MembrAnEs for STationary application with RObust mechanical properties

Maestro

GA 256647

Deborah Jones

CNRS Montpellier

Project & Partnership description

Beneficiary name	Country	Partner Type
Centre National de la Recherche Scientifique (Montpellier)	France	Research
Solvay Speciality Polymers	Italy	Industry
Johnson Matthey Fuel Cells Ltd	United Kingdom	Industry
Università di Perugia	Italy	Research
Pretexo	France	SME

Application Area 3

SP1-JTI-FCH.2009.3.2:

Materials development for cells, stacks and balance of plant

www.maestro-fuelcells.eu

Start date: 1st January 2011	Duration: 39 months
Cost: €2.2 million	FCH-JU funding: €1.04 million
Contract type: Collaborative Project	FCH-JU grant number: 256647

Objectives & Motivation

MAESTRO principal objectives

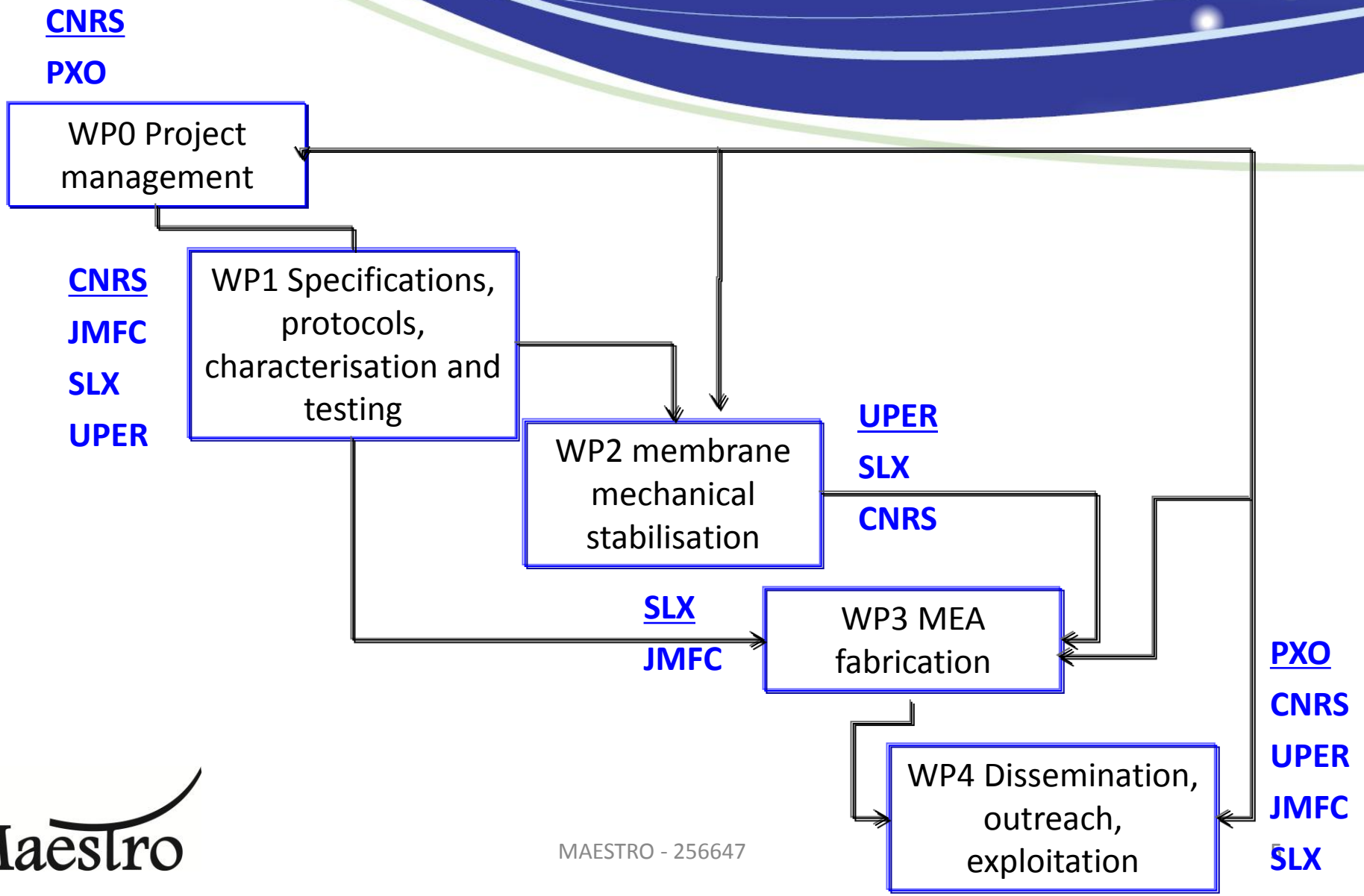
- Improve the mechanical properties of the low equivalent weight short side chain Aquivion™ perfluorosulfonic acid (PFSA) ionomer to:
  - Enable use of highly functionalised (high ion exchange capacity, low equivalent weight– *high conductivity*
  - Reduce membrane thickness – *low area resistance*
- Increase lifetime by reducing performance degradation of MEAs integrating these membranes

- Benchmark membrane: Aquivion E790-03S
  - low EW short side-chain PFSA 790 g/mol
- MAESTRO targets use of EW 700 g/mol

Milestones

MS no.	Milestone name	Impact on Project	Due	Achieved	Go/NG
MS 1	Coordinated approach to membrane and MEA characterisation	Characterisation protocols used across the four technical partners	M 6	M 6	✓
MS 2	Improve tensile properties by 20% compared with a state of the art low EW short side-chain PFSA membrane, measured under the same conditions.	Enabled phase 1 down-selection of promising mechanically stabilised membranes for MEA fabrication	M18	M6	✓
MS 3	Improve tensile properties by 50% compared with a state of the art low EW short side-chain PFSA membrane, measured under the same conditions.	Enabled selection of membrane for MEA fabrication for durability test	M30	M18	✓
MS 4	Improved durability in AST designed to accelerate chemical and mechanical degradation, and similar or improved performance as state of the art low EW short side-chain PFSA membrane, measured under the same conditions.	Provided membrane and MEA technology for the stack durability testing of Task 1.4	M33	M 33	✓

Project organisation



Membrane developments in WP2

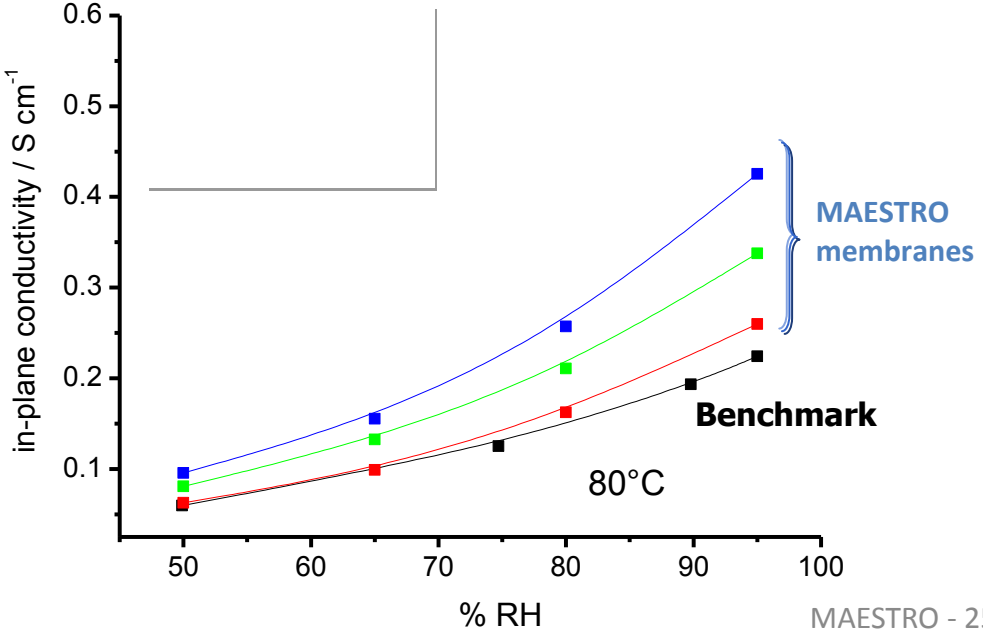
- **MAESTRO 2.2.** SLX has developed mechanically stabilised low EW Aquivion by *cross-linking*
- Improved conductivity compared with the benchmark, without detriment to mechanical properties
- **MAESTRO 2.4.** CNRS has developed *reinforced membranes*
- Significant increase in mechanical properties of low EW Aquivion and improved conductivity compared with the benchmark
- **MAESTRO 2.5**
- UPerugia has developed *inorganic-organic* membranes
- Improved conductivity compared with the benchmark and improved mechanical properties

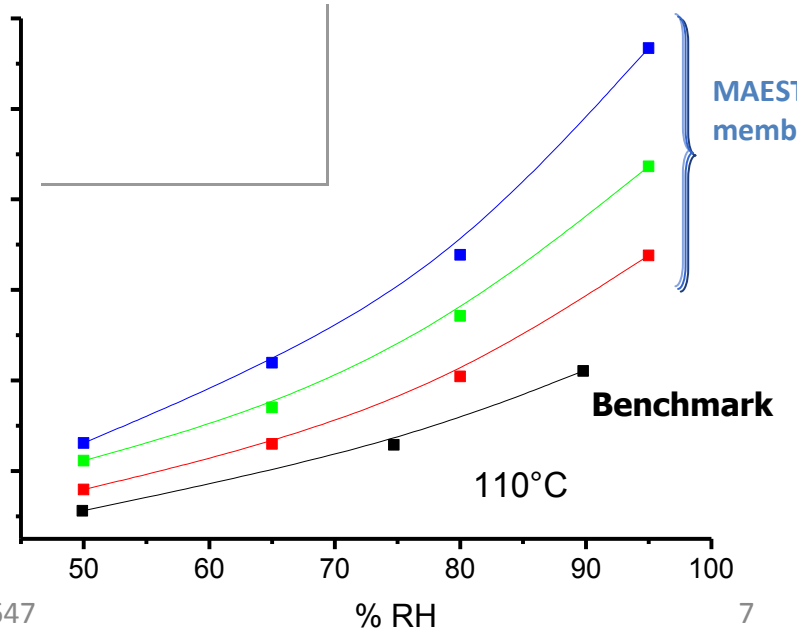
Project achievements

- The approaches developed to mechanical stabilisation do not compromise conductivity and, in some cases, improve the conductivity of the project start point, state-of-art SSC membrane
- Conductivity >100 mS/cm at 80-110 deg C, 50% RH

  Conductivity >400 mS/cm at 80-110 deg C, 95% RH

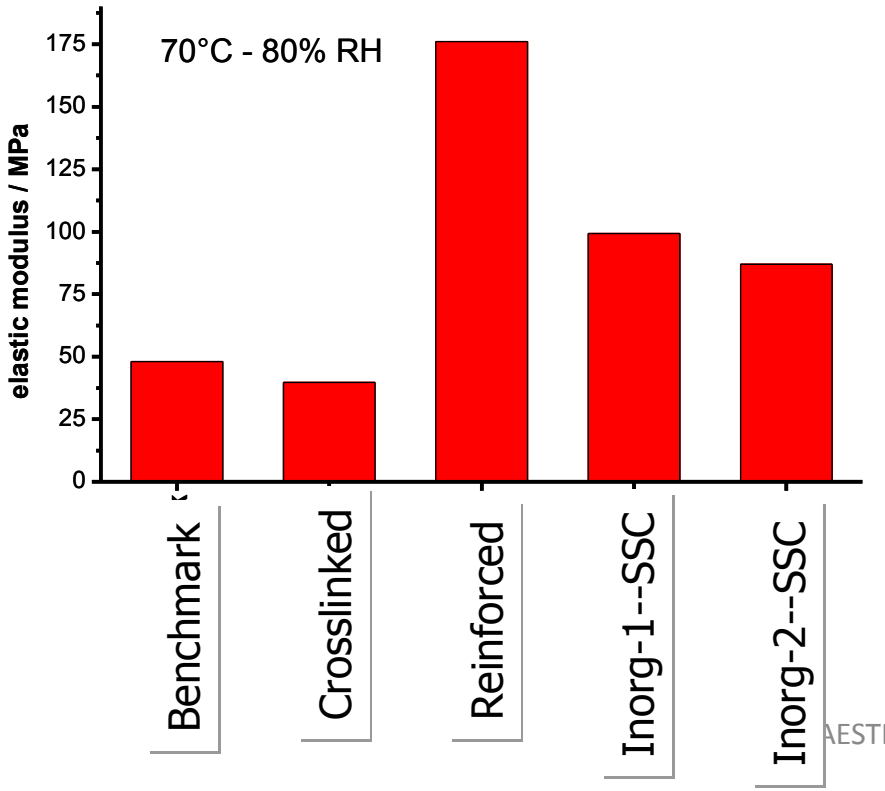
Inorganic-organic membranes with enhanced PFSA backbone compatibility

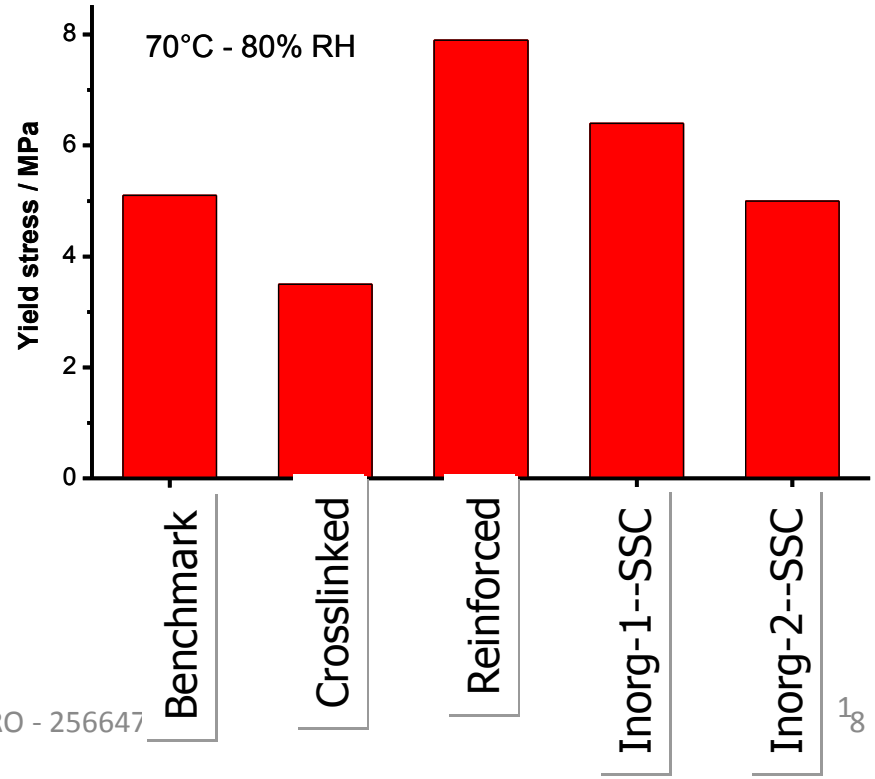




Project achievements

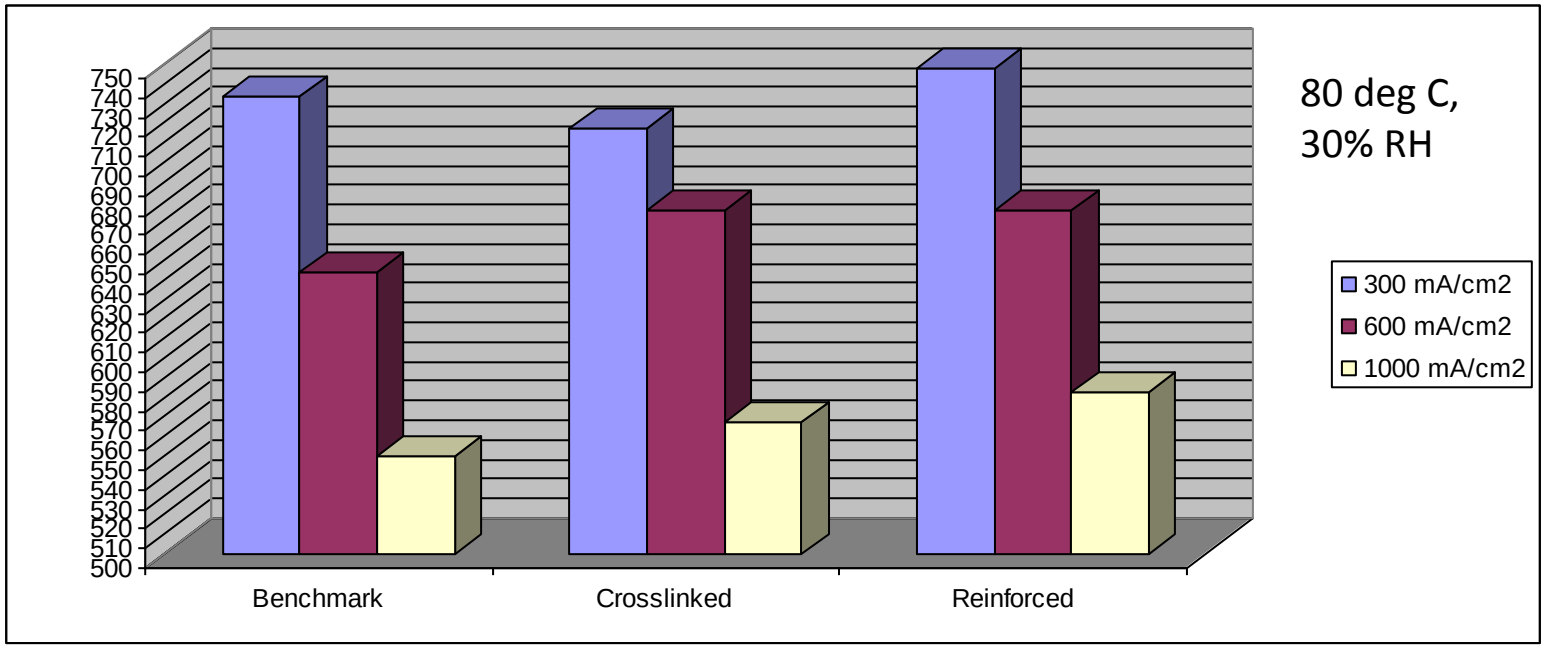
- **Mechanical properties have been significantly improved compared with the project benchmark**
- **Elastic Modulus increased by >300%; yield stress by >50%**





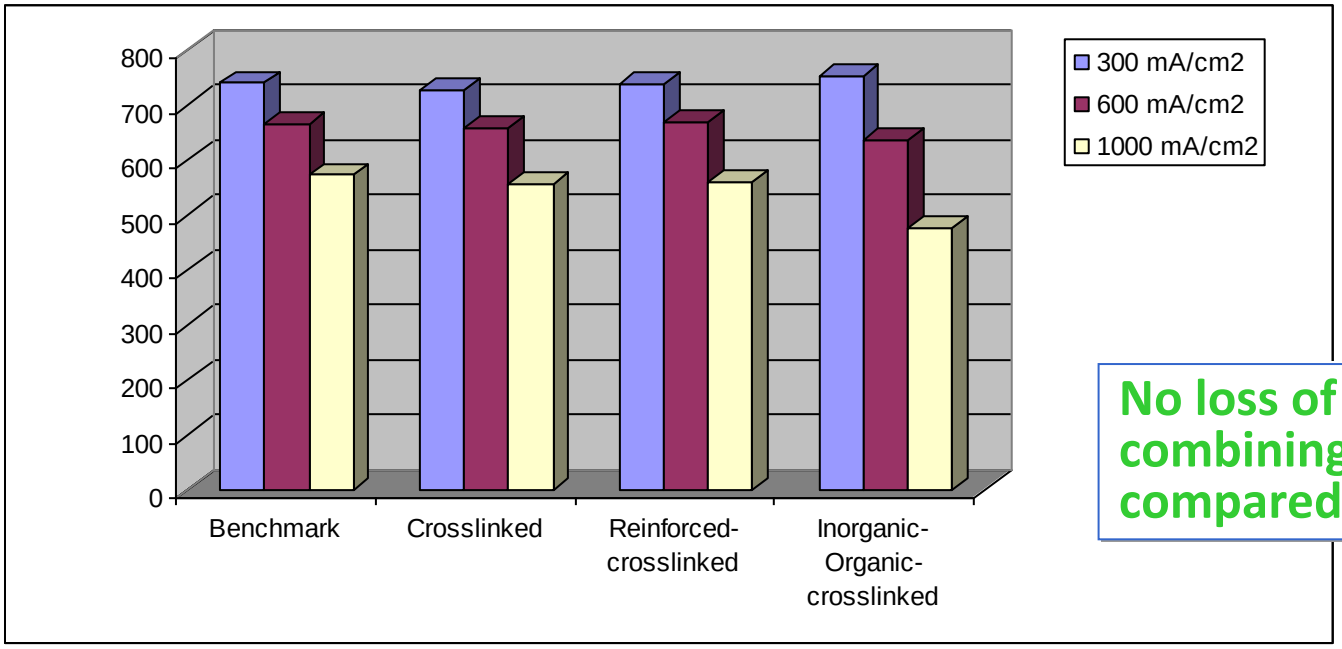
Project achievements

- **MEAs incorporating cross-linked low EW and novel reinforced low EW SSC membranes show improved performance in *in situ* fuel cell testing at hotter, drier conditions compared to the project start point, state-of-art SSC membrane**



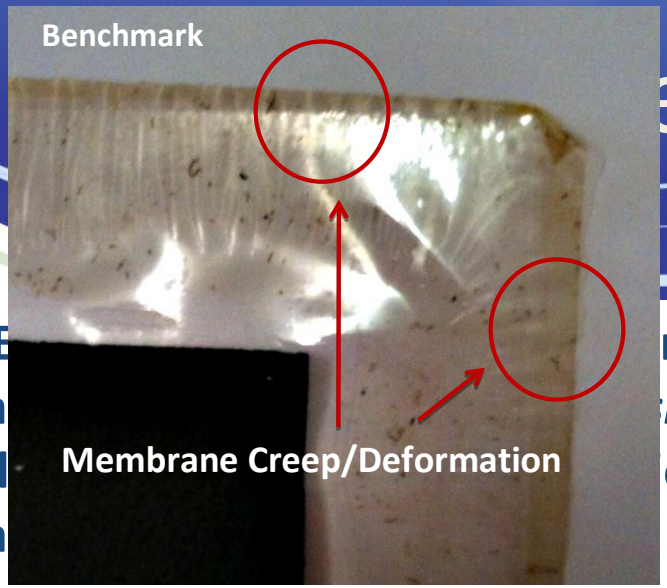
Project achievements

- **Given the encouraging results shown by several of the membrane stabilisation approaches by project mid-term, the decision was made to also develop a "double-strand' approach, simultaneously associating the two most prospective membrane stabilisation routes. This has further increased cooperation between partners and added further value to the project.**



No loss of performance by combining approaches compared with benchmark

evements



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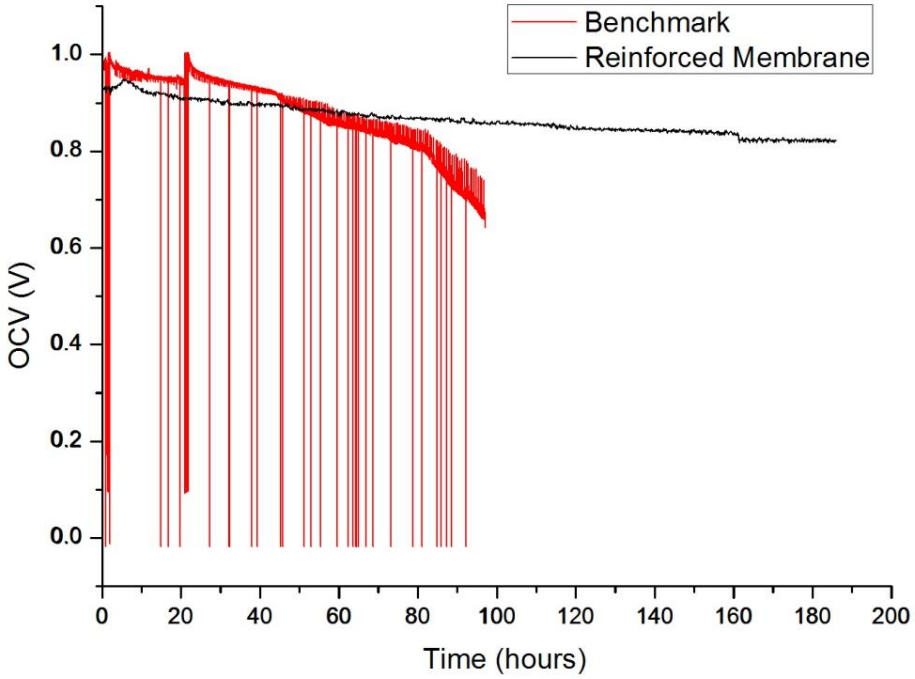
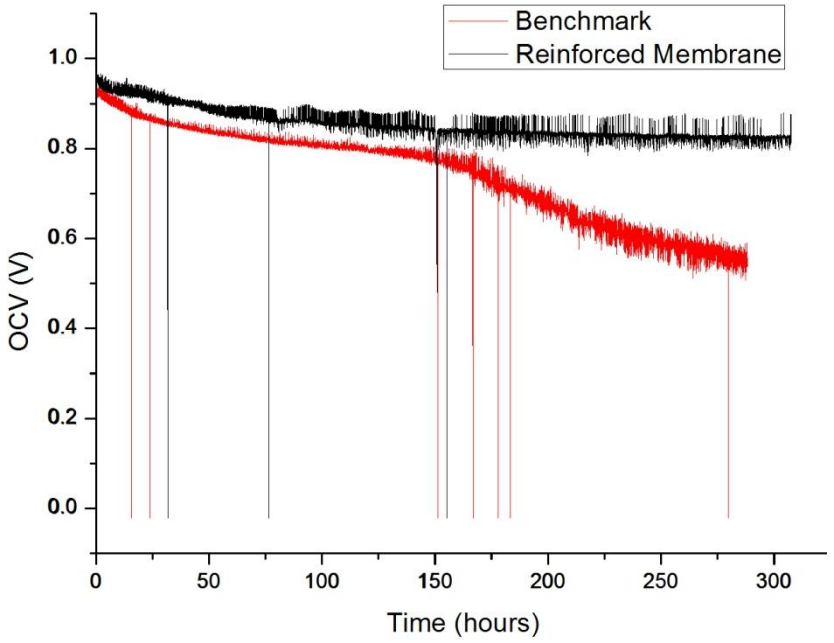
OCV, 90 deg. C, 13% RH



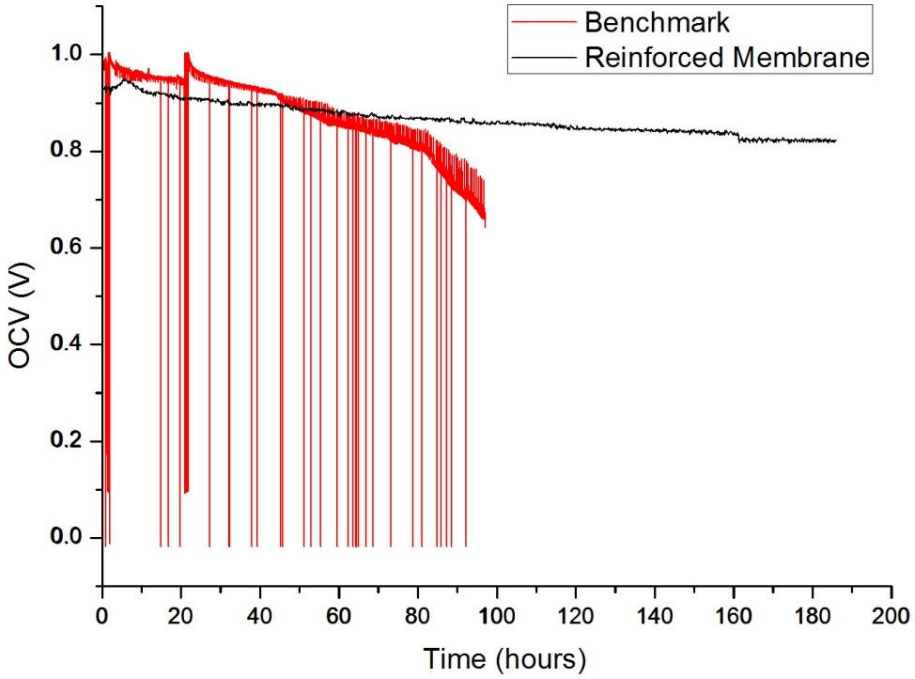
OCV, 90 deg. C, wet/dry cycle



Project achievements

- **Novel reinforced low EW SSC membranes show improved MEA durability (lower voltage loss, longer lifetime) in *in situ* testing designed to accelerate chemical and/or mechanical degradation, compared to the project start point, state-of-art SSC membrane**

OCV, 90 deg. C, 13% RH



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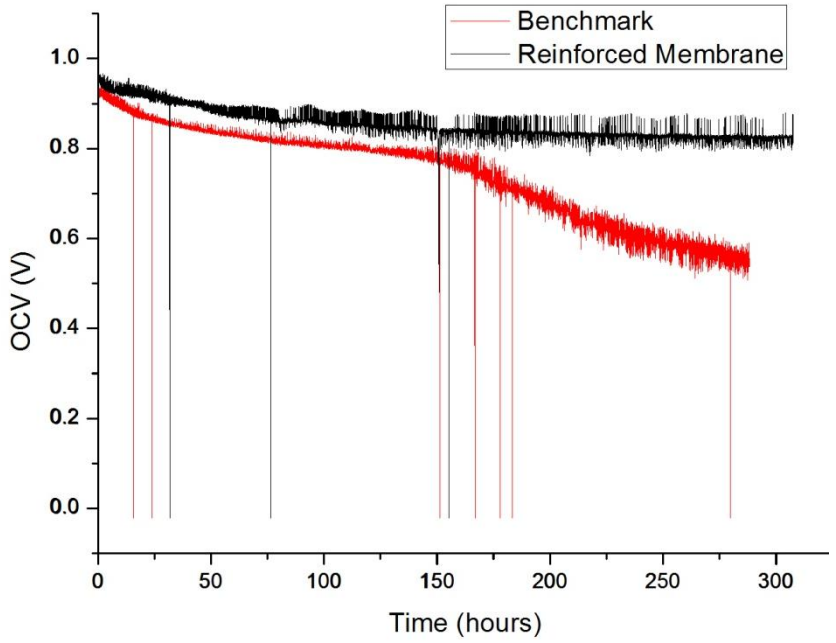

Current status

- **M18: Initial membranes down-selected and transferred from WP2 (membrane mechanical stabilisation) to WP3 (MEA fabrication)**
- **M30: Further down-selection based on results of MEA performance, and durability in AST compared with the project benchmark – 3 prospective membrane types**
- **M30: Project target extended to durability testing in a stack to allow parallel testing of MAESTRO membranes - Project extended to 39 months**
- **M33: membrane types scaled up and delivered for MEA fabrication for durability testing**
- **M35: 9 cell stack running in the first leg of a "four seasons" test protocol associating load cycling, continuous operation, stop/start cycles**

Final project target: stack operation with MAESTRO MEAs in conditions simulating "1 year" of µ-CHP operation conditions within a 1000 hour time period and up to 4000 hours, with <10% initial voltage degradation

Enhancing cooperation and future perspectives

Next steps – MAESTRO2

- RTD for focussed development of best membrane candidates, their applications-specific optimisation, and scale-up
- RTD associating MAESTRO1 achievements with means to suppress chemical degradation
- RTD for the catalyst layer and electrode design and development in MEAs using the new membranes, for further performance and durability optimisation

Future perspectives

- Excellent perspectives for future collaboration
- Excellent perspectives for future exploitation, including by the two industrial partners.
- Possible need for collaboration with SMEs – or creation of start-up company for the fabrication of the materials to be used as membrane reinforcement.

Cross-cutting issues

Dissemination

- Project website is regularly visited
- Dissemination activities via conference presentation and journal publication, including an all-partner review article
  - 6 conference presentations (E-MRS, ECS, FDFC, SSPC, CARISMA, EFCF, JPS, CSC)
  - 3 articles published, 3 manuscripts in preparation

Training and Education

- 3 post-doctoral fellows and 1 Masters student trained in routes to membrane mechanical stabilisation, membrane characterisation, MEA development, performance & durability testing

FCH JU Programme Adherence – AIP 2009

AIP09 Section 3.2 Specific topic for the 2009 Call for Proposals

"SP1-JTI-FCH.2009.3.2: Materials development for cells, stacks and balance of plant"

Projects are expected to cover:

- **Development and design of materials to improve performance of both cells and stack and BoP components. Mechanical, thermal and electro-chemical stability should be considered and lifetime and degradation issues relevant to production cost for single cells and stacks**
- **Investigation of failure mechanisms… robust low resistance membranes in PEMFCs…**
- **New and improved material production techniques to reduce cost, emissions and**
- **improve yields, quality and performance in industry relevant cells…**
- **The consortium should include academia, research institutes, material producers and cell/stack manufacturers**

FCH JU Programme Adherence - MAIP

- **MAIP Section 3.4.3 Stationary Power Generation & Combined Heat & Power:**
- *The overall objective of AA-Stationary is* to **improve the technology for fuel cell stack** and balance of plant components to the level required by the **stationary power generation and CHP markets** by **bridging the gap between laboratory prototypes and pre-commercial systems.**
- … RTD proposed will be **highly application orientated**…
- …to achieve the **principal technical and economic specifications** necessary for **stationary fuel cell systems** to compete with existing and future energy conversion technologies.
- … to deliver **new or improved materials at a component … level.** RTD directed towards **developing components** … as well as **novel architectures** for cells…leading to **step change improvements** over existing technology in terms of **performance, endurance, robustness, durability and cost**…. **degradation and lifetime fundamentals related to materials** and typical **operation environments**…
- … **substantial effort** is needed to address **lifetime requirements of 40,000 hours for cell** and stack, as well as **competitive costs**
- … **test campaigns for product validation** under real market conditions.