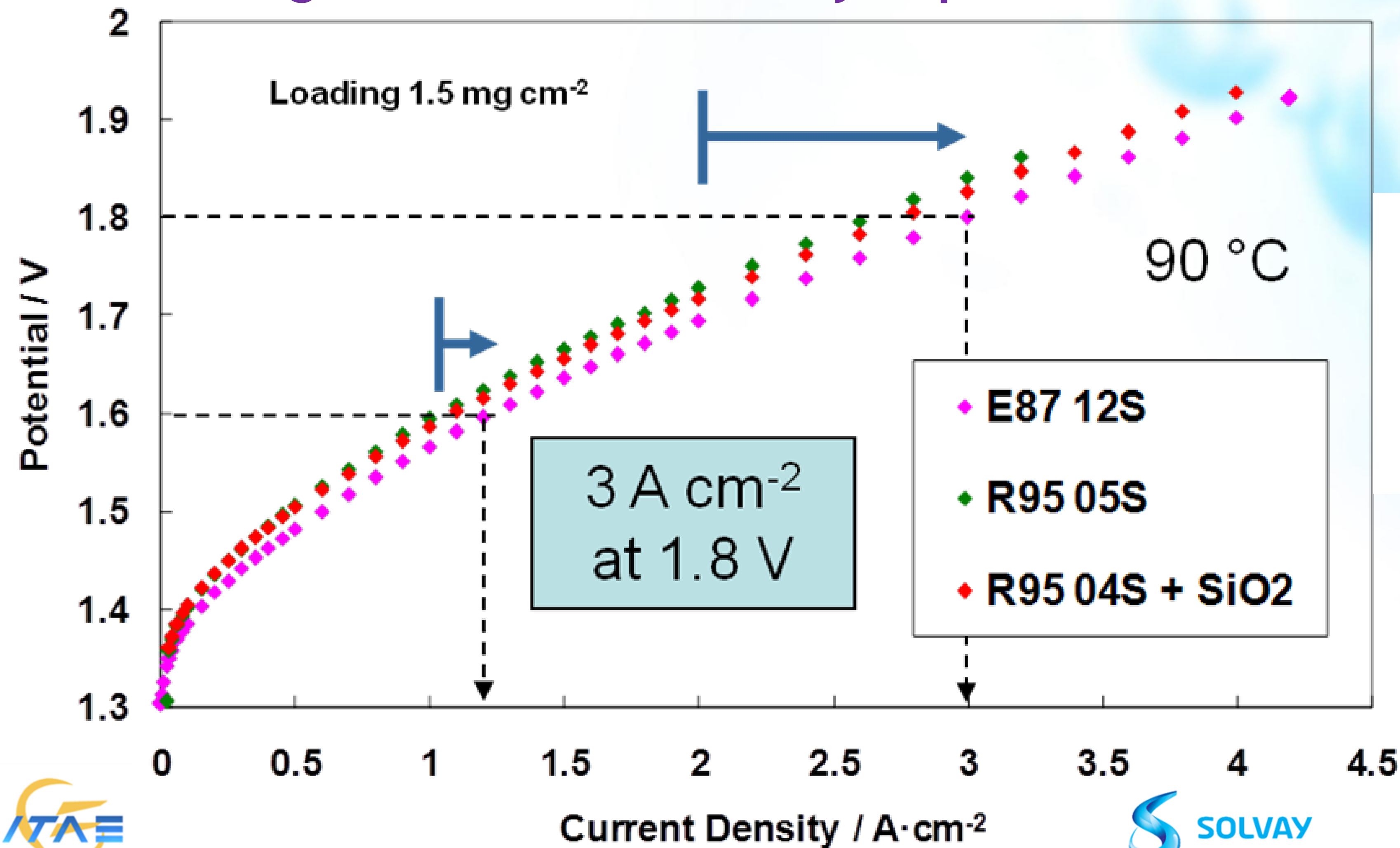
Short side-chain ionomer

The Solvay Aquivion ionomer is characterized by both larger crystallinity and higher glass transition temperature than Nafion



PROGRESS ACHIEVED IN THE PROJECT

Single cell water electrolysis performance

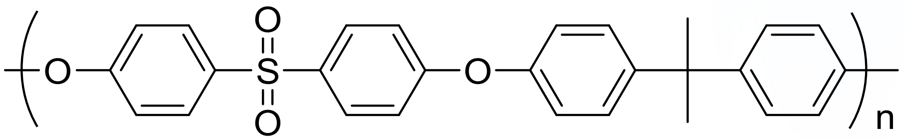


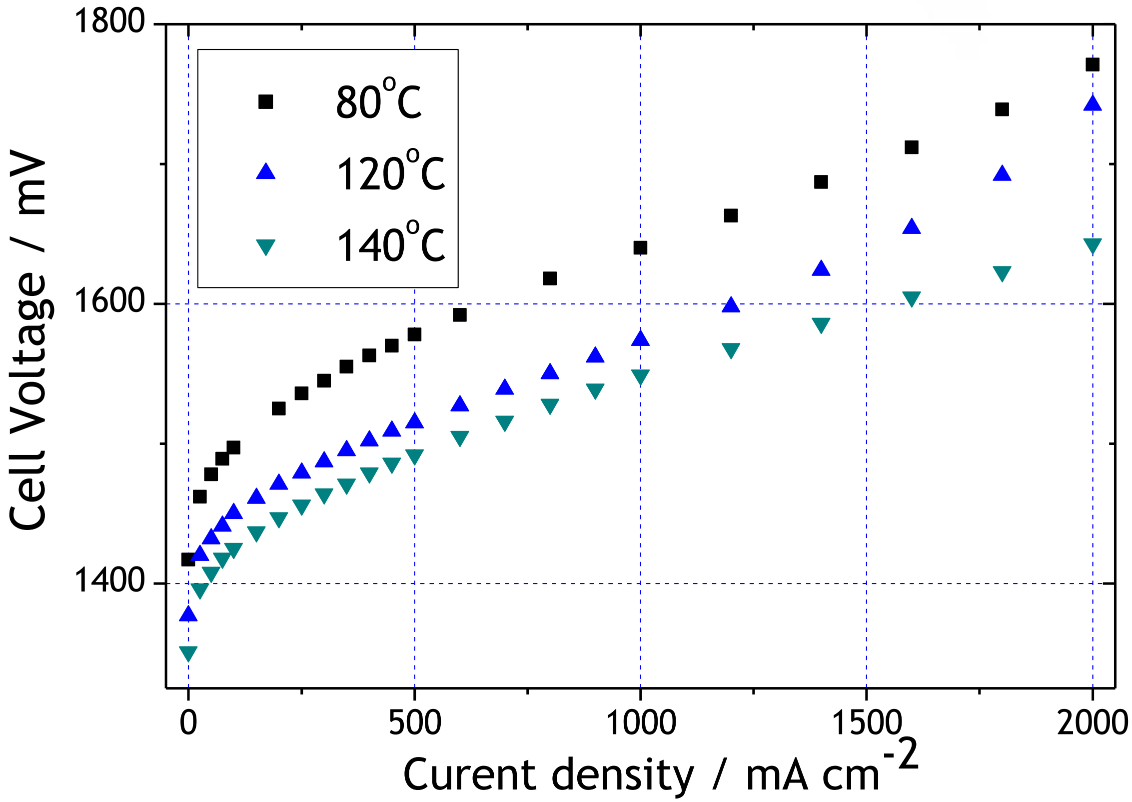
CNR-ITAE catalysts in combination with Solvay Aquivion ionomers

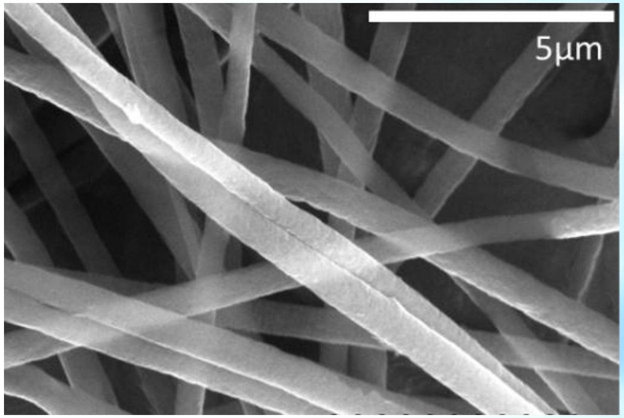
PROGRESS ACHIEVED IN THE PROJECT

High temperature operation

Composite membrane of Aquivion and electrospun polysulfone nanofibre mats







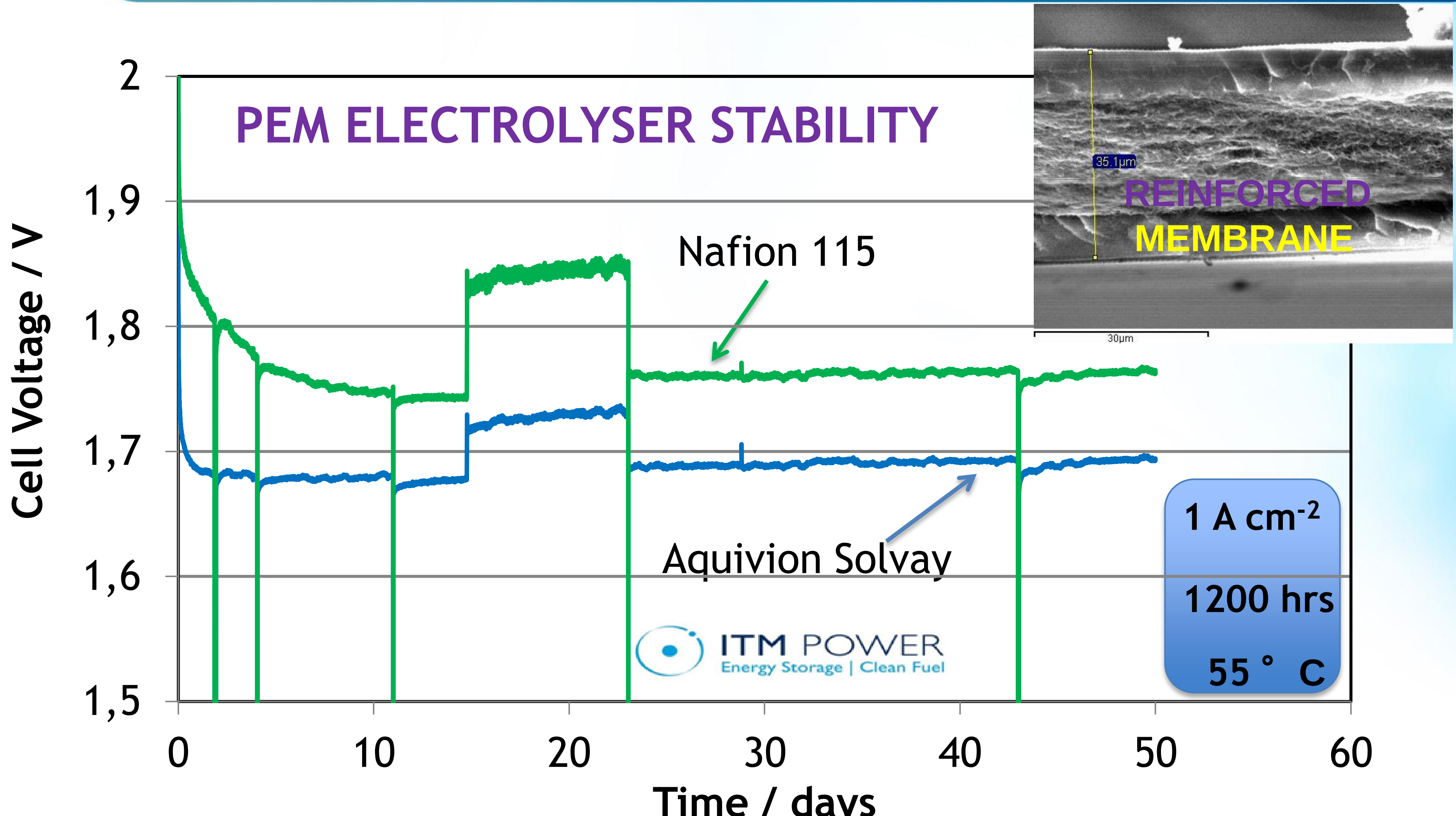
<1.8 V @ 2 A cm^{-2} reached at 80 °C

<1.6 V @ 1 A cm^{-2} reached at 80 °C

1.55 V at 140 °C

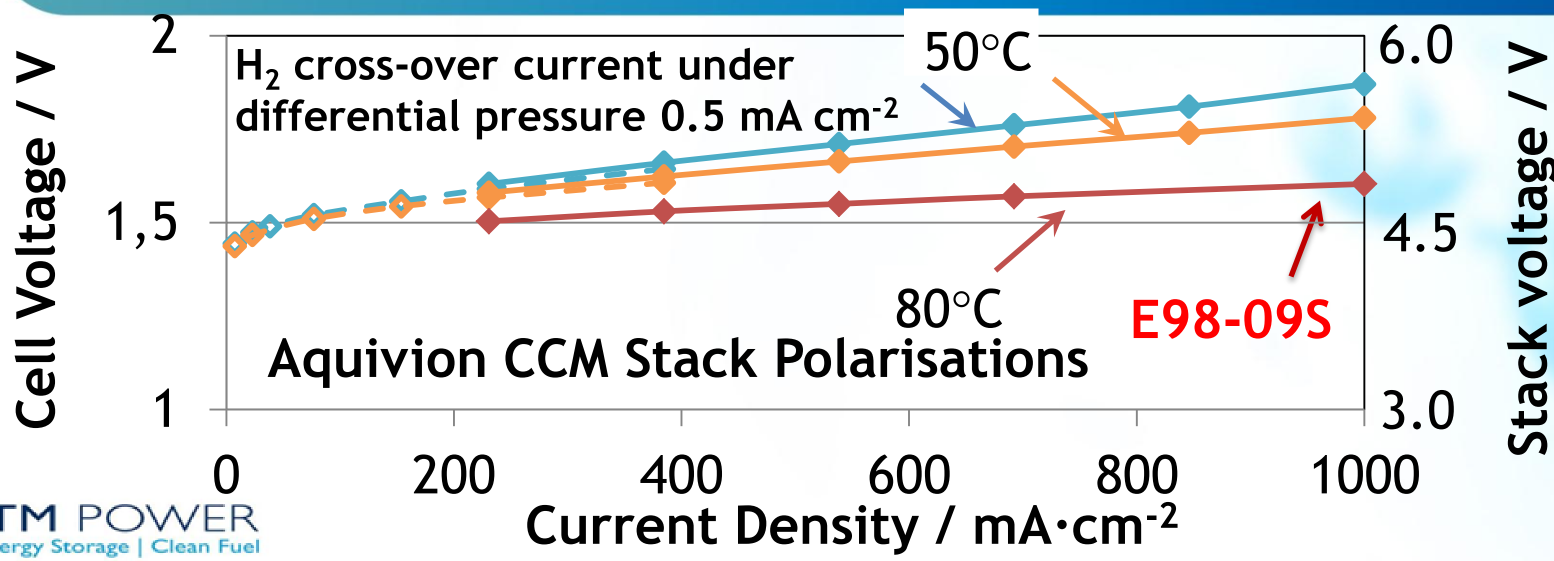
SOLVAY
asking more from chemistry®

PROGRESS ACHIEVED IN THE PROJECT

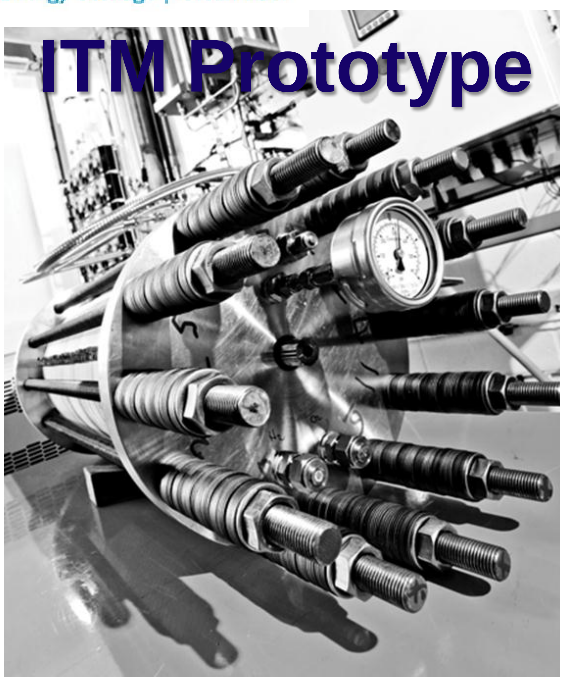


PEM electrolyser single cells containing MEAs
with same catalyst loading and different membranes

PROGRESS ACHIEVED IN THE PROJECT



ITM POWER
Energy Storage | Clean Fuel



PROGRESS BEYOND THE STATE OF THE ART

- Performances of 3 A cm^{-2} at 1.8 V vs. < 2 A cm^{-2} at 1.8 V cell voltage (Catalyst loading 1.5 mg cm^{-2}).
- Stability improvement ~8 µV/h at 1 A cm^{-2} vs. 20-30 µV/h
- Operating temperatures up to 140 ° C vs. 60-80 ° C.
- Energy consumption < 4 kWh/Nm^3 H_2 at current density of 1 A cm^{-2} .
- From 2 to 4 times reduction in the cost of MEA components (catalyst and membrane) through the reduction of noble metal loading and the use of cost-effective membranes.

RISKS AND MITIGATION

- **HIGH TEMPERATURE OPERATION OF THE PEM ELECTROLYSIS SYSTEM**

  – High temperature operation up to 140 ° C has been demonstrated in single cell but….

  – ….ion exchange resin cartridges used in the PEM electrolysis systems are not able to operate above 70-80 ° C: it is not possible to get full advantage of high temperature operation.

  – Individuation and/or development of ion exchange resin cartridges operating at higher temperatures appears necessary.

  – However, no revision of original targets necessary since these are already achieved at 55° C.

RISKS AND MITIGATION

- PEM ELECTORLYSER USING LOW LOADING PRECIOUS METALS
  - Performance and efficiency targets almost achieved with 0.5 mg cm^{-2} noble metal loading but…
  - ….long term stability not consistent with the project target using the low loading approach
  - Both performance and stability targets are achieved with 1-1.5 mg cm^{-2} catalyst loading.
  - Stack tests are carried out with 1.5 mg cm^{-2}

SYNERGIES WITH OTHER PROJECTS AND INITIATIVES

- The project is not co-funded by any other agency
- Link to previous work carried out within the framework of EU and national projects (FP6 AUTOBRANE, RINNOVA, etc.)
- Collaboration with a Marie Curie ITN SUSHGEN project: joint workshop
- Collaboration between CNR Italy-CIDETEQ Mexico and CNR (Italy) – ASRT (Egypt) in the framework of a bilateral projects on PEM electrolysis and regenerative fuel cells

HORIZONTAL ACTIVITIES

- Training/education of 3 post-doctoral researchers in materials science, processing and assessment (TRE, CNRS) and 1 PhD student (CNRS)
- Work in safety, regulations, codes, standards: 2 public deliverables published in the Electrohypem web site; JRC is in charge of protocols harmonisation
- General public awareness: Information activities to increase public awareness of hydrogen production from renewable power sources through the web site, dissemination and courses on hydrogen technologies addressed to university and high school students including the visit to the research laboratories, etc.

DISSEMINATION ACTIVITIES

- 6 Publications in international peer-reviewed journals (3 dealing with membranes, 1 dealing with catalysts, 1 dealing with PEM electrolyser system, 1 review article)
- 15 Presentations at conferences and workshops
- A PEM electrolysis workshop is organised (11th December 2014) as a side event of the Euro-Mediterranean Hydrogen Technologies Conference, Taormina

http://www.itae.cnr.it/emhytec2014/electrohypem.html

http://www.electrohypem.eu

EXPLOITATION PLAN

- **Exploitation of the project results is first carried out inside the Consortium.**
- Solvay is currently commercializing membranes and ionomer dispersions for fuel cells but not a specific product for the electrolysis application; since the interest in electrolysis is growing, the natural exploitation of the results of the project is the creation of a production line for membranes and dispersion dedicated specifically to this application.
- TRE is active in the field of renewable energy sources. They will use the results of the project to implement their renewable power sources with cost-competitive electrolysis plants for different applications and especially as a means of storage of surplus energy.
- ITM is presently producing a set of commercial PEM electrolyser; they will use project results to implement their products and expand the range of applications.
- The industrial partners will also seek to inform potential customers of positive results arising from the project in accordance to the IPR considerations.
- Deployment of components and systems based on project results, initially in terms of niche market, expected after termination of the project (ITM, Solvay, TRE).

EXPECTED IMPACT

- **The decentralised hydrogen production may represent an important option for the future. This implies the use of small systems directly coupled to wind/solar sources for hydrogen generation and its storage.**

- The aim of the project is to contribute to the road-map addressing the achievement of a wide scale decentralised hydrogen production infrastructure
- The scope is to develop a sustainable and cost-effective hydrogen production technology in order to meet an increasing share of the hydrogen demand for energy applications from carbon-free or lean energy sources.

ACKNOWLEDGEMENT

Electrohypem

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New Energy World JU

fuel cells & hydrogen for sustainability

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