ARTEMIS
(Contract number 303482)

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http://www.artemis-htpem.eu

PROJECT OVERVIEW

- Automotive pemfc Range extender with high TEMperature Improved meas and Stacks
- SP1-JTI-FCH.2011.1.5 – Next generation European MEAs for transportation applications
- Start date 01/10/2012; end date 30/09/2015
- Budget: total budget = 2,822,692 euros

  FCH-JU contribution = 1,747,884 euros

- Development of new materials for High Temperature PEMFC (160-180 °C) → from the catalysts and the membrane to the MEA and their implementation into stacks. Scaling up to a 3 kWe high temperature Stack as final goal.
- Stage of implementation: 24 months (66 %)

PROJECT TARGETS AND ACHIEVEMENTS

Status before project	MAIP target 2008-2013	Project Target	Current status/ achievements	Expected final achievement
A few commercial producers	New materials for high temperature MEAs and Stacks	Membrane, catalysts, GDL, plate materials development	Membrane and plate materials components satisfy defined specifications at M18	All components integrated in self standing MEAs. Implementation in a HT stack
140 -180 °C	high temperature operation	Operation @ 130 °C and beyond	Operate @ 160 and 180 °C	Materials operate up to 180 °C
A few commercial stack manufacturers	MAIP 1- 10 kW built stack	0.3 kWe stack	Under development for month 24	3 kW stack
N/A	Transportation application	Operation as a range extender	Operating protocols defined	Use of the defined protocols

PROJECT TARGETS AND ACHIEVEMENTS

Status before project	AIP target 2011	Project Target	Current status/ achievements	Expected final achievement
0,4 W/cm² @ 160 °C	Quantitative target MEA	First generation MEA performance; 0.3 W/cm² @ 1 A/cm²	0.45 W/cm² achieved @ 1 A/cm²	0.5 W/cm² @ 1 A/cm²
0.15 S/cm	Quantitative membrane target	Conductivity >0.1 S/cm @ operation temperature	0.12 S/cm achieved @ 140 °C	0.12 S/cm
N/A	Membrane and catalysts scale-up	Provide sufficient material for stack building	Membrane A4 sheets available Catalysts available	transfer for MEA preparation
	catalysts	Pt loading reduction	Specific alternative catalysts developed	Use in final MEAs

PROJECT TARGETS AND ACHIEVEMENTS

Status before project	AIP target 2011	Project Target	Current status/ achievements	Expected final achievement
	Stack plate materials	High temperature and acidic environment compatibility. HT design	No degradation in H_3PO_4 environment	Stack building
N/A	Degradation phenomenon understanding	Modelling tools development	Model developed and used to assess FC performance and GDL degradation	Support for GDE development
N/A	Hybridisation	Models for range extender use of HT PEMFC stack	Model developed and simulated on European drive cycles	Adapt model to increase the rangeability of an EV-HT PEMFC range extender

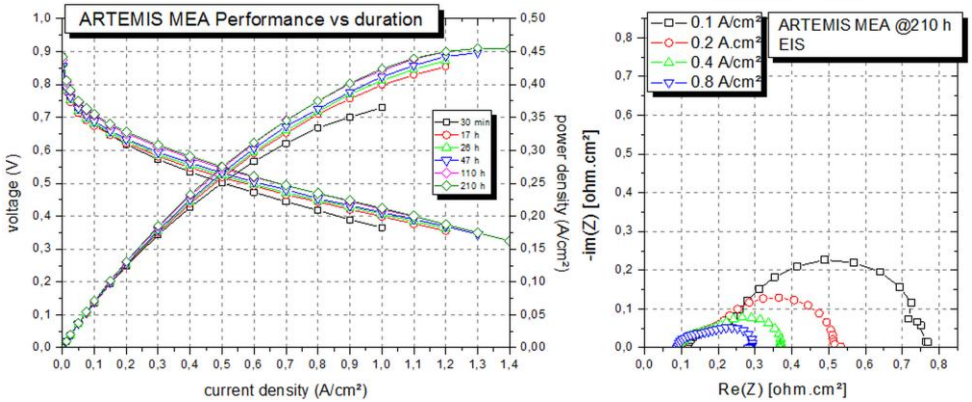
PROJECT TARGETS AND ACHIEVEMENTS

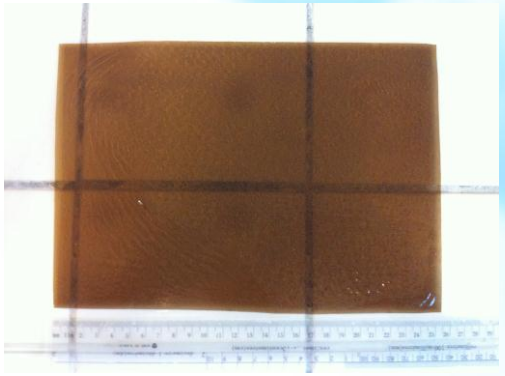
- Advances achieved with respect to international technological state-of-the-art

International state of the art (SoA)	International level SoA	Project target	Present project SoA	Comments on progress/status
Performance of commercially available MEA	0.4 W/cm² @ 1 A/cm²	0.5 W/cm² @ 1 A/cm²	0.45 W/cm² @1.2 A/cm²	Target expected to be reached for the last generation MEA

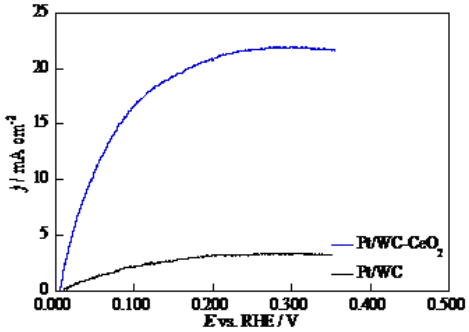
PROJECT TARGETS AND ACHIEVEMENTS

- membrane



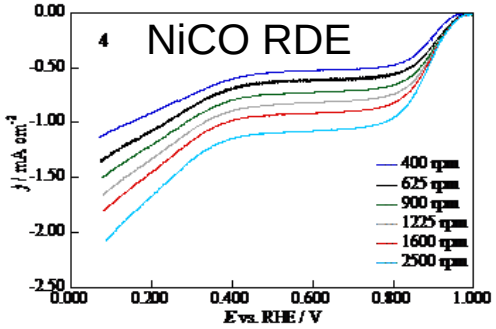


- anodic low Pt loading and alternative cathodic catalysts
  - Anode : Pt/WC-CeO_2



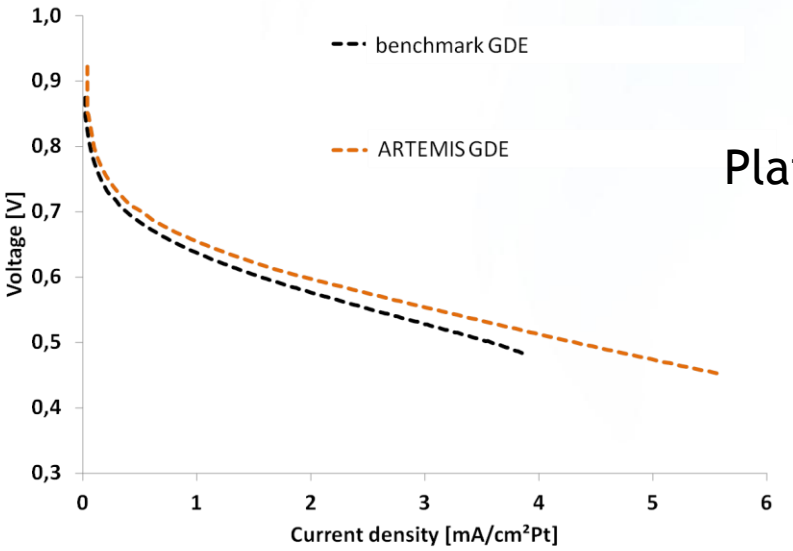
Pt based catalysts in H_2/CO (40 ppm) in H_3PO_4 15 M, at 60 °C.

  - cathode: FeCo, NiCo on MWCNTs



PROJECT TARGETS AND ACHIEVEMENTS

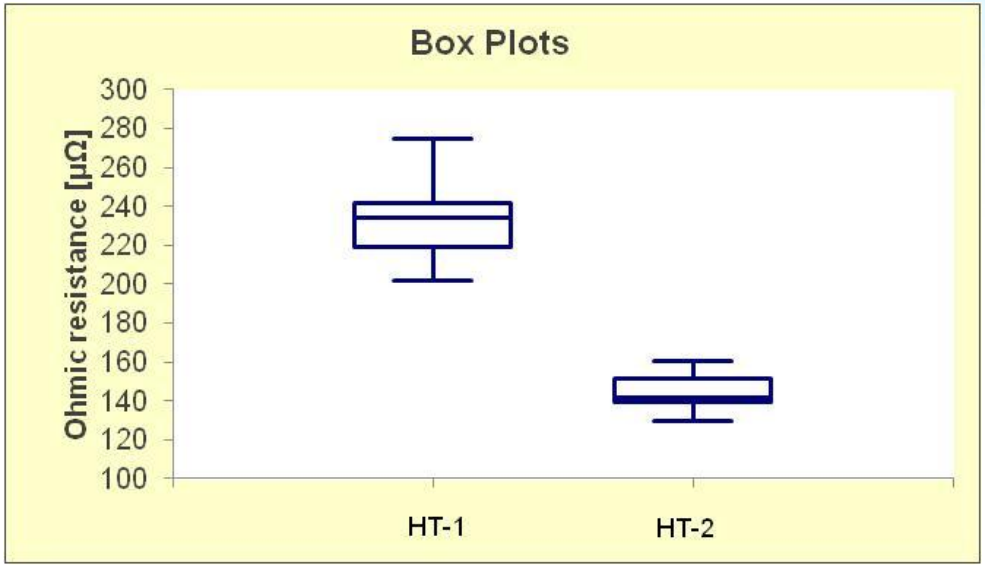
- GDEs



Platinum utilisation

- Plate materials

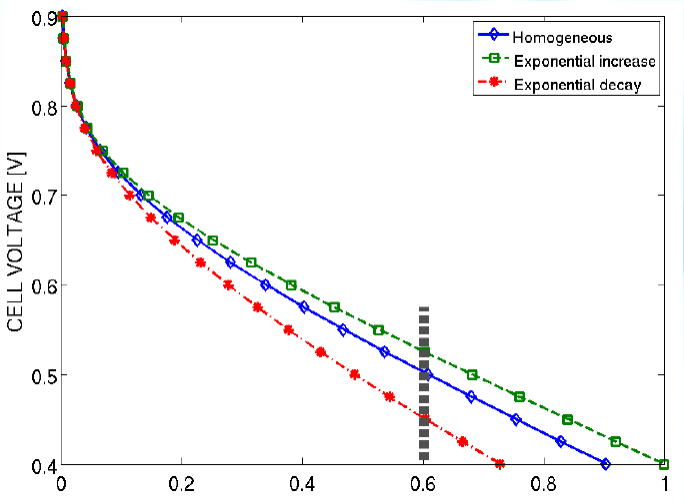
AST results => new formulation



PROJECT TARGETS AND ACHIEVEMENTS

- Modelling activities

Model defined to avoid pulling stress and achieve better catalyst utilisation => GDE fabrication, catalyst layer distribution and microporous layer porosity



- range extender drive cycle strategy

	NEDC UDC	Artemis Urban	WLTC city cycle
Trip distance [km]	4.07	4.85	7.84
H_2 consumption [g/Cycle]	**19.0**	**33.1**	**37.1**
Specific H_2 consumption [g/km]*	**4.67**	**6.82**	**4.73**
Fuel tank capacity [g]		700	
Fuel tank equivalent cycles	36	21	18
CS mode allowable cycles	unlimited	500	11
Final cycles	**36**	**21**	**11**
Battery range [km]		160	
H_2 range [km]	**147**	**102**	**86**
Total Range [km]	**307**	262	246

PROJECT TARGETS AND ACHIEVEMENTS

Next steps within the end of the project:

- Membrane and catalysts preparation scale-up
- MEA fabrication
- HT Stack building and testing 0.3kWe

  → go to 3 kWe stack

- Developed range extender drive mode applied to stack testing
- Use of modelling tools to produce high performance catalytic layers

RISKS AND MITIGATION

- MAIP 1-10 kW built stack:
  - scale up to the 3 kWe stack fabrication: go/no go decision
  - depends on the progress in the development of second generation MEAs materials and on the preliminary results given by the 0.3 kWe stack tests
  - Eventual remedial action: use commercial MEAs

RISKS AND MITIGATION

- AIP Membrane and catalysts scale-up :
  - Scaling up production:

    large area membrane production and batch reproducibility

    large amount of catalyst production

    MEA preparation feasibility and reproducibility

  - Eventual remedial action: use commercial MEAs

HORIZONTAL ACTIVITIES

- Training activities:

  - 1 PhD student and 1 post-doc (RP2) trained in HT PEMFC membrane development and characterisation, MEA characterisation

  - 1 post-doc trained in development and application of modeling tools

- Project work in safety, regulations, codes, standards, general public awareness

  - Participation in the FCH-JU “Harmonisation Protocols” effort

DISSEMINATION ACTIVITIES

- **Conference presentations:**

- *10th International Conference for Mesoscopic Methods in Engineering and Science*, Oxford, UK, July 2013.
- *European Conference on Materials & Technologies for Sustainable Growth*, Bled, Slovenia, September 2013.
- *European Hydrogen Energy Conference*, Seville, Spain, March 2014
- *International Society of Electrochemistry*, Lausanne, Switzerland, August-September 2014
- Matériaux 2014, Montpellier, France, November 2014

- **Publication**

Pore-scale modeling of fluid flow through gas diffusion and catalyst layers for high temperature proton exchange membrane (HT-PEM) fuel cells, U. R. Salomov, E. Chaivazzo, P. Asinari, Computers and Mathematics with Applications, 67, 393-411, (2014) doi.org/10.1016/j.camwa.2013.08.006.

EXPLOITATION PLAN/EXPECTED IMPACT

- RTD projects:

  ARTEMIS, new membrane, electrocatalysts, support, and bipolar plate materials are developed specifically for MEAs for application as a range extender for transportation application. Final results will help in:

  –The development of membrane materials with properties appropriate for transportation APU fuel cell application.

  –The development of novel catalysts allowing for reduction in platinum group metal catalyst loadings, compared with those currently used in HT-PEM.

  –The optimisation and demonstration of HT-MEA processing at pilot scale

  –The demonstration of performance and long-term stability under automotive range extender fuel cell conditions of a HT-PEM stack

EXPLOITATION PLAN/EXPECTED IMPACT

- Exploitation:
  - Commercial HT Stack technology by Nedstack
  - Membrane, catalysts, MEA large scale production by CNRS, Cidetec, Nedstack, CEA
  - End-user: CRF