Enhanced performance and cost-effective materials for long-term operation of PEM water electrolysers coupled to renewable power sources- ELECTROHYPEM (Contract number 300081)

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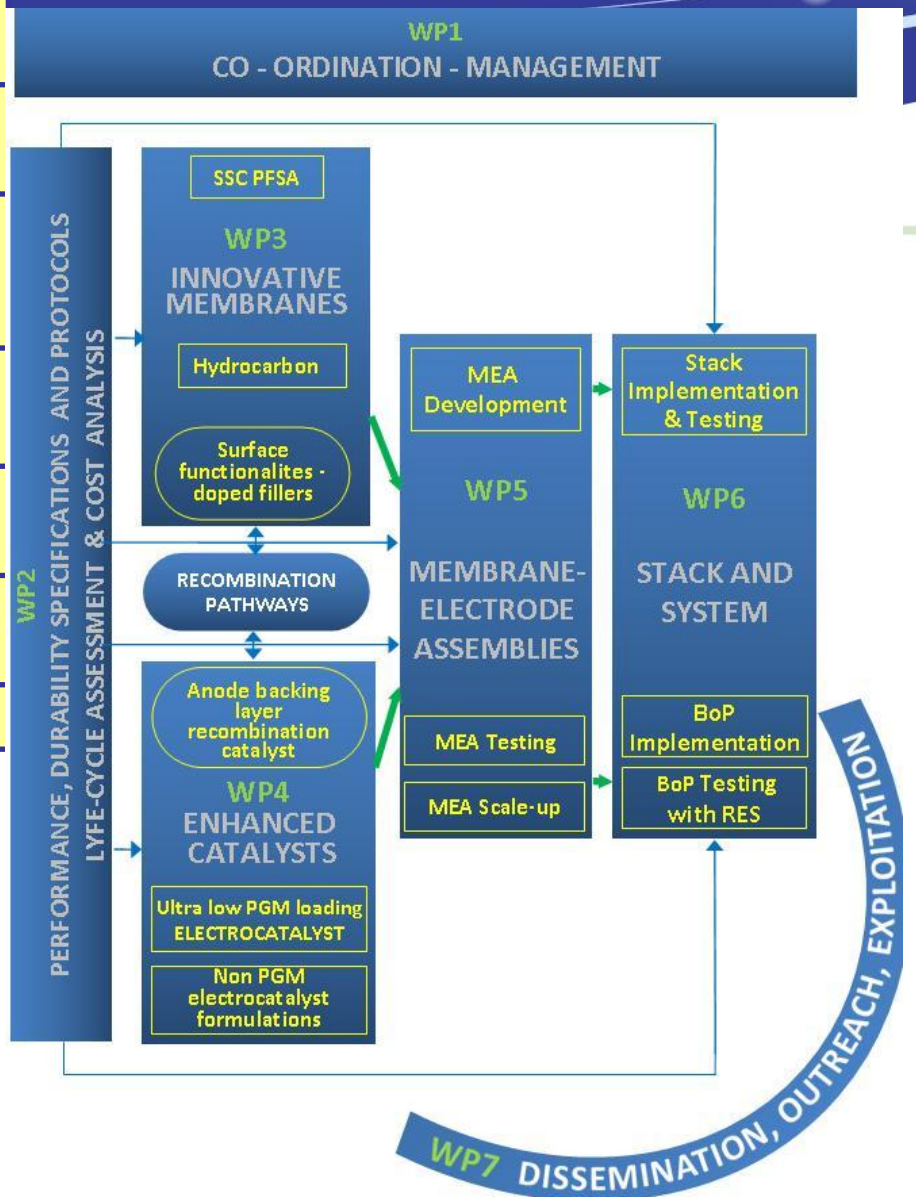
Project information

0. Project & Partnership description

Beneficiary name	Country	Partner type
CONSIGLIO NAZIONALE DELLE RICERCHE (CNR-ITAE)	Italy	Research
JOINT RESEARCH CENTRE, INSTITUTE FOR ENERGY AND TRANSPORT (JRC-IET)	Belgium	Research
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE (CNRS)	France	Research
SOLVAY SPECIALTY POLYMERS ITALY S.P.A. (SLX)	Italy	Industry
ITM Power (Trading) Ltd (ITM)	United Kingdom	Industry
TOZZI RENEWABLE ENERGY (TRE)	Italy	Industry

Start date: 1st July 2012	Duration: 36 months
Total Cost: € 2,842,312	Requested EU contribution: € 1,352,771
Collaborative project	Theme: SP1-JTI-FCH.2011.2.7 Innovative Materials and Components for PEM electrolysers



ELECTROHYPEM objectives:

The overall objective of the ELECTROHYPEM project is to 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.

The focus of the project is concerning mainly with low-cost electrocatalysts and membrane development. The project is addressing the validation of these materials in a PEM electrolyser (1 Nm^3 H_2/h) operating in the presence of renewable power sources.

The aim is to contribute to the road-map addressing the achievement of a wide scale decentralised hydrogen production infrastructure.

Electrohypem targets:

M18 — Membrane: Conductivity better than 200 mS/cm & H_2 permeation rate <6.25 10^{-5} cm s^{-1}

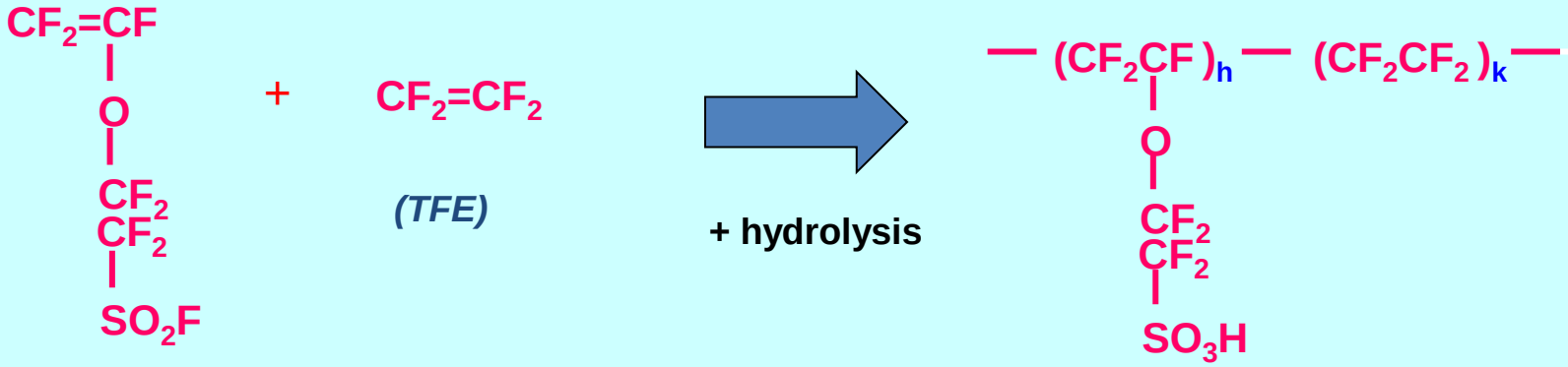
M24 — Catalysts: PGM loading <0.5 mg cm^{-2}; OER overpotential < 0.1 V vs. E thermoneutral, HER overpotential < 0.05 V vs. RHE at 1 A cm^{-2}

M32 — MEA: Current density better than 1 A cm^{-2} @ 1.6 V/cell degradation <15 μV/h.

M36 — Stack: Energy consumption < 4 kWh/Nm^3 H_2 at 1 Nm^3 h^{-1}

Membrane development

Aquivion® PFSA free radical polymerization

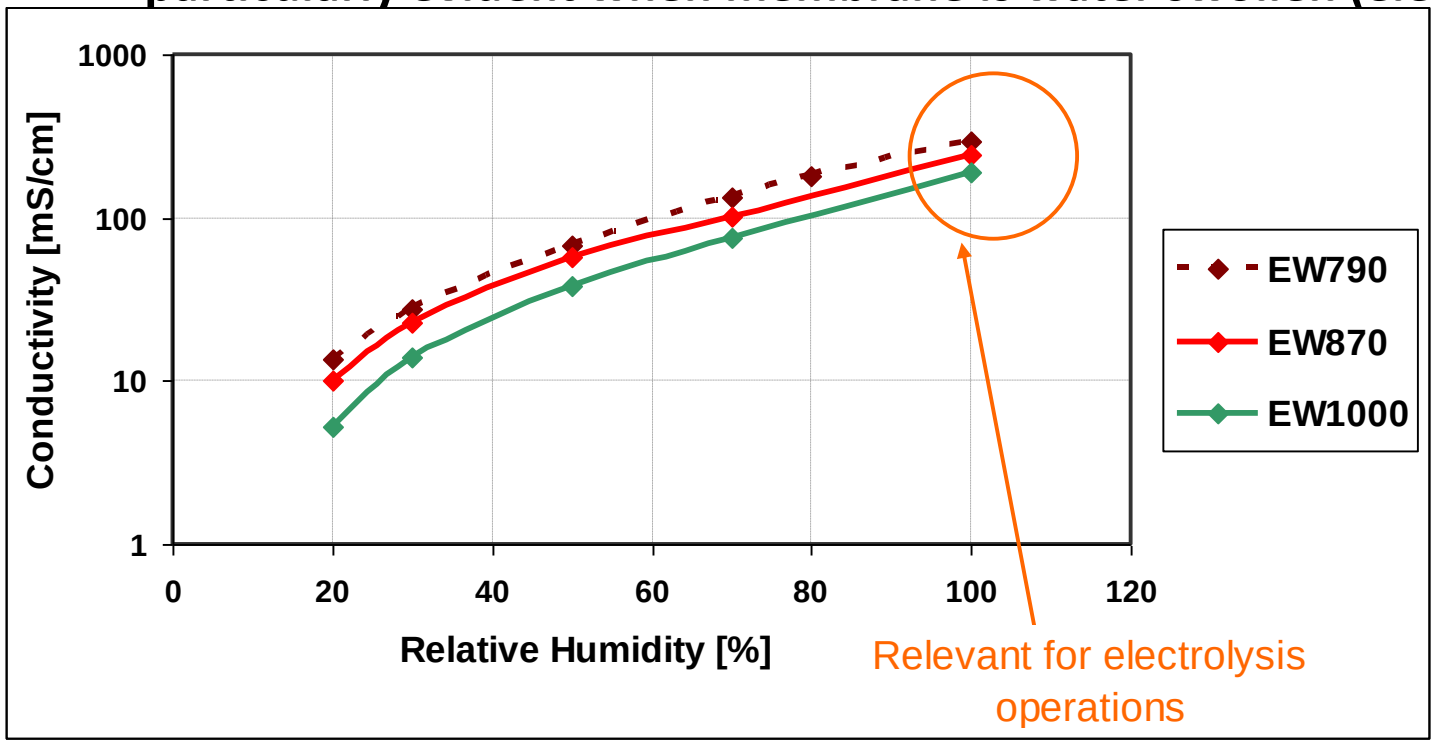


Baseline material proposed: E87-12S (extruded, 120 micron, 870EW, stabilized membrane)

1st improved material: E100-10S (extruded, 100 micron, 1000EW, stabilized membrane)

SOLVAY MEMBRANE DEVELOPMENT

Ionic conductivity reduced when increasing the EW, but the effect is not particularly evident when membrane is water swollen (electrolysis)

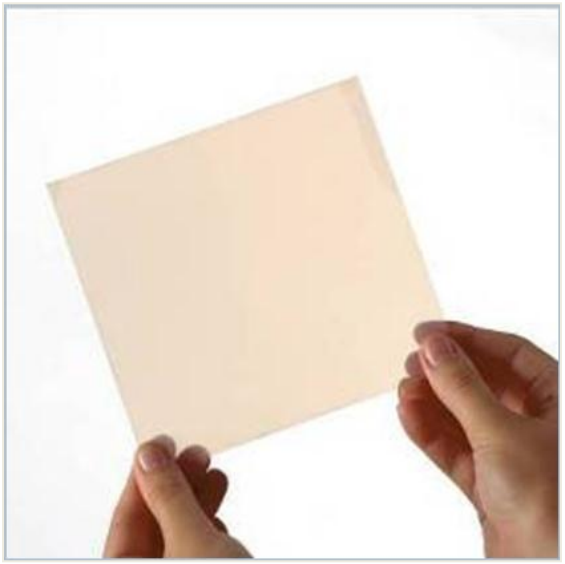


Proton conductivity Approaching the Project Target: 200 mS/cm

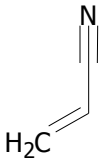
The different thickness of E87-12S (120 um) and E100-10S (100 um) is expected to compensate the conductivity gap

ITM MEMBRANE DEVELOPMENT

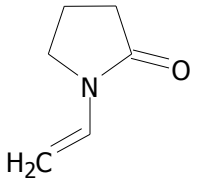
- Objective: To manufacture highly conductive low cost electrolyser membranes
- Approach: New hydrocarbon membranes – based on free radical polymerisation of monomer mixtures
- Early progress
- By altering the chemistry increased conductivity has been attained.
- Initial formulations developed based on a trade off between mechanical strength and conductivity.



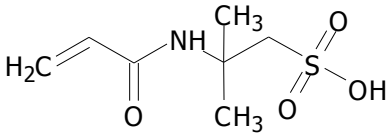
Monomer examples:



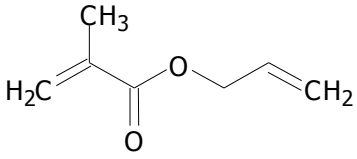
Hydrophobic



Hydrophilic



Ionic conductor

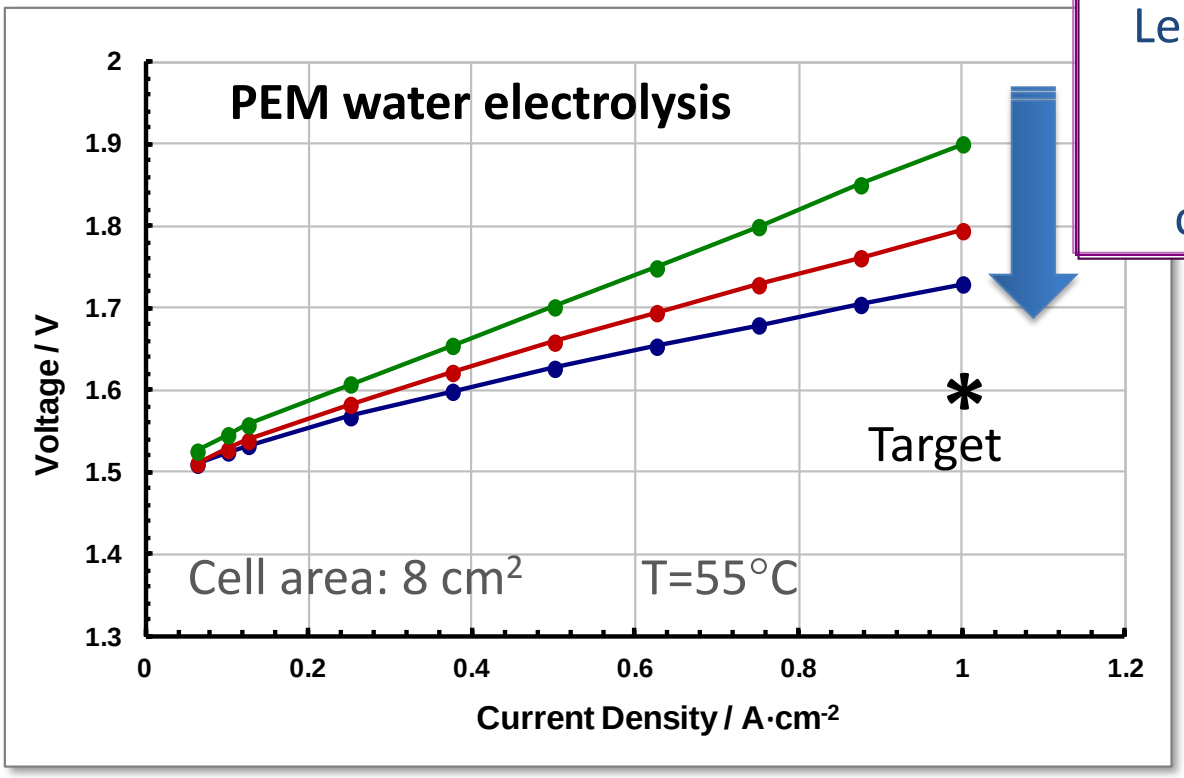


Crosslinker

ITM POWER
Energy Storage | Clean Fuel

Technical Achievements and Progress

INCREASING CONDUCTIVITY



Less cross-linker equals Increased conductivity

Anode: Ir/Ru Oxide

Cathode: Pt Black

Pressure: Atmospheric

Ionomer Equivalent Weight: 729 – 773 g·mol^{-1}

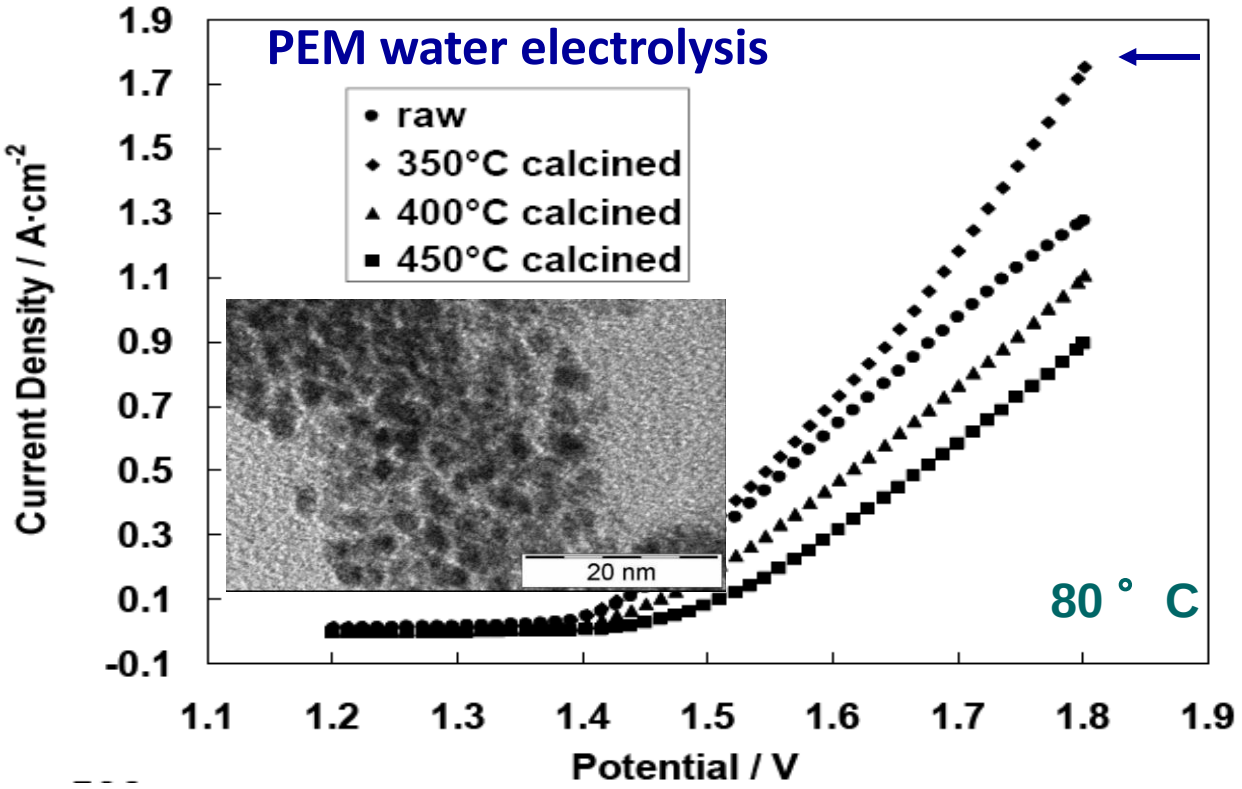
Membrane Thickness: 210 – 230 µm (wet)

By lowering the amount of cross-linker ITM have managed to increase the conductivity of their hydrocarbon membranes but potential strength still need issues to be addressed

ITM POWER
Energy Storage | Clean Fuel

CNR-ITAE CATALYST DEVELOPMENT

Nanosized unsupported IrO_2 anode - Pt/C cathode



1.75 A· cm^{-2} @ 1.8 V

Performance approaching the Project Target:

2 A· cm^{-2} @ 1.8 V

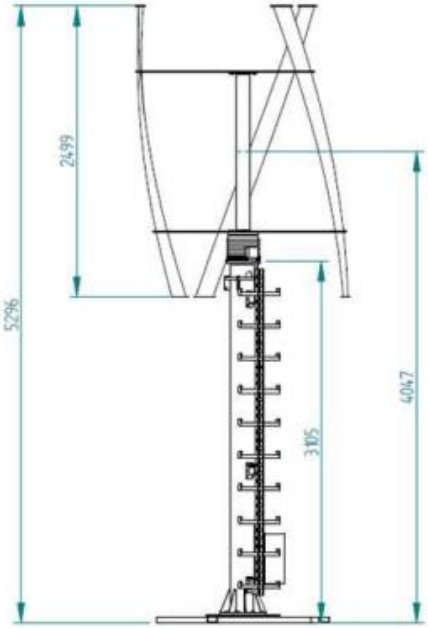
But PGM loading

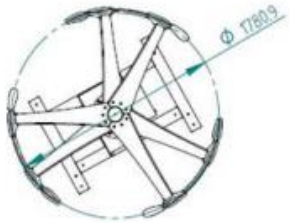
3.6 mg cm^{-2}

Vs.

0.5 mg cm^{-2} Project target

Coupling PEMWE to renewable power sources e.g. microeolic





Characteristics of the prototype:

-Rated power 1.5 kW at a wind speed of 13 m/s

-Cut in at wind speed of 4 m/s

- Cut out at wind speed of 20 m/s

Alignment with AIP 2011/MAIP

Part 2, Slide 1/4

Electrohypem:

The expected impact related to the SP1-JTI-FCH.2: Hydrogen Production & Distribution area of the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) ANNUAL IMPLEMENTATION PLAN 2011 is described as follows: “to develop a portfolio of sustainable hydrogen production, storage and distribution processes which can meet an increasing share of the hydrogen demand for energy applications from carbon-free or lean energy sources”.

R&D in innovative hydrogen production from renewable energy sources is reported among the priority topics for this application area.

regarding specifically the Topic SP1-JTI-FCH.2011.2.7 Innovative Materials and Components for PEM electrolysers, the scope is “Systematic materials research to reduce the total life cycle costs related to current PEM electrolysers… by replacing current commercial materials for membranes, catalysts and bipolar plates with low cost materials”.

Electrohypem

The project contents entirely fulfil these aims and expected impacts and, specifically concern with research on functional materials and technology for PEM electrolysers as well as their direct coupling to renewable energy sources.

In accordance with the specific area on Hydrogen Production & Distribution and the topic SP1-JTI-FCH.2011.2.7 Innovative Materials and Components for PEM electrolysers, the proposal deals specifically with cost-effective and enhanced durability components for PEM electrolysers amenable to be integrated with renewable energy sources.

The approaches are clearly oriented towards long term innovation.

Alignment with AIP 2011/MAIP

Expected output AIP Area: Hydrogen Production & Distribution Topic: 2.7 Innovative Materials and Components for PEM electrolysers Call: 2011		**Objectives of the project**	**Results up to date**
Prototype PEM electrolyser, utilising enhanced materials (electrodes and membrane)	Hydrogen production capacity > 1 Nm^3/h	Rated capacity > 1 Nm^3/h	Some novel materials tested in small laboratory single cell prototypes
	Efficiency of 75% (LHV)	Energy consumption < 4 kWh/Nm^3 H_2 at 1 Nm^3 h^{-1} Energy Efficiency > 74% (LHV)	1.72 V at 1 A cm^{-2} Voltage efficiency vs. thermoneutral potential $\varepsilon_{\Delta H}$~0.86; Voltage efficiency vs. reversible potential $\varepsilon_{\Delta G}$~0.72;
	Voltage increase < 15 µV/h at constant load	Voltage increase < 15 µV/h at **1 A cm^{-2}**	Started preparation of oxide supported catalysts and membranes with higher mechanical strength
	Stack cost <2.500 €/Nm^3 H_2 in series production;	Stack cost <<2.500 €/Nm^3 H_2 Rated capacity: 1 Nm^3 h^{-1} H_2 → PGM from 300 € (4 mg cm^{-2}) to 40 € (0.5 mg cm^{-2}); Membrane costs<100 €/kg, density of 100 g/m^2 will result in 10 €/ m^2.	Started preparation of low cost membranes and low PGM content electrocatalyst

Alignment with AIP 2011/MAIP

Part 2, Slide 4/4

Priorities and topics possibly under/over-estimated in the AIPs in terms of technical challenge

- Development of membrane electro-catalysts and MEAs for PEM electrolyser, satisfying the required targets of proper performance and durability by using cost effective materials such as novel hydrocarbon membranes and low PGM loading electrodes represents a key aspect to advance in this technology

- It requires more support to be addressed to research efforts for breakthrough materials capable of operation in a wide range of operating conditions, advanced MEAs characterised by a novel design and optimised architectures for the specific applications.

Electrohypem addresses and contributes to:

- **Training/education** of 2 post-doctoral researchers in materials science, processing and assessment (TRE).
- **Dissemination** of project results through publication in international peer-reviewed journals, conference presentations and via the project web site:
  - ✓1 conference presentation (invited);
  - ✓1 publication submitted.
- **Public awareness:** information activities to increase public awareness of hydrogen production from renewable power sources through the web site during dissemination activities addressed to university and high school students with the visit to the research laboratories, etc.

- **Technology Transfer / Collaborations**
  - ***link to previous work concerning with PMEWE assessing carried out within the framework of national projects (RINNOVA etc.).***
  - ***Collaboration between CNR Italy-CIDETEQ Mexico in the framework of a bilateral project on PEM electrolysis and regenerative fuel cells***

- **Project Future Perspectives**
  - **Collaboration with other projects, institutes, and other entities are expected during the prosecution of the project**
  - **Need/opportunities for international collaboration**
  - **Possible contribution to the future FCH JU Programme**