ALKAMMONIA

Ammonia Fuelled Alkaline Fuel Cells for Remote Power Applications

AIP / APPLICATION AREA	AIP 2012 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2012.3.5: System level proof of concept for stationary power and CHP fuel cell systems at a representative scale.
START & END DATE	01 May 2013 – 30 Apr. 2017
TOTAL BUDGET	€ 2,883,721
FCH JU CONTRIBUTION	€ 1,962,548
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: AFC Energy PLC (UK)

Partners: Universität Duisburg-Essen (DE), UPS Systems (Fuel Cell Systems) (UK), Zentrum für Brennstoffzellen-Technik GmbH (DE), Paul Scherrer Institut (CH), FAST - Federazione Delle Associazioni Scientifiche E Tecniche (IT) [Acta Spa (IT)

PROJECT WEBSITE/URL

Alkammonia.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

In project ALKAMMONIA a proof-of-concept system designed to provide power in remote applications is being developed and tested. The project integrates three innovative and proven technologies: a highly efficient and low-cost alkaline fuel cell system, and a novel ammonia fuel system which consists of a fuel delivery system and a cracker system for generation of a hydrogen rich gas. These components are being developed to produce a prototype, integrated system showing the benefits of the concept. Once the system has been integrated it will be rigorously tested and the results will be shared with leading telecommunication end-users.

PROGRESS/RESULTS TO-DATE

- A pre-prototype fuel cell system has been built
- Life-Cycle and economic analyses have been carried out
- Modelling of system components has been carried out
- A high-level integrated system design has been produced
- A scientific paper has been published and the project presented at conferences and workshops

FUTURE STEPS

- A full-prototype fuel cell system will be built
- Further socioeconomic analysis will be carried out
- Ammonia Cracker will be designed, built and tested
- Modelling and adaption of system and stack components
- A 3-5kW Integrated, Ammonia fuelled, alkaline fuel cell system will be produced and run for 3 months

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Complete Alkaline fuel cell model produced
- New fuel cell flow-field design developed
- Life Cycle Analysis published (J.Power Sources, 275 (2015) 322-335)
- Data on cracking catalyst gathered
- Effect of Ammonia on Alkaline fuel cell quantified

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Pre-commercial demonstration (installed capacity)	Multi-MW installed electrical capacity in the EU for precommercial demonstration	Seamless integration of the cracker and the alkaline fuel cell technologies into a flawlessly functioning proof-of-concept system, which complies with all relevant fuel cell regulation and CE marking directives.	A novel fuel cell system has been designed, built and is currently being tested. An updated system and stack are in preparation. Due to departure of a partner, the ammonia cracker work will begin shortly. A high-level integrated system design has been developed.
MAIP 2008-2013 AIP 2012	Commercial viability of systems Integration and application of new technologies in Ammonia fuel processing and cell and stack technology.	Cost of € 1,500 - 2,500/kW for industrial/commercial units Novel system architectures, including new fuel processing and storage materials and processes	A flawlessly functioning ammonia cracker that uses a combustion process to provide the heat for the dissociation process A flawlessly functioning 3-5kW stack, based on an improved design of AFC Energy's current fuel cell stack, which demonstrates the following characteristics: • Stack efficiency > 50% when using pure Hydrogen • Stack weight under 40kg/kW A flawlessly functioning AFC balance of plant with the following characteristics: • Parasitic power requirements of <4% of stack output for the entire design operating range • BoP costs of less than 1.500 €/kW	Work carried out by the original cracker partner suggests that the burning of "off-gas" will improve the efficiency of cracking. Higher efficiency will be possible from the cracking technology. This should result in a lowered cost. Modification of AFCEN's stack technology has been tested on full (~5kW) stacks showing the potential for improving efficiency and reducing weight. A pre-prototype balance of plant has been built and is currently being tested. This testing will provide feedback for modifications to be made and implemented in a full prototype system.
AIP 2012	Development of PoC prototype systems that combine advanced components into complete, fully integrated systems		A flawlessly functioning ammonia cracker, 3-5kW stack, AFC balance of plant seamlessly integrated into a flawlessly functioning proof-of-concept system	A novel fuel cell system has been designed, built and is currently being tested. An updated system and stack are in preparation.
AIP 2012	Integration and testing of PoC prototype systems complete with fuel delivery and processing sub-systems; interface with devices necessary to deliver power, with or without heat and/or cooling		Demonstrate three months continuous operation of the system using liquid ammonia.	3 months has been allocated at the end of the project for this activity
AIP 2012	Cost effectiveness, Environmental impact, Market analysis.	Assessment of the fuel cell system's ability to successfully compete with existing technologies operating in the target application(s)/market(s). Dissemination of results to industry and research	Demonstrate cost competitiveness of the integrated 3-5kW proof-of-concept system against other technologies competing in the same target market(s). A detailed analysis of the environmental and socio-economic impacts of the proof of concept system that addresses its sustainability performance, including a comparison with competing systems	Economic and life cycle analysis have been carried out and disseminated. Additional data is currently being gathered for multi-criteria decision analysis and further cost analysis
AIP 2012	CE Compliance	The PoC system will be required to comply with all relevant CE regulations and international fuel cell system standards	Seamless integration of the cracker and the alkaline fuel cell technologies into a flawlessly functioning proof-of-concept system, which complies with all relevant fuel cell regulation and CE marking directives.	The high-level system design has been completed and other practical activities will be focused at the end of the project. Literature reviewing and data gathering is ongoing

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

CISTEM

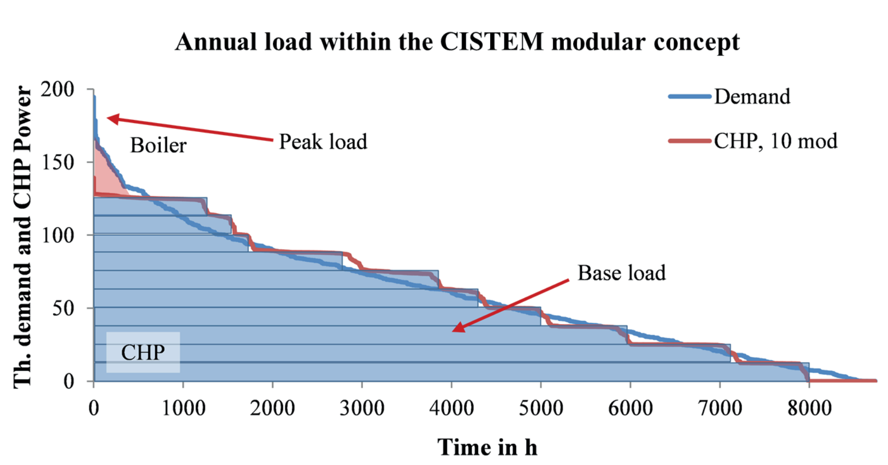
Construction of Improved HT-PEM MEAs and Stacks for Long Term Stable Modular CHP Units

AIP / APPLICATION AREA	AIP 2012 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2012.3.5: System level proof of concept for stationary power and CHP fuel cell systems at a representative scale; SP1-JTI-FCH.2012.3.1: Cell and stack degradation mechanisms and methods to achieve cost reduction and lifetime enhancements
START & END DATE	01 Jun. 2013 - 31 May 2016
TOTAL BUDGET	€ 6,097,180
FCH JU CONTRIBUTION	€ 3,989,723
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: NEXT ENERGY · EWE-Forschungszentrum für Energietechnologie e.V.

Partners: Danish Power Systems Ltd., inhouse engineering GmbH, Eisenhuth GmbH & Co KG, University of Castilla-La Mancha, University of Chemistry and Technology Prague, ICI Caldaie S.p.A., Oel-Waerme-Institute GmbH



PROJECT WEBSITE/URL

www.project-cistem.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

Key issue of CISTEM is the development of durable HT-PEM based 4 kW stack modules (including reformer) that are suitable for larger CHP systems up to 100 kWel. The modular concept will be investigated in a Hardware-in-the-Loop test bench with one module physically installed and the others emulated by software. The development strategy starts on the single component level and rises up to the complete CHP system. So, research and development includes the most important components like MEAs, bipolar plates, reformer system and the final CHP unit design with all necessary Balance-of-Plant (BoP) components.

PROGRESS/RESULTS TO-DATE

- 2000 h long-term test of BoA-MEAs at 0.3 A/cm^2 with a degradation rate < -4 μV/h.
- SiC-TiC as catalyst support shows the best electrochemical behavior and the lowest ECSA decrease and agglomeration (40% Pt/SiCTiC).
- Bipolar plate material PPS shows highest stability and lowest acid uptake after operation.
- Completion of development of full-scale fuel processor and reformer.
- Extension of modeling to 3D stationary model of fuel cell stacks consisting of 100 cells.

FUTURE STEPS

- Delivery and evaluation of optimized full stacks
- Testing of BoP components in H-i-L environment
- Finalization of CHP system operational evaluation
- Reduction of platinum loading
- Conversion of stationary to dynamic model and implementation of catalyst degradation

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Progress of project is in the desired time frame.
- FC electrical efficiency has been improved to more than 40% by different measures.
- Significant improvement of degradation rates while using MEAs with thermally cured membranes.
- Short stack long term testing support improved durability of the FC stack.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Small scale commercial application range 5-50 kW and midscale industrial range		Up to 100 kW	BoP component specifications finished Short stack evaluation in progress Full stacks are currently manufactured Fuel processor development finished
MAIP 2008-2013	Electrical efficiency	> 40%	Up to 45%	42% gross efficiency calculated (gain by oxygen enrichment not included)
MAIP 2008-2013	Lifetime	> 20.000 hours	Extended lifetime up to 40.000 hours	Currently under investigation – MEA degradation rate < 4 μV/h obtained 10.000 h durability test on components in progress
AIP 2012	Increased knowledge on degradation and failure mechanisms	*MEA and BPP degradation*	Accelerated stress testing on MEAs to access lifetime predictions is still in progress.	AST's predict improvement in lifetime. 10.000 hour BPP material test is still in progress. Degradation rate MEA < 4μV/h
AIP 2012	PoC prototype modular CHP system based on HT-PEM technology	One module, consisting of two 4 kW HT-PEM stacks and one reformer, in a H-i-L- environment		Short stacks have been tested. Full stacks are currently manufactured. BoP component specifications finished.

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

DeMStack

Understanding the Degradation Mechanisms of a High Temperature PEMFC Stack and Optimization of the Individual Components

AIP / APPLICATION AREA	AIP 2012 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2012.3.1: Cell and stack degradation mechanisms and methods to achieve cost reduction and lifetime enhancements SP1-JTI-FCH.2012.3.5: System level proof of concept for stationary power and CHP fuel cell systems at a representative scale
START & END DATE	01 May 2013 - 30 Apr. 2016
TOTAL BUDGET	€ 2,576,615.00
FCH JU CONTRIBUTION	€ 1,495,680.00
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Institute of Chemical Engineering Sciences, Greece

Partners: Fundación CIDETEC (Spain), Institute of Chemical Technology Prague (Czech Republic), Advent Technologies S.A. (Greece), General Joint Research Centre, Institute for Energy (Belgium), Helbio S.A. (Greece) and Prototech AS (Norway)

PROJECT WEBSITE/URL

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PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

The activities of DeMStack are on the stack optimization and construction based on the high temperature MEA technology of Advent S.A.. The aim is to enhance the lifetime and reduce the cost of the HT PEMFC technology. The strategy involves improvements based on degradation studies and materials development. A fuel processor will be constructed, operating on natural gas or LPG, which will be combined and integrated with the fuel cell stack. The robustness of the stack, the simplicity of BoP, the operational stability and the user friendly operation of the integrated system into a commercially reliable product, will be demonstrated.

PROGRESS/RESULTS TO-DATE

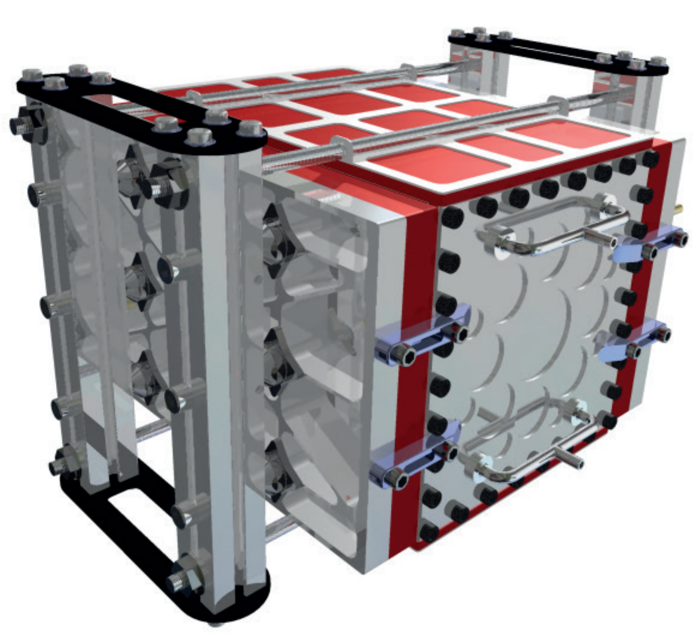
- Scaling up of the component materials of the MEAs (PEMs and electrocatalysts) has been performed.
- Best performing MEAs have been selected
- Different designs for the bipolar plates, fuel cell stack and fuel processor have been completed.
- Two high temperature stacks of 1 kW are currently under construction.

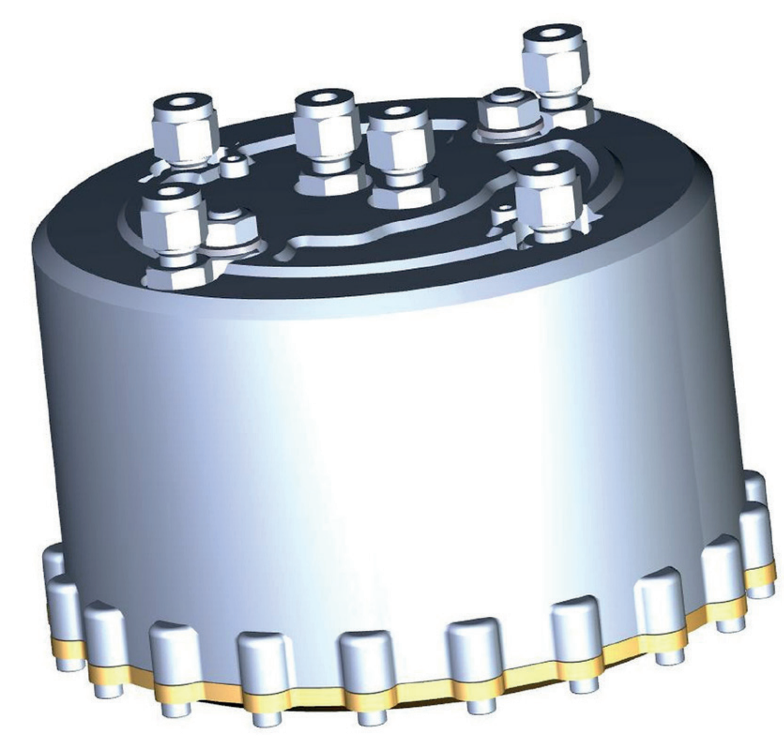
FUTURE STEPS

- Construction of two stacks with different material and engineering concepts.
- Integration with a fuel processor and demonstration of the effective operation of at least one of the systems.
- Validation of the effective architectures of flow fields on bipolar plates and high and stable performance of the optimized MEAs.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Optimized, efficient, robust materials and architectures for the components of the stack.
- Decreased cost compared to current high temperature PEMFC technology.
- Construction of a micro-CHP system comprising a 1kW high temperature PEM fuel cell and a reforming unit operating on natural gas or LPG.





CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	FC stack cost (€/kW)	4,000	<3,000	27,000 for prototype. Projected cost for mass production (as resulted from cost analysis) is close to the project objectives.
AIP 2012	FC stack life time (h)	20,000	5,000 (accelerated basis)	N/A (test not performed yet)
AIP 2012	FC system electrical efficiency (%)	35-45(for power units)	>45	>45 (Already validated efficiency using preliminary designs)

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

DURAMET

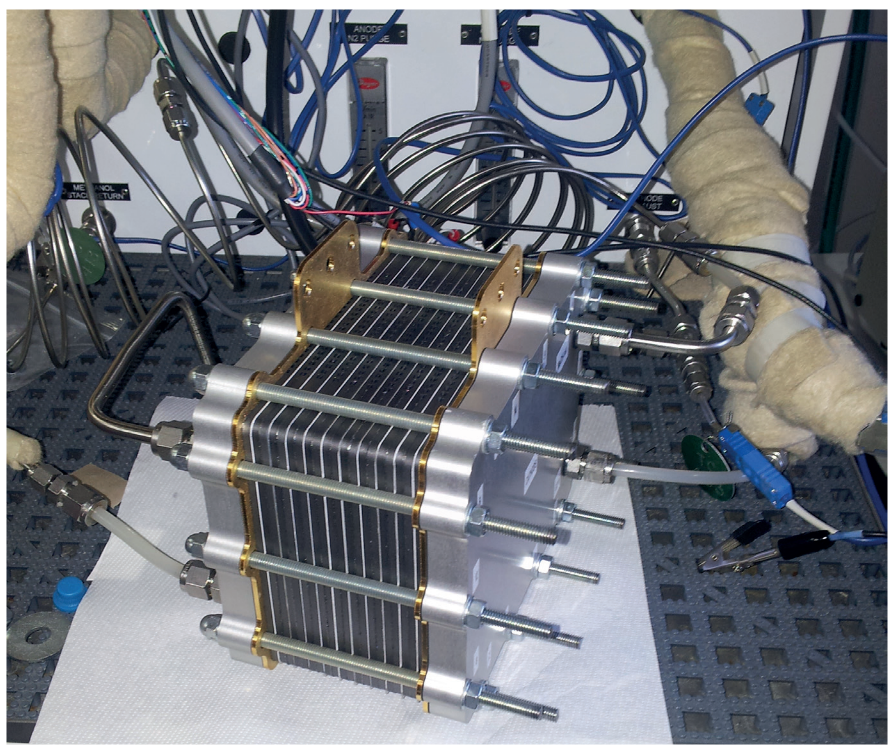
Improved Durability and Cost-Effective Components for New Generation Solid Polymer Electrolyte Direct Methanol Fuel Cells

AIP / APPLICATION AREA	AIP 2010 / AA 4: Early Markets
CALL TOPIC	SP1-JTI-FCH.2010.4.4: Components with advanced durability for Direct Methanol Fuel Cells
START & END DATE	01 Dec. 2011 - 30 Nov. 2014
TOTAL BUDGET	€ 2,956,874
FCH JU CONTRIBUTION	€ 1,496,617
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CONSIGLIO NAZIONALE DELLE RICERCHE (CNR-ITAE)

Partners: CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE (CNRS), FUMA-TECH GESELLSCHAFT FUER FUNKTIONELLE MEMBRANEN UND ANLAGENTECHNOLOGIE MBH (FUMA-TECH), CENTRO RICERCHE FIAT SCPA (CRF), TECHNISCHE UNIVERSITAET MUENCHEN (TUM), IRD FUEL CELLS A/S (INDUSTRIAL RESEARCH & DEVELOPMENT A/S) (IRD), POLITECNICO DI TORINO (POLITO), PRETEXO (PXO), European Commission, Directorate-General Joint Research Centre, Institute for Energy, Petten (JRC-IET)



PROJECT WEBSITE/URL

http://www.duramet.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

The Duramet project deals with enhanced Direct Methanol Fuel Cells (DMFCs). DMFCs working at low and intermediate temperatures (up to 130-150 °C) have been postulated as suitable systems for power generation in the field of portable power sources, remote and micro-distributed energy generation as well as for auxiliary power units (APU) in stationary and mobile applications. These systems are characterised by high energy density, lightweight, compactness, simplicity as well as easy and fast recharging. The main objective of DURAMET is to develop cost-effective components for DMFCs with enhanced activity and stability in order to reduce stack costs and improve performance and durability.

PROGRESS/RESULTS TO-DATE

- Innovative membranes with enhanced conductivity and reduced cross over for wide temperature operation have been developed
- Enhanced nanosised ternary electrocatalysts demonstrated
- Membrane-electrode assembly (MEA) performance of 250 mW cm^{-2} achieved at 130 °C (1 mg cm^{-2} noble metal loading)
- Passive mode portable ministack (1 W) demonstated
- High temperature APU stack (200 W) demonstrated
- Durability tests carried out. The APU stack showed, in a > 500 hrs life-time test, a performance decay less than 5% during operation at 70 °C.

FUTURE STEPS

- Further reduction of the noble metal loading to 0.5 mg cm^{-2} while maintaining same performance
- Dissemination and exploitation of project results

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- In order to be competitive within the portable and distributed energy generation markets, the DMFCs must be reasonably cheap; they should be characterised by high durability and capable of delivering high power densities
- All the stack materials contribute to the final characteristics of practical DMFC devices determining their performance, efficiency and cost
- Enhanced materials and components (catalyst, membranes and MEAs) have been developed providing performance better than the state of the art at lower precious metal loading
- Novel materials have been successfully validated in both high temperature bipolar and passive mode monopolar stacks.
- These systems are promising candidates for portable electric power sources and auxiliary-power-units because of their high energy density, lightweight, compactness, simplicity as well as easy and fast recharging.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Area Early Market: To develop and deploy a range of fuel cell based products capable of entering the market in the near term	Research and technological development in order to achieve application readiness of stationary-type fuel cells in typical power ranges between 2 – 10 kW.	Development of cost effective and enhanced durability components for DMFCs amenable to be integrated in auxiliary power units (150 W) and for portable powers sources (1-2 W)	DMFC components developed and validated in compact portable power units of 1.3 W and short APU stack of 200 W
AIP 2010	Proof-of-concept on the component level	Enhanced membrane conductivity with low cross over	Membrane Conductivity better than 50 mS/cm for DMFC with methanol (MeOH) cross-over lower than 5x10^{-7} mol.cm^{-2}.min^{-1}	Membrane Proton Conductivity >50 mS cm^{-1} at 60 °C and >50 mS cm^{-1} at 120° C for mixed functionality and composite membranes MeOH cross-over < 6 10^{-7} mol.cm^{-2}.min^{-1} (permeation)
AIP 2010	Proof-of-concept on the component level	Enhanced performance and stability	DMFC Performance ≥ 50-250 mW cm^{-2} for low temperature, high temperature operation; Degradation: two times less than benchmark MEAs Precious metal loading (PGM) loading <0.5-1 mg cm^{-2};	DMFC Performance > 70 mW cm^{-2} at LT (low PGM); ~250 mW cm^{-2} at HT; Stability over 1500 hrs; PGM loading <1 mg cm^{-2};
AIP 2010	Integration in at least one DMFC stack solution and proof of durability under simulated real operating conditions	Component validation in practical units	Components validation in short stacks (150 W active, and 1 W passive mode); 500 hrs durability test	200 W power obtained with a 10 cell (10x10 cm^2) stack at T>90°C; 1.3 W under passive mode operation, monopolar configuration Durability tests successfully completed: > 500 hrs life-time test, a performance decay less than 5% during operation at 70 °C.

ENDURANCE

Enhanced Durability Materials for Advanced Stacks of New Solid Oxide Fuel Cells

AIP / APPLICATION AREA	AIP 2013 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2013.3.1: Improving understanding of cell & stack degradation mechanisms using advanced testing techniques, and developments to achieve cost reduction and lifetime enhancements for Stationary Fuel Cell power and CHP systems
START & END DATE	01 Apr. 2014 - 31 Mar. 2017
TOTAL BUDGET	€ 4,414,192.60
FCH JU CONTRIBUTION	€ 2,556,232.00
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Università degli Studi di Genova

Partners: SOLIDPOWER S.p.A., Marion Technologies, Fundacio Institut de Recerca de l'Energia de Catalunya, Deutsches Zentrum Für Luft und Raumfahrt EV, Institute of Electrochemistry and Energy Systems - Bulgaria Academy of Sciences, Centre National de la Recherche Scientifique, Commisariat à l'Energie Atomique et aux Energies Alternatives, SCHOTT AG, HTceramix SA, Ecole Polytechnique Federale de Lausanne, Università di Pisa

PROJECT WEBSITE/URL

www.durablepower.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

Based on SoA SOFC stack a descriptive model is refined to become a trustworthy predictive model for the stack life. The stack is then described with its minimum number of elements called «minima phenomena». Specific microsamples representative of a well defined zone of the stack are used to test improved materials and to refine the models. A Degradation Rate, Mode and Effect Analysis is applied to make a ranking list of phenomena, to set adequate Early Warning Output Signals with the related Counterstrategies to achieve the goal of the project: to improve the durability and reliability of the SOFC stack.

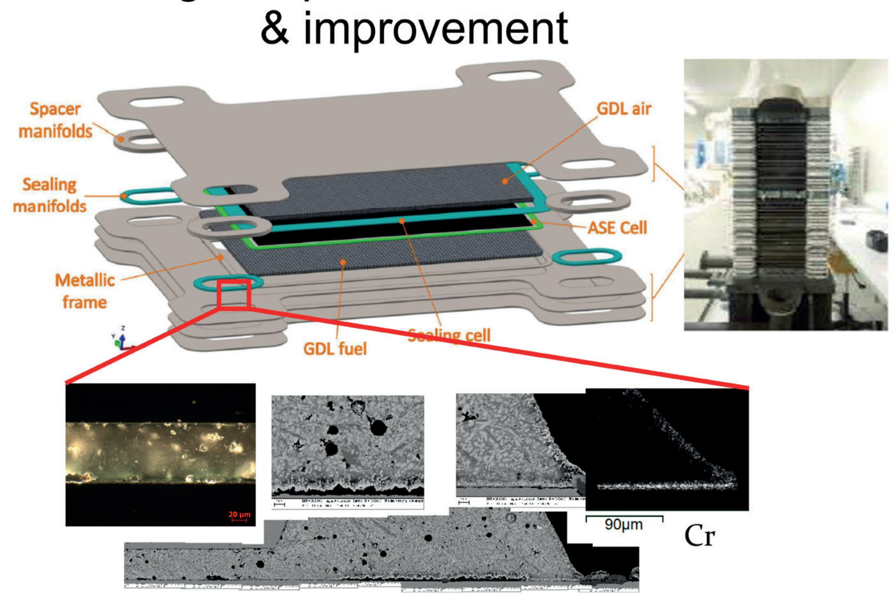
PROGRESS/RESULTS TO-DATE

- Ranking list of degradation mechanisms and phenomena
- Internal sources of degradation: operating conditions
- External sources of degradation: row materials and manufacturing processes
- Improved descriptive model based on real cell microstructural data
- Cycles and harsh conditions tests on real samples

FUTURE STEPS

- Introduction of improved materials (electrolite diffusion barrier, sealant)
- Experimental sessions based on micro samples specifically designed to: investigate internal sources of degradation; test improved materials and to refine models

Stacking components characterization & improvement



- Implementation of Intensive Active Tests and Analysis (IATA) based on EIS to the segmented cells in a short stack
- Introduction of predictive models
- Distribution of the serious game «The Lost Colony» as core of the dissemination toolkit. The alpha version will be ready in september, the Beta version tested during a national Festival of Science (Genoa, Italy) in October 2015. A refined Beta version will be distributed by the internet in spring 2016.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Manufacturing processes are reliable but further attention has to be paid of raw materials
- SoA materials can be improved in order to better match the manufacturing and functioning requests: e.g. denser barrier layer, stable sealant at operating conditions
- Anode «evolution» during operation is one of the most sensitive processes: specific investigations on operated samples (short and segmented stacks from 1.5kh to 4.3kh) and duly designed experiments gave important information on the evolution of Ni particles and porosity. Further researched are focused on the relationships between Ni particles modifications and working local parameters.
- The sealing material was found subject to several modifications induced by the temperature and the polarization (when joining to adjacent metallic interconnects). Cations diffusing from the metal substrate (other than the expected Cr ions) are found and their effect on the sealant properties is under investigation. A diffusion barriers is applied and new sealant formulations are under preparation for further tests. This should improve the durability of the stack structural materials.
- Existing models have been refined using real microstructural features from the fresh and the operated cells. The model is related to specific moments in the operating life, the next step will be to find time depending parameters to be introduced into the models. Other materials, as the sealant, will be investigated with the aim to model their behaviour.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	2015: Cost for industrial/commercial units	of € 1,500 - 2,500/kW	The actual stack costs lie in the range of 6 and 8 k€/kW, depending on the actual application (fuel type, lifetime specs etc.) which can impact current density and thus Capex/kW	N/A (test not finalized)
AIP 2013	Degradation and failure mechanisms over the long term	Identify, quantify and document relevant mechanisms	a) FMEA b) identification of interfaces and stack systems c) Advanced predictive modelling	45% a) FMEA implementation: as Degradation Rate, Mode and Effect Analysis (DR.MEA). b) Minima Phenomena principle to understand the origin and predict the consequences of materials and interfaces evolution in the stack. c) models refinement by using microstructural data and electrochemical data from stacks and specific microsamples designed to better follow and then predict the minima phenomena
AIP 2013	Improved components of cells and stacks	Identify improvements, and verify these in existing cells and stack design	Statistical validation loop on companies stacks (i.e. the core of the project)	A set of samples has been specifically designed to mount and test improved materials before to apply them in short and segmented stacks.
AIP 2013	Improved long term performance	Adjustments to materials, design and manufacturing processes, based on statistically conclusive data	Statistical validation loop on companies stacks (i.e. the core of the project)	10% A set of microsamples mounting SoA sealant and a diffusion barrier was aged and is under investigation to prove and quantify the improvement toward the same material operated in a real stack.
AIP 2013	Improved robustness to cycling and transient operating conditions	Demonstration in conditions comparable to relevant applications	Design of samples and experiments to check SoA materials, components at operating conditions.	20% Thermal cycling tests have been performed on Metal-Sealant-Metal and Metal-Sealant-Cell samples. Red-ox cycles have been performed on cells and single anodes. Specific experiments and samples have been designed and a work plan organized, most of experiments are actually running.
AIP 2013	Development of accelerated testing strategies for specific failure modes backed by modelling or specific experiments	Verification of the method(s) used and validation of claimed improvement(s)	Ranking and meaning of acceleration factors. Design of samples representing a specific zone inside the stack. Test carried in parallel with SoA materials and improvements are followed in real time with electrochemical measurements. Post-experiment characterization of the samples.	20% Acceleration factors are under investigation: T, Polarization, Current Load, gases composition. On Metal-Sealant-Metal samples a comparison is actually performed between samples aged in dry or wet fuel atmosphere. Diffusion barriers between metal and sealant are investigated after long lasting ageing at operating conditions.

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

EURECA

Efficient Use of Resources in Energy Converting Applications

AIP / APPLICATION AREA	AIP 2011 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2011.3.1: Next generation stack and cell design
START & END DATE	01 Jul. 2012 - 31 Aug. 2015
TOTAL BUDGET	€ 6,299,714.20
FCH JU CONTRIBUTION	€ 3,557,295.20
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: NEXT ENERGY

Partners: CEA, CEGASA, CIDETEC, Eisenhuth, FORTH, Fraunhofer ISE, inhouse, UB

PROJECT WEBSITE/URL

www.project-eureca.com

PROJECT CONTACT INFORMATION

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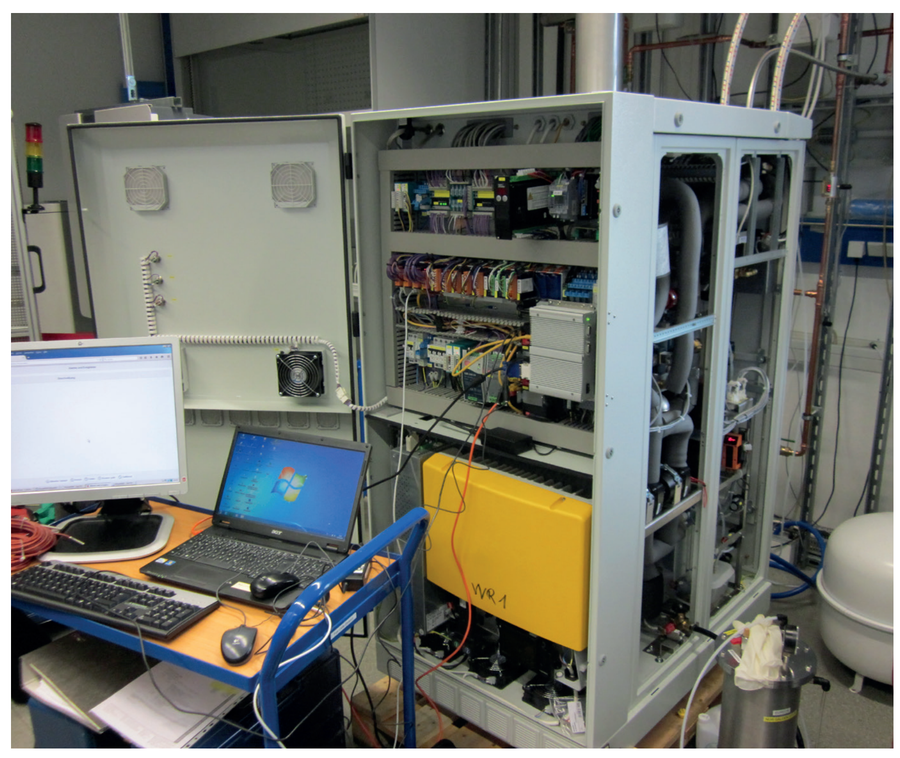
MAIN OBJECTIVES OF THE PROJECT

The EURECA team develops the next generation of μ-CHP systems based on advanced PEM stack technology. The idea is to overcome the disadvantages of complex gas purification, gas humidification and the small temperature gradient for the heat exchangers in a heating system. In the EURECA project we will develop a new stack generation based on PEM technology with operating temperatures of 90°C to 120°C. Thus results in a less complicated and therefore in a more robust μ-CHP system with reduced costs. The development of a new stack generation includes various parallel working packages and tasks.



PROGRESS/RESULTS TO-DATE

- Membrane development
- Catalyst development
- Stack and system design development
- System simplification
- Design-to-cost approach

FUTURE STEPS

- Integration of MT PEM Stack into μ-CHP system
- Evaluation of the system

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Efficient energy supply
- Middle temperature fuel cell are a reasonable bridge between high and low temperature fuel cell
- Influence from components to system costs and properties sharps the development strategy

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Cost of 4,000 - 5,000 €/kW for micro CHP	4-5,000 €/kW	< 3,000 €/kW	< 5,000 €/kW
AIP 2011	New architectures, adaptation of cell and/or stack designs to specific applications and system designs		Fully organic concept, optimized compound for BPP, catalyst support based on WC_x	Several stacks have been set up and tested before applying the new design onto the system
AIP 2011	Design to cost		Reduced system complexity, optimized production and assembly, lower Pt content	Cost assessment is on-going
AIP 2011	Simplification of design and manufacturing of cells, stacks and/or stack modules (power generation units)		Reduced system complexity, optimized production and assembly	The second stage fuel gas purification will not be removed
AIP 2011	Efficiencies	35% (based on integrated reformer solution)	Electrical efficiency of 40%	Efficiency analysis is on-going
AIP 2011	Lifetime	>10,000 hours (stack) >20,000 hours (system)	Stack >12.000 h	Stack and System are still running
AIP 2011	Costs	< 3000 €/kW_{el} (hydrogen fuel cell system)	>3000€/kW_{el}	Cost assessment is on-going

EVOLVE

Evolved Materials and Innovative Design for High Performance, Durable and Reliable SOFC Cell and Stack

AIP / APPLICATION AREA	AIP 2011 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2011.3.1: Next Generation stack and cell design
START & END DATE	01 Nov. 2012 - 31 Oct. 2016
TOTAL BUDGET	€ 5,711,231.88
FCH JU CONTRIBUTION	€ 3,105,093.00
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Deutsches Zentrum für Luft- und Raumfahrt e.V. - DLR

Partners: Alantum Europe GmbH, Association pour la recherche et le développement des methodes et processus industriels – ARMINES, Ceramic Powder Technology AS - CERPOTECH, Consiglio Nazionale delle Ricerche, Institut Polytechnique de Grenoble, SAAN Energi AB, CERACO Ceramic Coating GmbH

PROJECT WEBSITE/URL

www.evolve-fcell.eu

PROJECT CONTACT INFORMATION

Dr. Rémi Costa
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MAIN OBJECTIVES OF THE PROJECT

Beyond the state of art EVOLVE aims at the development of a new SOFC architecture, combining the beneficial characteristics of the previous cell generations, the so called Anode Supported Cells and Metal Supported Cells, while implementing cutting-edge electro-catalyst at the anode side. The final goal being the demonstration of robust cell architecture, allowing higher flexibility towards On/Off cycles, and higher tolerance towards fuel impurity. The project focus on the development of cells and its upscaling in size to what is relevant for its integration into energy supply devices and practical demonstration and assessment against existing SOFCs.

PROGRESS/RESULTS TO-DATE

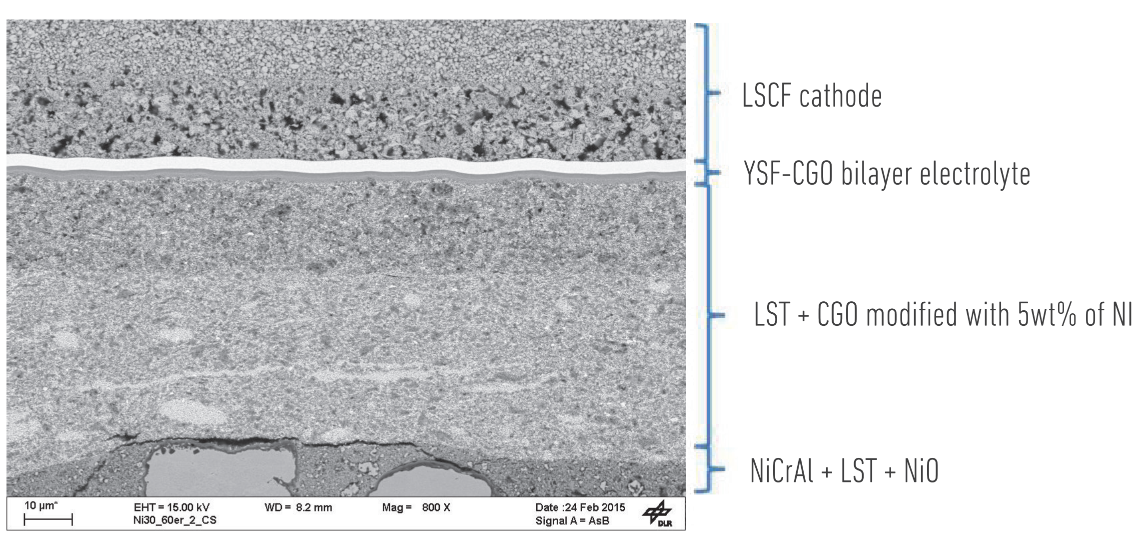
- Prototype showing 350 mW/cm^2 at 0.7V and 750°C demonstrated.
- Proven stable against 10 redox cycles without quantifiable degradation.

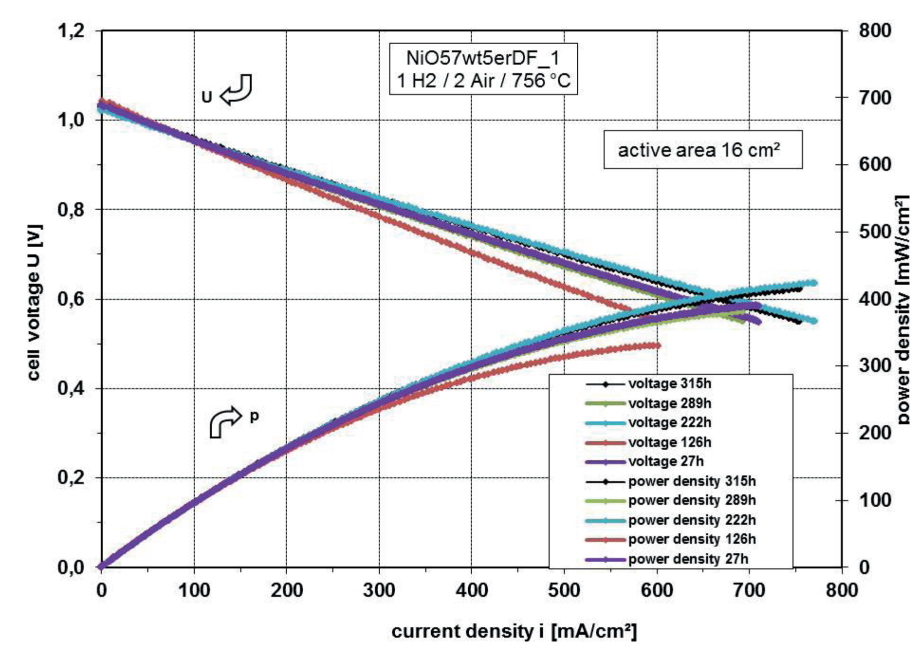
FUTURE STEPS

- Identification and understanding of degradation mechanisms.
- Upscaling in size of cells.
- Demonstration of cell architecture at the stack level to be evaluated against redox cycles and long term degradation
- Recommendation for materials and microstructure for cells for improved cell performance.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Thin film electrolyte has been successfully developed and demonstrated
- Power density of 350 mW/cm^2 at 0.7V and 750°C with Hydrogen as fuel has been obtained.
- Cell architecture has been proven redox stable (10 times) without significant degradation.
- Cell architecture including thin film electrolyte can be used for other classes of SOFC and SOEC





CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	2020 target: must sustain repeated on/off cycling (CHP Unit)	Cell survives at least 50 redox cycles		Cells survived 10 redox cycles. Objective to be achieved at cell level in October 2016
MAIP 2008-2013	2020 target: (CHP Unit) Life Time expected > 20 000hours	Degradation rate of cell voltage below 0.25% per 1000 hours with H_2 as fuel		30 % of degradation of power density for 500 hours of operation in potentiostatic conditions. Origin of degradation is under investigation. Unexpected high degradation rate measured on proof of concept cells. Degradation mechanisms not yet fully understood to propose adequate mitigation strategy. Target revised.
AIP 2011	Improved Tolerance to contaminants with respect to state of art FCs	Not yet evaluated		Target needs to be revised
AIP 2011	Improved start-up time from room temperature to 30% of power rating below 1 hour	Heating rate of 25K/min for thermal cycles.		Under evaluation
AIP 2011	Decreased material consumption	Demonstrate up-scalability of cells & Use realistic model cost analysis, establish processing sequences and practices for the cell components to attain optimal cost-to-quality ratio		Reduction from 100µm to 3µm the thickness of the electrolyte required for comparable gas tightness at level 50 mm x 50mm. Implementation of thin film coating technology (EB-PVD) in replacement of plasma spraying (VPS). Technology being up-scaled.

PROGRAMME REVIEW 2015

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

LASER-CELL

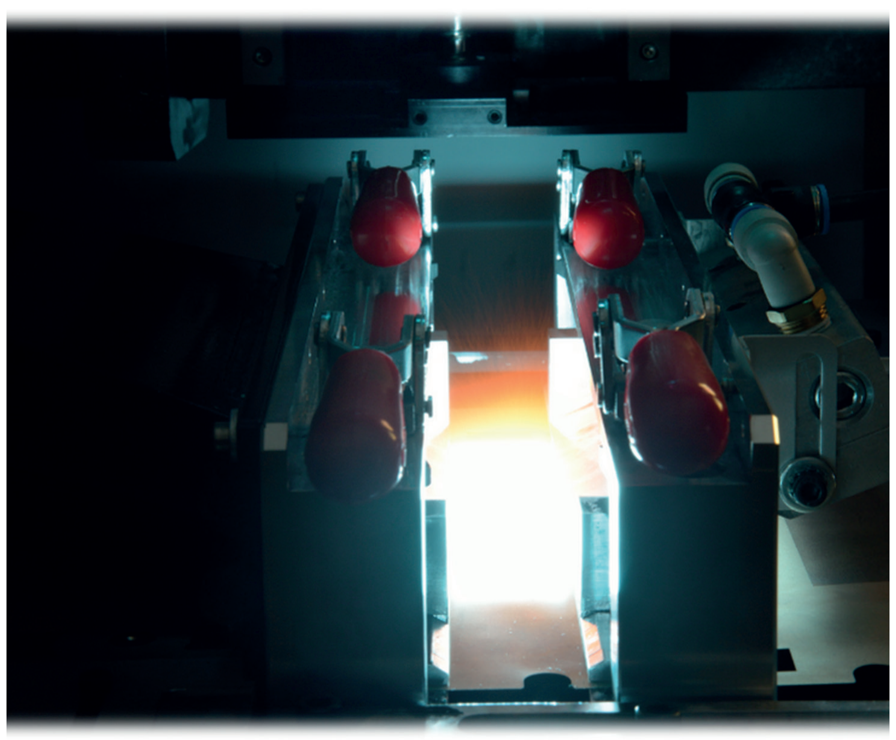
Innovative Cell and Stack Design for Stationary Industrial Applications Using Novel Laser Processing Techniques

AIP / APPLICATION AREA	AIP 2010 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2010.3.2: Next generation cell and stack designs
START & END DATE	01 Dec. 2011 – 31 Nov. 2014
TOTAL BUDGET	€ 2,877,089.60
FCH JU CONTRIBUTION	€ 1,421,757
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: AFC Energy

Partners: CenCorp, Technical Research centre of Finland (VTT), Air Products, Nanocyl, University of Duisburg Essen



PROJECT WEBSITE/URL

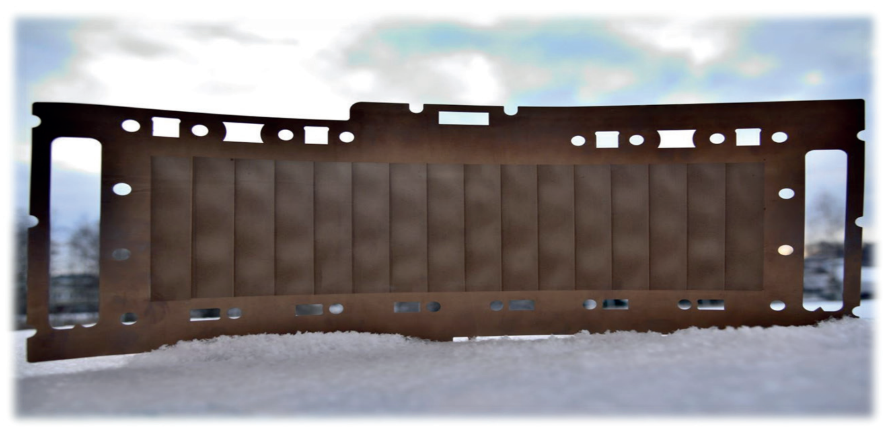
www.lasercell.eu

PROJECT CONTACT INFORMATION

Mr Christopher TAWNEY
ctawney@afcenergy.com

MAIN OBJECTIVES OF THE PROJECT

The project's aims were the following: Designing a novel AFC based on laser-processed substrates that provide optimised technical and commercial characteristics. Assessing and adapting state-of-the-art laser manufacturing techniques and incorporating their benefits (while taking account of their restrictions) in the fuel-cell design. Designing an innovative fuel-cell stack to operate in industrial stationary settings which delivers safety, mass manufacture, ease of assembly, recyclability, serviceability and optimal performance. Combining these aspects to establish the cost-competitiveness of the AFC technology in comparison with all competing technologies – confirming for the first time the commercial viability of AFCs in large-scale stationary applications.



PROGRESS/RESULTS TO-DATE

- Laser sintering and laser drilling investigated as methods for making AFC substrates
- Metal and conductive (filled) plastics investigated as substrate materials
- Novel methods for reducing leakage current devised
- Laser drilled, metal substrates selected for prototype
- Advances used to build prototype stack which was then tested

FUTURE STEPS

Project complete but the following areas show future promise

- Continued modelling of Alkaline fuel cells
- Laser sintering technique development
- Conductive polymer substrates
- Further commercial development for fuel cells
- Commercial application in areas outside of fuel cells

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The electrode substrate costs decreased by over 70 % and stack production costs were reduced by 31 %.
- Significant advances in laser-drilling technology for metal sheets were demonstrated and drilling speeds above project targets were achieved.
- Laser sintering at Hundreds mm^3 per second was achieved; 20 to 150 times faster than with commercial equipment
- Modelling has been used to show the major influences on the polarisation of alkaline fuel cells and to investigate the effects of substrate conductivity on polarisation response
- Laser procesable, conductive, filled polymers were developed and show great promise for further application

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Cost of € 1,500 - 2,500/kW for industrial/ commercial units	<€ 2,500/kW	<€ 1,000/kW	€1255 per kW shown in modeled cost
AIP 2010	Development of materials to improve performance of single cells stacks and BoP components	longer lifetime and lower degradation	6,000 + hours @ 300 mAcm-2 (stack) < 0.5% per thermal cycle for a stack < 0.1% per load cycle for a stack	7,000 hours extrapolated lifetime on AFCEN's stack testing regime.
AIP 2010	research on novel architectures for cell and stack design to provide step change improvements over existing technology	Improved efficiency and cost	< €1,000 per kW AND < 40 mV Leakage Current	€1255 per kW shown in modeled cost AND < 40 mV Leakage acheived in lab trials
AIP 2010	Development activities to improve a) The performance of individual components of fuel cell systems	Improved function	Develop and test a substrate manufactured using a novel or improved route from an optimised material	A prototype stack was manufactured and tested.

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

LiquidPower

Fuel Cell Systems and Hydrogen Supply for Early Markets

AIP / APPLICATION AREA	AIP 2011 / AA 4: Early Markets
CALL TOPIC	SP1-JTI-FCH.2011.4.3: Research and development of 1-10kW fuel cell systems and hydrogen supply for early market applications
START & END DATE	01 Oct. 2012 - 31 May 2015
TOTAL BUDGET	€ 3,688,326
FCH JU CONTRIBUTION	€ 1,999,872
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Dantherm Power A/S (former H2Logic)

Partners: Catator AB, Dantherm Power A/S, Zentrum für Brennstoffzellen-Technik Gmbh

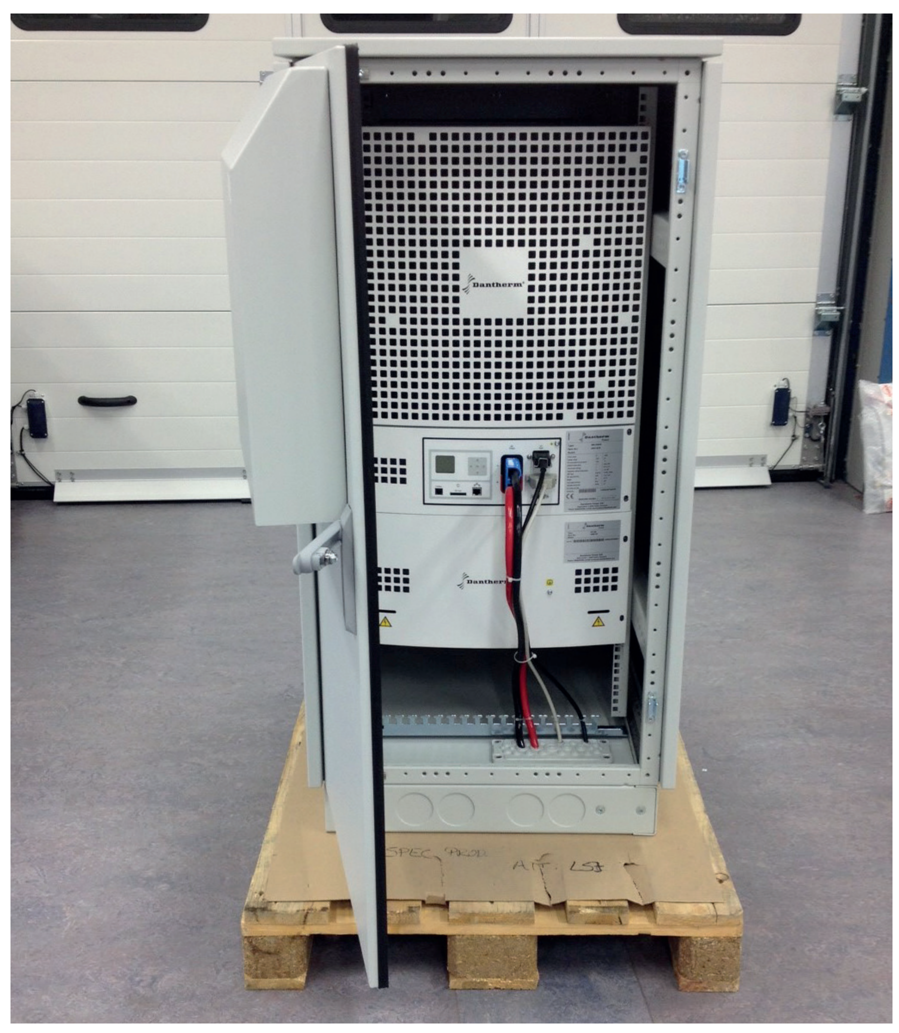
PROJECT CONTACT INFORMATION

kfj@dantherm.com

MAIN OBJECTIVES OF THE PROJECT

The LiquidPower project objectives are:

- R&D of a fuel cell system for Back-up-power and Telecom applications (BT)
- R&D of a fuel cell system for material handling vehicles (MH)
- R&D of a methanol reformer for onsite Hydrogen supply, enabling the low cost hydrogen for the early markets of BT and MH



PROGRESS/RESULTS TO-DATE

- Theoretical R&D of back-up power fuel cell system conducted. Most of the practical work conducted and tests are started
- Theoretical R&D of material handling fuel cell system conducted
- Reformer system developed and shipped to ZBT, H_2-capacity of 9 m^3/h verified
- Full scale PSA system (capacity up to 10 m^3/h) developed and ready for coupling, CE conformity procedure defined, actual cost exceed the defined targets by a factor of 1.5

FUTURE STEPS

- Continued R&D of material handling fuel
- Initiating the last tests on back-up power fuel cell system
- Coupling of reformer and PSA
- Initial operation and test phase of full scale PSA and coupled system
- Verification of components and final cost evaluation

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Methanol-reformer system and PSA-system are developed
- Functionality of the full scale PSA-system can only be demonstrated in coupled operation
- More time are required in order to reach the objectives for materials handling

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Material handling fuel cell system cost	€1.500/kW	€1.800/kW	€2.200
MAIP 2008-2013	Back-up power fuel cell system cost	€1.500/kW	€1.300/kW	€1.300
MAIP 2008-2013	Material handling fuel cell system efficiency	50%	52-55%	>52%
MAIP 2008-2013	Backup power fuel cell system efficiency	45%	45%	45%
AIP 2011	Hydrogen cost at point of consumption	€7/kg	€7/kg	€9-11/kg

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

MATISSE

Manufacturing Improved Stack with Textured Surface Electrodes for Stationary and CHP Applications

AIP / APPLICATION AREA	AIP 2013 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2013.3.2: Improved cell and stack design and manufacturability for application-specific requirements for Stationary Fuel Cell power and CHP systems.
START & END DATE	01 Oct. 2014 - 30 Sep. 2017
TOTAL BUDGET	€ 3,192,819.80
FCH JU CONTRIBUTION	€ 1,684,717.00
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: COMMISSARIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES

Partners: ZENTRUM FUR SONNENENERGIE- UND WASSERSTOFF-FORSCHUNG BADEN-WURTTEMBERGSTIFTUNG, NEDSTACK FUEL CELL TECHNOLOGY BV, INHOUSE ENGINEERING GMBH, AREVA STOCKAGE D'ENERGIE SAS

PROJECT WEBSITE/URL

http://matisse.zsw-bw.de/general-information.html

PROJECT CONTACT INFORMATION

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Jeremy.Allix@cea.fr

MAIN OBJECTIVES OF THE PROJECT

MATISSE is a 36-month project targeting to the delivery of PEMFC advanced cells and stacks for stationary applications. The project methodology will include assessment of stack incremented with new materials and process developed during the project. The project will address three stack designs for each of the stationary conditions of operation of the fuel cell i.e. H2/O2, H2/Air and reformate H2/Air

PROGRESS/RESULTS TO-DATE

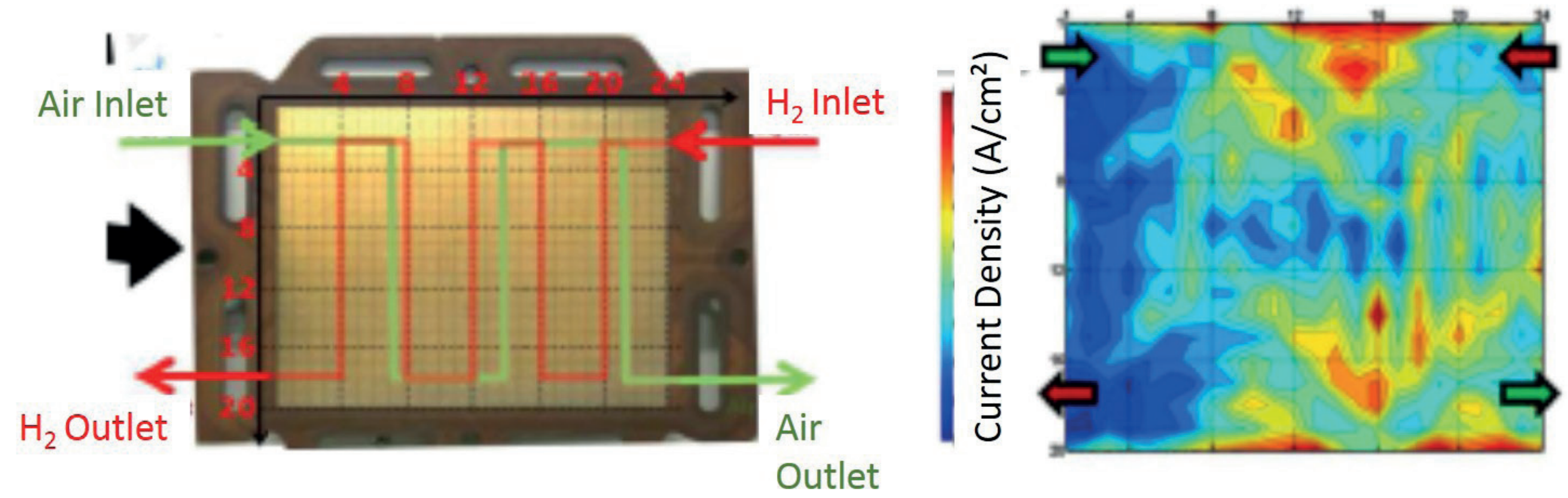
- Anti-wicking
- Mapping of MEA reference
- Gasket deposition on MEA

FUTURE STEPS

- Optimised MEA
- Test in stack for each application
- MEA structured

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Anti-wicking should improve MEA durability
- Mapping will allow a smart MEA structuration
- Automatisation of MEA manufacturing



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP OR AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
SP1-JTI-FCH-2013.3.2 topic objectives	MEA performances and durability	Projects must build on existing cell and stack expertise within the consortium... focus on improving cell and stack technology	All partners have large expertise on Cell and stack. CEA will bring new technological design development on cell and stack. ZSW will especially bring technical expertise in testing of PEMFC systems	Stack testing in process
SP1-JTI-FCH-2013.3.2 topic objectives	MEA performances and durability	Improved system efficiency over the SoA	Better catalytic activity and better water management should be achieved thanks to the X-Y gradient electrode that allows improving water management	First structured MEA has been supplied to partner
SP1-JTI-FCH-2013.3.2 topic objectives	Process development	Components including Robustness, Lifetime, Performance, Cost	- MATISSE will propose two solutions of gasket and subgasket (anti-wicking) in order to improve cell robustness - Optimised catalyst formulation and protection towards contamination will be done with anti-wicking architecture and improved catalyst within MATISSE - X-Y gradient electrode design will be considered - Automatised process and optimized catalyst loading will be used	Anti-wicking technology inserted Subgasket deposition technology on progress (Benchmarking of material)
	Durability	Improved robustness (lifetime) to be proved by operating in simulated or reallife environments over a period of time that is sufficiently long to enable credible lifetime prediction	Stacks will be tested under real environment conditions. An endurance test of 5,000 h on large scale stationary bench will be considered on seven different stacks. Smart grid bench and mCHP bench will also used to be characterised at a representative level the stack developed in MATISSE. Accelerated stress test will be done in some case to predict real lifetime	AST in progress

METPROCELL

Innovative Fabrication Routes and Materials for Metal and Anode Supported Proton Conducting Fuel Cells

AIP / APPLICATION AREA	AIP 2010 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2010.3.1: Materials development for cells, stacks and balance of plant (BoP)
START-DATE	01 Dec. 2011 - 31 May 2015
TOTAL BUDGET	€ 3,447,874.39
FCH JU CONTRIBUTION	€ 1,822,255.00
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: FUNDACION TECNALIA RESEARCH & INNOVATION

Partners: EUROPAICHES INSTITUT ENERGIEFORSCHUNG ELECTRICITE DE FRANCE/ UNIVERSITAT KARLSRUHE (TH), Centre National de la Recherche Scientifique, DANMARKS TEKNISKE UNIVERSITET, TOPSOE FUEL CELL A/S, Ceramic Powder Technology AS, HÖGANÄS AB, MARION TECHNOLOGIES S.A.

PROJECT WEBSITE/URL

http://www.metprocell.eu/

PROJECT CONTACT INFORMATION

Dr.-Ing. María PARCO
maria.parco@tecnalia.com

MAIN OBJECTIVES OF THE PROJECT

- Development of novel electrolyte (e.g. BTiO2, substituted perovskites $A^{II}B^{IV}B'^{IV}M^{III}M'^{III}O_3$) and electrode materials (e.g. NiO-electrolyte anodes, MIEC cathodes) with enhanced properties for improved proton conducting fuel cells (PCFCs) dedicated to 500-600°C.
- Development of alternative manufacturing routes using cost competitive thermal spray technologies.
- Development of innovative PCFC configurations on the basis of both metal supported and anode supported cell designs.
- Upscaling of manufacturing procedures for the production of flat Stack Cells with a footprint of 12 x 12 cm.
- Bring the proof of concept of these novel PCFCs by the set-up and validation of prototype like stacks in relevant industrial systems.

PROGRESS/RESULTS TO-DATE

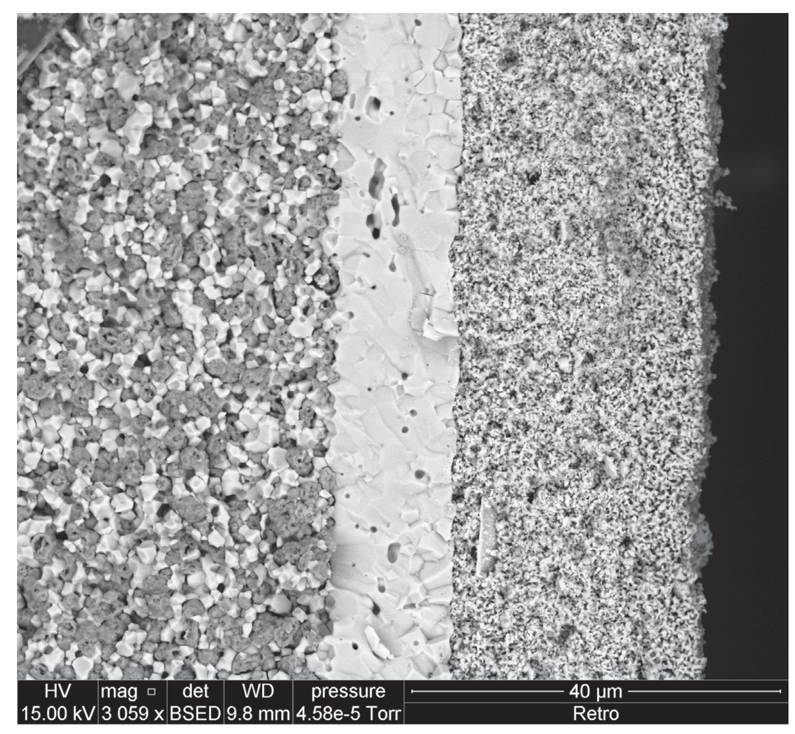
- Well performing electrode/electrolyte materials dedicated to a service temperature range between 550-650°C have been developed:
  - Electrodes: BSCF-BCYZ/BCY composite cathodes with an Area Specific Resistance (ASR) down to 0.44 ohm.cm^2; BCYZ-NiO anodes with ASR down to 0.07ohm.cm^2 and σ_e >1000 S.cm^{-1}.
  - BCZYYb-ZnO electrolytes with σH^+ of 14 mS.cm^{-1}.
- Anode supported button cells (Conf. Ni-BCZY / BCZY-ZnO / SmBSCF-BCZYYb / SmBSCF) with very high maximum power densities of 513, 630, 762 mW.cm^{-2} at 600, 650 and 700°C, respectively [using air as the oxidant gas and humid H_2 (3%vol. H_2O) as fuel gas - cell geometry: 30x30 mm].
- Cell up-scaling: Up-scaled anode supports with metallic behaviour and good percolation of the nickel phase, σ_{e^-} = 1280 S.cm^{-1} at 600°C, crack-free 600 μm thick (some improvements are still required to avoid small defects in the target support geometry of 120 x 120 mm s). NiO-BCYZ / BCYZ-ZnO / BCYZ-BSCF cells up-scaled to 69 x 69 mm^2.
- Low cost ferritic stainless steels (Iron Chromium steels) supports with Thermal Expansion Coefficients (TEC) close to that of the electrolytes ($10 \cdot 10^{-6}$ K^{-1}). Improved support post-treatment with a Y –base coating to guarantee a high corrosion resistance under the target service conditions (i.e. humid H_2 (4% H_2O/H_2) at 600°C). Weight increase of σ 0.4% after oxidation tests for 1500h.
- The PCFC technology has been assessed for the first time in electrolysis mode, with promising results: 900 mA.cm^{-2} at 1.3 V and 700°C. Degradation rate of 7%/kh.

FUTURE STEPS

All technical activities have been closed.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- New electrode/electrolyte materials dedicated to the PCFC technology with improved electrochemical performance at 550-650 °C have been developed.
- The target for FC performance at single cell level has been achieved on anode supported cells: PCFCs with a max. power density at 600°C well over the project target of 400 mW.cm^{-2}.
- Well performing anode supported PC single cells with a representative geometry of 60 x69 mm^2 were delivered, but the manufacturing procedure must still be improved to reach a satisfactory stack cell quality.
- The primary electrical performance of PC cells based on the metal configuration was not yet sufficient and need further R&D. However, it can be noted that an expected metal supported PCC electrical performance of 0.3 W/cm^2 would be sufficient to target a competitive cell cost of 2.5 €/W (potential reduction to 1.7 €/W for large scale production) vs. anode supported cell configuration.
- In electrolysis mode, considering potential electrical performances already validated in the frame of the project at lab scale and a potentially lower depreciation of system with time (hyp: 20,000h) at lower temperature, the price of hydrogen produced could be competitive with SOC technology operating even at higher temperature (4.6 €/kg$_{H2}$ @600°C).



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Lifetime requirements of CHP units	40,000 hours for cell and stack	FC degradation 2% or less over 500 h under fuel cell	Durability & Micro-cogeneration profile (NiO-BCYZ / BCYZ-ZnO / BCYZ-BSCF): • Durability: $\delta V/V$= +3,6%/1000h; • Micro-cogeneration (dynamic) profile: $\delta V/V$= -1,5%/1000h.
MAIP 2008-2013	Solutions to specific identified failure mechanisms	Reduction of the operating temperature under 600 °C to prolong the service life of metal supported cells	Electrode/electrolyte materials with improved performance at 600°C: • The ASR target for cathode< 0.5 ohm.cm^2 at 600°C. • Anode kinetics: <0.1 ohm.cm^2 at 600°C. • Conductivity of electrolyte σ_{H+} >2 mS.cm^{-1} at 600°C	Electrochemical properties of electrode/electrolyte materials at 600°C: • BSCF/BCZY cathodes with ASR down to 0.44 ohm.cm^2; SmBSCF-BCZY / cathodes with higher chemical stability and electrochemical performance. • BCZY-NiO anodes with ASR down to 0.07ohm.cm^2 and σ_e >1000 S.cm^{-1} • BCZYYb-ZnO electrolytes with σH^+ of 14 mS.cm^{-1}. Single PCFCs with a max. power density of 513 mW.cm^{-2} at 600°C.
MAIP 2008-2013	New material production techniques/Cost reductions	Micro-CHP (residential): 5,000 € per system (1kWe + household heat) in 2020	• Higher power densities in comparison to SOFC at lower temperatures using well established wet chemical routes (Target: Proton Conducting fuel cells with a max. power density of 400 mW.cm^{-2} at 600°C). • Development of low cost ferritic steel supports. • Reduce the need of sintering steps by alternative manufacturing routes (anode/electrolyte deposition by thermal spraying)	• For a cell configuration based on Ni-BCZY / BCZY / BSCF –BCZY operating at 600°C with a power density of 0.49 W/cm^2 @0.7V): Expected production cost is 2.6 €/W • Same PCFC operating at 700°C with a power density of 0.7 W/cm^2 @0.7V): Expected production cost is 1.8 €/W. • Reduction of price of substrate cost by a factor 6 possible (ref. size: 50 x 50 mm):~6.3 € for a Ni-BCZY anode support vs. 0.7 € for a metal support (ref. production volume of 12 ton/y for the porous metal substrate). • For the developed metal supported PCFC (anode/electrolyte deposited by thermal spraying + cathode by screen printing), an electrical performance of 0.3 W/cm^2 would be sufficient to target a competitive cell cost of 2.5 €/W vs. anode supported cell configuration. Potential reduction to 1.7 €/W for large scale production) (Current performance: 43 mW.cm^{-2} at 650°C).
MAIP 2008-2013	Decentralized production of H_2 (Electrolysis from renewable electricity)	Unit capacity (3.0 t/day) / Efficiency: 67%	Assess the potential of the PCFC technology under electrolysis mode for the first time.	900 mA.cm^{-2} at 1.3 V and 700°C Degradation rate of 7%/kh. The PCFC technology has been assessed at lab scale level in electrolysis mode. Lower ASR in EC mode compared to FC mode. SoA > Maximum Power density of SOEC in the low temperature range, i.e. 500-700°C: 600 mA. cm^{-2} at 1.3 V and 700°C [He JPS 195 (2010)].

METSAPP

Metal Supported SOFC Technology for Stationary and Mobile Applications

AIP / APPLICATION AREA	AIP 2010 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2010.3.1: Materials development for cells, stacks, and balance of plant
START & END DATE	01 Nov. 2011 - 31 Dec. 2015
TOTAL BUDGET	€ 8,021,949.67
FCH JU CONTRIBUTION	€ 3,366,631.24
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Technical University of Denmark (DK) (since October 2014)

Partners: Sandvik Materials Technology (SE), Topsoe Fuel Cell A/S (DK) until October 2014, AVL List GmbH (AT), Chalmers University of Technology (SE), Karlsruhe Institute of Technology (DE), University of St. Andrews (UK), ICE Strömungsforschung GmbH (AT), JRC – Joint Reasearch Centre (NE), Elringklinger AG (DE) since March 2015

PROJECT WEBSITE/URL

www.metsapp.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

The aim of the METSAPP project is to develop novel cells and stacks based on a robust and reliable up-scale-able metal supported technology with the following primary objectives:

- Robust metal-supported cell design, with an area specific resistance (ASR), ASRcell < 0.5 Ohmcm^2, 650 °C
- Cell optimized and fabrication upscaled for various sizes
- Improved durability for stationary applications, degradation < 0.25%/kh
- Modular, up-scaled stack design, stack ASRstack < 0.6 Ohmcm^2, 650 °C
- Robustness of 1-3 kW stack verified
- Cost effectiveness, industrially relevance, up-scale-ability illustrated.

PROGRESS/RESULTS TO-DATE

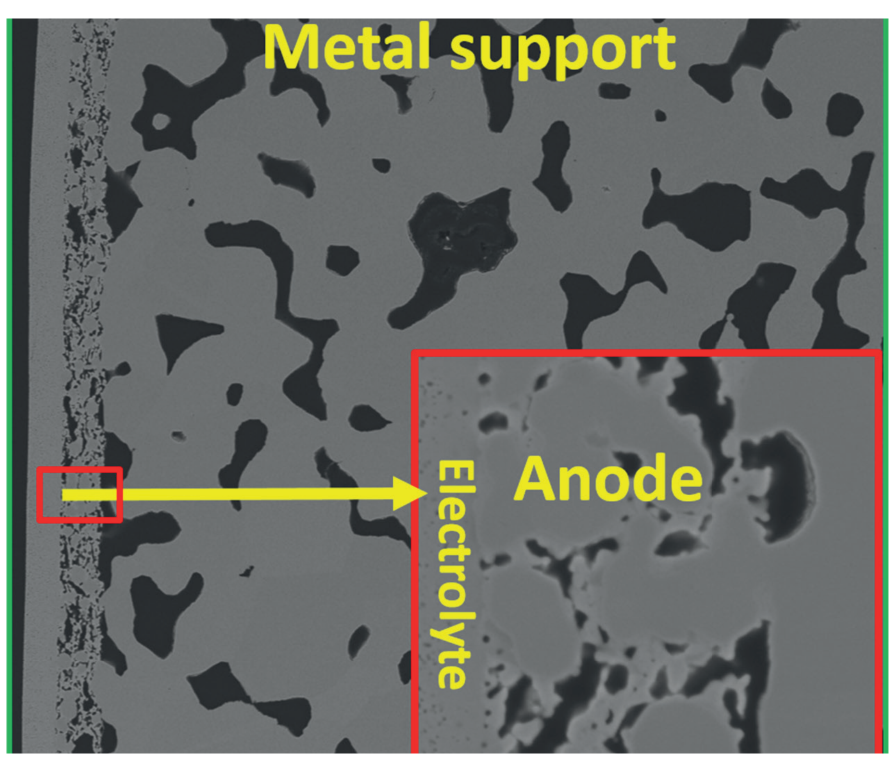
- Robust metal-supported cell design, ASRcell < 0.5 Ohmcm^2 and ASRcell in stack < 0.6 Ohmcm^2, 650 °C achieved.
- Up-scalability demonstrated on cell level. Metal-supported cell fabrication in different sizes, up to footprint size of > 300 cm^2. More than 100 cells of 12x12 cm^2 size produced.
- Novel anode materials and designs as well as nano-structured coatings for metal supports and interconnects have been developed
- Advanced multi-scale computational modelling tools including computational fluid dynamics (CFD) and finite element methods (FEM) have been developed from micro-level to stack level
- Improved understanding of mechanical and thermomechanical behaviour of porous metals

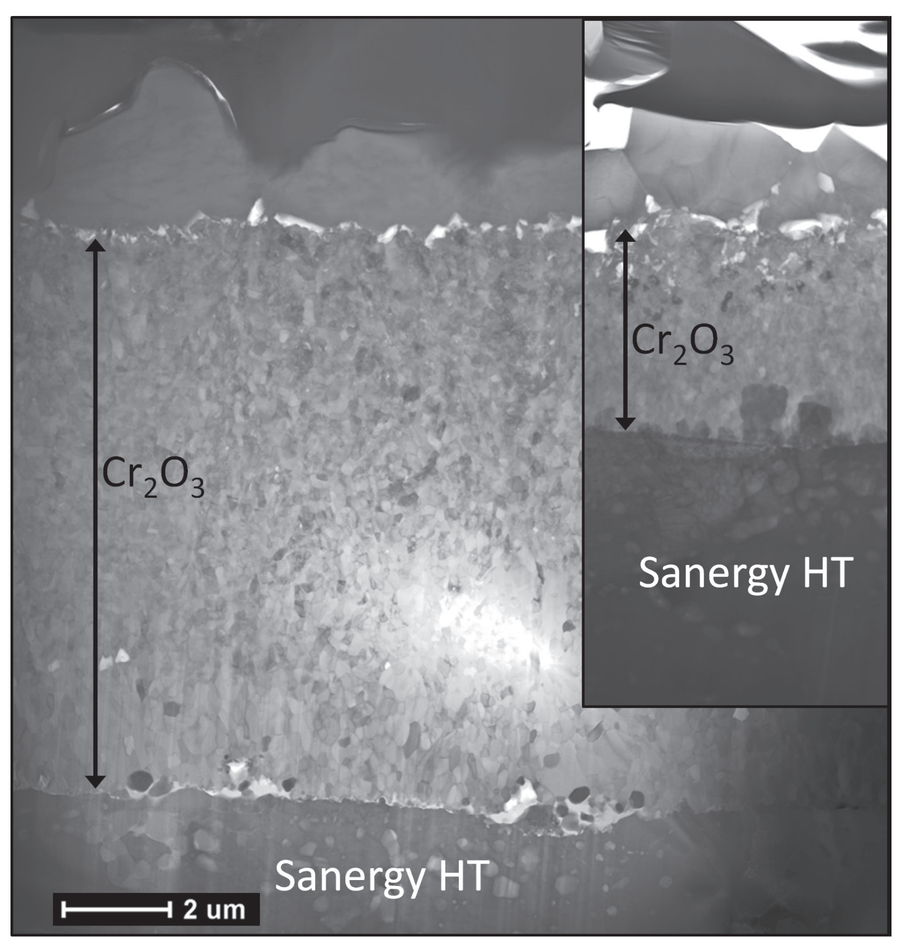
FUTURE STEPS

- Evaluation of novel anode layers for stability in operating environment
- Integration of cells into new stack design and demonstrate performance of the new stack
- Complete demonstration of interconnect coatings on both anode and cathode sides

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Development of novel materials and components with the required targets is a huge challenge – high risk, high gain.
- Fabrication of metal-supported cells with low cost processes is promising but challenging – new materials take time to integrate
- Increased effort and focus on computational modelling and simulation facilitates the development of concepts
- If the novel materials developed in the project are verified in cells and stacks, there is a potential for the metal-supported cell technology developed in METSAPP





CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Improved durability for stationary applications, degradation	Address lifetime requirements for 40 000h	Cell degradation < 0.25%/kh	New cell with integrated novel anode with promising low degradation rate being developed.
MAIP 2008-2013	Developing components as well as novel architectures for cell and stacks leading to step change improvements over existing technology. Cost effectiveness, industrially relevance, up-scale-ability illustrated	Cost of € 4,000 - 5,000/kW for micro CHP	Show that ferritic stainless steel as support structure is a cost efficient alternative for nickel based anode support.	Successfully shown that ferritic stainless steel is a promising alternative to nickel based anode support. Up-scalability proven on cell level.
AIP 2010	Development of materials to improve performance of single cells, stacks, and BoP components, in terms of longer lifetime and lower degradation.	Similar or better than state-of-the-art.	ASR_{cell} < 0.5 Ωcm^2 at 650 °C	ASR_{cell} < 0.5 Ωcm^2 at 650 °C on single cells. ASR_{cell} < 0.6 Ωcm^2 at 650 °C in stacks.
AIP 2010	Investigation on materials production techniques. Optimize materials and up-scaling		Various cell sizes demonstrated. Interconnect coatings up-scaled	Footprint of cell > 300 cm^2 demonstrated. More than 100 12x12 cm^2 cells produced. Coating line at Sandvik.
AIP 2010	Development of materials to improve performance of single cells, stacks, and BoP components, in terms of longer lifetime and lower degradation.	Similar or better than state-of-the-art.	ASR_{stack} < 0.6 Ωcm^2 at 650°C	ASR_{cell} < 0.6 Ωcm^2 at 650°C in stacks. Need to verify on new stack design.

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

MMLCR=SOFC

Working Towards Mass Manufactured, Low Cost and Robust SOFC Stacks

AIP / APPLICATION AREA	AIP 2010 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SSP1-JTI-FCH.2010.3.2: Next generation cell and stack designs; SP1-JTI-FCH.2010.3.1: Materials development for cells, stacks and balance of plant.
START & END DATE	01 Jan. 2012 - 30 Jun. 2015
TOTAL BUDGET	€ 4,727,248.40
FCH JU CONTRIBUTION	€ 2,067,975
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: University of Birmingham

Partners: Forschungszentrum Jülich GmbH, BORIT, Rohwedder Micro Assembly GmbH, CSIC, Bekaert, Turbocoating, SOLIDpower SpA

PROJECT WEBSITE/URL

www.mmlcr-sofc.eu

PROJECT CONTACT INFORMATION

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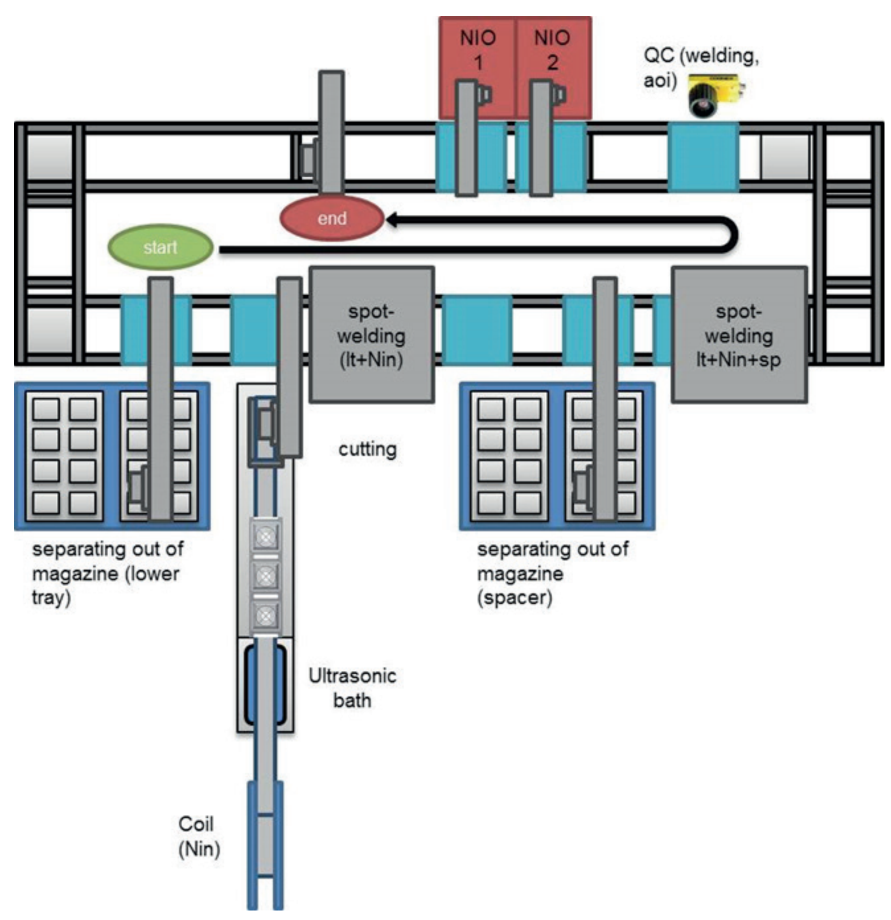
MAIN OBJECTIVES OF THE PROJECT

The project looked into further developing and optimising a cassette-type SOFC design and then developing prototype mass-manufacturing equipment to build such stacks.



PROGRESS/RESULTS TO-DATE

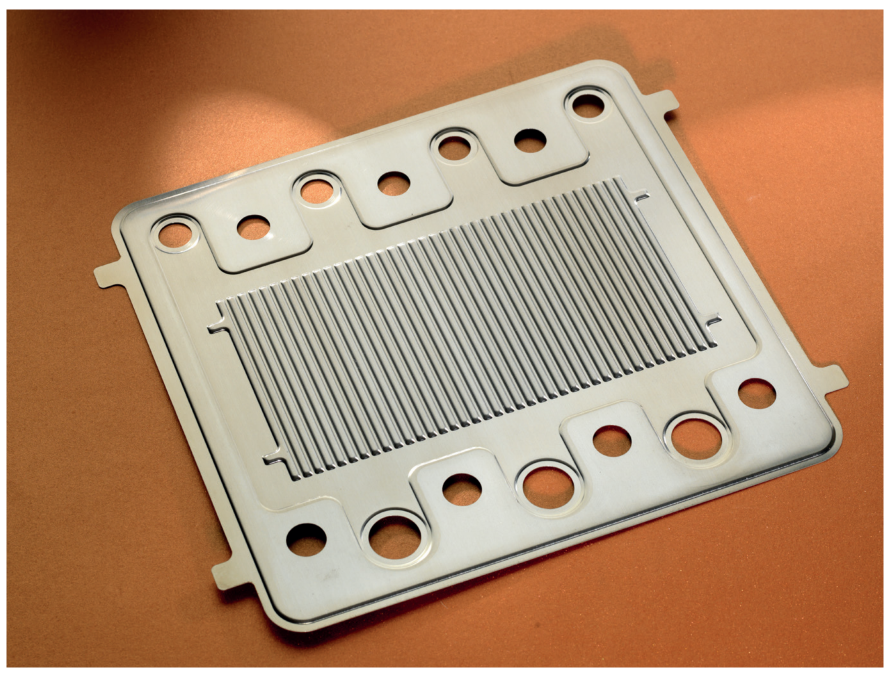
- D1.0 design updates implemented and first prototype stacks tested
- D 2.0 accomplished and manufactured, testing initiated
- more power and better cycling capability implemented in D2.0
- D2.n improvements designed and ready for implementation
- design of automated manufacturing line completed; one prototype assembly sub-station to be built
- D2.1 with simplified manufacturing realised and ready for testing; D2.2 with improved protective coatings realised and ready for testing

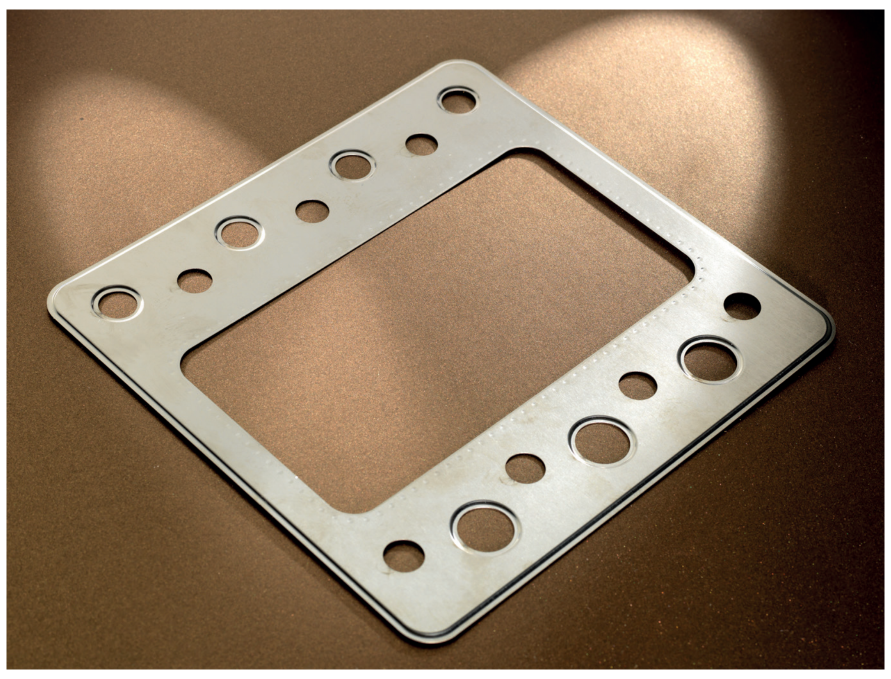
FUTURE STEPS

- project has ended 30 June 2015
- stack technology will be carried over into several vehicle APU development projects
- initial talks with technology early investors ongoing

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- D1.0 design performed well overall
- better start-up and cycling capabilities expected with D2.0
- D2.1 / D2.2 variants perform well, long-term stability to be proven (tests ongoing after project ends)
- further design variants are being tested 'ex-situ' on small samples or single components but not full stacks





CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	SOFC system cost	SOFC System cost <4000€/kW	low-cost manufacturing and materials saving design; stack cost 2kW 600€	ongoing
MAIP 2008-2013	start-up time	< 1 hour	rapid startup: cold-start in 30 minutes	no D2.n rapid startup testing yet; 45 minute startups on D1.0 design
MAIP 2008-2013	thermal cycling	several 100 with 5% performance loss	500 with 10% performance loss	D2.n has begun but not yet reached high numbers of cycles

ONSITE

Operation of a Novel SOFC-Battery Integrated Hybrid for Telecommunication Energy Systems

AIP / APPLICATION AREA	AIP 2012 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2012.3.5: System level proof of concept for stationary power and CHP fuel cell systems at a representative scale; SP1-JTI-FCH.2012.3.4: Component and sub-system cost and reliability improvement for critical path items in stationary power and CHP fuel cell systems.
START-DATE	01 Jul. 2013 - 30 Jun. 2016
TOTAL BUDGET	€ 5,525,440.67
FCH JU CONTRIBUTION	€ 3,012,038
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Consiglio Nazionale delle Ricerche – Istituto di Tecnologie Avanzate per l'Energia "Nicola Giordano" (Italy)

Partners: efceco (Germany), Ericsson Telecomunicazioni (Italy), FIAMM ESS (Italy), HTCeramix (Switzerland), Bonfiglioli Vectron GmbH (Germany), Instytut Energetyki (Poland), Haute Ecole Specialisee de Suisse Occidentale (Switzerland)

PROJECT WEBSITE/URL

www.onsite-project.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

The overall objective of ONSITE is the construction and operation of a containerized system, based on SOFC/NaNiCl battery hybridisation, that generates more than 20 kW at high efficiency and economically competitive costs.

The demonstration of the system shall take place on a real site of an existing telecom station. Starting from SOFC previous research results, commercially available power electronics and NaNiCl batteries will improve next generation SOFC systems and adapt them to the requirements for telecom stations.

PROGRESS/RESULTS TO-DATE

- System design and subsystem specifications
- 2.5 kW SOFC subsystem tested
- Thermal and electrical SOFC-batteries integration design
- A preliminary market assessment completed
- bidirectional grid tie DC/AC designed

FUTURE STEPS

- Set-up of the control electronics. The focus of this topic is the adaption of the control to the higher switching frequency and to the selected converter topology
- First SOFC-sodium nickel chloride battery hybrid system realization and test
- Design of the final containerized proof-of-concept
- Selection of the site for the final on-field test
- Test on SOFC subsystem

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Tests showed naturalgas fed SOFC generator electrical efficiency = 40%; > 600 hrs; > 1 MWh produced
- Hybridization (SOFC + sodium nickel chloride batteries) allows final system costs reduction (in terms of €/kW)
- The final system should enable Telecom energy station integration in the future Smart Grids / Smart Buildings scenarios

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	FC system efficiency (%)	55%+ (elec); 85%+ (total)	55%+ (elec); 85%+ (total)	40% (elec); 86% (total)
MAIP 2008-2013	FC system cost (€)	4,000 €/kW	< 4,000 €/kW	N/A (cost evaluation not finalized yet)
AIP 2012	Development of Proof-of-concept prototype systems	Development of Proof-of-concept systems that combine advanced components into complete, fully integrated systems	The expected 20 kW PoC will integrate well-developed subsystems (i.e. 10 kW SOFC, ZEBRA batts, Power electronics and thermal mgmt) into a containerized TLC power supply system operating as a whole.	• System design • SOFC subsystem tested (> 600 hrs; 1Mwh produced) • Design of the thermal and electrical SOFC-batteries integration
AIP 2012	Development of Proof-of-concept prototype systems	Integration and testing of proof-of-concept prototype systems complete with fuel delivery and processing sub-systems; interface with devices necessary to deliver power, with or without heat and/or cooling	• Feed in: NG and LPG; • Electrical output: 20 kW @ 48Vdc / 230Vac; • Heated water @ 70/80°C • integration with heat pump to produce both heat (reaching an overall higher efficiency) and cold (where needed, e.g. cooling TLC shelter during the field test).	Telecom sites assessment in terms of electrical and thermal loads has been performed
AIP 2012	Final application and market assessment	Assessment of the fuel cell system's ability to successfully compete with existing technologies operating in the target application(s)/market(s)	Demonstration of > 2,000 hours of operation during field test at Ericsson as real TLC site. A final Market evaluation is expected.	A preliminary market assessment completed. An agreement with a Telecom Operators is being finalised.

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

PROSOFC

Production and Reliability Oriented SOFC Cell and Stack Design

AIP / APPLICATION AREA	AIP 2012 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2012.3.2: Improved cell and stack design and manufacturability for application specific requirements
START & END DATE	01 May 2013 - 30 Apr. 2016
TOTAL BUDGET	€ 7,359,054,20
FCH JU CONTRIBUTION	€ 3,011,000,00
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: AVL List GmbH

Partners: Dynardo GmbH, Technical University of Denmark, Forschungszentrum Jülich GmbH, Karlsruhe Institute of Technology, Imperial College, Joint Research Centre Petten Former partner TOFC stopped its activities. HTceramix and EPFL committed to join the project.

PROJECT WEBSITE/URL

www.prosofc-project.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

The PROSOFC project aims at improving the robustness, manufacturability, efficiency and cost of state-of-the-art SOFC stacks so as to reach market entry requirements. The key issues are the mechanical robustness of solid oxide fuel cells (SOFCs), and the delicate interplay between cell properties, stack design, and operating conditions of the SOFC stack. The novelty of the project lies in combining state of the art methodologies for cost-optimal reliability-based design (COPRD) with actual production optimization.

PROGRESS/RESULTS TO-DATE

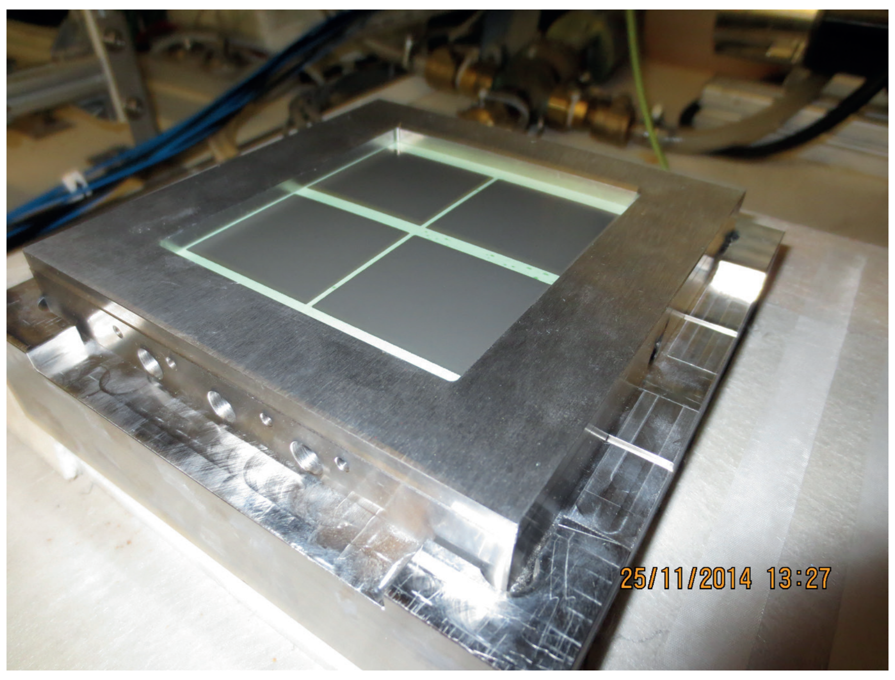
- Probabilistic design approach and random field models for materials and loads established
- 2D model addressing cell cracks set up for COPRD optimization and model homogenisation methodology established
- Electrochemical characterization of SoA cells performed and mechanical characterization of SoA cells ongoing
- First tests with close-to-reality cell test equipment carried out

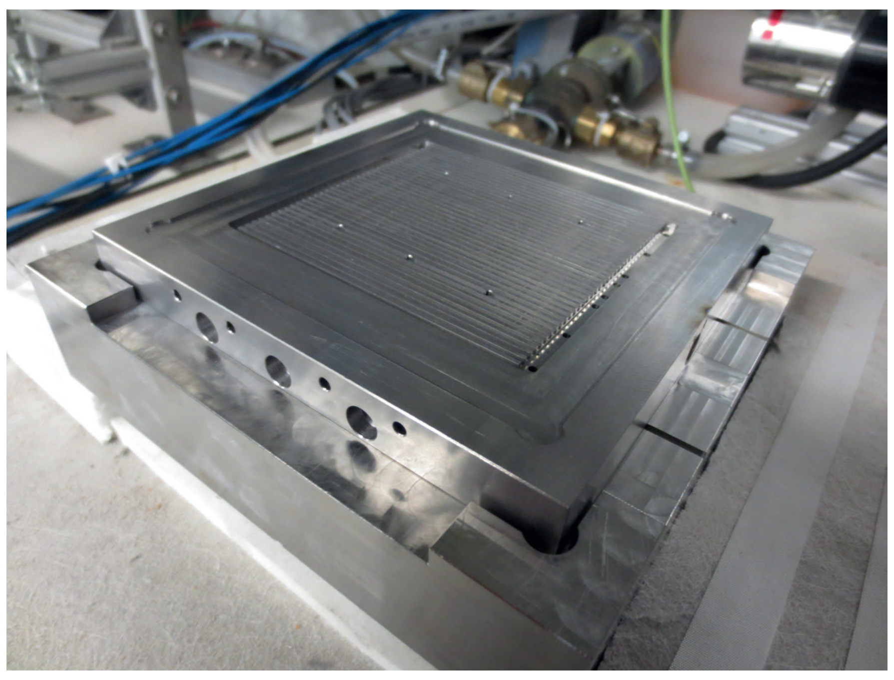
FUTURE STEPS

- Further development of stack simulation model towards 3D temperature and stress distribution
- Testing of mechanical material behaviour in relation to production and microstructure
- Long term stack testing for reliability validation
- Cell tests under stack like conditions with close-to-reality cell test equipment for simulation validation

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- SOFC exhibits complex multi-physics compared to other areas where COPRD has been applied
- Failure mode description is a big challenge and need further studies
- Cell improvements have a significant impact on production costs





CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
AIP 2012	Improved electrical efficiency	N/A	ASR (Area Specific Resistance)=600mOhm*cm2	650 mOhm cm^2
AIP 2012	Better robustness, better lifetime, improved manufacturing methods	N/A	Identify major failure modes and link them to stack design and production using an statistical simulation approach Operation in real life environment >4000 h	Major failure modes identified Statistical simulation model linked with stack model On-going stack tests
AIP 2012	Cost reduction	N/A	Index 75 (M36)	Index 33
AIP 2012	Improved manufacturing methods	Stack scrap rate: 5% by 2017	N/A	Stack scrap rate 15%
AIP 2012	Higher power density	N/A	N/A	No improvements yet, awaiting improved robustness through COPRD optimisation
MAIP 2008-2013	Electrical efficiency (SOFC system)	55%+ (SOFC)	Indirectly targeted	Decrease of ASR will lead to higher electrical efficiency. However, main target is robustness of stacks.
MAIP 2008-2013	Lifetime/Durability (SOFC System)	20.000 h	Indirectly targeted	Within the project stack long term tests are performed to validate the durability. An improved stack lifetime will contribute to the whole durability of the SOFC system.
MAIP 2008-2013	Cost (SOFC system)	<4000 EUR/kW	Indirectly targeted	All AIP targets will contribute to significantly lower stack costs and thus lead to lower system costs. However, only stack costs can be considered in this project.

SCORED 2:0

Steel Coatings For Reducing Degradation in SOFC

AIP / APPLICATION AREA	AIP 2012 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2012.3.4: Component and sub-system cost and reliability improvement for critical path items in stationary power and CHP fuel cell systems
START & END DATE	01 Jul. 2013 - 30 Jun. 2016
TOTAL BUDGET	€ 3,656,757.60
FCH JU CONTRIBUTION	€ 2,183,023.00
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: University of Birmingham

Partners: VTT, EPFL, ENEA, TCL, TurboCoating, SOFCpower

PROJECT WEBSITE/URL

www.scored-2-0.eu

PROJECT CONTACT INFORMATION

Prof Robert Steinberger-Wilckens
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MAIN OBJECTIVES OF THE PROJECT

The project looks into coated steel components for SOFC with markedly improved properties with regard to chromium release, contact resistance and scale growth. Optimised combinations of protective layer materials with different steel qualities (including low-cost options) will be chosen for testing and influence, practicality and cost of different methods of coating analysed.

PROGRESS/RESULTS TO-DATE

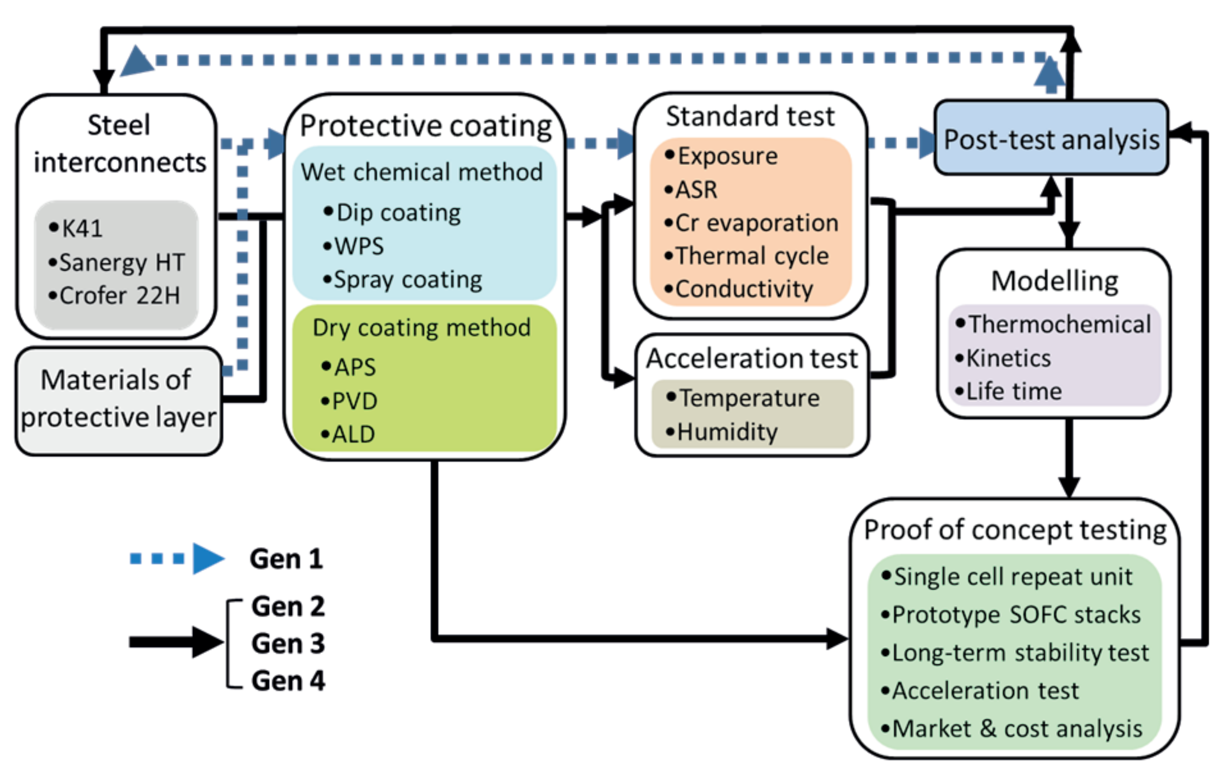
- sample choice & preparation
- test matrix established
- first and second generation test coatings
- systematic testing & analysis ongoing

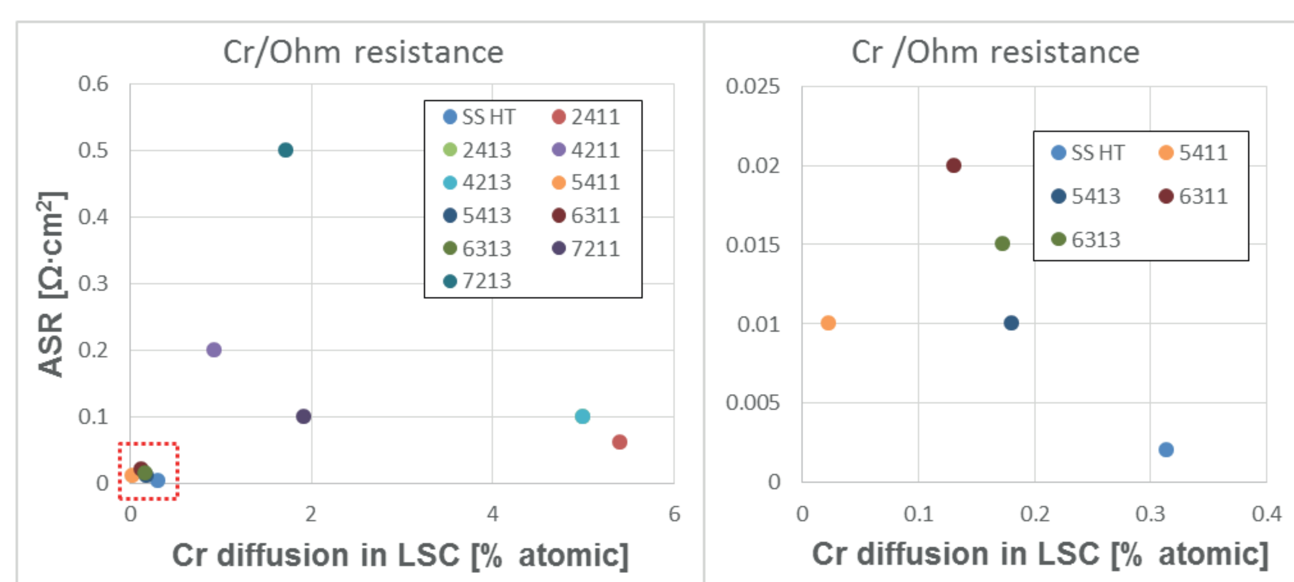
FUTURE STEPS

- continuation of systematic analysis
- preparation of subsequent coating generations
- validation tests with single SOFC cells
- building prototype stacks for long-term testing
- project extension to allow longer testing period

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- new types of surface treatment (instead of coating layers) are being evaluated – this might constitute a new approach at corrosion protection





CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	SOFC system life time (h)	>20,000	>40,000 (>10,000 proven within project)	excellent stability of some coatings proven up to 3000 hours; stack tests pending/ongoing
MAIP 2008-2013	System cost (€/kW)	<4 000	inherent contribution to low-cost interconnects (IC); IC are only one cost element of many, though, therefore no further statements can be made on stack costs	N/A (cost modelling follows later)

SECOND ACT

Simulation, Statistics and Experiments Coupled to Develop Optimized and Durable µCHP Systems Using Accelerated Tests

AIP / APPLICATION AREA	AIP 2013 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	AIP SP1-JTI-FCH.2013.3.1 - Improving understanding of cell & stack degradation mechanisms using advanced testing techniques, and developments to achieve cost reduction and lifetime enhancements for Stationary Fuel Cell power and CHP systems
START & END DATE	01 May 2014 - 30 Apr. 2017
TOTAL BUDGET	€ 4,643,707
FCH JU CONTRIBUTION	€ 2,523,254
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA

Partners: IRD FUEL CELLS, NEDSTACK, ICI CALDAIE, POLIMI, DLR, JRC, SINTEF, TU-Graz

PROJECT WEBSITE/URL

http://www.second-act.eu/

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

- Analysing long term lifetime tests data from systems to identify main causes for failure
- Conducting tests to investigate degradation in single cells and stacks
- Developing, applying and validating AST (Accelerated Stress Tests) and specific harsh tests for failures
- Developing and applying in-situ and ex-situ analyses for better identification and local resolution of mechanisms
- Developing statistical approach and models, including stochastic/deterministic, reversible/permanent degradations and heterogeneities.
- Demonstrating improvements on tolerance to applications' relevant modes with modified components (materials, design, processes...) for Pure H2 or Reformate PEMFC and DMFC

PROGRESS/RESULTS TO-DATE

- Manufacturing and delivery among partners of reference MEAs for single cells and stack testing (ageing studies conducted on 25cm^2 devices, large size single unit cells of 200 cm^2 and stacks from 5 to 70 cells using test stations or real systems)
- Definition and application on reference components of ageing conditions based on real systems operation (H2 and reformate PEMFC or DMFC) and of accelerated cases based on previous projects or state of the art.
- Identification of available ageing data for statistical analyses from systems, stacks and single cells ageing tests of past projects and now on-going project
- Degradation investigations with specific experiments including local measurements thanks to segmented cells implemented in single cells or stacks to describe initial heterogeneities and their evolution due to ageing combined with ex-situ local characterizations of components.
- Development of degradation models describing particularly selected reversible mechanisms to be implemented in performance models describing heterogeneous operation at cell level for further understanding of links between ageing conditions, components and performance losses.

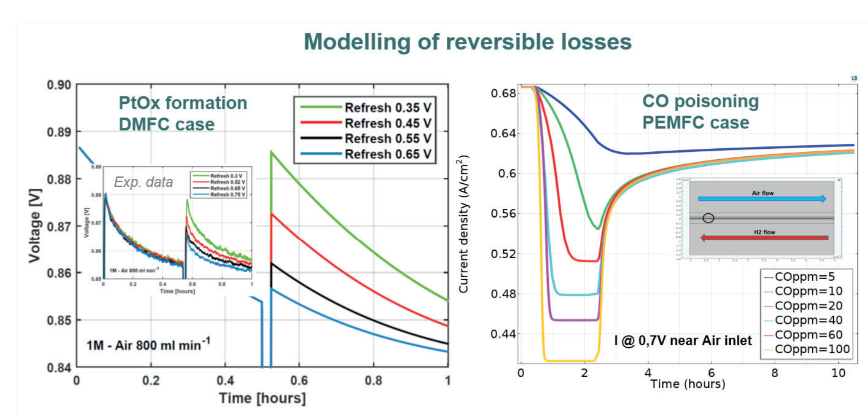
FUTURE STEPS

- Based on ageing data, experimental and modelling investigations: identification of major causes for performance degradation related to heterogeneous operation
- Identification of first set of possible improvements, selection and implementation of more relevant in single cells or stacks
- Selection of the more relevant tests to be applied for improvements validation
- Application of the ageing experimental and modelling tools to the proposed improved components for evaluation and further understanding.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Extensive ageing tests completed for data collection including several tests of cells and stacks of 1000 hrs and more than 3000 hrs on a power plant reaching 50000hrs of operation
- Initial heterogeneities related to fuel conditions identified, as well as the impact of ageing on the heterogeneities evolution with S++ in a stack (e.g.: relatively higher losses at fuel outlet and lower at fuel inlet during ageing under reformate due to non-homogeneous CO content)
- Description of the effect of pinholes on local performance losses for normal operation or with fuel starvation thanks to small instrumented PEMFC segmented cell.
- Development of specific experiments with a segmented cell coupled to internal reference for the local degradation analysis of a DMFC and modelling validation of reversible losses during DMFC operation.
- Development of DMFC or PEMFC degradation models related to reversible performance losses: due to oxide formation or to CO poisoning.

Major expected findings (end of the project): modifications of materials, design or manufacturing process of stacks core components allowing systems' lifetime improvement.



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Stationary FC system lifetime	1-Degradation and lifetime fundamentals related to materials and typical operation environments for all power ranges. 2-Proposal of new or improved materials General aim of 40,000 h	1-Better understanding of cell and stack degradation for Pure H2 or Reformate PEMFC and DMFC 2-Demonstrating lifetime improvements thanks to stack core components modifications (enabling >20,000 h for H_2 syst. case)	Combined experimental and modelling studies: ageing tests in single cells, and stacks in representative or accelerating conditions, local in-situ analyses with segmented cells, simulation of reversible degradation mechanisms for implementation in unit cell performance models
AIP 2013	Systems degradation causes	Identify, quantify and document relevant degradation and failure mechanisms over the long term (i.e. >20,000 hours)	Collection, production and statistical analysis of ageing data from cells, stacks and systems related to the three technologies of industry partners.	Collection of ageing data from past projects and existing field test systems Additional ageing tests of stacks in progress on tests stations and also in the 70kW power plant reaching 50000hrs.
AIP 2013	Systems lifetime improvement	Identify improvements, and verify these in existing cell and stack design	Integration and testing of improved core components (materials, electrodes design or process) for demonstrating measurable lifetime improvement at satck level and potential lifetime enhancement at system level	NA *Part of the work in preparation: first ideas of components modifications considered, to be selected and implemented during the second part of the project*
AIP 2013	Applications-relevant investigations (degradation and improvement)	Quantification of mechanisms and verification of improvements by accelerated testing and/or by durability testing under harsh conditions, compared to application-relevant conditions.	For quantification: iterative loops of testing and numerical simulation coupled with advanced in-situ or ex-situ analyses. For verification: measurement of improvements based on comparison of degradation slopes or % of voltage losses at selected operating points when applying AST or harsh specific tests representative of major degradation cause or failure mechanism for each FC technology considered. Target of the project is to aim for > 20,000 hours (maximum duration currently reached by stacks integrated in H2 fed systems considered).	*Reversible and non-reversible degradation of performance studied with extended ageing tests coupled with ex-situ analyses and modelling for better evaluation of each mechanisms impact.* *Proposal and application of accelerating degradation tests for the different technologies.*

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

T-CELL

Innovative SOFC Architecture Based on Triode Operation

AIP / APPLICATION AREA	AIP 2011 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2011.3.1: Next generation stack and cell design; SP1-JTI-FCH.2011.3.4: Proof-of-concept fuel cell systems.
START & END DATE	01 Sep. 2012 - 29 Feb. 2016
TOTAL BUDGET	€ 3,424,167.80
FCH JU CONTRIBUTION	€ 1,796,267.00
PANEL	Panel 4- Stationary Heat and Power RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Chemical Process and Energy Resources Institute - Centre for Research & Technology Hellas

Partners: Foundation for Research and Technology Hellas - Institute of Chemical Engineering Sciences, Centre National de la Recherche Scientifique, Ecole Polytechnique Fédérale de Lausanne, Instituto de Ciencia de Materiales de Sevilla, MANTIS Deposition LTD, Prototech AS, SOFCpower

PROJECT WEBSITE/URL

www.tcellproject.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

The project objective is the investigation of the synergetic effect of advanced Ni-based cermet anodes modified via doping with a second or a third metal in conjunction with triode operation, in order to control the rate of carbon deposition and sulphur poisoning. A detailed mathematical model will be developed so as to describe the triode mechanism thus enabling prediction of the behavior of triode SOFCs as a function of cell design and operational parameters/conditions. Proof of the triode concept will be provided through the development and performance evaluation of a prototype triode stack, consisting of at least four repeating units.

PROGRESS/RESULTS TO-DATE

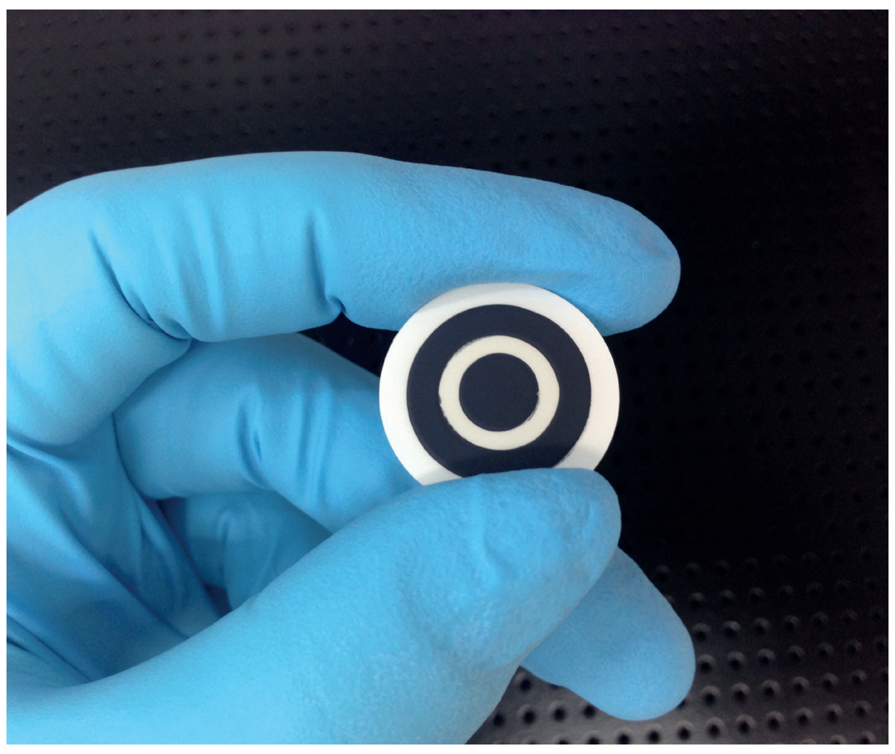
- Preparation of complete triode cells with standard and modified anodes
- Complete physicochemical characterization of modified powder and electrodes
- Preparation of Ni-YSZ thin film anodes by magnetron sputtering
- Assessment of the effect of triode operation on cell performance and carbon deposition rate
- Development of a simple model describing the dependence of fuel cell and auxiliary circuit potential

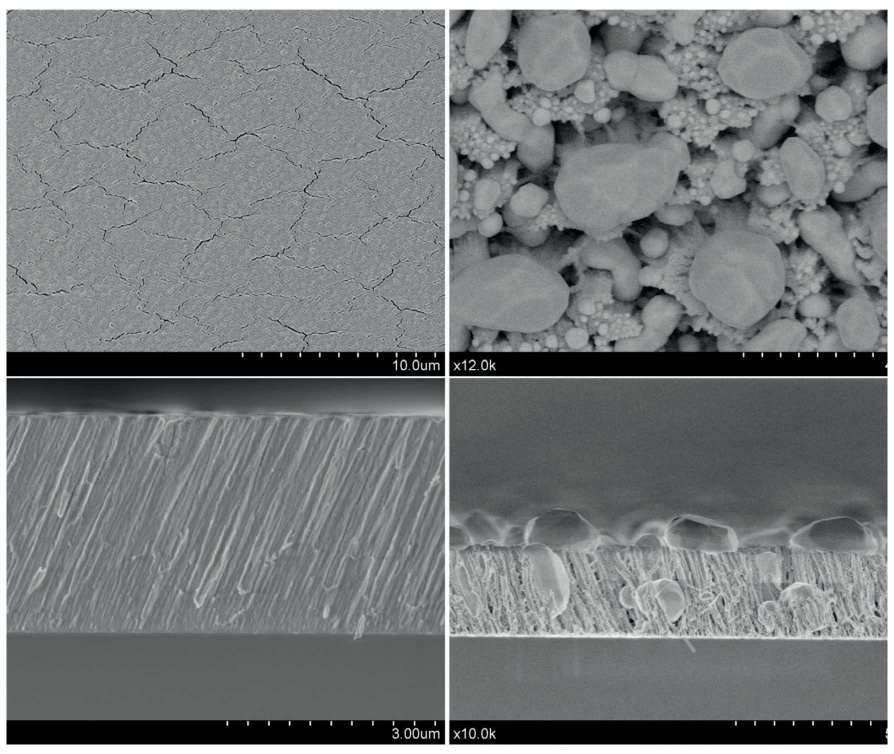
FUTURE STEPS

- Incorporation of Au and Mo nanoparticles into the anodes in order to get a well-controlled dispersion of these two elements in the other zones of the electrodes
- Further investigation of sintering and stability of Au and Mo modifiers
- Investigation of cell geometry on fuel cell power enhancement under triode operation
- Further developments and verification of the model in order to reflect the experimental data
- Design and construction of a 4-cell triode stack

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The synergy between Au-Mo-Ni regarding electrocatalytic stability under CH_4 steam reforming has been proven
- The addition of Au and Au-Mo doped materials modifies the reducibility of both Ni/YSZ and Ni/GDC catalysts
- The magnetron sputtered Ni-YSZ films exhibit good electrical conductivity and can serve as buffer layer between anode and the electrolyte
- Triode operation results in 40-50% lower carbon deposition rate on commercial anodes
- The minimization of the resistance between the cathode and auxiliary electrode is crucial for triode performance





CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Electrical efficiency (natural gas and biogas fuels)	55% (mid-term 2015)	>55% (natural gas fueled in presence of ~30ppm sulphur)	N/A (test not finalized)
MAIP 2008-2013	Durability/Reliability (stack lifetime)	20,000 hrs (mid-term 2015)	40,000 hrs	Triode operation results in 40-50% lower carbon deposition rate (test not finalized)
AIP 2011	New architectures, adaptation of cell and/or stack designs to specific applications and system designs	N/A	N/A	Preparation of triode cells
AIP 2011	New materials and/or strategies to improve tolerance to contaminants	N/A	N/A	Development of Au and Mo modified Ni-based cermet anodes
AIP 2011	Improved tolerance to contaminants with respect to state of art FCs	N/A	N/A	Triode operation results in 40-50% lower carbon deposition rate
AIP 2011	Improved electrical efficiency over the state of the art	>50%	>55%	N/A (test not finalized)
AIP 2011	Lifetime	> 25,000 hours (stack)	40,000 hrs	Preparation of triode cells