ELECTROHYPEM

(Contract number 300081)

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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: 100% project duration passed

PROJECT TARGETS AND ACHIEVEMENTS

Programme target AIP (2011)	Project Target	Final achievements	Next steps
Hydrogen production capacity > 1 Nm^3/h	Novel materials: Rated capacity > 1 Nm^3/h	Materials validated in a stack with capacity ~1.2 Nm^3/h	Using the developed components in > 100 Nm^3/h capacity stacks
Efficiency of 75% (LHV)	Energy Efficiency > 75% (LHV); < 4 kWh/Nm^3 H_2	Energy consumption < 3.6 kWh/Nm^3 H_2 at a current density of 1 A cm^{-2} for a 1.2 Nm^3/h stack (η~77% vs. LHV)	Energy consumption < 4 kWh/Nm^3 H_2 in large size PEM electrolysis systems (0.5 MW)
Cell Perfomance n.a.	Cell Perfomance 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; 3.2 A cm^{-2} at 1.8 V at 90° C; > 1 A cm^{-2} at 1.55 V at 140° C	Cell Performances >4 A cm^{-2} at 1.8 V at 90° C achieved with PGM loading: 0.5 mg cm^{-2}

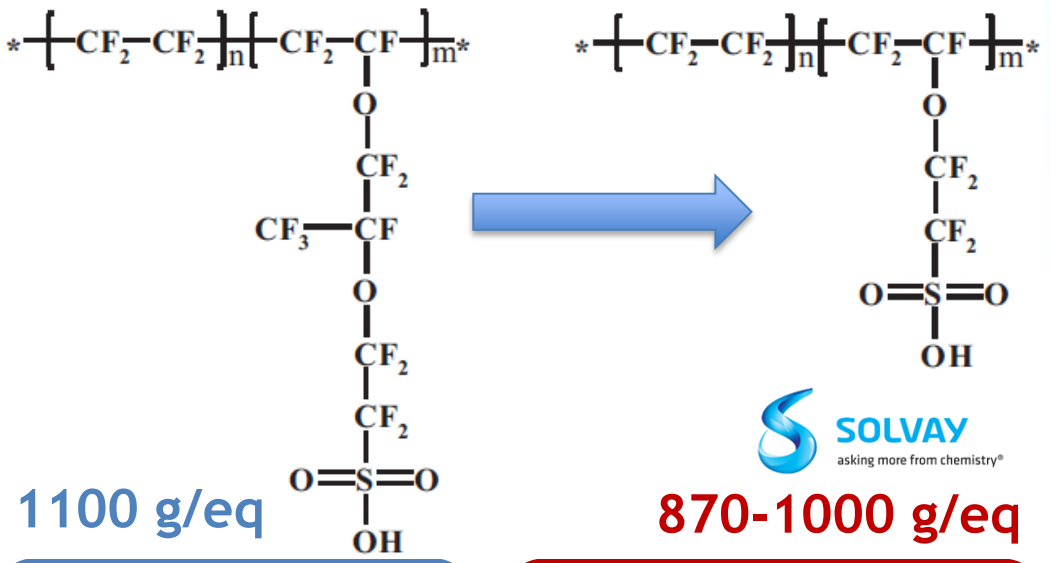
PROJECT TARGETS AND ACHIEVEMENTS

Programme target AIP (2011)	Project Target	Final achievements	Next steps
Noble metal loading n.a.	Noble metal loading <0.5 mg cm^{-2}	Cell voltage increase ~30 mV at 3 A cm^{-2} by reducing the total noble metal loading from 2 to <0.5 mg cm^{-2}	Reduction of the total noble metal loading to 0.2-0.3 mg cm^{-2}
Cell Voltage increase < 15 µV/h at constant load	Cell Voltage increase < 15 µV/h at 1 A cm^{-2}	Cell Voltage increase ~5 µV/h (1000 hrs) at 1 A cm^{-2} with 1.5 mg cm^{-2} noble metal loading	Only one stack replacement in a PEM electrolysis system with 20-years life-span
Cell Voltage increase < 15 µV/h at constant load	Cell Voltage increase < 15 µV/h at 1 A cm^{-2}	Cell Voltage increase ~15 µV/h (1000 hrs) at 1 A cm^{-2} with 0.5 mg cm^{-2} noble metal loading	Reduction of voltage decay to < 5 µV/h with ultra-low catalyst loadings

PROJECT TARGETS AND ACHIEVEMENTS

Programme target AIP (2011)	Project Target	Final achievements	Next steps
Stack cost <2.5 k€/Nm³ H_2 in series production	Stack cost <<2.500 €/Nm³ H_2	PGM from 4 mg cm^{-2} (300 €) to <0.5 mg cm^{-2} (~30 € per Nm³/h) Aquivion membrane cost: 100 € per Nm³/h H_2 production rate	Catalyst cost in large scale production (<8 € per Nm³/h) Membrane cost <10 €/m² i.e. <10 € per Nm³ H_2 /h
Stack cost <2.5 k€/Nm³ H_2 in series production	Stack cost <<2.500 €/Nm³ H_2	New stack configuration The traditional "bipolar plates" have been replaced for lower costs components and injection moulded parts	The combination of CCM savings and bipolar plates coatings developed in ElectroHyPEM can lower the cost of a production stack by 26%

PROGRESS ACHIEVED IN THE PROJECT



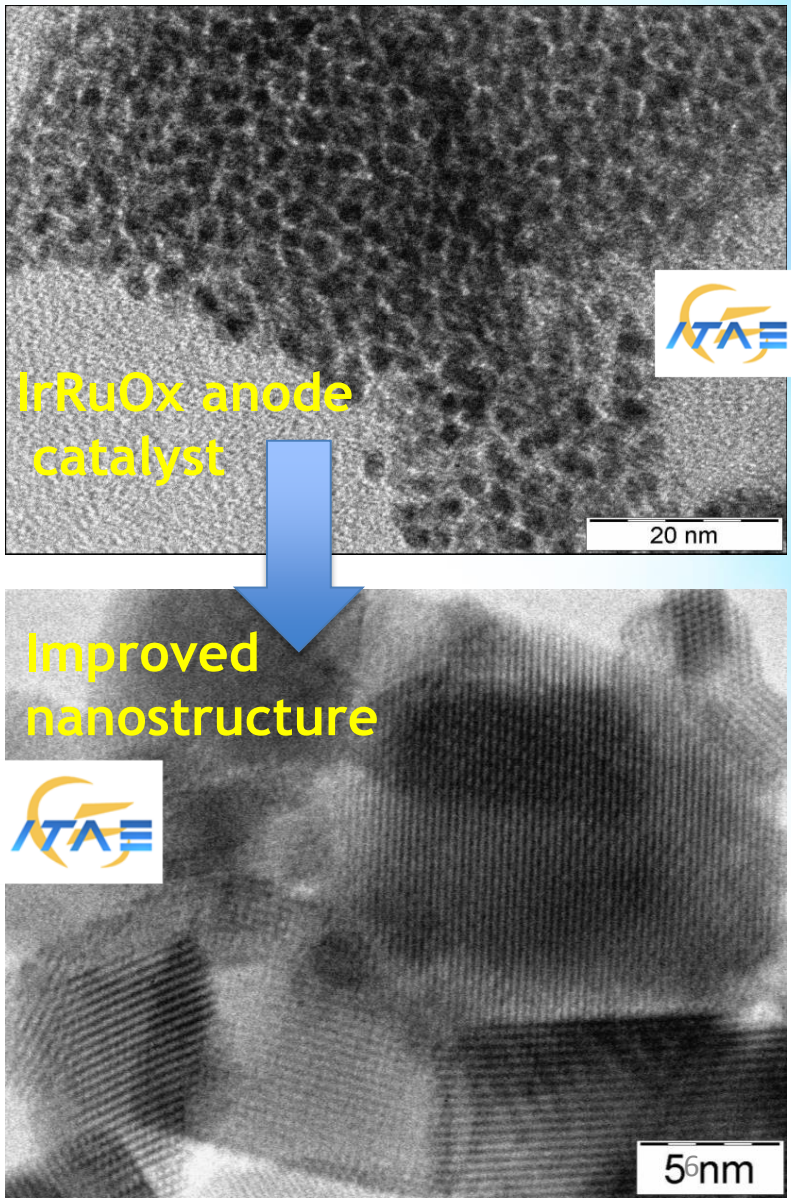
Nafion ®

Long side-chain ionomers

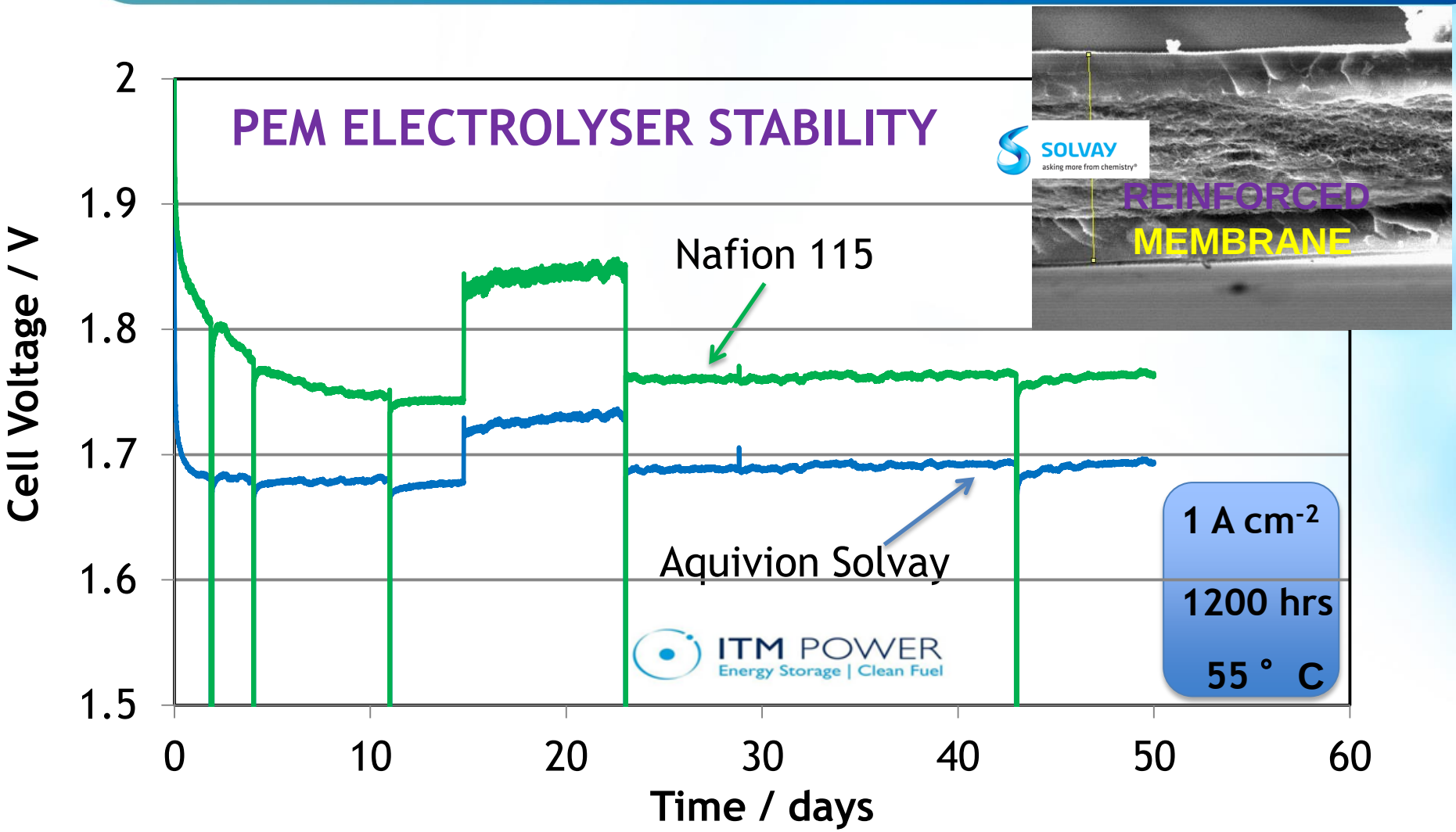
Aquivion ®

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

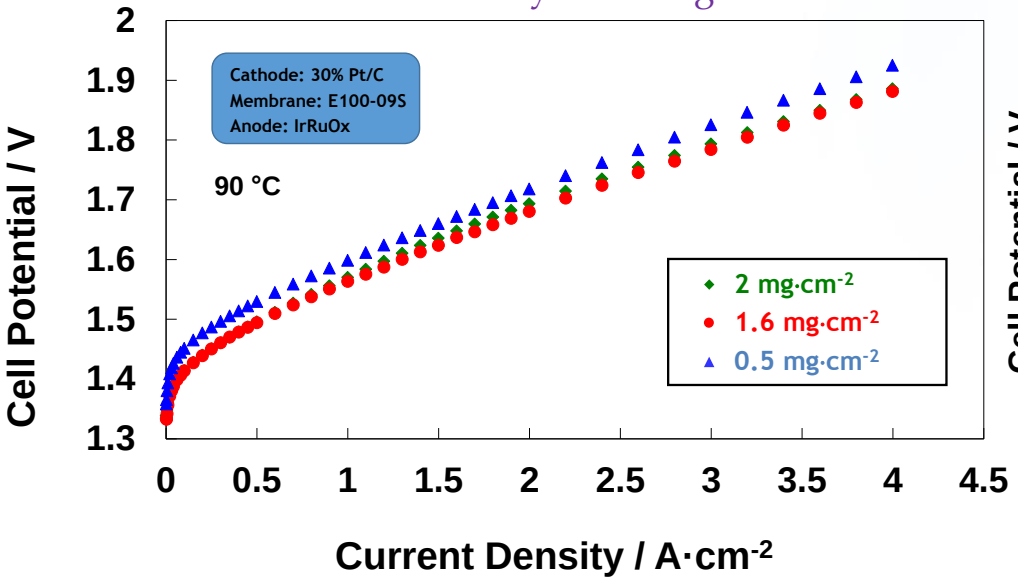


PEM electrolyser single cells containing MEAs with same catalyst loading and different membranes

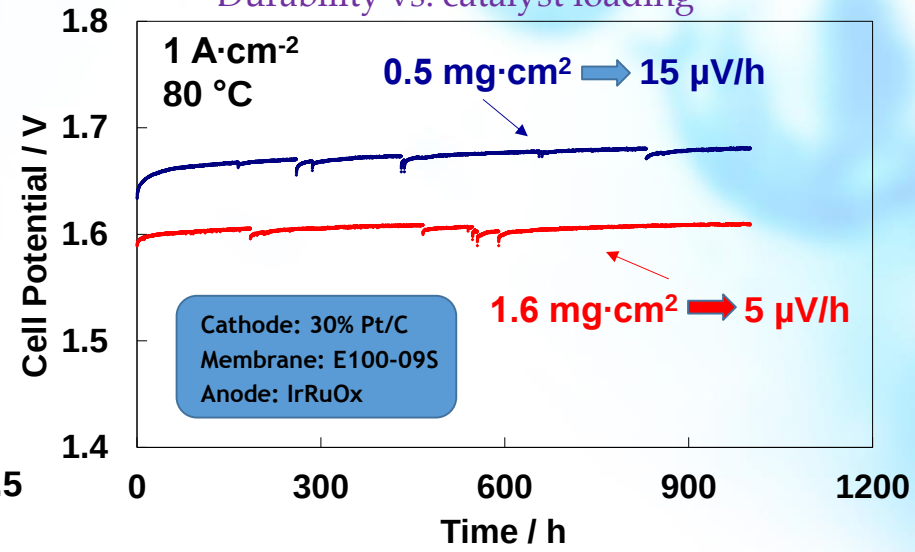
PROGRESS ACHIEVED IN THE PROJECT

Single cell water electrolysis performance

Effect of total catalyst loading



Durability vs. catalyst loading



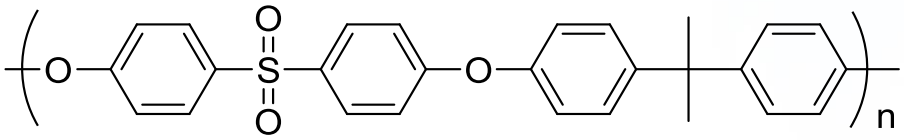
Decrease of cathode catalyst loading of **5 times** did not cause significant loss
Decrease of anode catalyst loading of **3 times** causes a performance loss of 30 mV

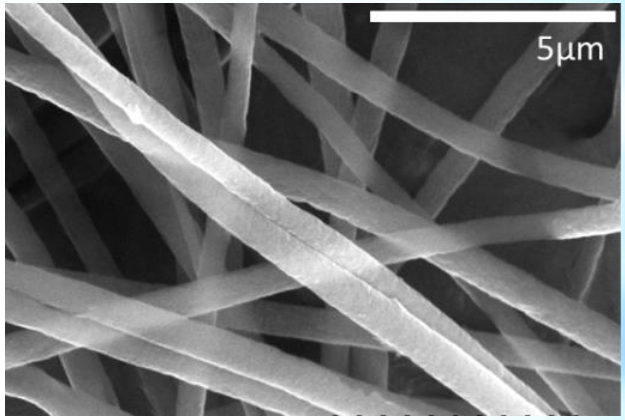
Decrease of cathode catalyst loading of **3 times** causes a similar increase in the degradation rate from 5 to 15 µV/h

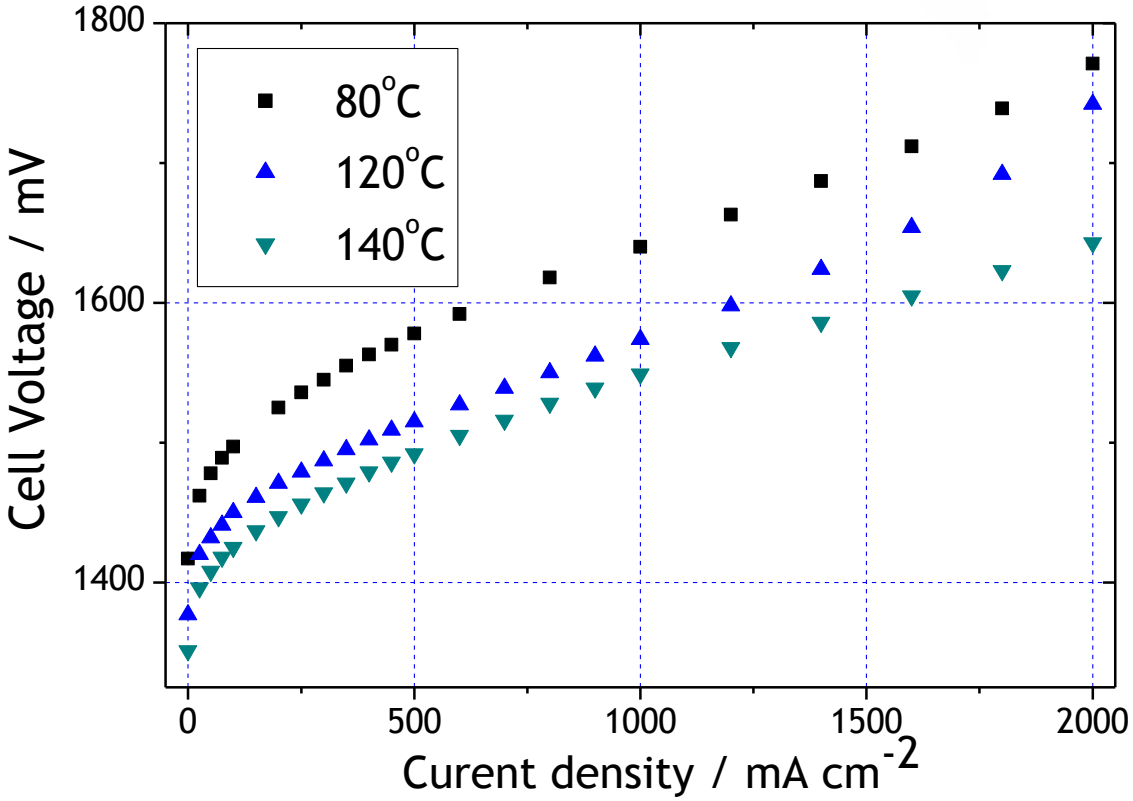
PROGRESS ACHIEVED IN THE PROJECT

High temperature operation

Composite membrane of Aquivion and electrospun polysulfone nanofibre mats







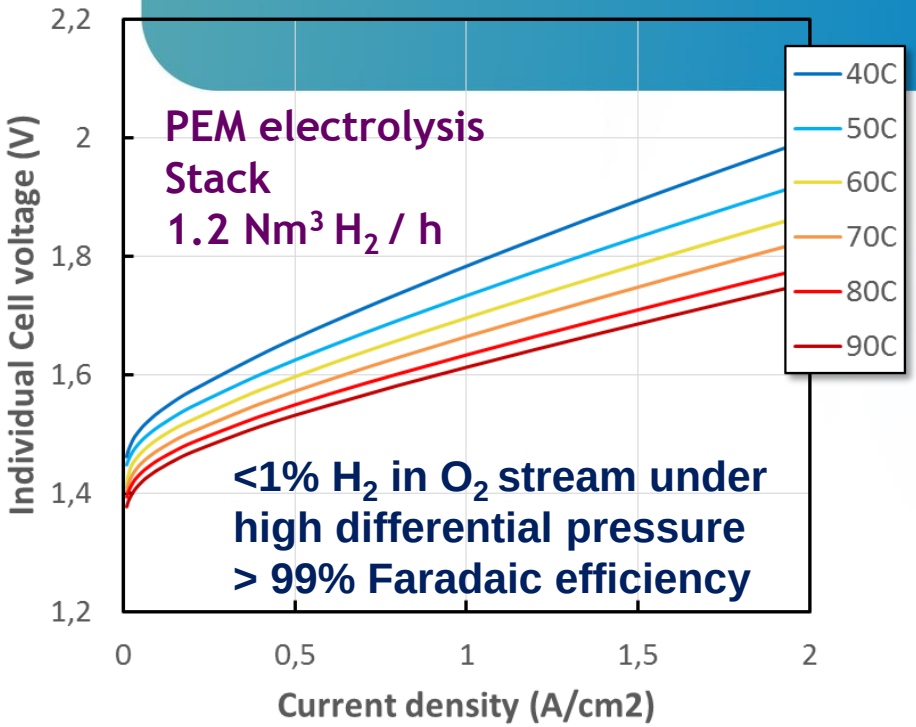
<1.8 V @ 2 A cm^{-2} reached at 80 °C

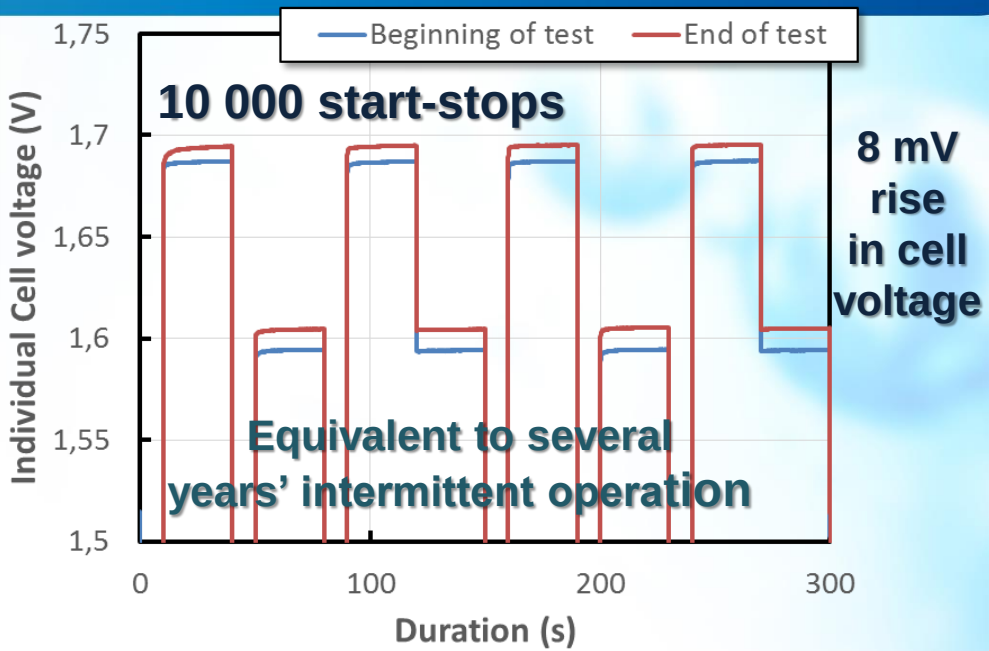
<1.6 V @ 1 A cm^{-2} reached at 80 °C

1.55 V at 140 °C

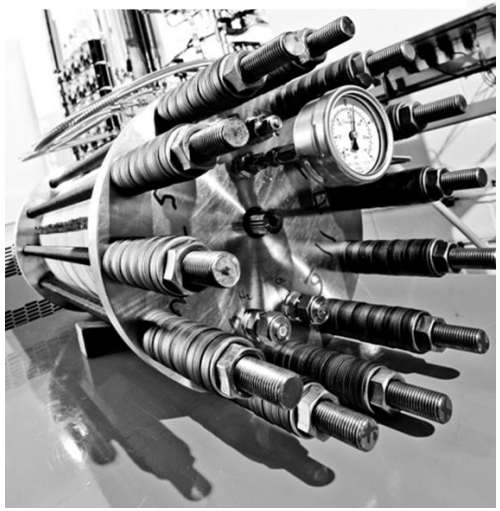
PROGRESS ACHIEVED IN THE PROJECT

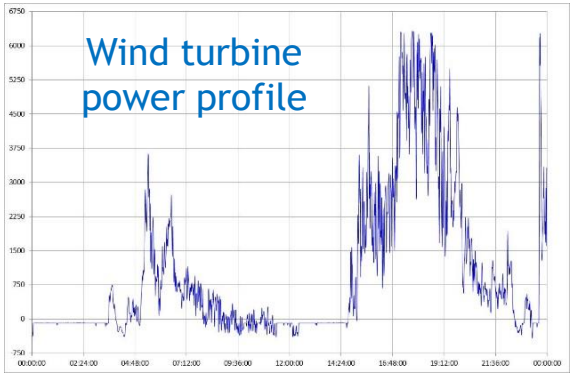
Electrohypem





ITM POWER
Energy Storage | Clean Fuel





SYNERGIES WITH OTHER PROJECTS AND INITIATIVES

- The project was 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 (CNRS): 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.

http://www.electrohypem.eu

DISSEMINATION ACTIVITIES

- 8 Publications in international peer-reviewed journals (3 dealing with membranes, 2 with catalysts, 1 on MEAs, 1 dealing with PEM electrolyser system, 1 review article)
- >20 Presentations at conferences and workshops
- A PEM electrolysis workshop was organised (11th December 2014) as a side event of the Euro-Mediterranean Hydrogen Technologies Conference, Taormina

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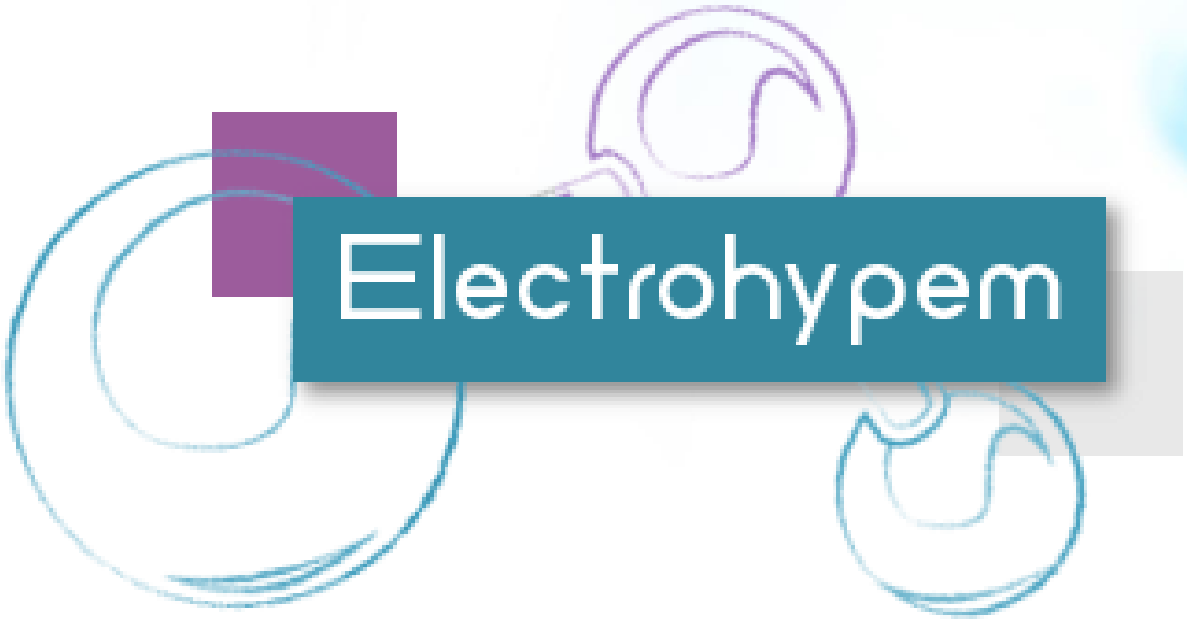
EXPLOITATION PLAN

- **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 within the first two years 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.
- The project results can also find application in large-size electrolysers for grid-balancing service especially in grids sharing large amounts of renewable power sources.

ACKNOWLEDGEMENT



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FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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