PROGRAMME REVIEW
REPORT 2015

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

http://fch.europa.eu/
Email: fch-ju@fch.europa.eu

More information on the European Union is available on the Internet (http://europa.eu).
Luxembourg: Publications Office of the European Union, 2016

ISBN 978-92-9246-140-9 (online), 978-92-9246-141-6 (print)
ISSN 2443-6038 (online), 2443-602X (print)
doi:10.2843/79560 (online), 10.2843/115860 (print)

Printed in Belgium
PRINTED ON ELEMENTAL CHLORINE-FREE BLEACHED PAPER (ECF)

FCH JOINT UNDERTAKING

Publicly available

PROGRAMME REVIEW REPORT 2015

TABLE OF CONTENTS

LIST OF ACRONYMS

AC	Alternating current
AFC	Alkaline fuel cells
AE	Alkaline electrolyser
AIP	Annual Implementation Plan
APU	Auxiliary power unit
AWP	Annual Work Plan
BoP	Balance of plant
BUP	Back-up power
CGH_2	Compressed gas hydrogen
CHP	Combined heat and power
CO_2	Carbon dioxide
CSA	Coordination and support action
DC	Direct current
DAFC	Direct alcohol fuel cell
DMFC	Direct methanol fuel cells
DoA	Description of action
DoE	United States Department of Energy
DoW	Description of work
EU	European Union
FP7	EU Seventh framework programme for research and technological development
FC	Fuel cell
FCEV	Fuel cell electric vehicle
FCH	Fuel cell and hydrogen
FCH JU	Fuel Cells and Hydrogen Joint Undertaking

GDL	Gas diffusion layer
GHG	Greenhouse gas
H_2	Hydrogen
H2020	Horizon 2020
HHV	Higher heating value
HRS	Hydrogen refuelling station
HT	High temperature
IA	Innovation action
IEA	International Energy Agency
IPHE	International Partnership for Hydrogen and fuel cells in the Economy
IPR	Intellectual property rights
ISO	International Organisation for Standardization
kW	Kilowatt
LCA	Life-cycle assessment
LH_2	Liquid hydrogen
LHV	Lower heating value
MAIP	Multi-Annual Implementation Plan (2008-2013)
MAWP	Multi-Annual Work Plan (2014-2020)
MCFC	Molten carbonate fuel cells
MEA	Membrane electrode assembly
MHV	Materials handling vehicles
MW	Megawatt
NOx	Nitrogen oxide
OEM	Original equipment manufacturer
PAFC	Phosphorous acid fuel cell
PCFC	Proton conducting fuel cell
PEM	Proton exchange membrane
PEME	Proton exchange membrane electrolyser
PEMFC	Proton exchange membrane fuel cell

PGM	Platinum group metals
PM	Particulate matter
PNR	Pre-normative research
PoC	Proof-of-concept
PRD	Programme Review Days
RCS	Regulations, codes and standards
RES	Renewable energy sources
RIA	Research and innovation action
RTD	Research and technological development
SET-Plan	Strategic Energy Technology Plan
SME	Small and medium-sized enterprise
SMR	Steam methane reforming
SoA	State-of-the-art
SOEC	Solid oxide electrolyser cell
SOFC	Solid oxide fuel cell
SOx	Sulphur oxide
TRL	Technology readiness level
UAV	Unmanned aerial vehicle
UPS	Uninterruptible power supply
US, USA	United States of America

SECTION 01

PROGRAMME REVIEW

01

INTRODUCTION

1.1 FUEL CELL AND HYDROGEN TECHNOLOGIES CONTRIBUTING TO EU GOALS

At the end of 2015, the European Union (EU), together with 195 another signatories, signed up to the COP21 conclusions to reduce greenhouse gas (GHG) emissions with the aim of limiting increases in global temperatures to 2 °C overall and 1.5 °C by the end of the century. This event reiterated the commitment of Europe and its Member States to substantial GHG reductions by 2030, 2050 and in the longer term.

Earlier in 2015, Europe's Energy Union Package[1] (Communication from the European Commission to the other European Institutions) was announced with the vision of creating a secure, affordable and sustainable energy economy in Europe. At the heart of this package is the commitment to transform the energy system to deliver climate change reductions and other objectives, including the 'Europe2030' target, which themselves were updates on the 2020 goals.

FIGURE 01 | EVOLUTION OF EUROPE'S ENERGY GOALS AND TARGETS

20-20-20 Goals by 2020	Europe 2030 energy strategy
20 % renewable in the energy mix 20 % increase in energy efficiency (vs. business as usual) 20 % decrease in GHG emissions (vs. 1990)	27 % renewable in the energy mix 27 % increase in energy efficiency (vs. business as usual) 40 % decrease in GHG emissions (vs. 1990)

These climate goals sit alongside others focused on supporting energy security through a greater use of indigenous resources, including renewable energy sources (RES), and better energy efficiency, whilst there is also formal recognition of the need for a more sustainable and competitive European economy.

It is widely recognised that the transformation of the European energy system will be achieved through a variety of measures, including the wide-scale introduction and deployment of innovative energy technologies. The European Strategic Energy Technology Plan (SET-Plan) identifies eight sets of technologies (see Figure 2) with a role to play in a future sustainable energy system. Fuel Cell and Hydrogen (FCH) technologies are one of these eight sets.

---

[1] Energy Union Package: A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy, COM 2015 (80) Final, February 2015 (goo.gl/vSyPWq)

FIGURE 02 | EUROPEAN STRATEGIC ENERGY TECHNOLOGY PLAN

FCH are highly efficient and extremely versatile technologies and, through the use of green hydrogen (H_2), can provide zero-emission solutions to a range of energy and transport challenges.

Furthermore, H_2 is a flexible and scalable energy vector which can be used for short- and longer-term energy storage. Critically, production of green H_2 can be used for industrial-scale, seasonal storage of excess RES, whilst also enabling the shift of energy from the power to the transport sectors. As such, FCH technologies are highly complementary to other energy technologies identified in the SET-Plan.

1.2 THE ROLE OF THE FCH JU

The Fuel Cells and Hydrogen Joint Undertaking (FCH JU) was first established by the European Council in May 2008[2] for the period 2008-2013 as a public-private partnership with the aim of accelerating the commercialisation of FCH technologies in Europe. This recognised the part that FCH technologies could take in providing longer-term solutions to Europe's energy challenges, whilst also acknowledging the globally competitive and leading role of Europe's industry and research sectors.

The budget for the FCH JU in the period 2008-2013 totalled EUR 940 million, jointly funded by the European Commission (under the EU's Seventh Framework Programme (FP7) for Research and Technological Development) and Europe's FCH industry and research communities. The FCH JU has supported basic and applied research to address technology challenges and weaknesses, and demonstration activities to advance technology readiness across a range of applications in the transport and energy sectors, as well as in the early market, hydrogen production, distribution and storage fields. Further cross-cutting activities supporting the commercialisation efforts have included: safety, regulations, codes and standards (RCS), pre-normative research (PNR), socio-economic and life-cycle analyses, and training and education.

---

[2] Council Regulation (EC) 521/2008, 30 May 2008 (http://goo.gl/9aerHq)

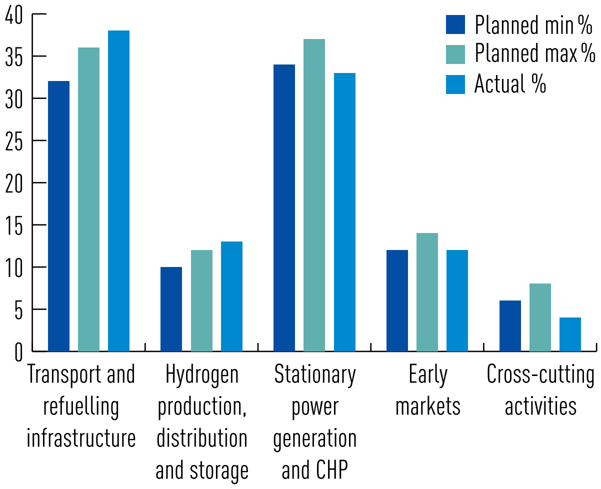
The FCH JU's strategy, objectives and actions have been developed and undertaken by and in cooperation with Europe's FCH stakeholders: industry, including SMEs and large, national and multinational businesses, research centres and universities, together with the Member States and Associated Countries, and Europe's regions and municipalities. The FCH JU's primary strategy document was the Multi-Annual Implementation Plan (MAIP) which set out the scope and details for basic, breakthrough and applied research and demonstration activities according to five main 'application areas':

- Transport and refuelling infrastructure
- Hydrogen production and distribution
- Stationary power generation and combined heat and power
- Early markets
- Cross-cutting issues.

The FCH JU programme has supported research and demonstration projects funded, on average, 50/50 through grants and through in-kind contributions by industry and research entities. Projects have been selected through a process of competitive calls for proposals held at least annually. Between 2008 and 2013, seven calls were issued and 155 projects were selected for support. Of these, 81 projects had been completed by November 2015, of which 46 were closed (all payments and obligations closed).

The actual and planned distribution of funds within FP7 is shown by application area in Figure 3 below. This indicates that distribution of the actual funds is proportionally similar to the initial plans, other than for cross-cutting activities.

FIGURE 03 | PLANNED AND ACTUAL DISTRIBUTION OF FUNDS BY APPLICATION AREA WITHIN FP7



Following the success of the initial programme, the FCH JU was renewed[3] for the period 2014-2020, within the 2014-2020 EU Framework Programme for Research and Innovation, Horizon 2020 (H2020), giving rise to the FCH 2 JU. The objectives and operations have remained largely unchanged. Within the new mandate, to align with the general H2020 nomenclature, the former *Implementation* Plans (Annual or Multi-Annual, AIPs and MAIP) have been succeeded by *Work* Plans (Annual or Multi-Annual, AWPs and MAWP).

---

[3] Council Regulation (EC) 559/2014, 6 May 2014 goo.gl/p5iuUg

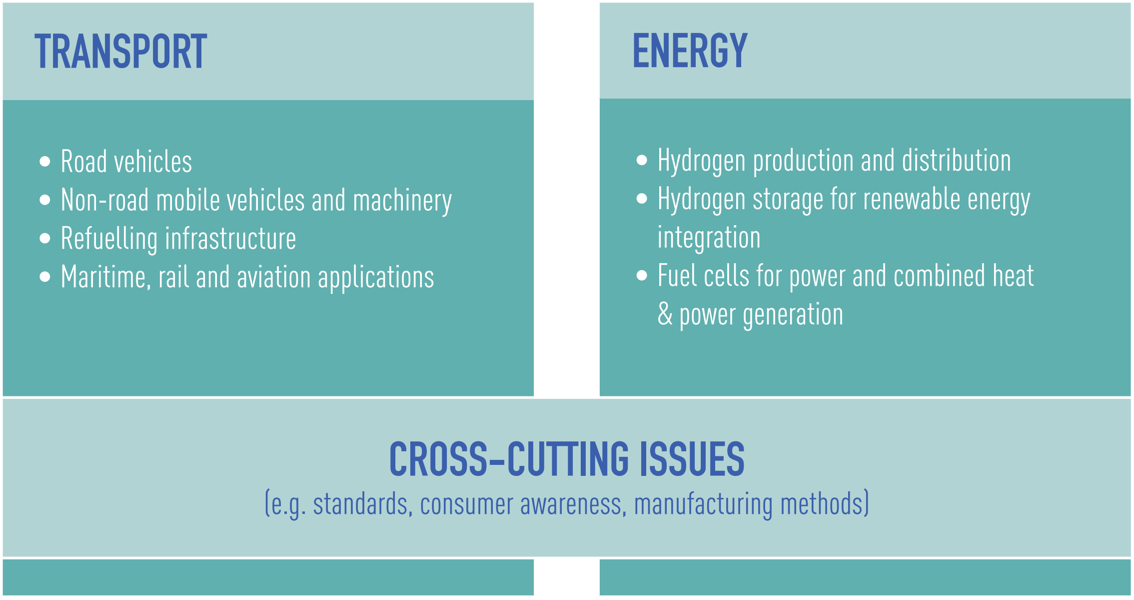
The MAWP 2014-2020 sees a shift in focus towards those applications that can be widely deployed in the 2020 time frame for two innovation pillars:

The MAWP 2014-2020 sees a shift in focus towards those applications that can be widely deployed in the 2020 time frame for two innovation pillars:

- FCH Technologies for Transportation Systems
- FCH Technologies for Energy Systems, covering stationary fuel cells for heat and/or power, and hydrogen production, distribution and storage.

Early market activities have been absorbed by the appropriate pillar. Cross-cutting issues supporting these two pillars remain unchanged. A further category of overarching projects is envisaged, covering projects which will combine elements of the two pillars. All these are shown in Figure 4 below.

FIGURE 04 | FCH 2 JU ACTIVITIES UNDER THE MAWP 2014-2020 STRUCTURE

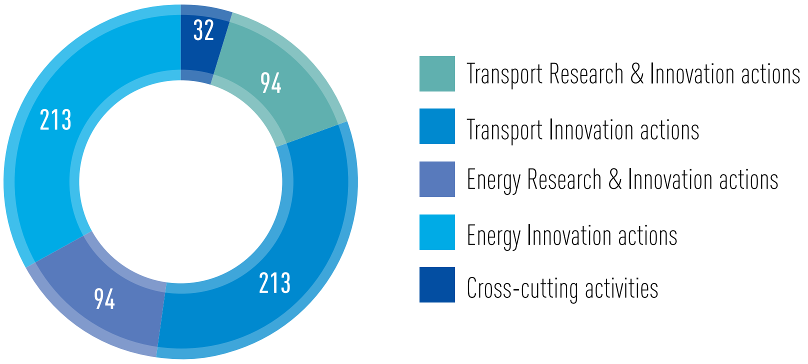


Overall activities foreseen include:

- Innovation actions (IA): demonstrations;
- Research and innovation actions (RIA): longer-term and breakthrough research, research and technology development, specific pre-normative research (PNR) and work towards regulations, codes and standards (RCS);
- Coordination and support actions (CSA): accompanying measures supporting and coordinating other programme activities.

EUR 1,300 million will be mobilised to support the above activities over the period 2014-2020. The planned distribution of funds by pillar and type of action is shown in Figure 5 below.

FIGURE 05 | PLANNED DISTRIBUTION OF THE FCH 2 JU BUDGET ACCORDING TO THE MAWP 2014-2020 (MILLION EUR)



Under Horizon 2020, two calls have been issued to date and 30 projects selected; of these, 14 had signed contracts by November 2015. One more was signed in December 2015 but was not included in any of the presentations and discussions related to the Programme Review Days 2015.

Beneficiaries/participants

Between them, the FCH JU and FCH 2 JU have supported 170 projects (up to the 2014 call, including the project signed in Dec. 2015) involving a total of 1473 participations from 611 unique beneficiaries (some participating in more than one project), some of which did not request any financial contribution. Funding was distributed according to the statistics shown below:

- Industry (35 %)
- SMEs (25 %)
- Research organisations (29 %)
- Higher education institutes (2 %)
- Others (8 %)

The participants originate from 23 EU Member States plus several Associated Countries.[4] The highest numbers of beneficiaries are located in the largest Member States: Germany, France, Italy and the United Kingdom.

1.3 THE FCH JU PROGRAMME REVIEW 2015

In 2011, the interim evaluation of the FCH JU recommended periodic reviews of its portfolio of projects to ensure that they aligned with the strategy and objectives set out in the multi-annual plan. Annual reviews began in November 2011 and the 2015 review is the fifth in the series.

---

[4] Countries associated with the EU's Horizon 2020 Framework Programme for Research and Innovation

The review process begins each summer and involves a team of international experts in the FCH field. The team assesses and evaluates the portfolio against three primary criteria:

- Achievements of the project portfolio against the objectives of both the multi-annual and annual plans;
- Progress towards the FCH JU's horizontal objectives in the fields of RCS, PNR, safety, life-cycle and socio-economic analyses, education, training and public awareness;
- The extent to which interactions and co-operation are promoted within the FCH JU portfolio, and between the portfolio and projects supported by other European instruments, the Member States and internationally.

Review panels

The 2015 review followed the same format as in 2014, with 100 projects divided into six 'panels'. These represent over half of the total of 169 projects supported by the FCH JU to date, of which 155 originated under FP7 and 14 as part of Horizon 2020.[5]

The Programme Review 2015 covered those projects that were active in the period July to October 2014. These 100 projects were all supported under FP7, either having started before October 2014 or having ended after July 2014.[6] Projects were classified using the categorisation adopted in 2014 according to the MAWP 2014-2020 (two pillars + cross-cutting + overarching, bearing in mind that no overarching project has yet been financed).

Each panel focused on a specific subject area and comprised between 14 and 21 projects. These projects were assessed as a group against the three criteria mentioned above, rather than individually, although exemplar good practice projects were highlighted. The six panels are shown in Table 1 below.

TABLE 01 | PANELS FOR THE 2015 REVIEW

PILLAR/ACTIVITY	PANEL NAME	TOPICS
Transport	1. Transport demonstration	Projects targeting the demonstration and proof of concept (PoC) of FCH applications in the transportation pillar
	2. Transport RTD	Basic and applied research projects tackling subjects related to the transportation pillar
Energy	3. Stationary heat and power demonstration	Projects targeting the demonstration and PoC of FCH stationary heat and power applications in the energy pillar
	4. Stationary heat and power RTD	Basic and applied research projects tackling subjects related to FCH stationary heat and power applications
	5. Hydrogen production, distribution and storage	All projects addressing hydrogen production, distribution and storage issues
Cross-cutting	6. Cross-cutting	Projects addressing cross-cutting issues

---

[5] The grant agreement of a 15th project financed under call 2014 had not yet been signed at the time of the PRDs 2015 and was hence excluded from all the statistics and presentations, as well as from this report.

[6] Projects started after October 2014 were not included as it was unlikely that they would have obtained significant results by summer 2015, while those that ended before July 2014 had already been reviewed in the Programme Review 2014, meaning that it was unlikely that any new results would have been produced.

A team of 19 FCH international experts undertook the review process. Initial assessments were conducted remotely, followed by the final assessment undertaken by six members of the FCH 2 JU Scientific Committee acting as 'rapporteurs' (one per panel) during the Programme Review Days (PRDs) held in Brussels at the Charlemagne building on 17 and 18 November 2015. Each project was assessed remotely by at least three reviewers using information provided by the projects themselves and a report template designed by the FCH 2 JU Programme Office, along with publicly available information. Each reviewer compiled a written report which was sent to the Programme Office and rapporteur for each panel.

The rapporteurs (one per panel) also attended the PRDs and complemented their reviews on the basis of the presentations and discussions as well as on the project posters exhibited during the PRDs.

Likewise, the Scientific Committee members acting as rapporteurs also co-chaired the PRD presentation sessions alongside project managers from the Programme Office. These sessions comprised 15 to 20 minute presentations, followed by question and answers, by selected projects from each portfolio. Projects making presentations were selected by the Programme Office on the basis of their quality, maturity, achievements and interest.

After the PRDs, the rapporteurs drew up consolidated 'rapporteur reports' which were then sent to both the Programme Office and the external author of the present Programme Review Report.

This Programme Review Report summarises the findings of the panel reviews and is organised around the six panels listed in Table 1 above.

02

TRANSPORT PILLAR

2.1 OBJECTIVES

The aim of the transport pillar is to accelerate the commercialisation of FCH technologies in transport through a programme of demonstration and research projects. FCH technologies play an important role in the reduction of emissions, including GHG and other emissions such as SOx, NOx and particulate matter (PM) from Europe's transportation activities, especially road transport. Zero-emission transport is possible through the use of 'green' hydrogen and fuel cells. The FCH JU programme of demonstration projects focuses on proving technology readiness and developing customers' acceptance whilst expanding the number of fuel cell electric vehicles (FCEVs) and the hydrogen refuelling network across Europe. In parallel to this, the research and innovation programme is focused on delivering better-performing fuel cells and hydrogen refuelling station (HRS) systems whilst also lowering costs. Together, these programmes are contributing directly to the early-stage deployment of FCH in transport applications across Europe.

2.2 BUDGET

The FCH JU's MAIP set out a budget of between 32 % and 36 % of total spending for transportation and refuelling infrastructure activities (excluding off-road vehicles) for the period 2008-2013. The second phase of the FCH JU has set a target for the same activities at 47.5 % of the total budget for 2014-2020 in the MAWP (the new multi-annual plan).

A total of 42 transportation projects were supported by the FCH JU in 2008-2014, with a total grant value of about EUR 240 million. The distribution of this amount is provided in Table 2 below.

TABLE 02 | DISTRIBUTION OF THE FCH JU'S FINANCIAL CONTRIBUTION ACROSS TRANSPORT ACTIVITIES

TRANSPORT ACTIVITY	SEGMENT	FCH JU MAX CONTRIBUTION (MILLION EUR)	NUMBER OF PROJECTS
Transport demonstration	Car	76.5	5
	Bus	61.4	4
	MHV	23.1	5
	APU (including UAV systems)	22.2	8
Transport RTD	Bipolar plates	4.9	2
	HRS	12.0	3
	MEA	21.3	9
	Stack, cell modeling	16.2	4
	Storage	2.0	1

Demonstration projects numbered 22, with a combined financial contribution of EUR 183.1 million). The greatest value has been devoted to car demonstrations, followed by buses.

Research and Technology Development (RTD) projects received EUR 56 million of FCH JU contributions, spread over 19 projects, with the majority of funds allocated in 2011 (EUR 21 million), 2012 (EUR 17 million) and 2014 (EUR 13 million).

Another project which received support but did not come under either the RTD or demonstration category is NEXTHYLIGHTS, a coordination and support action addressing the preparation of large-scale hydrogen vehicle demonstration projects in Europe.

2.3 FOCUS AREAS AND ACHIEVEMENTS

2.3.1 DEMONSTRATION

Focus areas

The following main segments in demonstration projects have been covered by FCH JU projects:

- Cars – build up the number of fuel cell vehicles deployed in Europe, reduce vehicle cost and demonstrate market readiness;
- Buses – deploy increasing numbers of buses across Europe, improve fuel economy and reliability and reduce cost per vehicle;
- Material handling vehicles (MHVs) – achieve system cost reductions, increase numbers of units deployed in Europe and prove the business case;
- Auxiliary power units (APUs) – validate the technology and identify markets over a range of road, air and marine applications;
- Refuelling infrastructure – develop necessary infrastructure networks with redundancy at a competitive cost.

The emphasis of the transportation demonstration programme is to prove technology readiness, reliability, robustness, fuel efficiency and sustainability, together with confirmation of customer acceptance and ease of use, to enable full commercialisation in the medium term.

The strategy of FCH 2 JU in the four key segments is complemented by:

- Fuel cell cars – the opportunity to work alongside Europe's FCH-leading Member States' hydrogen mobility initiatives, namely in France, Germany, Scandinavia and the UK;
- Fuel cell buses – advancing the case for fuel cell buses through a coalition of more than 80 entities including bus manufacturers and local government and operators across 45 locations;
- APUs – continue work on current applications to ensure that the technology meets customers' needs, whilst demonstrating the typical applications;
- MHVs – develop the business case for MHVs in the European context.

Between 2008 and 2014, the FCH JU supported 22 projects over eight calls. The distribution of these is shown below.

TABLE 03 | TRANSPORT DEMONSTRATION PROJECTS SUPPORTED BY THE FCH JU

	NUMBER OF PROJECTS		
FOCUS AREA	FINISHED BY JUNE 2015	LIVE IN JUY 2015	TOTAL
Cars	1	4	5
Buses		4	4
MHVs	2	3	5
APUs	2	6	8
Refuelling infrastructure	(included in demonstration projects above)		

Achievements

The FCH JU-supported projects are deploying large numbers of fuel cell vehicles across Europe.

Cars (and light goods vehicles) – More than 450 vehicles (including plug-in electric vehicles with fuel cell range extenders) have been or will be deployed across a number of Member States through five projects: H2MovesScandinavia (completed in 2012), HYTEC (completed in August 2015), SWARM (ongoing, 2012-2017), HYFIVE (ongoing, 2014-2017) and H2ME (just started, 2015-2020). In addition, 40 HRS to serve fuel cell cars either have been or will be installed. The successive demonstration projects have:

- Increased markedly in ambition with H2ME planning to deploy more than 300 cars;
- The HRS network is being expanded across Europe in conjunction with national initiatives;
- Cost per vehicle has reduced significantly over the lifetime of the FCH JU.

Buses – 67 buses have been or will be deployed in cities, towns and regions across Europe along with 11 new bus-ready HRS in four projects: CHIC, High V.LO-CITY, HYTRANSIT and 3EMOTION. As with the car demonstrations, these projects have been able to demonstrate:

- A reduction in cost per bus over time, with 3EMOTION committed to less than EUR 1 million/vehicle vs. typical prices in 2012 reported well above 1.2 million;
- Improvement in fuel consumption from 30kg/100km to less than 10kg/100km;
- Expansion of geographical coverage, with buses now deployed in England, Scotland, Norway, Belgium, Switzerland and Northern Italy and further developments foreseen in the Netherlands and Central Italy.

MHVs – over 400 MHVs are planned for use across Member States in four projects: HyLIFT-DEMO (finished), MobyPost, HyLIFT-Europe and HAWL. Another MHV project, SHEL, was discontinued earlier than planned and did not produce significant results.

To date, MHVs have:

- Operated for over 12 000 hours with overall availability of 95 %;
- Undertaken 4000 refuellings with 99.5 % HRS availability;
- Developed the business case for Europe.

APUs – eight projects (DESTA, FCGEN, HYCARUS, HYPER, PURE, SAFARI, SAPIENS and SUAV) have developed or are developing APUs for a range of applications, including trucks, aerospace (UAV and aeroplanes) boats and recreational vehicles. Further developments are necessary in some applications, but project results are proving their viability.

2.3.2 RESEARCH AND INNOVATION

Focus areas

The Programme Review 2015 portfolio of transportation RTD projects is very similar to preceding years with a focus on the following research areas:

- Membrane electrodes assembly (MEA) – activities to develop and improve fuel cell membranes for transportation;
- Catalysts – improvements to raise performance levels and reduce costs;
- Gas diffusion layer (GDL)- optimisation of gas distribution at the electrodes surface;
- Bipolar plates – development of materials for better performance and reduction of costs;
- Manufacturing and process development – activities to support the near-term production of components and subsystems;
- Methodologies and tools – creation and development of modelling and other tools to help industry undertake projects;
- System and balance-of-plant (BoP) components – development and improvement of components for better performance and/or reduced cost;
- Advanced refuelling developments – projects to develop hydrogen refuelling technologies and storage options.

Achievements

The research topic coverage by project is shown in Table 4 below.

TABLE 04 | DISTRIBUTION OF FCH JU TRANSPORT RTD PROJECTS ACROSS THE VARIOUS RESEARCH AREAS

	Membrane-Electrode Assembly									Bipolar plates			Stack & Subsystems			Modelling & Simulation	H_2 storage	Hydrogen Refuelling Stations	
	PEMICAN	ARTEMIS	CATHCAT	IMMEDIATE	IMPACT	IMPALA	CATAPULT	SMARTCAT	NANOCAT	STAMPEM	COBRA	AUTOSTACK	AUTOSTACK-CORE	VOLUMETRIQ	PUMAMIND	COPERNIC	PHAEDRUS	H2REF	NEWBUSFUEL
Call year	2009	2011				2012				2011	2013	2008	2012	2014	2011	2012	2011	2014	
Membranes	X	X	X	X	X			X				X	X	X					
Catalysts	X	X	X	X	X		X	X	X			X	X	X					
GDL				X	X	X						X	X	X					
Bipolar plates										X	X	X	X	X					
Manufacturing & process development										X		X	X	X		X			
Methodology & Tools	X	X			X	X	X							X	X			X	X
BoP components														X		X			
HRS (advanced)																	X	X	

Projects covered in this Programme Review are indicated in red. Grey cells refer to finished projects and green cells refer to projects from call 2014 that started in 2015.

The transportation research portfolio addresses all the focus areas above:

- Nine projects are working on a range of approaches to improve fuel cell units, i.e. addressing membranes, catalysts and GDLs: PEMICAN, ARTEMIS, CATHCAT, IMMEDIATE, IMPACT, CATAPULT, SMARTCAT and NANOCAT. Only one project had been completed by June 2015 (PEMICAN, finished in 2014). Two projects (ARTEMIS and IMPALA) finished later in 2015, and a further five are due to finish either in 2016 or early in 2017.

- STAMPEM (finished in June 2015) and COBRA (ending in 2017) address the advanced technology of bipolar plates, with the development of advanced coatings for better performance and lower costs, as well as improved fabrication processes.

- Research and development of fuel cell stacks is being undertaken by AUTOSTACK–CORE (2012-2016), a successor of the AUTOSTACK project (2008-2011), whilst VOLUMETRIQ is a new project addressing stack manufacturing.

- Cell modelling was the focus of PUMAMIND, a project which finished at the end of 2015 (therefore not completed at the time of the Programme Review).

- Hydrogen storage and refuelling developments are the goal of four projects: COPERNIC is looking at improved manufacturing and the reduced cost of compressed gas hydrogen (CGH_2) cylinders; PHAEDRUS, researching several aspects of HRS systems, including electrochemical compression, proton exchange membrane (PEM) electrolysis and advanced dispensers; H2REF is focused on compression and buffering technology development; and NEWBUSFUEL is undertaking engineering studies for refuelling of future large bus operations.

The majority of these projects started in 2011 and 2012, and either ended in 2015 or are due to finish in 2016-2017. There is now an opportunity for the FCH 2 JU to assess further needs over the period to 2020 and to initiate a new wave of projects in 2016 and 2017.

2.4 REVIEW FINDINGS

2.4.1 DEMONSTRATION

During the 2015 review exercise, 15 demonstration projects in the transportation pillar were reviewed, and are shown in Table 5 below. Of these, eight made presentations on the review day, as indicated in bold in Table 5. H2ME, which began in June 2015, also made a presentation although it did not take part in the review process as it only started at the time of the exercise. H2ME is the largest FCEV and HRS demonstration project supported by the FCH JU to date.

TABLE 05 | LIST OF TRANSPORT DEMONSTRATION PROJECTS REVIEWED

SEGMENT	PROJECT ACRONYM	DESCRIPTION
Car	**HYFIVE**	Deployment of 110 FCEVs and six HRSs in three European regions
	HyTEC	Demonstration of up to 30 new H_2 vehicles in Denmark and the UK, in three classes: taxis, passenger cars and scooters
Bus	**CHIC**	Deployment of fuel cell hybrid buses, plus hydrogen refuelling infrastructure in five phase 1 cities; together with learning from phase 0 cities
	High V.LO-City	Implementation of a fleet of 14 fuel cell hybrid buses in three regions across Europe, plus H_2 production and refuelling infrastructure
	HYTRANSIT	Demonstration of fuel cell hybrid buses in Aberdeen (Scotland) with an emphasis on longer routes
MHVs	**HAWL**	Demonstration of hydrogen FC forklift trucks in logistics warehouses
	HyLIFT-EUROPE	Expansion of deployment of FC hydrogen systems for MHVs
	MOBYPOST	Development of FCEVs for delivery application and local hydrogen production and refuelling form renewable energy
APUs (including UAV systems)	**DESTA**	Demonstration of European solid oxide fuel cell (SOFC) APUs for trucks
	FCGEN	Development and demonstration of a PoC fuel cell auxiliary unit on-board a truck
	HyCARUS	Design of generic PEM hydrogen-air fuel cell systems for use in aircraft
	HYPER	Development and demonstration of a portable power pack with integrated modular FC and hydrogen storage system
	PURE	Development of FC APUs for recreational marine applications
	SAPIENS	Development and deployment of SOFC APUs for recreational vehicles

Relevance to programme objectives

The 2015 review found the portfolio of projects to be comprehensive and aligned with the FCH JU strategy and objectives as set out in the multi-annual plans (MAIP 2008-2013 and MAWP 2014-2020). Achievements to date were viewed as largely good, contributing to Europe's competitive position in FCH demonstrations in the transport sector.

Generally, the portfolio was complementary and overlapping was minimal, with an emphasis on the progression of demonstration projects, building on previous projects and achievements: for example, H2ME builds on the activity of HYFIVE. These projects are helping to build a credible infrastructure at key locations in and across Member States. Coordination of infrastructure activity across the FCH JU portfolio and with other Member States' activities was highlighted as a key achievement to date.

Gaps were observed in two areas: the application of FCH technology in the field of rail transport, and better integration of APU technology for the marine, air and road transport sectors.

Reviewers expressed a concern that the issue of reducing costs was not adequately addressed in the portfolio. There was also a view that some of the complex projects, such as HyTRANSIT and HYFIVE, were struggling to address all their objectives, with the focus being on the deployment of vehicles and installation of HRS.

Reviewers were most concerned about the portfolio of projects versus the state-of-the-art (SoA). Generally, self-assessments provided by the projects were considered weak, with few projects providing the detail the reviewers were looking for, although there were some good examples, e.g. CHIC and HYTEC. This issue reappears over successive PRDs. As such, the reviewers recommend that the Programme Office plays a greater role in ensuring that such self-assessments and the information provided is improved in future PRDs.

Buses

Europe currently has the world's largest fuel cell bus fleet, largely thanks to the FCH JU and its four active demonstration projects – CHIC, High V.LO City, and HyTRANSIT – and the recent 3Emotion project which began in early 2015. 3EMOTION bridges the gap between previous projects and the larger-scale procurement and deployment anticipated by Europe's fuel cell bus community and public transit operators.

Recommendations

The reviewers identified very important achievements by the fuel cell bus portfolio to date, including: improved fuel cell stack lifetimes, better fuel consumption and greater operational reliability. It is significant that the FCH JU is the world leader in the demonstration efforts for fuel cell buses.

Nevertheless, the reviewers felt that projects should work to improve the exploitation and dissemination of their results, especially regarding vehicle costs, with an emphasis on better, clearer strategies. However, it is worth noting that further activities by the FCH 2 JU, in collaboration with bus manufacturers and operators, are addressing these and other issues, including the upscaling of deployment and operations.

Cars

The impact of the FCH JU portfolio on the demonstration of cars and HRSs in Europe is growing and will, if all plans are realised, be very substantial. All the projects are making effective contributions, a position which will be reinforced by the H2ME project.

MHVs and APUs

At best, activity in the MHV and APU fields is mixed. Deployment numbers of MHVs fall short of expectations, even though some projects have been running for three years. Although the APU projects cover a range of applications, it is becoming apparent that project results are also failing to meet performance objectives, especially in terms of fuel efficiencies, and further development is necessary.

Complementarity with other projects/programmes

All projects show a degree of linkage with other projects in the FCH JU portfolio, providing the opportunity for shared learning and results. However, reviewers noted that there is room for improvement, with some exemplar projects developing their links well – e.g. CHIC, DESTA and HYTEC – whilst others simply list projects with which they have some form of linkage, without explaining how this might be beneficial.

The reviewers recommended that coordination and linkages also be improved between projects within the FCH JU portfolio and those funded by other European initiatives, e.g. Regional and Structural Funds plus projects supported directly by Member States. They were also concerned by the apparent poor showing in terms of international relationships, with the implication that projects were not taking advantage of opportunities to connect with and learn from demonstrations being undertaken in other countries/regions of the world. Reviewers recommended that clear guidelines be provided for projects on encouraging links with European Member State and international projects. One of the benefits of such links could be the leverage effects of projects and the coordination of activities to maximise impacts. It is arguable that this is already being achieved by the bus and car demonstration projects where Europe-wide consortia exist and which link into Member States' hydrogen mobility initiatives.

Horizontal and dissemination activities

Horizontal and dissemination activities were evident to a greater or lesser degree in all projects. Training activities tend to be pursued mostly in those projects with strong academic/university participation. However, demonstration project reviewers expected stronger action in this area. Similarly, there was insufficient evidence of work on safety and RCS issues, with the expectation that this activity would be more apparent.

More generic dissemination activities and public awareness-raising was seen to be positive across the portfolio. Significant participation in conferences and workshops, plus the preparation of reports and papers was assessed as good. Projects with good public awareness-raising activities included CHIC, HYTEC and MobyPost, which pursued extensive activities including launch events, test-drive opportunities, school visits, participation in fairs or local festivals, a shuttle service at public events and substantial press presence. The reviewers also noted that there was a growing web presence through websites, social media and blogs.

Efforts in the publications and patents field were assessed as moderate, which is understandable given the high technology readiness level (TRL) of these projects.

Reviewers wondered whether dissemination and horizontal activities could be further stimulated with the introduction of a 'prize' for the highest impact projects. Such a scheme could encourage projects to go beyond the "minimal compliance" to contractual arrangements. The reviewers also encourage joint activities with the European Institute of Innovation and Technology.

Exploitation plans

Exploitation plans among the portfolio of projects were variable: whilst it was recognised that some projects were able to point to high-quality plans for exploiting project results, others appeared to have a poor appreciation of customers' needs and views, which was especially true of APU projects. Projects perceived to have good plans include HYFIVE, HYTRANSIT, FCGEN and HYTEC. Reviewers were keen to see projects make more use of value analysis and value engineering as well as providing creative solutions to infrastructure deployment.

2.4.2 RESEARCH AND INNOVATION

Fourteen projects were reviewed as part of the PRD 2015, they are listed in Table 6 below, where those making presentations during the two review days are highlighted in bold.

TABLE 06 | LIST OF TRANSPORT RESEARCH PROJECTS REVIEWED

RESEARCH AREA	PROJECT ACRONYM	DESCRIPTION
Bipolar plates	COBRA	Development and industrialisation of new metallic bipolar plate coatings demonstrating a higher corrosion resistance, lower electrical resistance and lower price
	STAMPEM	Research and development of improved stability and reduced costs of bipolar plates through use of durable coating materials
HRS	**PHAEDRUS**	Development and validation of high pressure hydrogen for electro-chemical decentralised refuelling station
MEAs	ARTEMIS	Development of new MEA based on phosphoric acid doped alternative polybenzimidazole-type polymers
	CATAPULT	New catalyst structures and concepts for automotive power trains using ultra-thin film coatings on novel nano-structured supports
	CATHCAT	Development of new MEA, operating at 100 °C with an emphasis on the cathode side
	IMMEDIATE	High-performance MEA with thermal stability up to 160 °C through materials development and process optimisation
	IMPACT	Development of MEA with ultra-low Pt loading and improvement of lifetime combined with investigation of degradation phenomena and mechanisms
	IMPALA	Improvement of MEA performance through four levels and durability via development of improved GDL
	NANO-CAT	Reducing Pt loading of catalyst structures by development of Pt alloys as well as innovative Pt free (bio-inspired) structures
	SMARTCAT	Development of new and innovative electrodes using tri-metallic low-platinum content based catalyst nano-structured layers
Stack, cell modelling and developments	AUTOSTACK-CORE	Development of best-in-class automotive stack hardware with superior power density and performance whilst meeting commercial target costs
	PUMA-MIND	Development of predictive durability modelling tool as a function of components composition and operating conditions
Storage	COPERNIC	Increasing the maturity and competitiveness of CGH_2 manufacturing processes

Relevance to programme objectives

Projects in the transport research portfolio were found to be aligned with the MAIP objectives, whilst project targets corresponded to those of the AIP. Outstanding projects in the portfolio include SMARTCAT, COBRA, CATAPULT and AUTOSTACK CORE.

AUTOSTACK CORE was seen as a key project within the portfolio. As a follow-on project from AUTOSTACK (2008-2011) it provides a starting point for the evolution of the next stage of the FCH JU programme. It also creates the opportunity to evaluate promising catalyst and MEA materials sets.

In terms of SoA, FCH JU projects compare well at international level. The targets are relevant to the needs of the sector, but analysis is required on those projects working on MEAs to ensure that future project targets are equally as relevant. Further assessment is also necessary of the developments needed to fulfil the MAIP targets.

In addition, it has been recommended that outputs from the automotive-focused projects are assessed and evaluated by the European automotive sector, as original equipment manufacturers (OEMs) are best placed to assess the relevance of project results. Where possible, it is also recommended to insert newly developed catalysts and MEAs into stack hardware. However, such developments are rarely drop-in replacements and further work, perhaps in new FCH JU calls, will be necessary.

Assessing gaps and overlaps is challenging given that eight projects in the panel focused on catalysts and membranes. However, although they had similar targets they also had different approaches to achieving those targets. Nonetheless, reviewers suggested that the various PEMFC projects required evaluation to assess these different pathways and their potential for adoption by OEMs. The reviewers also recommended that harmonisation of test procedures and protocols become mandatory in future projects to ensure that data and results from different projects are comparable. Similarly, a common costs methodology is needed to rigorously assess the potential cost reduction of each technological development explored under the various projects. Further, it was noted that AUTOSTACK CORE could act as a point of coordination and leadership for the project portfolio, whilst PUMA MIND could be considered as a means of model validation for different projects.

Issues raised by the reviewers include:

- MEA optimisation projects consistently face scale-up and fabrication challenges, which needs to be taken into account in future calls for proposals;
- Project assessment of SoA, development challenges, possible solutions and future pathways could provide the FCH JU with valuable information for the content of future calls;
- Analysis of 'real' SoA for specific technologies is required to determine whether some FCH JU targets, e.g. cost and durability, are realistic and achievable, or are simply too ambitious in the relevant time frame.

As regards MAIP targets, reviewers noted that some projects questioned the relevance and suitability of long-term targets (for power density and durability, for example), for a three-year project period. Achieving these targets will take considerable resources and collaboration over time periods longer than the MAIP currently allows. As such, there was a view that intermediate targets could be more useful as 'stepping stones' to the future.

Reviewers raised the issue of the relevance of certain projects in the portfolio to industry's needs, especially in the few cases where there is no OEM among the partners. A more formal assessment of projects and feedback could be undertaken by industry, notably OEMs. Reviewers also noted than in the USA, the USCAR fuel cell technology team provides consensus feedback to the US Department of Energy (DoE) on annual presentations made by projects.

Complementarity with other projects/programmes

Complementarity between the FCH JU and other European projects shows an improvement over previous years. More projects were able to describe the linkages and synergies with other projects, and many of the beneficiaries participate in several projects, with every one having between four and 14 partners also involved in other FCH JU projects.

Reviewers found the extent of interactions to be encouraging, and believed that this was enabling projects to shorten their learning curves. Although confidentiality and intellectual property rights (IPR) issues inhibit full disclosure of results in many cases, reviewers recommended that joint workshops and meetings between FCH JU projects, already organised ad hoc (four were held in 2015), should become standard practice. Further, it is evident that the current project portfolio is building on the work of prior projects, helping to create knowledge and know-how and minimising 'reinvention'.

Reviewers still wanted to see ties strengthened and proposed that in the future projects with similar objectives and targets hold mandatory joint meetings to ensure good communication with others. With so many projects in the PEM area, the reviewers wanted to see additional steps taken to integrate the results to grow the knowledge base and European excellence in this domain.

Evidence for relationships and linkages with Member State-supported projects was sparse. Two projects, CATAPULT and STAMPEM, reported benefits from national RTD programmes, whilst some benefit can be gained from coordination. However, reviewers stated that this was an area for improvement, noting the benefits of leveraging national and regional research efforts whenever possible.

The reviewers' assessment of international linkages, for which only two projects provided information, was also qualified. There is a desire to see more international links with a view to accelerating learning for all parties. As such, reviewers proposed the introduction of international workshops with USA, Japan, Korea and China; encouraging major businesses with activities across several regions to play a greater role in projects; and more FCH JU projects should take advantage of participating in USA DoE working group public meetings.

Horizontal and dissemination activities

The portfolio of projects shows strong activity for the general dissemination of project results, but poorer efforts in other horizontal activities such as education, training, safety and RCS.

All projects were regarded as 'quite active' in the area of conference presentations, reports and workshops. Publication activity was also perceived to be good, with some projects particularly active e.g. COBRA, IMMEDIATE. Nonetheless, reviewers believe that open access to project deliverables deserves the additional 'encouragement' implemented by the FCH JU under Horizon 2020 activities, subject to IPR considerations. The recent addition of public deliverables on the FCH JU website will provide further dissemination opportunities in this direction.

More disappointingly, there were few examples of patent applications across the portfolio; reviewers expected to see more activity, especially for projects active in the area of MEA development. Public-awareness activities were recorded by ten of the projects describing their efforts, which included websites, press releases as well as attendance at meetings. However, reviewers expressed the view that projects were underestimating the efforts necessary to make a good impact.

Projects' descriptions of their work on safety and RCS included input from four projects participating in the harmonisation of testing activities and two in ISO code developments. Reviewers were especially keen to see more of this type of activity harmonisation. However, half of the projects provided no information at all on this aspect, which hindered an accurate assessment by the reviewers.

Education and training activities were found to be limited in most projects, with efforts often focused on hiring advanced degree students. However, it is worth noting that education and training efforts are rarely seen as critical activities by projects whose focus is technology research and innovation.

Exploitation plans

Exploitation plans varied across the portfolio. Projects with a strong research focus and academic participation in the consortium appear to concentrate on delivering the results first and foremost, with limited recognition given to the need to exploit these. Indeed, some projects noted that further research was necessary prior to exploitation. In contrast, projects with plans considered to be above average, e.g. COBRA, IMPACT and PHAEDRUS, provided details on their plans for commercialisation, although even these had weaknesses in terms of market analysis of end-customer demand. Reviewers expected more, in particular, from the few projects headed by an industrial partner.

03
ENERGY PILLAR

3.1 OBJECTIVES

The objective of the energy pillar is to accelerate the commercialisation of FCH technologies for stationary fuel cells and the production of green and low-carbon hydrogen as an energy vector in Europe. The widespread deployment of competitive technologies will deliver substantial benefits in terms of energy efficiencies, emissions and security, together with maximising the integration of RES into the energy system. As such, the FCH JU programme supports activities in three areas:

- Stationary fuel cells (power and heat) demonstrations and PoC activities to prove technology capability and readiness;
- Stationary fuel cells (power and heat) research and innovation for performance, durability and cost improvements;
- Hydrogen production pathways from RES, handling, distribution and storage technologies to enable hydrogen to become a major energy vector for Europe.

These activities are supported by a substantial budget with the long-term objective of advancing the technologies to the point where they are economically competitive with current power- and heat-generation technologies.

3.2 BUDGET

The total budget for the energy pillar under the FCH JU MAWP is set at 47.5 % of the total FCH JU budget for the period 2014-2020. Budgets under the previous Multi-Annual Plan (MAIP 2008-2013) were 44-49 % of the total FCH JU funds, with 34-37 % earmarked for stationary fuel cells and 10-12 % for hydrogen production, distribution and storage. A further small proportion was allocated to "early markets" activities which, since 2014, have been subsumed into the transport and energy pillars.

To date, 96 projects have received financial contributions from the FCH JU totalling more than EUR 240 million across several types of technologies. The distribution of projects in the three activity areas is shown in Table 7 below, with about EUR 100 million for stationary demonstration and PoC projects, EUR 77 million for stationary fuel cell RTD, and EUR 64 million for hydrogen production, distribution and storage.

TABLE 07 | DISTRIBUTION OF FCH JU FINANCIAL SUPPORT ACROSS THE ENERGY PILLAR

ACTIVITY AREA	SEGMENT	FCH JU MAX. CONTRIBUTION (MILLION EUR)	NUMBER OF PROJECTS
Stationary heat and power demonstration	- Field demonstration	50.5	6
	- System PoC	16.8	8
	- Improvement of components and their interaction	20.8	10
	- Portable generators, back-up and UPS power systems	13.9	4
Stationary heat and power RTD	- Materials	10.1	5
	- Components and integration	16.6	6
	- Diagnostics and controls	7.3	4
	- Degradation and lifetime	21.1	11
	- Next generation of stack and cell design	22.3	9
Hydrogen production, distribution and storage	- Electrolyser	32.3	15
	- Reformers	10.6	5
	- Biomass	3.8	2
	- Concentrated solar	5.2	3
	- Photo-electrochemical	4.0	2
	- H_2 storage	6.6	4
	- H_2 distribution	3.6	3

3.3 FOCUS AREAS AND ACHIEVEMENTS

3.3.1 DEMONSTRATION ON STATIONARY FUEL CELLS

Focus areas

The FCH JU has developed a programme of activities to support demonstration and PoC projects for stationary FC:

Demonstration – supports field demonstrations of:

- all sizes of combined heat and power (CHP) units to establish operational performance capabilities, prove technology readiness to potential end-users, and develop the knowledge and know-how for installing, operating and maintaining units in real applications
- Portable, back-up power (BUP) and uninterruptible power supply (UPS) systems;

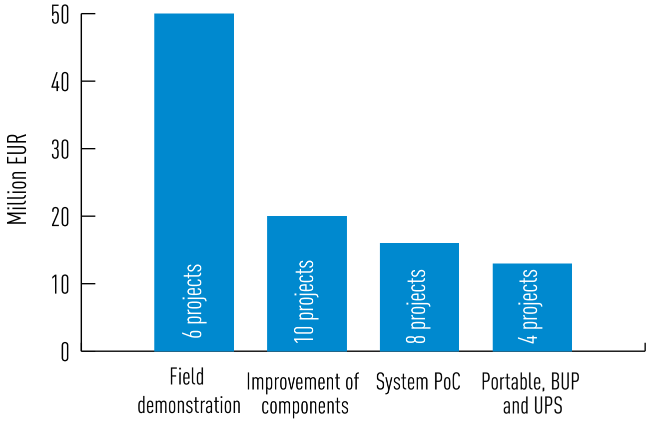
- PoC – supports projects seeking to validate and test whole-system concepts, usually around technology readiness level (TRL) 5;
- Improvement of components – supports projects focused on improving the performance, reliability, durability and cost of BoP components for the FC systems, alongside control sub-systems.

The portfolio is technology neutral and thus includes SOFC and PEMFC technologies, plus others such as alkaline and molten carbonate. Specific goals set out in the MAIP include:

- Demonstration/deployment of 1000 micro-CHP units (domestic use) by 2015;
- Reduction of CAPEX to 2000 €/kWe (micro-CHP) and 3000-4000€/kWe (large-scale units) by 2020;
- Raising durability to 40 000 hours for stacks used in large-scale CHP units.

Since 2008, the FCH JU has made financial contributions to 28 projects totalling around EUR 100 million, equivalent to about 20 % of the total FCH JU budget. The breakdown by focus area is shown in Figure 6 below.

FIGURE 06 | FCH JU DEMONSTRATION AND POC PORTFOLIO SUPPORT AND PROJECT NUMBERS



Achievements

Specific achievements have been attained in the portfolio in a number of fields:

- Installation of more than 350 micro-CHP units across ten Member States, with a further 450 due to be added in 2016, whilst cost reductions of 25 % have been achieved, and electrical efficiency targets reached;
- Construction and operation of more than 3 MW of industrial- scale PEMFC and alkaline fuel cell (AFC) units across three key projects in Germany, France and China, achieving 61 % efficiency and using by-product hydrogen;

These demonstration projects have contributed to learning and development in fuel cell system installation, operations and maintenance, increased production volumes enabling cost reductions, and improved reliability and durability of systems in the field.

In addition, the range of PoC, components and diagnostics and control projects have resulted in cost reductions and efficiency improvements for specific components, as well as durability. Projects include TRI-SOFC, DIAMOND, FLUMABACK, SOFCOM and SAPPHIRE.

3.3.2 RESEARCH AND INNOVATION ON STATIONARY FUEL CELLS

Focus areas

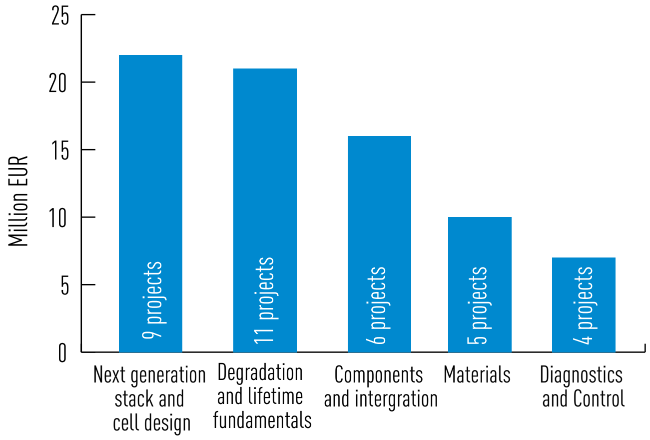
Fuel cell research and development has five key focus areas:

- Materials development – to improve key materials used in fuel cell systems, primarily cells and stacks, but also components;
- Degradation and lifetime fundamentals – to understand FCH performance phenomena, especially degradation issues, and hence increase the lifetime of cells and stacks;
- Next-generation cell and stack design – to develop more efficient, longer-lived and lower-cost cells and stacks, alongside manufacturing and process development for these;
- Components and integration – development of components, including balance of plant for fuel cell systems;
- Diagnostics and control – development of software and measurement devices for fuel cell diagnostics and control systems.

The overall objective is to contribute to the wider targets for stationary fuel cell systems noted above for the demonstration projects. Improved efficiencies, reduced degradation and lower costs are key targets. Projects are primarily focused on SOFC and PEMFC technologies.

Funding of the different focus areas is given in Figure 7 below, with 'next-generation cell and stack' activities accounting for the largest proportion, followed by 'degradation and lifetime fundamentals'. A total of 35 projects have received funding, totalling EUR 77 million.

FIGURE 07 | FCH JU STATIONARY RTD PORTFOLIO SUPPORT AND PROJECT NUMBERS



Achievements

Primary achievements to date include:

- Materials (MAESTRO, METPROCELL, METSAPP, RAMSES and SCOTAS-SOFC): improved performance of existing materials and development of new materials for cells and stacks, e.g. membranes and MEAs with improved mechanical properties (e.g. MAESTRO and ENDURANCE); new materials for lower temperature SOFC (e.g. SCOTAS-SOFC, EVOLVE, METSAPP, RAMSES) including a promising new ceramic anode material; and materials with enhanced power density for proton-conducting fuel cells (PCFCs) (METPROCELL).

- Degradation and lifetime fundamentals: improved understanding of degradation and lifetime fundamentals, e.g. development of PEMFC stacks with enhanced lifetimes (e.g. STAYERS, DEMSTACK, LOLIPEM); development of accelerated testing regimes for PEMFC and SOFC cells and stacks (e.g. SOFC-Life, PREMIUM ACT, KEEPEMALIVE); and study of degradation mechanisms (DEMMEA, MCFC-CONTEX, ROBANODE, SECOND ACT) and lifetime prediction methodologies (ENDURANCE). Cell and stack design: next-generation cell and stack design – projects developing new cell and stack designs for SOFC, AFC and PEMFC technologies (e.g. DURAMET, EURECA, EVOLVE, LASER-CELL, MATISSE, MMLRC=SOFC, PROSOFC, T-CELL, INNO-SOFC).

- Fuel cell cost and component issues: addressing a range of cost and production issues for SOFC and PEMFC technologies with a view to lowering the cost through materials and components (e.g. DURAMET, MMLRC=SOFC) as well as those focused on specific components and system issues (e.g. SECOND ACT).

- Diagnostics and control: projects aiming to control and predict problematic issues according to non-invasive online measuring and/or the development of prediction algorithms based on available information in view of enhancing system lifetime and reducing downtimes (D-CODE, DESIGN, GENIUS, HEALTH-CODE).

3.3.3 DEMONSTRATION AND RESEARCH AND INNOVATION ON HYDROGEN PRODUCTION, DISTRIBUTION AND STORAGE

Focus areas

The focus areas for hydrogen production, distribution and storage can be grouped into the four categories below:

- Hydrogen production through electrolysis – this covers development of a range of electrolysis technologies, with current effort in the areas of alkaline and PEM electrolysis, short-term solutions, and high-temperature (HT) electrolysis, longer-term solutions;

- Innovative green hydrogen production methods – development of hydrogen production technologies with a long-term potential for sustainable hydrogen production, including concentrated solar, photo-electrochemical, biomass and biological;

- Innovative reformers – reformer development for distributed hydrogen production from a number of feedstocks, including biogas, biodiesel and diesel;

- Hydrogen storage and distribution – materials, design and development of hydrogen storage capability, plus hydrogen filling technologies.

Objectives and targets for this wide range of projects are variable, but essentially focus on better performance, e.g. higher efficiencies, greater capacities, hydrogen production rates/day and lower costs, while minimising environmental footprint.

- Older PEM electrolyser (PEME) projects in the FCH JU portfolio are targeting hydrogen costs of less than 15€/kg, although in the longer term the cost must fall considerably further, and capacities per single stack 100Nm3/h will need to be addressed; HT electrolysers are focusing on increasing efficiencies to 85-95 %;

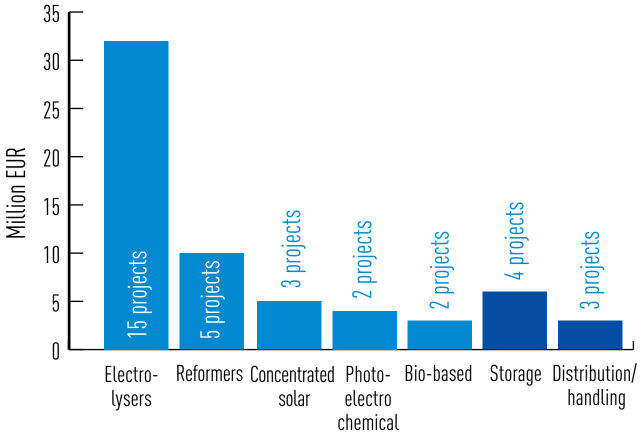
- Other H_2 production technologies have ambitions related to their particular readiness level, i.e. concentrated solar and photo-electrochemical are looking to achieve lifetimes of > 1000 h as an interim target;

- Reformer technology development based on new feedstock is seeking to achieve efficiencies of >70 %.

Storage projects are aimed at the fast filling of tanks and increased capacities.

A total of 34 projects on hydrogen production, distribution and storage have been supported by the FCH JU since 2008; the value of this support is EUR 66 million. Work on electrolyser developments has received about half of this total funding, reflecting the large number of projects in this domain. Otherwise, the distribution of funds and project numbers are similar for biomass, reformer and hydrogen storage projects, as shown in Figure 8 below.

FIGURE 08 | DISTRIBUTION OF FUNDING AND PROJECT NUMBERS FOR HYDROGEN PRODUCTION, DISTRIBUTION AND STORAGE PROJECTS



Achievements

To date, the portfolio of projects had made good progress against the programme objectives:

- Electrolysers – the projects cover low-, medium- and high-temperature electrolysers; two completed projects have advanced technology for AE with advanced membranes in the RESelyser project and optimisation of efficiency in Elygrid; PEME developments are being tackled by the NOVEL, MEGASTACK, ELECTROHYPEM and DON QUICHOTE projects leading to reduced energy requirements whilst achieving the project cost targets for H_2 using renewable electricity sources of 13€/kg; HT electrolyser developments of HELMETH, SOFIA and ELECTRA have achieved efficiencies of 86 % at stack level. Electrolyser size has gradually increased over the duration of FCH JU, going from kW-size at the beginning to current demonstration projects at MW scale.

- Innovative renewable hydrogen production – seven projects have improved the performance of innovative production technologies, such as SOL2HY2, HYDROSOL-3D and HYDROSOL-PLANT for concentrated solar, with capacities of 0.75MWth pursued in the latter; ARTIPHYCTION (finished in October 2015) and PECDEMO concern photo-electrochemical hydrogen production pathways; UNIFHY and HYTIME are developing hydrogen production from biomass and biological routes respectively.

- Innovative reformers – work undertaken by COMETHY on advanced catalyst for steam reforming, NEMESIS2+ on diesel and biodiesel reforming, and BIOROBUR and HY2SEPS-2 on biogas reforming and advanced purification methodologies have made some progress towards efficiency and cost targets with further progress considered possible. A new project, BIONICO, which started in 2015, aims to demonstrate a biogas reformer within an integrated reforming/ separation reactor.

- Hydrogen storage and distribution – BOR4STORE, SSH2S and EDEN have hit capacity targets for solid state hydrogen storage of 9-10 % weight of material, but considerably lower when considering the complete system. Costs are still prohibitive; project HYTRANSFER is focused on the fast filling of compressed hydrogen tanks to improve hydrogen refuelling times for end-users of FCEVs.

In addition to the financial support to projects, the Programme Office also commissioned studies on electrolysers, energy storage and green hydrogen production technologies.

3.4 REVIEW FINDINGS

3.4.1 DEMONSTRATION ON STATIONARY FUEL CELLS

The 2015 review comprised 18 projects which included demonstration and PoC along with components and diagnostics activities. These are shown in Table 8 below – the projects in bold made oral presentations during the PRD.

TABLE 08 | LIST OF DEMONSTRATION AND PROOF-OF-CONCEPT PROJECTS

FOCUS AREA	PROJECT ACRONYM	DESCRIPTION
Market capacity build and field demonstration	DEMCOPEM-2MW	Demonstration of a combined heat and power 2 MWe PEM fuel cell generator and integration into an existing chlorine production plant
	ENE.FIELD	European-wide field trials for residential fuel cell micro-CHP
	POWER-UP	Demonstration of 500 kWe alkaline fuel cell system with heat capture
	SOFT-PACT	SOFC micro-CHP field trials
Improvement of components and their interaction	**DIAMOND**	Diagnosis-aided control for SOFC power systems
	FERRET	Flexible natural gas membrane reformer for micro-CHP applications
	FLUMABACK	Fluid management component improvement for back-up fuel cell systems
	PEMBEYOND	PEMFC system and low-grade bioethanol processor unit development for back-up and off-grid power applications
	REFORCELL	Advanced multi-fuel reformer for fuel cell CHP systems
	SAPPHIRE	System automation of PEMFCs with prognostics and health management for improved reliability and economy
System proof of concept	ASTERIX3	Assessment of SOFC CHP systems built on the technology of HTceramix3
	FLUIDCELL	Advanced micro-CHP fuel cell system based on a novel bio-ethanol fluidised bed membrane reformer
	NELLHI	New all-European high-performance stack design for mass production
	SOFCOM	SOFC Combined Cooling, Heating and Power (CCHP) with poly-fuel: operation and maintenance

FOCUS AREA	PROJECT ACRONYM	DESCRIPTION
	STAGE-SOFC	Innovative SOFC system layout for stationary power and CHP applications
	TRISOFC	Durable SOFC tri-generation system for low carbon buildings
Demonstration of portable generators, BUP and UPS power systems	BEINGENERGY	Integrated low temperature methanol steam reforming and high temperature polymer electrolyte membrane fuel cell
	FCPOWEREDRBS	Demonstration project for power supply to telecom stations through FC technology

Relevance to programme objectives

In general, all projects satisfied the broad objectives of the related MAIP and AIP. The dominant technology is SOFC for CHP applications, primarily at the small domestic scale, closely followed by PEMFC.

A number of projects are making excellent progress towards the FCH JU objectives in the MAIP, with ASTERIX3, SOFCOM and DIAMOND seen by the reviewers as excellent projects. There are several others where the actual achievements are unlikely to reach the original objectives. This may reflect overly ambitious targets and indicates, as in the transport sector, that targets and objectives need to be defined carefully. Reviewers believe that more intermediate targets are required, with an emphasis on targets for subsystems and key components. This would assist project monitoring and identify where further lower-level TRL research is required.

ENE.FIELD is making good progress towards its objectives, targeting the micro-CHP market, whilst POWER-UP and DEMCOPEM-2MW involve larger FC systems based on AFC and PEMFC technologies respectively. To maximise value from these projects, it is felt that more feedback to the research community is necessary.

The portfolio maintains Europe at the leading edge of international development, although deployment in Europe substantially lags that of other regions/countries in the world, notably Japan, Korea and the USA. Of the 18 projects assessed, five were considered to be internationally competitive in terms of SoA, whilst another 11 were seen as leading in some aspects of the project objectives.

In terms of gaps and overlaps, large-scale natural-gas-fuelled systems for CHP and industrial power production are missing, which contrasts with activities in Korea and the USA. In general, there is little duplication in the portfolio, but reviewers noted that there is excess effort on reformer technology development. BUP and UPS are covered sufficiently, especially as these applications make little direct contribution to GHG emissions. As such, reviewers recommend that efforts are made to support larger-scale fuel cells, with no further efforts necessary on reformer technology and a re-evaluation of UPS and BUP systems.

Finally, with a view towards commercialisation, reviewers recommended further focus on cost reductions and longer lifetimes. This requires more lower-level TRL research and development on material degradation mechanisms and breakthrough research on lower cost materials, for example in future FCH JU calls. The potential for complementarity between RTD and demonstration projects should be exploited, as RTD has a critical role to play in providing the technology innovation required to continue the improvement of fuel cell systems over the medium and longer terms and should definitely be continued despite the current emphasis on higher TRLs.

Complementarity with other projects/programmes

As a whole, the project portfolio shows a good level of linkages with previous projects supported by the European Commission's Sixth Research and Development Framework Programme (FP6, 2002-2006) and the FCH JU, and with projects funded by Member State programmes. Building on prior projects ensures that past learning is retained and referred to in current projects, whilst shared learning is also enhanced by interactions with other FCH JU, European or Member State projects.

Thus, REFORCELL, NELLHI and SOFCOM all have linkages with previous projects, whilst ASTERIX3, FCpoweredRBS, BEINGENERGY, ENE.FILED and STAGE-SOFC have some interaction or support from national programmes. Nevertheless, reviewers recommended that interactions become more formalised in the FCH JU portfolio, possibly with an emphasis on inclusion in the project description.

By contrast, reviewers found it more difficult to assess projects with regards to international linkages and interactions. Here again, projects can benefit from shared learning, and the reviewers recommended that projects be encouraged to look outside Europe for collaboration and sharing opportunities.

Sharing results among projects is generally not extensive, although there is probably substantive sharing on an informal basis. The reviewers wondered whether more sharing could be encouraged given that large commercialisation has yet to occur, though they also recognise that issues of confidentiality create a formidable barrier. Nevertheless, where available, results from demonstration projects could be used to advise the RTD community on areas for further research.

Horizontal and dissemination activities

In general, dissemination is very strong across the portfolio in terms of websites, conference presentations and publications. All projects have a website, although the quality varies considerably, and some projects undertake additional public-awareness activities such as press releases and media inputs, e.g. SOFCOM, SOFC-PACT and ENE.FIELD. Research partners in consortia tend to be active in terms of conference presentations, and in scientific and technical publications, e.g. TRISOFC and NELLHI. However, patent activity is poor and only reported by SOFC-PACT and ASTERIX3. Reviewers stated that projects may not report all such activity and recommended that the FCH JU undertake an exercise to collect this information from projects on a formal basis.

In the fields of training and education, all projects had some components covering this, although these are not core activities for this portfolio of projects. Furthermore, the demonstration projects were identified as being active in the area of safety and RCS, but once again most of the other projects undertook little activity in this area.

Exploitation plans

Routes to market are generally clear for most projects, but plans for timing and strategy are considered to be weak. Some projects are targeting commercialisation in the early 2020s or even later, which is relatively late for projects starting in the period 2010-2014. Only five projects are targeting commercial activities prior to 2020.

However, although described as demonstration and PoC, some projects are clearly weighted towards lower-level TRL research, whilst the majority are led and coordinated by research organisations which, reviewers noted, is probably good for dissemination but not for actual exploitation. Although encouraging industry to take a greater and stronger role in leading projects could result in better exploitation plans, the challenges of commercialising a project will remain.

3.4.2 RESEARCH AND INNOVATION ON STATIONARY FUEL CELLS

There were 18 projects in this panel from across the range of focus areas, except for 'diagnostic control' which was not covered by any of the projects considered. The seven projects shown in bold in Table 9 made an oral presentation during the PRD.

TABLE 09 | LIST OF FUEL CELL RESEARCH AND DEVELOPMENT PROJECTS

FOCUS AREA	PROJECT ACRONYM	DESCRIPTION
Materials	METPROCELL	Development of innovative PCFCs and implementation of cost-effective fabrication routes
	METSAPP	Development of novel cells and stacks based on a robust and reliable scalable metal supported technology for stationary and mobile applications
Components and integration	ALKAMONIA	PoC of ammonia-fuelled AFC for remote power applications
	CISTEM	Construction of improved HT PEM MEAs and stacks for long-term stable modular CHP units
	DURAMET	Improvement of the durability and cost-effective components for new-generation solid polymer electrolyte direct methanol FC
	LIQUIDPOWER	FC systems and Hydrogen supply for Early markets
	ONSITE	Operation of a novel SOFC-battery integrated hybrid for telecommunication energy systems
	SCORED 2:0	Steel coatings for reducing degradation
Degradation and lifetime	**DEMSTACK**	Understanding the degradation mechanisms of a HT PEMFC stack and optimisation of the individual components
	ENDURANCE	Improvement of the durability and reliability of SoA stacks and cells by more efficient materials for SOFC
	SECOND ACT	Simulation, statistics and experiments coupled to develop optimised and durable micro-CHP systems using accelerated tests
Next generation of stack and cell design	**EURECA**	Development of next-generation of micro-CHP systems based on advanced PEM stack technology
	EVOLVE	Evolved materials and innovative design for high-performance, durable and reliable SOFC cell and stack
	LASER-CELL	Innovative cell and stack design for stationary industrial applications using novel laser processing techniques
	MATISSE	Manufacturing improved stack with textured surface electrodes for stationary and CHP applications
	MMLRC=SOFC	Working towards mass-manufactured, low-cost and robust SOFC stacks
	PROSOFC	Production and reliability oriented SOFC cell and stack design
	T-CELL	Innovative SOFC architecture based on triode operation

Relevance to programme objectives

Project activity within the portfolio is focused to a large extent on improving cell and stack durability and achieving lifetime targets, with an emphasis on degradation and lifetime fundamentals and improved new materials. Other projects are focused on fabrication and manufacturing or on novel systems and architectures. They cover the whole range of fuel cell electrolytes.

Reviewers consider that this portfolio addresses the programme objectives, and is aligned with the FCH JU strategy. However, they expressed concern that the multi-annual programme performance targets are usually given for whole systems, whereas projects are focused on individual sub-components, components and subsystems for which targets are not always defined by the FCH JU at multi-annual level. Some projects may thus appear to be working to their own targets within the global context, although on closer inspection they most often follow specific FCH JU targets defined in annual plans and call topics; possible additional project-specific goals are typically aligned with the call targets.

In terms of progress against targets, reviewers noted that several MAIP targets were unlikely to be met in the lifetime of the portfolio, notably in terms of cost and durability.

Assessment of the portfolio's SoA is hampered by a general lack on information provided by the individual projects. Where information is provided, it refers to European rather than international SoA, with reviewers noting that developments in Asia and North America were more advanced albeit often not mentioned. Comments on the issue of SoA confirm those made by reviewers in other panels and in preceding PRDs.

Duplication in the portfolio is viewed as minimal with projects using different approaches and focus even when they appear to overlap one another. However, this has led the reviewers to recommend better communication between similar projects. Gaps in the portfolio are not evident, with good coverage of the programme objectives (while no project on diagnostics was represented in the PRD 2015, a new project started in 2015 – HEALTH-CODE – is now active in this field while three others were completed in 2014). Nevertheless, reviewers did recommend that more attention be paid to accelerated durability testing for both components and systems.

In assessing the portfolio, the reviewers recommended that systems with the highest electrical efficiencies should be prioritised as these are most likely to be the most competitive in the future.

They also emphasised that basic research is still required to underpin the pathway to commercialisation, and as such should not be neglected. They noted that lower TRL activities are not part of the portfolio, reflecting the MAIP and MAWP preferences, but such projects would be important for achieving durability and cost targets, where the latter may require material breakthroughs in addition to manufacturing scale-up effects.

Complementarity with other projects/programmes

To summarise, the portfolio shows good linkages and interactions between projects at the FCH JU, European and Member State levels. However, international links are perceived to be weak, with the danger that European research activity is not aware of or able to learn from international developments.

Relationships between projects are based both upon the involvement of participants in previous projects, often operating across FCH JU projects, and those supported by the Member States. These networks are usually at the informal level, with shared learning through conference papers and public deliverables. METSAPP, PROSOFC and CISTEM are cited as good examples. The reviewers identified more formal interactions with Member State programmes as a means of leveraging funds, given the relatively low level of FCH JU funding for some projects (this was particularly true within FP7 but less so in Horizon 2020). They also recommended that the FCH JU institutes more formal links between projects within the portfolio to ensure shared learning, for example through joint workshops.

International links and interactions between the FCH JU portfolio and projects in the USA, Japan and elsewhere were considered to be weak. This may reflect limited information provided by the projects for the review, but nonetheless, the reviewers believe that more activity is needed in this area with further requirements specified in the 2016 AWP.

Horizontal and dissemination activities

As in other panels, the dissemination of results at scientific and technology conferences and in publications is considered to be a strength, with a good range and number of activities. However, the focus on fuel cell or electrochemical conferences and publications means that this dissemination effort has had limited impact beyond the immediate community and thus is not enhancing awareness of fuel cells amongst the public and end-users in the wider world.

Although project websites are available, they tend to be passive tools which do not necessarily impact on the public. Reviewers would like more effort be focused on disseminating to a wider audience, for example at climate and environment conferences, and via different media.

Efforts in the field of training and education are apparent for most projects with, for example, the employment of postdoctoral researchers. However, the reviewers consider that the number of such researchers is too low. More proactive training and education beyond project consortia is limited to participation by a few projects in summer schools and some education for schoolchildren.

Reviewers recommend that projects give higher priority to work in the safety and RCS fields. As commercialisation proceeds, RCS has to be further developed and standards enhanced, and Europe needs to be part of this process. Projects and the FCH JU are well placed to play a role in this important field.

Exploitation plans

Reviewers report a mixed view of the exploitation activities and plans of the FCH JU projects. In general, the higher the TRL the better the plans – for example, LASERCELL, T-CELL and SECOND ACT have credible plans.

3.4.3 DEMONSTRATION AND RESEARCH AND INNOVATION ON HYDROGEN PRODUCTION, DISTRIBUTION AND STORAGE

The hydrogen production, distribution and storage panel included 21 projects with activities ranging from electrolyser and reformers, through biomass and novel hydrogen production techniques to storage and distribution. These are shown in Table 10 below, with those making oral presentations during the PRD highlighted in bold.

TABLE 10 | LIST OF HYDROGEN PRODUCTION, DISTRIBUTION AND STORAGE PROJECTS

FOCUS AREA	PROJECT ACRONYM	DESCRIPTION
Electrolyser	Don Quichote	Demonstration of new qualitative innovative concept of hydrogen production from wind turbine electricity
	ELECTRA	Development of scalable fabrication of robust tubular HT electrolyser cells with proton conducting electrolytes
	ELECTROHYPEM	Development of cost-effective components for PEM electrolysers with enhanced activity and stability to reduce stack and system costs and improve efficiency
	ELYGRID	Improvements to integrate high-pressure alkaline electrolysers for electricity/H_2 production from renewable energies to balance the grid
	HELMETH	PoC of highly efficient power-to-gas with methane by thermally integrating HT electrolysis with methanation
	MEGASTACK	Stack design for a megawatt-scale PEM electrolyser
	NOVEL	Development and demonstration of an efficient and durable PEM water electrolyser utilising new materials

FOCUS AREA	PROJECT ACRONYM	DESCRIPTION
	RESELYSER	Development of high-pressure, highly efficient, low-cost alkaline water electrolyser that can be integrated with renewable energy power sources using an advanced membrane concept, highly efficient electrodes and a new cell design
	SOPHIA	Development of a new generation of solar integrated pressurised HT electrolysis
Reformers	BIOROBUR	Bio-gas robust processing with combined catalytic reformer and trap
	COMETHY	Intensification of hydrogen production processes, developing innovative compact and modular steam reformer to convert reformable fuels to pure hydrogen and adaptable to several heat sources
	NEMESIS2+	Development of small-scale hydrogen generation prototype fed by diesel and biodiesel at refuelling stations
Biomass	**HYTIME**	Construction of a prototype processes based on fermentation of biomass for delivering and development of a bio-hydrogen production system
	UNIFHY	Development of a biomass steam gasification process coupled to syngas purification to produce pure hydrogen from biomass
Concentrated solar	HYDROSOL-PLANT	Demonstration of a carbon dioxide (CO_2) -free hydrogen production and provision process, plus related technology using a two-step thermochemical water splitting cycle harnessing concentrated solar radiation
	SOL2HY2	Demonstration of hydrogen production through the realisation of open and hybrid sulphur cycles using solar energy
Photo-electrochemical	**ARTIPHYCTION**	Development and improvement of nano-structured materials for photo-activated processes and chemical systems for highly efficient low temperature water splitting using solar radiation
	PECDEMO	Development of a hybrid photo-electro-chemical /photovoltaic tandem device for light-driven water splitting
Hydrogen storage	BOR4STORE	Fast, reliable and cost-effective boron hydride-based high storage capacity solid-state hydrogen storage materials
	EDEN	Realisation of high-density hydrogen storage system in solid-state material for stationary and portable applications
Hydrogen distribution	**HYTRANSFER**	PNR for thermodynamic optimisation of fast hydrogen transfer

Relevance to programme objectives

Reviewers noted that all projects in the portfolio are relevant to the programme objectives. They believe that the FCH JU strategy, its approach and its emphasis on collaboration, including participation of SMEs, has enabled significant technical advances to be made.

Nonetheless, the review was hindered by the absence of sufficient information provided by the projects themselves. As such, it is not clear how and to what extent the specific programme targets are being addressed. Where information is available this often relates to specific project objectives and not to publicised metrics. However, reviewers also noted that programme targets are often difficult for single projects to relate to and can be too ambitious. They recommended that targets should be reviewed and, if necessary, intermediate targets be developed against which project achievements can be better assessed.

The reviewers highlighted potential shortfalls in the achievements of the portfolio to date, e.g. cost, reliability and performance targets, but also specific targets such as 5 t solid state storage and 1.5 t/day electrolysis using RES. They recommend that projects be encouraged to assess their progress realistically and possibly revise their targets, if this is deemed necessary, or extend their duration.

As with the projects in other sectors, the assessment against SoA proved challenging, given the paucity of information provided by the projects concerning the latest international developments, including, when available, relevant FCH JU studies. Nevertheless, the assumption is that the majority of projects are advancing SoA.

Gap analysis by the reviewers focused on the requirement to identify industrial needs, noting that industrial participation by large businesses was modest at best. Hence the recommendation that the FCH JU should assess the needs of larger companies with established hydrogen businesses and technology needs.

Similarities among projects were identified in a number of areas, e.g. methane catalysis and reformer projects. In the electrolysis area, the number of projects reflects differing approaches to the challenge.

To summarise, reviewers made a number of specific recommendations:

- Consolidation and prioritisation of the portfolio to provide a stronger focus on near-term, scalable RES-based hydrogen production; this would reduce fragmentation and increase resources available for critical objectives;
- Rigorous and transparent targets to provide better guidance for projects and to facilitate the monitoring of achievements, and identification of performance gaps, with a focus on costs;
- SoA assessments need to be based on more information and to be rigorous and transparent;
- Reconsider support for projects seeking to convert scarce biofuels to hydrogen because these fuels could be used to directly displace carbon containing fuels at higher efficiencies.

Reviewers noted that the portfolio comprises projects with very different objectives and at very different TRL levels, from very low to full-scale demonstration. A general comment made by the reviewers was that lower TRL projects appear to be performing better than higher-level projects for which cost, durability and efficiency targets are proving to be very challenging. Reviewers believe that some technology would benefit from further development at the lower TRL prior to PoC and demonstration.

Complementarity with other projects/programmes

The portfolio of projects shows reasonable interactions and linkages within the FCH JU portfolio and with projects supported by Member States, with 40 % of projects reporting national co-funding, e.g. Denmark, France and Spain. Furthermore, there are good examples of current projects building on previous projects funded in Europe or elsewhere, some of which go back to the European Commission's Fifth Research and Development Framework Programme (FP5, 1998-2002).

Nevertheless, the reviewers state that the FCH JU should work to strengthen collaboration where appropriate. Interactions and linkages could be improved, especially where projects are operating more or less in parallel, i.e. with a year or so lag. Reviewers further recommend that projects be encouraged to actively seek opportunities for the formal sharing of results and learning, for example through joint meetings and workshops. One possible area for improvement is greater interaction with lower TRL projects funded elsewhere in Horizon 2020, where relevant.

The projects tend to give international relationships less priority, and no projects were found with formal international links. There is evidence of less formal links with international agencies such as the International Energy Agency (IEA) and the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE). This lack of international exposure and collaboration is an issue which should be addressed by the FCH JU.

Horizontal and dissemination activities

Most projects provide an extensive list of reports, publications and conference presentations as part of their dissemination activities, but the reviewers questioned whether these were all related to the project outcomes, as opposed to objectives, and the value of this activity. They recommend that only those activities explicitly related to the project activity and outcomes are included as dissemination activities. Furthermore, the activity in terms of public awareness is limited, whilst few positive patent outcomes are reported.

Projects report some activity in the training and education field, primarily through the employment of researchers, but it is clear that this activity is not core to research and innovation projects. Work in the fields of safety and RCS are more valuable, and although few projects are actively involved at this stage, there are good examples of work with IEA, the IPHE and the European Educational Research Association (EERA), as well as standards committees. HyTRANSFER is seen as a good project in this regard.

Reviewers questioned how projects could effectively undertake these 'additional' activities when their clear objectives are to advance technology to accelerate commercialisation. At best, the impact is likely to be marginal, and often the activities will detract focus and resources from the critical technology challenges. More effective use of limited resources could, for example, focus these activities on specific 'approved' conferences and summer schools.

Exploitation plans

The quality of the portfolio's exploitation plans probably reflects the fact that the majority of projects are focused on research and innovation, rather than demonstrations looking to take a technology to market. As such, reviewers noted that plans vary in quality and detail. Similarly, assessment of potential impacts is weak. Good examples of exploitation plans include the EDEN project which has created a technology transfer board to bring the technology to the market.

Reviewers recommended that the FCH JU could support the development of exploitation plans through specific training for projects, and steering groups involving businesses that could be established to provide guidance, whilst more business should be encouraged to take on project leadership roles, and proposals should undergo more exploitation plan assessments at the evaluation stage.

04

CROSS-CUTTING

4.1 OBJECTIVES

Cross-cutting projects support commercialisation efforts in the energy and transport pillars through a range of market support measures. These are an essential part of the overall FCH JU project portfolio. Cross-cutting projects are intended to support market preparation and readiness through:

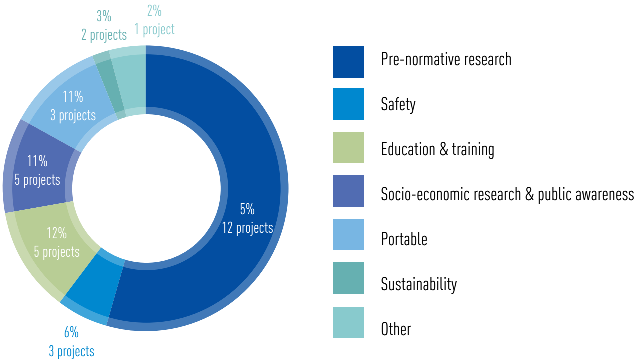
- Pre-normative research aimed at improving and strengthening harmonised RCS
- Safety issues for safe market introduction
- Raising public awareness and social acceptance
- Supporting education and training
- Undertaking socio-economic research, including for technology, environment and sustainability
- Research on sustainability, namely concerning recycling and dismantling
- Developing tools to assist the FCH activities, including new databases for knowledge sharing and studies on possible financing mechanisms.

Since 2014, projects addressing portable applications, previously classified within the 'early markets' application area, have also been categorised as cross-cutting.

4.2 BUDGET

To date, the budget for cross-cutting projects has totalled EUR 36 million, which is equivalent to 7 % of the total FCH JU budget. Further cross-cutting activities have been supported within the energy and transport pillars. Figure 9 below gives the cumulative spend for the period 2008-2014.

FIGURE 09 | DISTRIBUTION OF EUR 36 MILLION CUMULATIVE FCH JU SPENDING BY CROSS-CUTTING PROJECT TYPE



Thirty-one projects have been supported with EUR 36 million, with the majority (EUR 20 million) allocated to PNR topics and a further EUR 4.5 million for education and training. Projects for portable and niche applications have accounted for EUR 4 million, with a similar amount for socio-economic work. The remaining projects have addressed safety issues (three), life-cycle analysis (two) and technology monitoring (one).

4.3 FOCUS AREAS AND ACHIEVEMENTS

Focus areas

Both the existing and past cross-cutting project portfolios support a number of distinct fields (with the emphasis on the first two):

- **Pre-normative research**: research into aspects of FCH technologies of interest to the industry as a whole in view of gathering new knowledge to support the European FCH community and transferring it into RCS;
- **Safety aspects**: understanding safety issues associated with the deployment and adoption of FCH technologies in the various applications, e.g. transportation and stationary CHP, with an emphasis on technical safety;
- **Training and education**: actions to provide education and training for both the FCH sector – including but not limited to scientists, engineers and technicians – and for decision-/policy-makers outside the sector, as well as the professional education sector;
- **Social acceptance and public awareness**: general public conferences and workshops, brochures, public 'showrooms', e.g. museum displays; addressing and informing local authorities, certification bodies and first responders;
- **Socio-economic research** to determine the environmental and societal impact of FCH technologies, their effect on European GHG emissions and primary energy use, and on the economy;
- **Portable/niche applications**: projects undertaking research and innovation in specific applications in the portable and niche applications sector for FCH technologies, because these are not covered by the energy and transport pillars;
- **Sustainability**: supporting the development of specific tools for the sustainability assessment of FCH technologies, e.g. life-cycle analysis (LCA) methods, and addressing the issues related to recycling and dismantling;

- **Other** activities, including building databases for environmental, economic and socio-economic subjects as part of the knowledge management activity, identification and development of financial mechanisms to support market introduction, recycling projects for FCH technologies, and supporting portable applications and other niche markets for FCH technologies.

Achievements

To date, the FCH JU has supported 31 cross-cutting projects during the first phase of the FCH JU (2008-2013) as part of FP7 and over the current second phase mandate under Horizon 2020. The numbers by type are detailed below.

TABLE 11 | PROJECTS SUPPORTED BY THE FHC JU UNDER THE CROSS-CUTTING ACTIVITY

CATEGORY	ONGOING	FINISHED	TOTAL
PNR	6	6	12
Safety aspects	2	1	3
Education and training	2	3	5
Socio-economic research and public awareness	2	3	5
Portable and niche markets	1	2	3
Sustainability		2	2
Other		1	1
Total	13	18	31

These projects have produced the following positive outcomes:

- **PNR** – stack reference test activities; testing and design of components for hydrogen fatigue; modelling behaviour of pressure vessels; measurement of hydrogen refuelling accuracies; fast transfer of compressed hydrogen; guidelines for indoor use of FCH; hydrogen quality assurance; and mechanical impact on pressure vessels;

- **Safety** – assessment of best practice for computational fluid dynamics in safety analysis; assessing efforts to ensure that FHC technology is safe; and EU/USA joint collaboration on hydrogen sensors;

- **Training and education** – provision and development of training and education for a range of stakeholders, including first responder and public safety experts as well as regulators, but also to address the human resources challenges within the sector; international curriculum on FCH technologies;

- **Socio-economic research and public awareness** – improved understanding of the issues around social acceptance of hydrogen technologies;

- **Portable/niche applications** – development of technologies for methanol fuel reforming for portable fuel cells;

- **Sustainability** – development of methodology for the LCA of FCH technologies;

- **Other** – development of a tool for collecting data specifically tailored to the specificities of FCH technologies.

4.4 REVIEW FINDINGS

Fourteen cross-cutting projects were reviewed as part of the PRD 2015, four more than in 2014. These are shown in Table 12 below, with those making oral presentations highlighted.

TABLE 12 | LIST OF CROSS-CUTTING PROJECTS REVIEWED DURING THE REVIEW DAYS 2015

PROJECT ACRONYM	FULL TITLE
	PRE-NORMATIVE RESEARCH PROJECTS
STACKTEST	Development of PEM fuel cell stack reference test procedures for industry
SOCTESQA	Development of standardised industry wide test protocols for SOFC and solid oxide electrolyser cell (SOEC) assembly units according to different system applications
HYINDOOR	PNR for safe indoor use of fuel cells and hydrogen systems
MATHRYCE	PNR for metallic components exposed to hydrogen fatigue
FIRECOMP	Modelling the thermo-mechanical behaviour of high-pressure vessels in composite materials when exposed to fire conditions
HYPACTOR	Provision of recommendations for RCS regarding qualification of composite overwrapped pressure vessels and procedures for periodic inspections
HYCORA	Provision of information to lower the costs of hydrogen fuel quality assurance
	SAFETY ASPECT PROJECTS
H2SENSE	Cost-effective and reliable sensors for facilitating the safe use of hydrogen
H2TRUST	Development of H_2 safety expert groups and due diligence tools for public awareness and trust
SUSANA	Support to safety analysis of hydrogen and fuel cell technologies
	TRAINING AND EDUCATION PROJECTS
KNOWHY	Quality training for technicians and workers which is accessible, practical, scalable and sustainable
HYRESPONSE	Development of a European hydrogen training platform with a mock-up of real-scale transport and stationary applications
	SOCIO-ECONOMIC RESEARCH AND PUBLIC AWARENESS
HYACINTH	Understanding social acceptance of hydrogen technologies across Europe, with a communication and management toolbox
	PORTABLE PROJECTS
IRMFC	Development of a portable internal reforming methanol system for HTPEMFC

Relevance to programme objectives

The number and range of cross-cutting projects represents an improvement in the portfolio in 2015.

The new projects in PRD 2015 (HYACINTH and KNOWHY from the 2013 call) provide for a welcome strengthening of the portfolio, while it should be noted that five of the 14 projects mentioned above were completed by the end of 2015, with another four due to end in 2016. Further additions are expected from call 2014 (two projects started in September 2015) and call 2015 (grant agreement preparation in process).

The project portfolio is essentially aligned with the FCH JU´s (multi-) annual plans. More significantly, in reviewing each project in detail, the reviewers noted that the majority of projects are managing to fulfil their original objectives, and some are very impressive.

However, some projects have struggled to meet all their objectives, in part due to being overly ambitious.

In terms of the 'SoA', reviewers expressed satisfaction that the projects were advancing knowledge and know-how in the European context, but were less convinced about international comparisons, which again might be an issue with projects providing little or no information. As noted above, the broader range of projects for 2015 strengthens the portfolio, especially with regard to education and training.

Reviewers noted that a better exchange of information between the cross-cutting projects and others in the transport and energy portfolios would help to identify gaps in the portfolio and hence determine future need. They also put forward the idea that the FCH JU should ask industry to periodically review the portfolio and determine the value of these projects as regards supporting commercialisation. This could include an independent panel to assess projects in the critical RCS and safety fields.

Reviewers raised two further points for attention: first, how to ensure that project results remain available to the sector once the projects themselves have finished and websites have ceased operation; and secondly, how to create a database of all cross-cutting project achievements. In this they reflect the concerns expressed in previous PRD reviews regarding the sustainability and continuity of results and data, and hence highlight once again the need for the efficient dissemination of results and knowledge management. Hopefully, the intended addition of publishable summaries and public deliverables on the FCH JU website should improve the situation.

Complementarity with other projects/programmes

It has been acknowledged that cross-cutting projects have a critical role to play in supporting the commercialisation of FCH technologies, and that the complementarity and synergies of these projects is an important aspect of their activities. Whilst projects were good in terms of providing lists of other FCH JU or European projects they either have links or some form of association with, the actual content and strength of these linkages was extremely difficult to determine. Indeed, examples of good practice are limited for this assessment criterion.

Shared learning is a means of improving the quality and breadth of project results, along with the opportunity to eliminate duplication, accelerate learning and improve overall project quality. This is especially important in the pan-European and international context. Evidence from the review is mixed: some projects, such as H2SENSE and HYCORA, have critical links to similar projects in the USA, for example, whilst others appear to make little effort to benefit from international learning. The reviewers agree that international learning is a critical aspect of cross-cutting projects and links should be strongly encouraged. This confirms the views expressed in earlier PRDs.

In terms of sharing the results and learning, it is evident that more is being done in the portfolio as a whole than in previous years. Greater use is now being made of workshops for interested parties, whilst conference presentations and web presence also enable interested parties to access relevant results, although it was found that explanation of the latter varied significantly between projects.

Horizontal and dissemination activities

Reviewers found that, on the whole, the horizontal and dissemination activities in the cross-cutting project portfolio are suitable. As befits cross-cutting projects, the reviewers found that most projects were making efforts to ensure that project results are disseminated. In terms of contributions to training and education, reviewers would like to see a more systematic approach to publications and awareness-raising of training courses, and a common approach to how projects feed results into relevant standardisation and regulation development activities, both in Europe and globally.

As noted previously, all projects maintain websites, some of which have been assessed as very good in delivering valuable and valid information. These provide a useful means of making information available to interested parties, but are essentially passive dissemination tools.

Work on publications is variable: some projects limit activity to participation in conferences, whilst others involving academic or research institutes as partners tend to prefer the publication of papers in peer-reviewed journals. Again, as noted in previous PRDs, this type of dissemination is passive and publications or papers do not necessarily reach the end-users of cross-cutting projects. These dissemination channels should be complemented by more active, targeted activities, such as:

- Workshops – projects should hold more workshops, more often, rather than a single workshop towards the end of the project – this would allow greater involvement from industry and other parties, with more opportunities for learning and feedback;

- Advisory groups – projects should consider using industry advisory groups to ensure that the work remains relevant and allows for improvements. These are active dissemination activities which enable feedback and discussions with end-user groups and, as such, can potentially improve the outcomes of cross-cutting projects. This is the case for HYCORA, with benefits to both the project itself and industry.

Exploitation plans

The reviewers noted that the indicator of the success of cross-cutting projects is the uptake and exploitation of results by the range of stakeholders. Most exploitation plans in the traditional sense of the commercialisation of technologies are not relevant, but plans and actions to ensure that the results of projects are relevant, accessible, useable and used by industry and others are.

Credible exploitation plans are required in all cross-cutting projects. Such plans should include expected results, target audiences, message and information development, proposed channels and expected outcomes, including measurable indicators of success, e.g. engagement with industry and other stakeholders in terms of numbers attending workshops.

The reviewers found that projects demonstrate mixed success in addressing this critical aspect: some, such as SOCTESQA and HYCORA, are exemplary; others place too much emphasis on conference presentations and scientific papers with limited proactive dissemination and focus on the effectiveness of these activities.

05

FCH 2 JU-FUNDED STUDIES

The FCH JU has funded a number of studies on specific applications for FCH technologies as part of the commercialisation process. The objectives of these studies have usually focused on:

- Understanding the technical feasibility and market potential of the technologies;
- Establishing their competitive position with regard to other, usually incumbent, technologies;
- Developing strategies and pathways to achieve commercialisation.

Four studies were completed in 2015:

- Study on hydrogen from renewable resources in the EU
- Fuel cell electric buses – potential for sustainable public transport in Europe
- Advancing Europe's energy systems: stationary fuel cells in distributed generation
- Commercialisation of energy storage in Europe.

These studies were completed and published in 2015. The work was undertaken by globally leading consultancies contracted through a competitive bidding process to ensure high-quality, relevant and actionable outcomes. They were usually undertaken in collaboration with relevant stakeholders from industry and end-users, as well as others from industry associations and policy bodies. These four studies can be accessed on the FCH JU website. Two studies were presented at the PRD 2015: the Fuel cell electric bus study[7] and the Hydrogen from renewable resources[8] study. Two others were presented in the Programme Review 2014.

5.1 FUEL CELL ELECTRIC BUSES – POTENTIAL FOR SUSTAINABLE PUBLIC TRANSPORT IN EUROPE

This study[7], finalised in September 2015, reported on the progress towards the development of a strategy for fuel cell bus (FC bus) commercialisation. The work focused particularly on actions to deploy substantial numbers of FC buses across Europe with the aim of reducing bus costs to more affordable levels, kick-starting market roll-out.

---

[7] Fuel cell electric buses – potential for sustainable public transport in Europe http://fch.europa.eu/publications/fuel-cell-electric-buses-%E2%80%93-potential-sustainable-public-transport-europe

[8] Study on hydrogen from renewable resources in the EU, http://fch.europa.eu/publications/study-hydrogen-renewable-resources-eu

Roland Berger worked with a coalition of 83 separate entities comprising:

- bus operators and municipalities from Europe's cities and regions
- bus OEMs, including fuel cell system developers
- infrastructure OEMs and hydrogen suppliers, and
- a range of other stakeholders, including Member State agencies.

Using a common and shared fact base, the coalition was able to establish the environmental case for fuel cell buses, the operational case, and the demand requirements to ensure that OEMs are able to commit to developments to scale-up production and reduce costs.

There is a clear case for the use of FC buses in terms of the emissions benefits for cities and regions, both for GHG reductions and air quality. Using zero emissions CO_2, hydrogen ('green' hydrogen) a FC bus would save about 800 tonnes of CO_2 over a 12-year lifetime compared to a conventional diesel bus. These benefits would enable operators to meet commitments to decarbonise public transport and improve air quality, with the accompanying benefits for human health and enhanced property values reflecting higher quality environments. FC buses have also proven to be the most flexible of alternative drive-train options. They are capable of replacing diesel buses in terms of range, operational flexibility, infrastructure requirements and refuelling characteristics. They would allow bus operators to meet their environmental commitments whilst maintaining high levels of public transit services.

According to the study, Europe currently has or has imminent plans to put 84 FC buses into operation in 17 cities and regions in Europe and is the world leader in FC bus deployment. There are plans to roll out a further 300-400 FC buses in Europe by 2020. To achieve this, and more, the coalition identified the need to:

- Further reduce the costs of FC buses plus the associated infrastructure and hydrogen supply
- Undertake preparatory work for larger-scale deployments of 20+ buses per location
- Develop a European and Member State funding support framework for bus operators.

With public transport authorities within the European FC bus coalition representing 35 cities and regions from 12 European countries there is potential to deploy substantially more given the right conditions. In November 2014, five FC bus manufacturers signed a letter of understanding with Hamburg and London on FC bus commitments. This landmark event was followed by a letter of understanding signed by 45 public transport authorities and bus operators in June 2015 and handed to the EU Commissioner for Transport. The FCH JU has been instrumental in stimulating these next steps on the FC bus commercialisation pathway.

5.2 STUDY ON HYDROGEN FROM RENEWABLE RESOURCES IN THE EU

This study is focused on identifying pathways that could be used to produce green hydrogen as alternatives to the current standard industry steam methane reforming (SMR) process and water electrolysis. The objective is to identify the most promising pathways for emission-free hydrogen and propose content topics for forthcoming FCH 2 JU calls.

Through literature studies and a range of stakeholder interviews the study has examined 11 pathways to green hydrogen. It has detailed their feedstocks, scale and scalability, technologies and current TRL and applicability to either local and distributed or centralised generation.

Three core sources of RES have been identified: solar thermal energy, sunlight and biomass, with seven individual pathways selected for further analysis. This analysis has used SMR and water electrolysis as benchmarks and assessed each pathway against a series of parameters, including: TRL on the path to commercialisation 2015 to 2030, H_2 production costs (€/kgH_2), primary energy use and GHG emissions, along with feedstock availability and land use.

The seven initially promising technologies are:

- Five from biomass – biomass gasification or pyrolysis; super-critical water gasification of biomass; raw biogas reforming; fermentation (biological fermentation); and photo-fermentation (biological hydrogen production);

- Two from solar-thermal – thermo-chemical water splitting; and photo-catalysis using photo-electrochemical cells.

Initial findings show that whilst these technologies would be competitive by 2030 in terms of CO_2 emissions per kWh of hydrogen against SMR, they would not compare well with water electrolysis. Nonetheless, recognising that these are possible pathways, the recommendations for future FCH 2 JU calls should ensure that projects focus on specific challenges, the types of actions to address these, the potential impacts, and should start with a TRL of 3 with the potential for 'commercial' use in 2030.

06
CONCLUSIONS

6.1 OVERVIEW

The 2015 review of the FCH JU project portfolio re-emphasises the findings of 2014 and earlier years: the 100 projects considered represent a strong portfolio aligned with the principles of the FCH JU Multi-Annual Implementation Plan 2008-2013. As a whole, the project portfolio has been strengthened and improved since the first review in 2011. More projects are aligned to industrial needs, links between industry and the research community are stronger, and management and reporting are better. Furthermore, several projects have been identified as global leaders, most notably the bus demonstration projects.

Leading this portfolio are highly relevant and largely successful demonstration projects on cars, buses and HRSs, along with FCs for heat and/or power focused on the goal of technology commercialisation in Europe. Allied to this is a set of strategically important projects in the field of hydrogen production, distribution and storage, key to the longer-term production of green hydrogen.

Basic and breakthrough plus applied technology research projects are advancing the understanding and improvement of the basic materials, components and sub- and whole system technologies. Performance improvements and cost reductions underpin the competitive position of FCH technologies vis-à-vis the current incumbent technologies and their ultimate commercial success.

Inevitably, in such a large and complex portfolio there are points of weakness, either in individual projects or specific research and demonstration areas where targets are unlikely to be met. The 2015 Review points to the need to revise these and to work either to improve them where possible, or to rationalise where not.

6.2 PARTICIPATION IN THE FCH 2 JU PROGRAMME

One critical success of the FCH JU since its inception has been the development of a coherent and comprehensive strategy for commercialisation supported by a very wide stakeholder base. The FCH JU has supported 155 projects under FP7 and a further 30 have been selected for support as part of Horizon 2020, 15 of which have already started. There are 1473 participations, with 611 unique beneficiaries (a few of which are not receiving a financial contribution from the FCH JU).

Around 35 % of participants are large industrial businesses, emphasising the substantial commitment of resources, know-how and technology by European industry to FCH technologies. Innovative and entrepreneurial SMEs represent another 25 %. Industry efforts are supported by some of Europe's leading research institutes and universities in the fields of basic and breakthrough research – 31 % of participants.

The relevance of FCH technologies to Europe's future energy challenges is highlighted by the increasing numbers of municipalities and regions actively involved in demonstration projects. Public bus operators seeking zero-emission solutions for public transport are increasingly turning towards the potential of FC buses; the bus coalition, coordinated by the FCH JU, now counts some 45 bus operators amongst its numbers. Further, the FCH JU is actively coordinating its projects with more and more Member State hydrogen mobility initiatives. These activities are effectively leveraging the FCH JU's resources, multiplying funds and efforts towards the commercialisation challenge.

6.3 FCH 2 JU PORTFOLIO OF ACTIVITIES

The FCH JU portfolio has a balance between demonstration projects focused on proving technology readiness and pursuing early market opportunities, and basic, breakthrough and applied research projects focused on understanding basic phenomena, identifying technologies for the future, and improving performance and reducing cost.

The transport and hydrogen refuelling infrastructure portfolio comprises a series of increasingly ambitious demonstration projects for FC cars and buses, and supporting infrastructure with the aim of accelerating vehicle deployment in the coming years. These are supported by a series of research projects aiming to improve fuel cells and stacks to meet the stringent operating and cost targets.

The energy pillar has a similar structure of demonstration projects spread across Europe's Member States, notably for micro-CHP fuel cell units, and a broad range of PEMFC and SOFC technology research projects. These are aimed at the performance and cost challenges, especially in terms of durability and cost of ownership. The latter concern is the subject of a further set of projects engaged in the manufacturing and scale-up challenges.

The FCH JU has increased the number of projects focused on hydrogen production, distribution and storage challenges. Although currently research projects form the bulk of the portfolio, these are essential first steps towards the expansion of the demonstration element from kW to MW scale. This is particularly true of the range of electrolyser technology projects that will be key to future production of hydrogen from wind and solar power.

These application-focused projects are supported by a range of cross-cutting activities that are continuing to contribute to the horizontal objectives for safety, RSC, PNR, education and training, and socio-economic and environmental analysis.

6.4 LEARNING AND RECOMMENDATIONS

The 2015 Review experts identified a number of areas for improvement in the current portfolio and in the activities of the projects within the portfolio. These improvements and lessons learned echo those of previous reviews, emphasising their importance in ensuring the maximum effectiveness of the FCH JU and the resources at its disposal.

With the goal of accelerating the commercialisation of FCH technologies, the experts have reiterated the need to align the research activities with the needs of industry. The inclusion of industry participants in the consortia can provide vital guidance and ensure that work is relevant to industry needs. There are still some projects in the portfolio that are loosely aligned, if at all, with the needs of industry.

Rigorous SoA assessments are necessary to allow the portfolio activities to be assessed against the best in Europe and the world. At the same time, the multi-annual targets must be relevant, and whilst demanding, must also be achievable in the normal three-year duration of projects, hence the recommendation that more intermediate targets are taken into consideration. This should be quite feasible for Horizon 2020 projects since the MAWP 2014-2020 sets targets for 2017, 2020 and 2023; on the other hand, the targets in the MAIP 2008-2013 were limited to 2015 and 2020.

Projects failing to meet their targets must either put mitigating actions in place or be rationalised.

Feedback and the sharing of results and learning are arguably simple but highly effective ways of multiplying the effect of the FCH JU portfolio by limiting 'reinvention and rediscovery' and focusing on the critical issues. Whilst feedback and sharing is improving within the portfolio, with some international conferences with an impressive presence of FCH JU projects, this effort must be maintained, whilst also strengthening co-operation with other European and Member State projects and initiatives and, crucially, with international activities in Asia and North America.

The reviewers recognise the importance of the early market deployment of FCH technologies. However, they have expressed concern that such activity should not lead to neglect of the basic and breakthrough research that underpins these technologies. Improvements in performance and cost reductions will depend as much on a further understanding of basic phenomena as on manufacturing scale-up. As a part of this, reviewers emphasised the need to maximise feedback between demonstration and research projects. In addition, next and future generations of technologies are dependent upon the research activities of today.

The cross-cutting portfolio of projects has been strengthened over time, but still requires more concerted effort. The importance of the harmonisation of standards, educating stakeholders and the public, training future technologists, installers and maintenance operatives, and better understanding the socio-economic and environmental benefits and challenges for FCH technologies cannot be underestimated. The efforts of the FCH JU in these areas must be maintained and increased to support commercialisation in the energy and transport sectors.

6.5 OUTLOOK FOR THE FCH 2 JU

Since its inception in 2008, the FCH JU has successfully developed and implemented a strategy to advance the commercialisation of FCH technologies in the fields of transport and energy through a programme of demonstration and research projects. As a catalyst, the FCH JU has been able to mobilise and focus the efforts and resources of a diverse and fragmented stakeholder community from across Europe. Although this is a significant achievement, further work is required.

The FCH JU portfolio includes projects focused on manufacturing development and bringing down costs; this needs to be expanded, although work must continue on developing the science and technology underlying FCH technologies to ensure that they are competitive in terms of performance and cost of ownership.

Demonstration activities must expand to become more ambitious, include more stakeholders and become more widespread. This effort must be supported by market preparation activities in the fields of safety, RCS, education, training and others.

Moving FCH technologies along the commercialisation pathway is the next major challenge for the FCH JU: engaging and working with more stakeholders and leveraging more resources. Progress has been made in terms of creating and coordinating stakeholder coalitions across the value chain, adopting shared visions, strategies and action plans. The next step is to use its resources for more ambitious demonstration projects and to align these with Member State initiatives.

SECTION 02

PROJECT POSTERS

INDEX OF POSTERS

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

Mr Christopher TAWNEY
ctawney@afcenergy.com

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

ARTEMIS

Automotive PEMFC Range Extender with High Temperature Improved MEAs and Stacks

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.5: Next generation European MEAs for transportation applications
START & END DATE	1 Oct. 2012 - 31 Dec. 2015
TOTAL BUDGET	€ 2,822,692.00
FCH JU CONTRIBUTION	€ 1,747,884.00
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Centre National de la Recherche Scientifique (CNRS)

Partners: Commissariat à l'Energie Atomique et aux Energies Renouvelables (CEA), Nedstack, Fundaçion Cidetec, Centro Ricerche FIAT (CRF), Politecnico di Torino (PDT)

PROJECT WEBSITE/URL

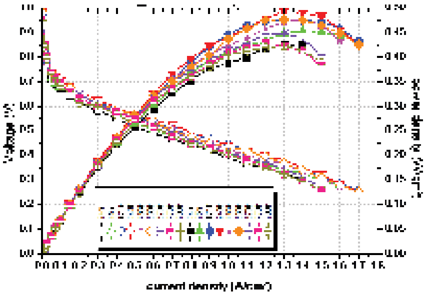
http://www.artemis-htpem.eu/

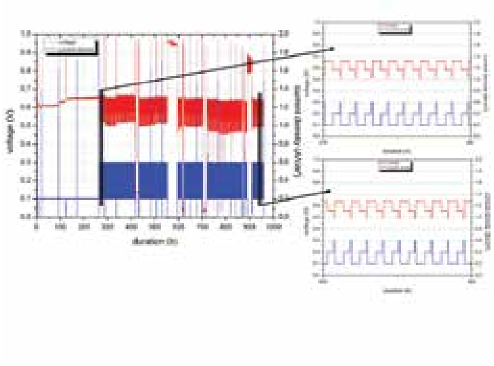
PROJECT CONTACT INFORMATION

Deborah Jones
Deborah.Jones@umontpellier.fr

MAIN OBJECTIVES OF THE PROJECT

The purpose of ARTEMIS is to develop and optimise alternative materials for a new generation of European MEAs to be integrated into a high temperature PEMFC stack. The MEAs will be based on novel acid doped polybenzimidazole type membranes and improved catalytic layers providing low catalyst loading and high efficiency at high temperature as well as a high tolerance to pollutants (CO, H_2S). Modelling tools will help to the understanding of degradation mechanisms and failure modes and will lead to increased durability and lifetime of the system.





PROGRESS/RESULTS TO-DATE

- Membrane conductivity of 0.15 S/cm at 140°C, ambient pressure, no humidification; final membrane generation delivered comprising polymer cross-linking and membrane reinforcement
- Anode catalysts undergoing scale-up
- Power density of 0.49 W/cm^2 at 1 A/cm^2 with MEAs comprising project membrane and project GDEs
- Plate materials stable in high temperature phosphoric acid environment and applied voltage relevant to operation conditions
- Modelling tools have provided input to the catalyst layer structure and acid loss mitigation strategies

FUTURE STEPS

- Complete on-going validation of MEA technology at large single cell level
- Supply of components for 0.3 kW stack and 0.3 kW stack build and test
- Complete upscale of anode catalysts and finalise activities on cathode catalyst
- ARTEMIS workshop on HT-PEMFC science and technology
- Larger scale stack build and test

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Results on project MEAs comprising project membranes and project electrodes at 25 and 50 cm^2 level are excellent (0.49 W/cm^2 @ 1A/cm^2) and surpass targets.
- Results on project MEAs provide >20% power density gain over international state of the art with membrane and GDEs from the project, and >13% with a mixture (50/50 wt%) of project catalyst and commercial catalyst on the anode side and project cathode GDE (0.45 W/cm^2 @ 1A/cm^2)
- New virtual methodology has been developed to simulate the range extender vehicle applications in particular using HT-PEMFC technology
- Project MEAs have been operated using a range extender protocol for close to1000 h, validating HT-PEMFC as a viable technology for automotive range extender 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	New materials for high temperature MEAs a	Component dependent	Activity, stability	Two components satisfy final targets
MAIP 2008-2013	2014 target high temperature operation	Operation @ 130 °C and beyond	Operate @ 160 and 180 °C	Materials operate 130 - 180 °C
AIP 2011	MEA power density	First generation MEA performance; 0.3 W/cm^2	0.35 -0. 4 W/cm^2 achieved @ 1 A/ cm^2	0.49 W/cm^2 achieved @ 1 A/cm^2
AIP 2011	Membrane conductivity	Conductivity >0.1 S/cm @ operation temperature	0.15 S/cm at 140 °C	0.15 S/cm at 140 °C, ambient pressure, no humidification

ArtipHyction

Fully Artificial Photo-Electrochemical Device for Low Temperature Hydrogen Production

AIP / APPLICATION AREA	AIP 2011 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2011.2.6: Low-temperature H_2 production processes
START & END DATE	01 May 2012 - 31 Oct. 2015
TOTAL BUDGET	€ 3,594,580.50
FCH JU CONTRIBUTION	€ 2,187,040.00
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Politecnico di Torino

Partners: HySyTech srl, Commissariat à L'Energie Atomique, Chemical Process Engineering Research Institute, Solaronix SA, Lurederra Foundation for Technical and Social Development, Tecnologia Navarra de Nanoproductos SL, Pyrogenesis SA

PROJECT WEBSITE/URL

www.artiphyction.org

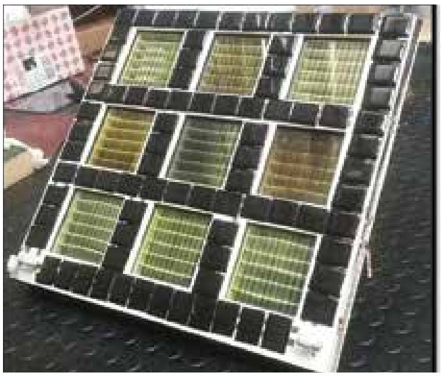
PROJECT CONTACT INFORMATION

Guido Saracco
guido.saracco@polito.it

MAIN OBJECTIVES OF THE PROJECT

The project aims at developing a Photo-Electro-Chemical Reactor for H_2 production capable of 5% conversion of solar energy into hydrogen (LHV) with:

1. Improved and novel nano-structured materials for photo-activated processes comprising photo catalysts, photo anodes interfaced with liquid or new polymer electrolytes
2. Chemical systems for highly efficient low temperature water splitting using solar radiation
3. a projected durability of >10,000 h
4. a modular approach capable to cope with small to medium scale applications ranging from 100 W for domestic use (ca. 3 g/h H_2 equivalent) to 100 kW (ca. 3 kg/h H_2 equivalent) for commercial use.



PROGRESS/RESULTS TO-DATE

- anodic and cathodic (photo) electro-catalysts identified and providing satisfactory activity in a non-optimised form.
- transparent conducting oxide precursors, powders and porous layers developed as electrode main structures supporting the electrocatalysts
- effect of pulsation of the electrolyte assessed
- final prototype modules (9 10x10 cm^2 modules each) designed and tested
- overall reactor prototype being assembled based on 12 parallel modules

FUTURE STEPS

- test complete prototype
- determine deactivation of performance degradation behaviour
- disseminate the results

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The partnership can anticipate that the original efficiency targets will be only partially achieved (50%).
- The main findings of the project lie in the assessment of the numerous efficiency drop causes that appear from lab scale to full scale; just to mention a few:
  - limited electron transfer through wider electrode surfaces based on transparent conducting oxides layers;
  - Impossibility to reduce the gap between the electrodes to minimise ohmic drops for large scale electrodes
  - ohmic losses linked to the Cu wires embedded in the prototype frame to connect the single photoactive electrode couples in parallel;
  - need to provide a bias through Si PV hosted in the area around the photoactive windows.
- These pieces of information will be quite fruitful to those that will attempt similar scale-up tasks in the near future.

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	Scale-up to cost effective capacity, as well more cost efficient, high performance materials for renewables based H_2 production	Applications ranging from 100 W for domestic use (ca. 3 g/h H_2 equivalent) to 100 kW (ca. 3 kg/h H_2 equivalent) for commercial use.	Test the smallest scale of the range aside.	A single module with 9 10x10 cm^2 electrodes has been produced. 12 of such modules are being assembled to produce the full scale ArtipHyction photoreactor.
AIP 2011	Sun-to-hydrogen conversion efficiency	5%	5%	2,5% efficiency achieved at small scale (2x2cm^2 electrodes) 1,5% achieved at full prototype scale (the above mentioned 9 tiles module).
AIP 2011	Durability	10000 h	10000 h	N/A (prototype will be tested for 1000 h (at the end of the project)

Asterix3

Assesment of SOFC CHP Systems Built in the Technology of HTceramix

AIP / APPLICATION AREA	AIP 2009 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2009.3.5 Proof-of- concept fuel cell systems
START & END DATE	01 Jan. 2011 - 31 Dec. 2014
TOTAL BUDGET	€ 3,096,890.80
FCH JU CONTRIBUTION	€ 1,361,894
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Dantherm Power A/S

Partners: HTceramix, EIFER, CNR ITAE

PROJECT WEBSITE/URL

http://asterix3.eu/

PROJECT CONTACT INFORMATION

peb@dantherm.com
clt@dantherm.com

MAIN OBJECTIVES OF THE PROJECT

The Asterix3 project aims to develop a proof of concept micro CHP system based on SOFC technology with progress beyond state of the art and towards the market requirements.

The requirements are used to create a design specification for all subsystems and finally for the Proof of concept system. Each seperate subsystem has its own set of objectives that is simulated and optimized for the proof of concept system in order to reach longest possible lifetime, high system efficiency and the ability to compete on investment cost with traditional technologies.

PROGRESS/RESULTS TO-DATE

- Subsystem "HoTbox™" has been modified in crucial points.
- All systems have been built, tested and evaluated upon
- Gross system efficiency measured at EIFER @713 W: 44.7%
- A complete CHP system have been built and tested with auxiliary burner and heat storage at Dantherm Power
- A new control system has been developed

FUTURE STEPS

- Bilateral conversations between HTceramix and Dantherm Power will determine whether or not to continue working on the system in the years to come

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- New solutions to improve the SOFC system have been developed within this project. However there is still a lot that has to be done before the system can become introduced to the market on commercial terms

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 AIP 2009	Electrical peak efficiency net AC	Not quantified	< 35%	Gross system efficiency measured at EIFER @713 W: 44.7%
	Electrical efficiency (Nominal average)	Not quantified	< 30%	This have been achieved – however the value was calculated as the PI wasn't available at the time
	Total efficiency of the system	Not quantified	< 90%	EIFER has measured a total efficiency of the system to 78,9 %.

AutoStack-CORE

Automotive Fuel Cell Stack Cluster Initiative for Europe II

AIP / APPLICATION AREA	AIP 2012 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2012.1.2: Next Generation European Automotive Stack
START & END DATE	01 May 2013 - 30 Aug. 2016
TOTAL BUDGET	€ 14,715,529.60
FCH JU CONTRIBUTION	€ 7,757,273
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW)

Partners: Belenos Clean Power Holding, BMW AG, Commisariat à l'énergie atomique et aux énergies alternatives (CEA), Reinz Dichtungs GmbH, European Commission Driectorate Joint Research Centre(JRC-IET), Freudenberg Fuel Cell Components Technologies (FFCCT), Paul Scherrer Institut (PSI), Powercell Sweden AG, Solvicore, Symbio FCell, Volkswagen AG, VOLVO

PROJECT WEBSITE/URL

http://autostack.zsw-bw.de

PROJECT CONTACT INFORMATION

Ludwig Jörissen
Ludwig.joerissen@zsw-bw.de

MAIN OBJECTIVES OF THE PROJECT

Development of an automotive PEM fuel cell stack fulfilling the specifications set out in the Auto-Stack Project (GA 245142) in three evolutions.

Evolutions 1 and 2 will be designed, built and tested in hardware, evolution 2 will be designed.

The stack and key components will be developed to automotive standards.

Component development will be done based on industrial manufacturing concepts.

Cost engineering is carried out, to make sure the design meets automotive cost targets.

PROGRESS/RESULTS TO-DATE

- Target specifications and design for evolution 1 stack and components established and validated
- Benchmark analysis confirming that specifications are state of the art and above
- 20 short stacks and 1 full sized stack assembled and tested for performance and endurance.
- 94 kW continuous power full size stack demonstrated
- Evolution 2 design underway.

FUTURE STEPS

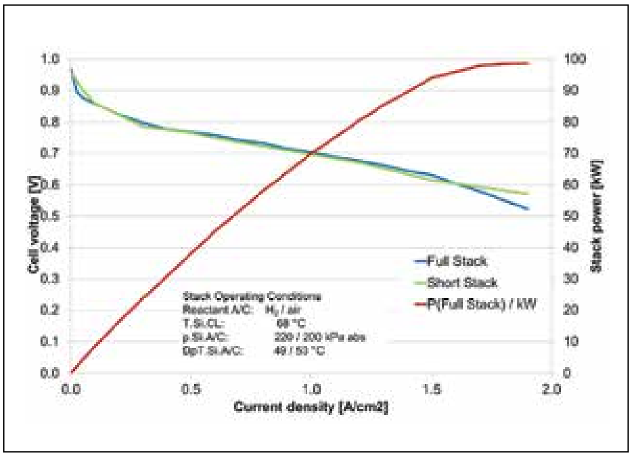
- Completion of evolution 2 design, increasing power density.
- Refinement of cost engineering based on evolution 2 design.
- Manufacturing and testing of evolution 2 design.
- Continuation of benchmark studies.
- Evolution 3 design documentation.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Evolution 1 hardware successfully designed, built and tested as short and full sized stacks 2.0 kW•kg^{-1}, 2.7 kW•l^{-1}, 47.32 €•kW^{-1}
- Successful proof of concept.
- Design based on industrially validated materials and components.
- Optimization potential identified and used for evolution 2.

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
		Integrate fragmented PEM stack research and development activities within Europe	Formation of a consortium of European key players from automotive industry, component manufacturers, stack integrators and research organizations	Consortium formed
AIP 2012	Development of a high power density automotive PEM fuel cell stack	Power 95 kW > 2 kW/kg > 2 kW/l > 5000 h	Final project objectives Power 95 kW 2.15 kW/kg 2.57 kW/l Degradation < 12 µV/h	Evolution 1 results Power 94 kW 2.03 kW/kg 2.7 kW/l Degradation 49.6 µV/h



BeingEnergy

Integrated Low Temperature Methanol Steam Reforming and High Temperature Polymer Electrolyte Membrane Fuel Cell.

AIP / APPLICATION AREA	AIP 2011 / AA 4: Early Markets
CALL TOPIC	SP1-JTI-FCH.2011.4.4 Research, development and demonstration of new portable Fuel Cell systems
START & END DATE	01 Sep. 2012 - 29 Feb. 2016
TOTAL BUDGET	€ 4,220,423.40
FCH JU CONTRIBUTION	€ 2,245,244.00
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Universidade do Porto (UPorto)

Partners: Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Teknologian Tutkimuskeskus VTT (VTT), SerEnergy A/S (Serenergy), Consiglio Nazionale Delle Ricerche (ITM-CNR), Universidad Politecnica de Valencia (UPVLC-ITQ), Inovamais - Serviços de Consultadoria em Inovação Tecnológica S.A.(INOVA+), RHODIA Operations (Rhodia)

PROJECT WEBSITE/URL

http://www.beingenergy.eu/

PROJECT CONTACT INFORMATION

Adélio Mendes
mendes@fe.up.pt

MAIN OBJECTIVES OF THE PROJECT

- Synthesizing, characterizing, and optimizing of catalysts for low temperature methanol steam reforming (LT-MSR, 180 °C) and the developing of strategies for industrial preparation of the selected catalysts;
- Development, characterization and optimization of a cell-reactor for the LT-MSR;
- Integration, characterization and optimization of the low temperature methanol steam reforming reactors with a high temperature polymer electrolyte membrane fuel cell (HT-PEMFC);
- Development, characterization and optimization of the LT-MSR/HT-PEMFC 500 We prototype.

PROGRESS/RESULTS TO-DATE

- The best Cu-based catalyst developed is more active than G66 MR from Süd Chemie, about 2 times more active ($W/F^0 = 30$ kg·mol^{-1}·s, 180 °C and 1:1.5 S/C), and produces less than 1000 ppm of CO at the working conditions;
- A very active Pd/ZnO catalyst has been obtained which is 4 times more active than the Cu/Zn/Al_2O_3 catalyst G66 MR from Süd Chemie;
- The reformer simulator is completed and reformer loaded with first catalyst was studied; a new design for the packed bed reformar was developed;
- Simulator predicting experimental results of combined unit was developed and the characterization of the lab scate intregrated system was performed;
- A newly developed bipolar plate material was tested and the fuel cell stack lifetime has increased; a liquid cooled system with liquid heated reformer

FUTURE STEPS

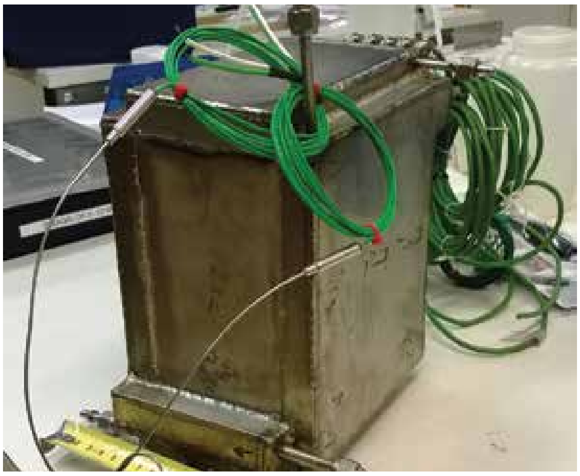
- Optimization and full characterization of the best performing in-house catalyst based on CuZnGa;
- The reformer with new design will be manufatured and integrated in the lab scale combined sytem;
- Optimization of a new energy integrated power supply using a liquid thermal fluid;
- Optimization of startup procedure to reach 15-20 minutes.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Development and characterization of a new and more active catalyst for the methanol steam reforming reaction – 2x more active and producing < 1000 ppm of CO at 180 °C;
- Development of an efficient heat exchange system between the reformer and the fuel cell stack based on a liquid thermal fluid;
- Development of a PPS based bipolar plates for high temperature fuel cells and development of PPS bipolar plates for integrated cellular reformer and fuel cell, benefiting the heat transfer between both reactors and the compactness;
- Fast start-up based on fuel burner and an efficient heat exchange system.

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	Lower emissions and use of multiple fuels	Not applicable	Methanol as fuel	Not applicable
AIP 2011	Electrical efficiency	30%	>35%	>35%
AIP 2011	Lifetime including 100 start-stop cycles	1000 h	>1500 h	Lifetime of fuel reached 8000 hours
AIP 2011	Specific size and weight of less	35 kg/kW and 50 L/kW	< 35 kg/kW and < 50 L/kW	40 kg·kW^{-1} and 77 L·kW^{-1}.



BioRobur

Biogas Robust Processing with Combined Catalytic Reformer and Trap

AIP / APPLICATION AREA	AIP 2012 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2012.2.3: Biogas reforming
START & END DATE	01 May 2013 - 30 Apr. 2016
TOTAL BUDGET	€ 3,843,868.40
FCH JU CONTRIBUTION	€ 2,486,180
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Politecnico di Torino

Partners: Technische Universität Bergakademie Freiberg (DE), Scuola universitaria professionale della Svizzera italiana (CH), Institut de recherches sur la catalyse et l'environnement de Lyon (FR), Chemical Process Engineering Research Institute / Centre for Research and Technology Hellas (GR), Erbicol SA (CH), HySyTech srl (IT) and UAB Modernios E-Technologijos (LT).

PROJECT WEBSITE/URL

http://www.biorobur.org

PROJECT CONTACT INFORMATION

Debora Fino
debora.fino@polito.it

MAIN OBJECTIVES OF THE PROJECT

BioRobur project will develop a robust and efficient biogas reformer aimed at covering a wide span of potential applications, from fuel cells feed (both high temperature SOFC or MCFC fuel cells and low temperature PEM ones, requiring a significantly lower inlet CO concentration) up to the production of pure, PEM-grade hydrogen.

PROGRESS/RESULTS TO-DATE

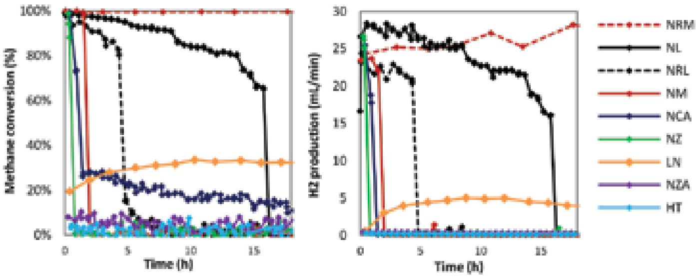
- Two biogas ATR catalysts and two soot trap catalysts have been selected for the final pilot plant testing and related coating routes for the selected.
- Innovative and suitable cellular ceramic supports for ATR catalyst support.
- Lab-scale reactor developed
- Control System and BOP components for the final pilot plant finalized
- LCA analysis (energy)

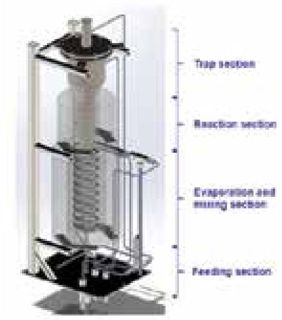
FUTURE STEPS

- Catalyst coating on ATR and Soot Trap supports from lab-scale to the final scale size to test the final Biorobur plant configuration.
- Pilot plant final adaptation.
- Biorobur demonstration plant testing campaign
- LCA analysis completed (energy & materials)
- Dissemination and training activities

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- 15%Ni-0.05%Rh/$MgAl_2O_4$ formulation for ATR is very efficient. High methane conversion even at severe GHSV conditions reached.
- $LiFeO_2$ and $LiCoO_2$ formulations were selected as the most prominent candidates toward to soot gasification.
- Innovative cellular ceramic for ATR catalyst supports selected and tested in two different lab-scale reactors.
- Feed system control strategy, including biogas pre-treatment finalized
- CFD Simulations of the Micro-structural Design of the Cellular Material





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	e.g. FC system life time (h)	>5,000	>10,000	N/A (test not finalized)
AIP 2012	Nominal production rate of pure hydrogen (kg/day)	50-250	100	N/A (test not finalized)
AIP 2012	CO concentration at the reformer exit (vol%) (dry basis)	<10	<10	N/A (test not finalized)
AIP 2012	Biogas to hydrogen conversion efficiency (%)	>65	>65	N/A (test not finalized)
AIP 2012	Materials costs for a 50 Nm^3/h hydrogen production rate (€)	<250.000	150.000	N/A (test not finalized)

BOR4STORE

Fast, Reliable and Cost Effective Boron Hydride Based High Capacity Solid State Hydrogen Storage Materials

AIP / APPLICATION AREA	AIP 2011 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2011.2.4: Novel H_2 storage materials for stationary and portable applications
START & END DATE	01 Apr. 2012 - 30 Sep. 2015
TOTAL BUDGET	€ 4,070,711.30
FCH JU CONTRIBUTION	€ 2,273,682
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Helmholtz-Zentrum Geesthacht GmbH

Partners: Abengoa Hidrógeno SA, Zoz Gmbh, Katchem spol. s.r.o., Aarhus Universitet, Institutt for Energieteknikk, Università degli Studi di Torino, Eidgenössische Materialprüfungs- und Forschungsanstalt, National Centre for Scientific Research "Demokritos"

PROJECT WEBSITE/URL

www.bor4store.eu

PROJECT CONTACT INFORMATION

Dr. Klaus Taube
klaus.taube@hzg.de

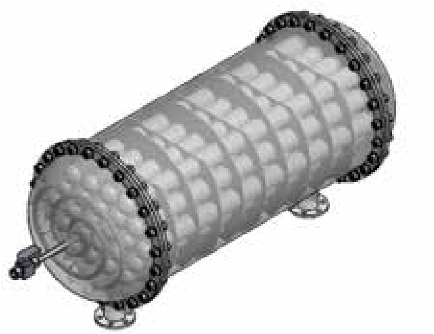
MAIN OBJECTIVES OF THE PROJECT

Development and testing of novel, optimised and cost-efficient boron hydride based hydrogen storage materials with superior performance (materials capacity more than 8 wt.% and 80 kg H_2/m^3) for SOFC applications.

Integration and experimental validation of the performance of a solid state hydrogen storage tank (containing ca. 10 kg storage material, ca. 1 kg H_2) with an SOFC in different conditions of operation.

PROGRESS/RESULTS TO-DATE

- Characterisation of a range of different high capacity boron hydride based hydrogen storage materials
- Characterisation of thermodynamic, kinetic and cycling properties. Scientific understanding of solid state reactions during hydrogenation.



- Selection of most suitable material for storage tank: $LiBH_4/MgH_2$ RHC.: ca. 10 wt.%, ca. 100 kg H_2/m^3. Loading time @ 50 bar < 1 h. Suitable temperature of operation 350 – 600°C, ie. suitable for SOFC application
- Establishment of simulation model of integrated SOFC – metal hydride tank systems. Analysis of different options for heat transfer between SOFC.
- Optimised version of heat exchange for integrated system established. Integrated system under construction.

FUTURE STEPS

- Optimisation of simulation system and verification by experiments
- Testing of prototype of 1.3 kW SOFC –metal hydride tank system with respect to functionality and cycling behaviour of storage material.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Cyclable boron hydride based material with high capacity exists, suitable for construction of solid state hydrogen storage integrated with SOFC, SOEC or other high temperature applications.
- Mechano-chemical processing of storage materials possible below 1 €/kg. Cheaper routes for synthesis of boron containing compounds from e.g. borax ores have to be developed in order to decrease raw materials cost. Also e.g. by use of waste and recycling alloys (e.g. Mg, Al).
- Simulation of material in storage tank and optimisation of thermal integration with SOFC shows feasibility and high energy efficiency of integrated system.
- Application perspectives: hydrogen supplied high temperature fuel cells, power – to – power applications with SOEC and SOFC or reversible SOC systems. Main advantage: high capacity at low refuelling pressures < 100 bar, provision of extra heating and cooling power due to chemical reactions in metal hydride.

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	High capacity hydrogen storage Storage of hydrogen in solid materials: 2010: 3 t cap. | 5 M€/t 2015: 5 t cap. | 1.5 M€/t 2020: 10 t cap. | 0.85 M€/t	Potential for cost below 500 €/kg of stored hydrogen	Capacity 1 kg of hydrogen, potential for cost below 500 €/kg = 5 M€/t	Capacity of several tons of hydrogen (exact number secret) in metal hydride tanks demonstrated in German FC powered submarines before 2010. BOR4STORE storage system will be modular. I.e. can be simply scaled up by multiplying number of modules to required capacity. Current materials cost level ca. 5000€/kg of stored hydrogen. Potential for further cost reduction by using waste and/or recycling materials, mechano-chemical materials processing, series production of storage tank system.
AIP 2011	Capacity	Storage materials with capacities ≥ 6 wt.%, ≥ 60 kg H_2/m^3	capacities of > 80 kg H_2/m^3 and > 8 wt.%	Ca. 100 kg H_2/m^3, 9 – 10 wt.% on materials basis. Capacities on system level to be calculated from final tank system construction.
AIP 2011	Temperature of operation	reversibly releasing hydrogen at operating temperatures compatible e.g. with PEM FC, HT PEM FC or SOFC / MCFC	Release temperature ≤ 450°C (compatible with SOFC)	Release temperature 350 – 450°C. Due to safety considerations, final tank system is designed for a maximum temperature of operation of 650°C.
AIP 2011	Loading and unloading speed	appropriate hydrogen loading and unloading kinetics for the envisaged application	Loading time < 1 h	Loading time < 1 h in materials testing, loading time of storage tank tbd. Tank system constructed such to guarantee a hydrogen flow of ca. 20 Nl/min over several hours of operation.
AIP 2011	Validation	Small scale prototype storage systems with significantly improved storage capacity compared to compressed gas storage (≥ 4 wt.%, ≥ 40 kg H_2/m^3)	Same	Storage system under construction
AIP 2011	Cost	Demonstrate the potential up-scaling for reaching in the long run a target cost of 500 €/kg of stored H_2 at the system level with a significant decrease of overall lifetime cost compared to the state-of-the-art in the special application. Possible integration of thermal energy to the storage system has to be taken into account in the economic assessment	Same	Prototype under construction

CATAPULT

Novel Catalyst Structures Employing Pt at Ultra Low and Zero Loadings for Automotive MEAs

AIP / APPLICATION AREA	AIP 2012 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2012.1.5: New catalyst structures and concepts for automotive PEMFCs
START & END DATE	01 Jun. 2013 - 31 May 2016
TOTAL BUDGET	€ 4,678,599
FCH JU CONTRIBUTION	€ 2,255,690
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: University of Montpellier

Partners: Johnson Matthey Fuel Cells Ltd, Volkswagen, Beneq, Technical University of Munich, Teknologian Tutkimuskeskus, Ulm University, PRETEXO

PROJECT WEBSITE/URL

http://www.catapult-fuelcells.eu

PROJECT CONTACT INFORMATION

Deborah Jones
Deborah.Jones@univ-montp2.fr

MAIN OBJECTIVES OF THE PROJECT

To develop ultra-low Pt loading MEAs using ultra-thin extended film coatings on novel nanostructured supports, and non-PGM catalysts and catalyst layers, to achieve platinum mass activity ≥ 0.44 A/mg Pt and platinum specific power density of ≤ 0.1 g/kW Pt, providing ≥ 2 kW/l in a short stack, demonstrated for complete MEAs on representative power train profiles.

PROGRESS/RESULTS TO-DATE

- Nanofibre supports and tie-layers developed using electrospinning and atomic layer deposition are corrosion-resistant, electronically conducting and scaleable
- Pt films deposited by atomic layer deposition on corrosion resistant fibrous supports display mass activity of 0.5 A/mg Pt.
- Novel non-PGM catalysts with ultra-low Pt content demonstrate high stability in MEAs
- Two patent filings and four journal publications
- Organisation of an international conference «Challenges towards Zero Platinum for Oxygen Reduction» 14-16 September 2015 www.efcd2015.eu, comprising a joint session with FCH-JU SmartCat, NanoCat and CathCat, and a satellite Fuel Cells Fundamentals Short Course on 13/09/2015.

FUTURE STEPS

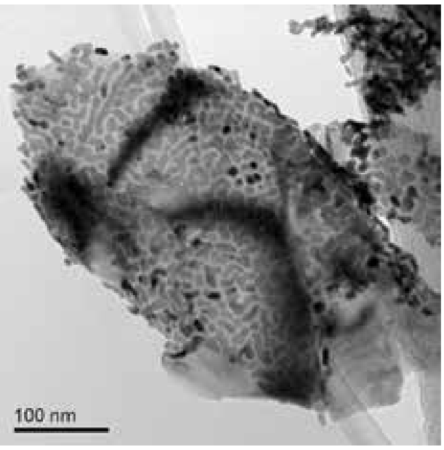
- Pursue process optimisation to obtain ultra-thin continuous Pt films on corrosion-resistant supports by atomic layer deposition and alternative, electrochemical deposition approaches
- Intensify efforts on MEA development and testing using nanofibre supported extended Pt films
- Develop stable hybrid PGM/non-PGM catalysts using most active non-PGM catalysts and initiate catalyst layer optimisation for non-PGM catalyst systems
- Determine structure—reactivity relation of the ORR on low index Pt surfaces using molecular dynamics calculations and pursue development of a voltage breakdown tool
- Evaluate MEAs in larger cell areas and undertake techno-economic assessment

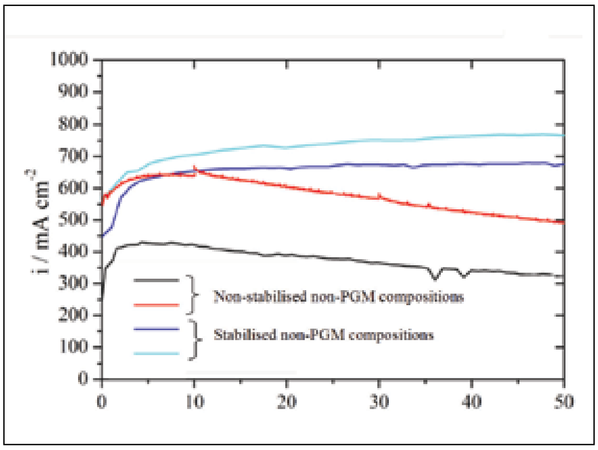
CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- CATAPULT is a very ambitious project covering development of novel nanostructured architectures for fuel cell catalyst materials with extremely challenging technical targets for the new materials and MEAs, as well as a level of scale-up.
- CATAPULT achieved its final mass activity target for nanofibre supported extended Pt films in ex situ electrochemical measurements by the project mid-term stage
- Current focus is on the further challenges presented by catalyst layer development from nanofibre supported extended Pt films to also achieve this target with MEAs
- Focus is also on use of alternative tie-layer compositions favouring Pt deposition as ultra-thin films
- A means to stabilise highly active non-PGM catalysts against voltage loss with time shows high promise for future development

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 life time (h)	>5,000	1000 h (accelerated protocol)	Planned in Project Year 3
AIP 2012	Pt specific power density (g/kW)	<0.1	Mass activity 0.44 A/mg Pt	Mass activity 0.5 A/mg Pt with nanofibre supported extended Pt films
AIP 2012	MEA power density	≥ 1.0 W/cm^2 at 0.67 V	≥ 1.0 W/cm^2 at 0.67 V	Too early to assess





CATHCAT

Novel Catalyst Materials for the Cathode Side of MEAs Suitable for Transportation Applications

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.5 & SP1-JTI-FCH.2011.1.6: Next generation European MEAs for transportation applications
START & END DATE	01 Jan. 2013 - 31 Dec. 2015
TOTAL BUDGET	€ 3,088,327.80
FCH JU CONTRIBUTION	€ 1,895,862.00
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: TU München

Partners: JRC, Université de Poitiers, Danmarks Tekniske Universitet, Chalmers UT, University of Padova, Ion Power, Forth Institute, Toyota Motor Europe

PROJECT WEBSITE/URL

Cathcat.eu

PROJECT CONTACT INFORMATION

Oliver Schneider
oliver_m.schneider@tum.de

MAIN OBJECTIVES OF THE PROJECT

Development of improved MEAs for low and intermediate temperature PEM, based on binary alloy catalysts with reduced Pt loading for the oxygen reduction reaction (ORR), and advanced carbon and oxide-based support materials. DFT calculations suggested a range of Pt and Pd – Rare Earth Element alloy compositions to be studied. Bulk analogues of those were to be manufactured and tested. Good performing materials are produced as catalyst nanoparticles. Synthesis of promising catalysts is up-scaled and integrated with advanced supports into MEAs for single cell testing. Both MEAs based on Nafion and on high temperature polymer electrolytes are applied.

PROGRESS/RESULTS TO-DATE

- Theoretical studies for all Pt-RE alloys of interest were carried out and validated with experimental studies on polycrystalline Pt-RE alloys, indicating that Pt$_5$Gd represents the best comprise between activity and durability, and outperforms Pt by a factor of 5.
- Pt-Gd nanoparticles are 3.6 times more active than Pt nanoparticles, from RDE tests a current density of 0.8 – 1.4 A cm^{-2} at a voltage of 0.9 V can be extrapolated.
- Chemical reduction, reduction in solid state at elevated temperatures and electrochemical deposition were explored to fabricated Pt-RE nanoparticles. Chemical reduction enabled RE-NP formation, but alloy formation was not successful. Solid state reduction resulted in partial formation of Pt-Y- alloy nanoparticles showing electrochemical performance exceeding a benchmark catalyst. Electrochemical deposition from ionic liquids and organic solvents enabled RE metal deposition.
- Modified supported materials have been developed and are now being upscaled for MEA testing with Pt catalyst
- First CathCat catalyst tested in single cell MEA

FUTURE STEPS

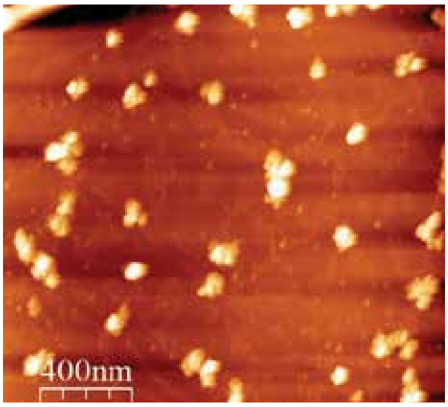
- Upscaling of Pt-Y alloy catalyst for MEA fabrication and subsequent testing
- MEA testing of Pt on NMC support and Pt/doped TiO$_2$-C support.
- Pt-RE NP preparation from ionic liquids/organic solvents and testing in RDE and MEAs
- Completion of studies on model alloys using nanoplasmonic sensing and scanning probe microscopy techniques

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Pt –rare earth alloys represent a group of improved catalysts permitting a reduction of noble metal content of MEAs by a factor of 4-5.
- Modified support materials can cause a further increase in catalytic activity
- Pt-rare earth nanoparticles show the maximum mass activity at larger particle diameter reducing problems with agglomeration
- DFT calculations can serve as a guide for the development of new catalyst materials
- Preparation of these alloys in nanoparticulate form by non-vacuum based methods successful, but not trivial

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 2011	Pt loading	<0.15g/kW	<0.1 g/kW	0.4 g/kW (0.4 mg/cm^2)
AIP 2011	BOL efficiency	>55%	>55%	56% at 1 A cm^{-2}; 50% @ 1.5 A cm^{-2}
AIP 2011	BOL Power	>1 W cm^{-2} @ 1.5 A cm^{-2}	>>1 W cm^{-2} @ 1.5 A cm^{-2}	0.9 W cm^{-2} @ 1.5 A cm^{-2}
MAIP 2008-2013	Life Time	>5000h	>5000h	N/A (test not finalized)



CHIC

Clean Hydrogen in European Cities

AIP / APPLICATION AREA	AIP 2009 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2009.1.1 Large-scale demonstration of road vehicles and refuelling infrastructure II
START & END DATE	01 Apr. 2010 - 31 Dec. 2016
TOTAL BUDGET	€ 81,8 million
FCH JU CONTRIBUTION	€ 26 million
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: EVOBUS GMBH

Partners: AIR PRODUCTS PLC, AZIENDA TRASPORTI MILANESI, BERLINER VERKEHRSBETRIEBE, ELEMENT ENERGY LIMITED, AIR LIQUIDE ADVANCED BUSINESS, HyCologne - Wasserstoff Region Rheinland e.V., INFRASERV GMBH & CO. HOCHST KG, BRITISH COLUMBIA TRANSIT, LINDE AG, LONDON BUS SERVICES LIMITED, THINKSTEP AG, PLANET PLANUNGSGRUPPE ENERGIE UND TECHNIK GBR, POSTAUTO SCHWEIZ AG, SHELL DOWNSTREAM SERVICES INTERNATIONAL BV, Spilett new technologies GmbH, SUEDTIROLER TRANSPORTSTRUKTUREN AG, TOTAL DEUTSCHLAND GMBH*TD, UNIVERSITAET STUTTGART, Vattenfall Europe Innovation GmbH, RUTER AS, Wrightbus Ltd, hySOLUTIONS GmbH

PROJECT WEBSITE/URL

www.chic-project.eu

PROJECT CONTACT INFORMATION

e-mail: h2businfo@chic-project.eu
Twitter: @CHICproject

MAIN OBJECTIVES OF THE PROJECT

- Implementation of clean urban mobility in 5 major EU regions through the deployment of 26 fuel cell electric buses (provided by different bus manufacturers) and hydrogen refueling stations
- Collaboration, transfer and securing of significant key learning from experimented cities included in the project (4 cities and 34 buses)
- Facilitation of the development of clean urban public transport systems into new EU regions
- Greater community understanding of "green" H_2 powered fuel cell buses, leading to increased political acceptance and commitment

PROGRESS/RESULTS TO-DATE

The CHIC project has demonstrated that the 36 fuel cell buses currently in operation can offer:

- Same operating range as a diesel bus demonstrated (up to 400km)
- Successful integration of hydrogen refuelling stations into busy bus depots, the stations show short refuelling (<10 min to completely refuel a bus) and high availability (>95%)
- High fuel efficiency with an average of 9kg of hydrogen/100km for 12m buses – which makes them 25 to 30% more energy efficient than their diesel counterparts
- Fuel cell buses achieve lower CO2 emissions than diesel buses of between 10 and 100%, depending on the primary energy source used for hydrogen generation.
- Most of the CHIC technical target have been hit (status April 2015):

PARAMETERS	TOTAL PHASE 1	PROJECT TARGET
Number of hours on the fuel cell system	166,250	160,000
Average fuel cell runtime per bus (hours)	6,394	6,000
Replacement of diesel fuel (litres)	1,054,210	500,000

FUTURE STEPS

- The CHIC cities are currently assessing the opportunity to continue the operation of fuel cell buses after the end of the project in December 2016 and to add fuel cell buses to their current bus fleet. Most of them are participating in the FCH JU Fuel Cell Bus Commercialisation Study, which is making plans to deploy a larger pan-European fleet of 500-buses by 2020, with the explicit aim of realising cost reduction
- Three additional EU-funded projects deploying fuel cell buses have started since the inception of CHIC: High V.LO-City, HyTransit and 3Emotion, while other fuel cell buses are in operation in Germany and worldwide. The CHIC project partners have developed materials ready to be shared with them and with cities interested in fuel cell bus deployment on HRS implementation procedures and investments, analysis on bus workshops investments, lessons learnt on trainings etc.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

CHIC has proved that fuel cell buses have the potential to be operated with the same operational flexibility as a conventional diesel bus, whilst offering: zero tailpipe emissions, contribution to decarbonisation of transport, reduced noise and vibration levels.

The following aspects will need to be tackled to allow a wider deployment:

1. Cost reductions, technical availability improvement (including spare parts availability) and harmonisation of regulations: The purchasing cost of a bus has been cut by 50% since 2011. Further cost reductions are required to allow for widespread deployment; these will be achieved within the FCH JU Fuel Cell Bus Commercialisation Study, a partnership between industry and local authorities (most of the CHIC cities are partners), which plans an expansion of the European fuel cell bus fleet to 500 by 2020
2. Further increase in availability: numerous technology teething issues have been resolved within CHIC and partners expect a diesel equivalent availability to be reached with increased scale in the supply chain
3. Regulations on designs for large hydrogen fuelling station, construction and safety need to be harmonised at an EU and international level– Key stakeholders are working on EU/international standards to simplify procedures and decrease cost

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
H_2-Infrastructure				
AIP 2009	H_2-Fuelling capacity	200 kg/day	200kg/day	All Phase 1 cities have reached the required refuelling capacity
AIP 2009	Availability of H_2-Refuelling station	98%	98%	> 98% at most sites > 92% at all sites about 96% across all sites
AIP 2009	H_2 OPEX (Operational Expenses)	<10EURO/kg	<10EURO/kg	All available OPEX figures from the Phase 1 Sites currently exceed the 10 €/kg target. This is partly due to low capacity factors of the units for on-site generation and therefore likely to improve with expected higher availabilities of the buses.
AIP 2009	H_2 purity and vehicle refuelling time	According to SAE or analogous specification	According to SAE or analogous specification	Not all contaminants can currently be measured with the accuracy stipulated in SAE J2719.
AIP 2009	H_2-Production efficiency	50-70%	50-70%	> 50% except one site
Additional target	Replacement of Diesel fuel		500.000 l	Phase 0 cities: 3.083.202 (as for April 2015) Phase 1 cities: 1.041.337 (as for April 2015)
Fuel Cell Buses				
AIP 2009	Fuel Cell life time	>6000 h	>6000 h	7306 h/bus (as for Apr 2015) excluding ICE buses in Berlin
AIP 2009	Fuel Cell Bus availability	>85%	>85%	68% based on operation time (as for Apr 2015)
AIP 2009	H_2-Consumption	<11-13kg/100km depending on drive cycle	<13kg/100km depending on drive cycle	12,0 kg/100km (only FC buses) (as for Apr 2014)
Additional target	Minimum running distance of fleet		2,75 Million km	7,89 Million km (as for Apr 2015)
Additional target	Minimum operation hours of fleet		160.000 h	394.541 h (as for Apr 2015)

CISTEM

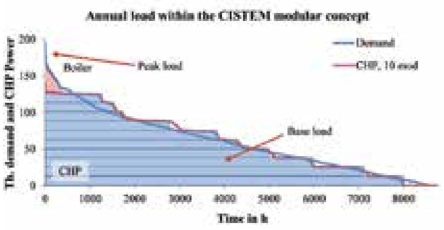
Construction of Improved HT-PEM MEAs and Stacks for Long Term Stable Modular CHP Units

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

Peter Wagner
Peter.wagner@next-energy.de

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.

COBRA

Coatings for Bipolar Plates

AIP / APPLICATION AREA	AIP 2013 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SPI-JTI-FCH.2013.1.2: Research & Development on Bipolar Plates for PEM fuel cells
START & END DATE	01 Apr. 2014 - 31 Mar. 2017
TOTAL BUDGET	€ 3,809,234
FCH JU CONTRIBUTION	€ 2,339,595
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA

Partners: BORIT, IMPACT COATINGS, SFC, CIDETEC, INSA LYON

PROJECT WEBSITE/URL

www.cobra-fuelcell.eu

PROJECT CONTACT INFORMATION

Gilles Moreau
Gilles.moreau1@cea.fr

MAIN OBJECTIVES OF THE PROJECT

The COBRA proposal aims to develop best-of-its-class bipolar plates for automotive stacks with superior corrosion resistance (corrosion <1μA/cm^2), higher conductivity (<25mOhm.cm^2) and durability (>5000h) while meeting commercial target cost (price <2,5€/kW). The project has a multidisciplinary character which implies joint efforts of specialists from various areas: chemistry, physics, material science, fuel cell engineering. Thus the COBRA consortium combines the collective expertise of bipolar plate and coating suppliers, system integrators and research institutes and thus removes critical disconnects between stakeholders.

PROGRESS/RESULTS TO-DATE

- Reference plates have been manufactured and tested on field in automotive and marine conditions.
- A complete post-mortem analysis has been done allowing new observations and understandings on corrosion topic.
- A model of Fuel Cells and Bipolar Plates ageing has been improved including corrosion behaviour.
- First coatings developments are on-going, with first results being very promising.

FUTURE STEPS

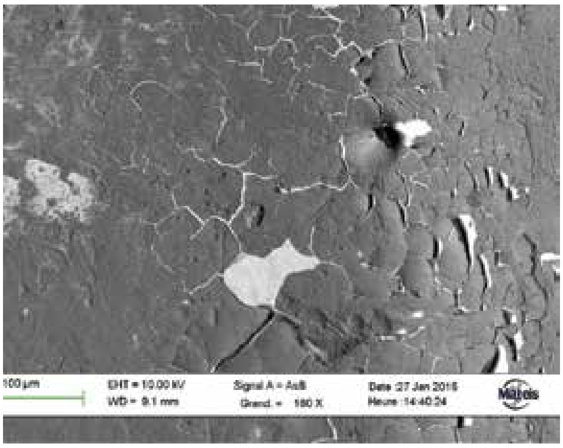
- Innovative manufacturing process and coatings will be further developed.
- As soon as the best coatings are defined, new plates will be manufactured
- New stacks, including innovative coatings, will be tested on-field in same conditions has references plates.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Corrosion mechanisms understanding
- Ageing tests developments
- Innovative coatings developments
- Innovative coatings commercialization

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	Durability (h)	>5,000	>5,000	N/A (test not finalized)
AIP 2013	Corrosion, anode (μA/cm2)	<10	<10	N/A (test on-going)
AIP 2013	Corrosion, cathode (μA/cm2)	<10	<10	0,77 (in FC conditions – to be compared to gold value: 0.72)
AIP 2013	Areal specific resistance (mΩ.cm2)	<25	<25	11
AIP 2013	Cost (for a production of 500.000 units)	<2,5€/kW	<2,5€/kW	N/A (study not finalized)



CoMETHy

Compact Multifuel-Energy to Hydrogen Converter

AIP / APPLICATION AREA	AIP 2010 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2010.2.2: Development of fuel processing catalyst, modules and systems; SP1-JTI-FCH.2010.2.3: Development of gas purification technologies.
START &END DATE	01 Dec. 2011 - 31 Dec. 2015
TOTAL BUDGET	€ 4,933,250.39
FCH JU CONTRIBUTION	€ 2,484,095.00
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: ENEA

Partners: Processi Innovativi Srl., Acktar Ltd., Technion, Fraunhofer IKTS, University of Salerno, CERTH, Aristotle University of Thessaloniki, University "La Sapienza", ECN, GKN Sinter Metals Engineering GmbH, University Campus Bio-medico" of Rome

PROJECT WEBSITE/URL

www.comethy.enea.it

PROJECT CONTACT INFORMATION

Alberto Giaconia
alberto.giaconia@enea.it

MAIN OBJECTIVES OF THE PROJECT

CoMETHy aims at developing a flexible membrane reformer operating at "low temperatures" (< 550°C), to convert different fuels (methane, ethanol, etc.) and adaptable to different heat sources (solar, biomass, fossil, etc.). Molten salts (MS) are used to collect and store the heat from concentrating solar plants (CSP) or alternative sources like biomass or Refuse Derived Fuel (RDF). The MS stream provides the process heat to the steam reformer, steam generator, and other unit operations.

This low temperature steam reforming (400-550°C rather than conventional 850-950°C) allows material cost reduction and leads to a compact device for multi-fuelled hydrogen production.

PROGRESS/RESULTS TO-DATE

- Advanced multi-fuel catalysts for methane/biogas and ethanol steam reforming at 400-550°C developed with enhanced heat transfer, low pressure drops, satisfactory catalytic activity.
- Suitable Pd-based hydrogen selective membranes identified and tested.
- Innovative molten salts heated membrane reformer designs developed and reactor prototypes successfully tested at the bench scale under representative operative conditions
- Pilot plant (2 Nm3/h of pure hydrogen production) constructed and ready for operation
- Techno-economic evaluation on CoMETHy solar steam reforming process resulted in competitive hydrogen production costs

FUTURE STEPS

- Completing operational tests of the pilot membrane reformer (2 Nm^3/h of pure hydrogen production) for PoC
- Completing the techno-economic optimization of the process under different operative conditions

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- CoMETHy is successfully achieving its objectives
- Besides the specific application to solar reforming, CoMETHy's findings have impact on catalyst and membrane technology, innovative reactor design, and small reformers
- Demonstration in relevant industrial environments is expected: industrial large scale hydrogen production by solar steam reforming and decentralized (small/medium scale) hydrogen production in refuelling stations

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	H_2 production from RES	Up to 50% of the H_2 energy suplied from RES; decarbonisation of transport; CO_2 lean or CO_2 free H_2	38% up to 100% reduction of CO_2 emissions and fossil fuel use in steam reforming processes using RES	Reactor prototypes proved the feasibility of the solar SMR, with 38-53% CO_2 emissions saving with respect to the traditional route. Reforming of biofuels (biogas, bioethanol) proved too, obtaining 100% renewable H_2.
MAIP 2008-2013	Materials performance	For decentralized production ... more cost efficient, high performance materials (e.g. membranes)	Proof of catalysts and membranes stability over 250 hours	Developed catalysts and membranes proved stable over 250 hours-on-stream. However, long-term durability of membranes needs to be improved.
MAIP 2008-2013	SMR process efficiency	By 2020: centralized SMR (CCS ready) efficiency > 72% and decentralized biogas SMR efficiency > 67%	SMR efficiency >70%	Process evaluations and experimental results lead to SMR efficiency (LLV base) > 70% when the plant capacity is > 5,000 Nm^3/h.
AIP 2010	Simplification and compactness of reactor design	Scalability from 2 to 750 Nm^3/h (hydrogen production rate)	PoC of one module with > 2 Nm^3/h hydrogen production	A compact reactor developed: one unit to achieve reforming, water-gas shift and H_2 separation. PoC with small prototypes successful, pilot reformer constructed.
AIP 2010	High performance reforming catalysts	Reforming catalysts with shift activity to get CO concentration < 10 vol%	CO concentration < 10 vol% in the gas product	Developped SMR catalysts lead to CO content < 5%vol, thus avoiding the need of shift reactors.
AIP 2010	Replacement of components	Catalyst replacement time < 4 hours	Catalyst replacement time < 4 hours	Replacement time for all catalysts and membranes in the pilot reactor lasted < 2 hours.

COPERNIC

Cost & Performances Improvement for CGH_2 Composite Tanks

AIP / APPLICATION AREA	AIP 2012 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2012.1.3: Compressed hydrogen on board storage (CGH_2)
START & END DATE	01 Jun. 2013 - 31 May 2016
TOTAL BUDGET	€ 3,445,217
FCH JU CONTRIBUTION	€ 2,005,396
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA

Partners: RAIGI, SymbioFCell, Wroclaw University of Technology, Seifert & Skinner & Associates, H_2LOGIC, ANLEG

PROJECT WEBSITE/URL

http://project-copernic.com/

PROJECT CONTACT INFORMATION

Fabien NONY
fabien.nony@cea.fr

MAIN OBJECTIVES OF THE PROJECT

The tank systems are likely to be greatly improved by means of:

- Enhanced materials (resins, partial replacement of carbon fibre with cheaper carbon grades, inserts)
- Innovative components (all-in-one on-tank valve with built-in pressure regulation, design with reduced number of parts, improved metal forming process, on/off board structural health monitoring)
- Enhanced composite design (less C-fibre, improved geometries, weight and volume reduction, maximum performance translation from fibre to composite, minimum degradation through processing)
- Improved composite quality (tank performance repeatability, porosity, ply thickness, reduced discrepancies between calculated and manufactured structures, quality control)
- Higher manufacturing process control and productivity (automation, improved winding numerical control)

PROGRESS/RESULTS TO-DATE

- Performance indicators defined and used for trade-off assessment and choice of alternative materials (fibre, resin)
- Improved low and high temperature behaviour of COPV (extreme temperature pressure cyclic test)
- Alternative pressure vessel geometries identified and benefit assessed compared SoA
- Optimized equipment configuration and winding patterns for fast robotic filament winding realised
- Integration of optical fiber based Structural Health Monitoring system with COPV (monitoring of manufacturing process, proof test)

FUTURE STEPS

- Conclusion on enhanced materials characterization
- Validation of optimized composite architecture and operational performance of COPV
- Conclude on multiscale model approach benefit compared to SoA
- Qualification of fully integrated on-tank-valve
- Validation of SHM system during COPV operation (cycling test)

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Significant improvements of COPV manufacturing are feasible
- 15% Carbon Fiber weight reduction is achieved
- Benefit of SHM through whole product life (from manufacturing to end of life) is under assessment
- Extensive cost/performance assessment methodology developed and applied to the project with respect to SoA and Specifications

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	Design and test criteria for high-pressure composite		Contribution to the advancement of relevant test methods by generation of accurate data material and processes sensitivity to tank performance and safety.	• Improvement of low and high temperature behaviour of COPV (extreme temperature pressure cyclic test). • Fulfilling of EC79 requirements for a chemical exposure test. • Monitoring strategies applied on COPV during testing to generate accurate data on materials and design behaviour • Identification and quantification of temperature increase inside COPV during extreme temperature cycling => potential feedback to Standard WG
AIP 2012	Development activities on materials		Assess alternative materials with the target to improve performance/cost ratio	• First choice of alternative materials selected • Vessels manufactured for alternative resin and fiber candidates. Behaviour is under characterization.
AIP 2012	Lower cost production processes		Assess manufacturing technology improvement strategies Reduce cost of metal bosses by a factor of 5	• Ongoing comparative assessment of conventional Vs. innovative winding technologies • Filament winding equipment upgraded and manufacturing cycle time reduction achieved • alternative boss manufacturing process under assessment. Optimization of boss design is ongoing in parallel to maximize performance/cost ratio and implement manufacturing process constraints
AIP 2012	Improved complete tank systems and related components characterised by reduced weight and volume. Pressure regulators, valves, sealing...	Gravimetric system density>4.8	• Improved composite designs for 15% weight savings • Increased gravimetric storage density system >4.8%wt • 20-30% cost reduction for innovative pressure components	• Improved design with >15% carbon fiber weight savings achieved • 5%wt achieved at tank level (37L@70MPa, still under optimization) • 4,4%wt achieved on system level (37L@70MPa, without Copernic OTV results) • Material characterization for improved hydrogen tightness • GHR exited the project at M18. Entrance of ANLEG is under validation by FCH to take over pressure component activities • OTV design defined. Waiting for FCH process validation to start the testing. Design compatible with targets.
AIP 2012	On- or off-board diagnosis systems for containers		Develop and assess non-destructive evaluation methods for structural health monitoring of COPV	Integration of SHM system during a high-pressure composite vessel manufacturing process (in order to control & improve it) and next use for monitoring of COPV integrity during proof test and regular operation (inspection of composite degradation during pressure loading: cyclic and static).

DEMCOPEM-2MW

Demonstration of a Combined Heat Power 2 MWe PEM Fuel Cell Generator and Integration into an Existing Chlorine Production Plant

AIP / APPLICATION AREA	AIP 2013 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2013.3.5 Field demonstration of large scale stationary power and CHP fuel cell systems
START & END DATE	01 Jan. 2015 - 31 Dec. 2018
TOTAL BUDGET	€ 10,524,200.40
FCH JU CONTRIBUTION	€ 5,466,525.00
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Akzo Nobel Industrial Chemicals B.V.

Partners: Nedstack Fuel Cell Technology B.V., MTSA Technopower B.V., Johnson Matthey Fuel Cells Limited, Politecnico di Milano

PROJECT WEBSITE/URL

www.demcopem-2mw.eu

PROJECT CONTACT INFORMATION

Nick Miesen: nick.miesen@akzonobel.com
Anna Molinari: Anna.molinari@akzonobel.com

MAIN OBJECTIVES OF THE PROJECT

The project main objective is to design, construct and demonstrate an economical combined heat and power PEM fuel cell power plant (2 MW electrical power and 1.5 MW heat) and integration into a chlor-alkali (CA) production plant. The project will demonstrate the PEM Power Plant technology for converting the hydrogen into electricity, heat and water for use in the chlor-alkali production process, lowering its electricity consumption by 20%.

The demonstration will take place in China as this is the ideal starting point for the market introduction.

PROGRESS/RESULTS TO-DATE

- Project website
- Basic design of PEM-unit ready
- Hazard and Operability Analysis
- Decision DC-DC or DC-AC conversion
- Model of integrated PEM-unit

FUTURE STEPS

- Validation of MEA design
- Stacks preparation
- Factory Acceptance Test of Unit
- Units shipment to China
- Installation by chlorine factory

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Industrial fuel cell system, rated at 2 MWe, and 1.5 MW heat fully integrated into the chlorine plant.
- Conversion to heat and power of the by-product/waste hydrogen and restitution of the energy content of the by-product/waste hydrogen to the production process
- Demonstration of the lifetime of PEM fuel cells well beyond 16,000 hours is one of the main objectives.
- Automatic operation with remote monitoring, backed-up by an advanced data-acquisition system that will enable improvement of parameters during the period of demonstration.
- Contribution to the general goals of the JTI FCH, as stated in the revised Multi Annual Implementation Plan, to have > 5 MW @ € 3,000/kW installed fuel cell capacity in 2015 and > 50 MW @ € 1,500/kW installed fuel cell capacity in 2020.

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 2008-13	Stationary Power Generation & CHP Industrial/Commercial, H_2 based	1 MW / 4,500 €/kW (baseline) >5 MW / 3,000 €/kW (2015 mid-term) 50 MW / 1,500 €/kW (2020 long-term)	2 MW / < 2,500 €/kW and potential for 20 more similar sized PEM power plants Commercial Introduction in 2017 and stepwise cost reductions to reach < 1,500 €/kW	N/A (tests not completed, project started in Jan 2015)

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

demstack.iceht.forth.gr

PROJECT CONTACT INFORMATION

Stylianos Neophytides
neoph@iceht.forth.gr

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

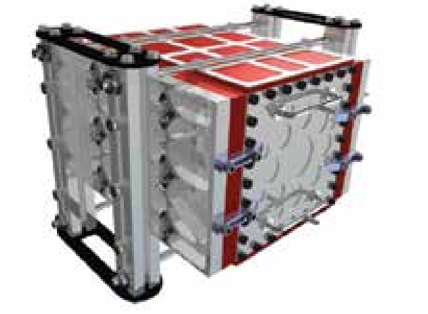
- Scaling up of the component materials of the MEAs (PEMs and electrocatalysts) has been performed.
- Best performing MEAs have been selected
- Different designs for the bipolar plates, fuel cell stack and fuel processor have been completed.
- Two high temperature stacks of 1 kW are currently under construction.

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)

DESTA

Demonstration of 1st European SOFC Truck APU

AIP / APPLICATION AREA	AIP 2010 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2010.1.5: Auxiliary Power Units for Transportation Applications
START & END DATE	01 Jan. 2012 - 30 Jun. 2015
TOTAL BUDGET	€ 9,841,007
FCH JU CONTRIBUTION	€ 3,874,272
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: AVL List GmbH

Partners: Eberspächer Climate Control Systems, GmbH & Co KG, Topsoe Fuel Cell A/S, Volvo Technology, AB, Forschungszentrum Jülich

PROJECT WEBSITE/URL

www.desta-project.eu

PROJECT CONTACT INFORMATION

Jürgen Rechberger
juergen.rechberger@avl.com

MAIN OBJECTIVES OF THE PROJECT

Demonstration of the first European SOFC APU on a Volvo HD truck, 1 year testing of 6 APU systems (3 of Eberspächer and 3 of AVL), Development and assembly of the final DESTA SOFC APU system, merging the most promising approaches of AVL and Eberspächer SOFC APU concepts, Significant improvements of SOFC stacks operated on diesel fuel.

PROGRESS/RESULTS TO-DATE

- Optimized DESTA APU systems developed and assembles
- Automotive laboratory tests performed (vibration, salt spray)
- APU integrated into Volvo heavy duty truck
- Truck daily operation test performed
- SOFC APU technology successfully demonstrated for heavy duty trucks

FUTURE STEPS

Project ended (30th of June 2015)

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Sucessful truck demonstration
- Proven daily use of APU products
- Technical performance targets demonstrated
- Difficult business case for application in heavy duty trucks
- ASC stack technology seems to have some limitations towards start-up time & cost

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	Electric System Efficiency	35%	35%	30%
AIP 2010	Anticipated Lifetime	>20.000h	>10.000h	2000h
MAIP 2008-2013	Emmission Reduction	Less than current	75%	70%
AIP 2010	Technology cost	<1000€/kW	<1000€/kW	~1500€/kW

DIAMOND

Diagnosis-Aided Control for SOFC Power Systems

AIP / APPLICATION AREA	AIP 2013 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2013.3.3 Stationary Power and CHP Fuel Cell System Improvement Using Improved Balance of Plant Components/ Sub-Systems and/or Advanced Control and Diagnostics Systems
START & END DATE	01 Apr. 2014 - 31 Mar. 2017
TOTAL BUDGET	€ 3,613,488.40
FCH JU CONTRIBUTION	€ 2,101,808.00
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: HyGear

Partners: COMMISSRIAT A L ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES, TEKNOLOGIAN TUTKIMUSKESKUS VTT, UNIVERSITA DEGLI STUDI DI SALERNO, HTceramix SA, INEA INFORMATIZACIJA ENERGETIKA AVTOMATIZACIJA DOO, INSTITUT JOZEF STEFAN

PROJECT WEBSITE/URL

http://www.diamond-sofc-project.eu/about/

PROJECT CONTACT INFORMATION

Ellart de Wit
Ellart.dewit@hygear.nl

MAIN OBJECTIVES OF THE PROJECT

The DIAMOND project aims at improving the performance of solid oxide fuel cells (SOFCs) for CHP applications by implementing innovative strategies for on-board diagnosis and control. Advanced monitoring models will be developed to integrate diagnosis and control functions with the objective of having meaningful information on the actual state-of-the-health of the entire system. The new concepts will be validated using two different SOFC systems.

PROGRESS/RESULTS TO-DATE

- List of faults and failures of SOFC CHP systems
- Definition of the operating windows of the test systems
- Review of existing control and diagnostic methods
- Definition of testing protocols
- Preparation of fault signature matrices, low level control schemes and soft sensors

FUTURE STEPS

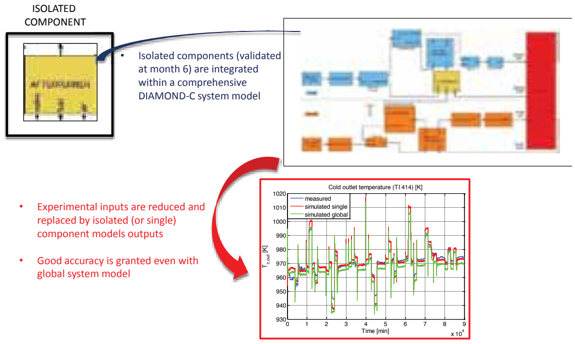
- Diamond A and C system testing for model data acquisition
- Development and implementation of advanced supervisory control
- Implementation of selected FDI schemes
- Evaluation of implemented control and FDI algorithms on the Diamond A and C systems
- Fault Signature Matrices for both Diamond C and A systems

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Several system characteristics have been made and validated with real-world system data (O/C, stack temp., reformer operation)
- It is recognized that a high-level control and FDI management system is necessary for system operation optimization
- Low-level control was designed and verified on the SOFC stack model. It provides much better stack temperature control and system efficiency than the open-loop operation. The low-level control will be upgraded with the supervisory controller which will be able to monitor and control the overall SOFC system 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	Electric efficiency	35%-45%	50%	No system test done yet Diamond C system net efficiency of >50% was first documented in 2013.
MAIP 2008-2013	Durability	30,000 hrs.	10 years, >85,000 hrs.	No system test done yet
AIP 2013	Advanced controls and diagnostics	Capable of optimizing efficiencies	Strategies to guarantee optimal operation	Diagnostic tools are being developed • Soft sensors for determining maximum stack temperature and O/C ratio developed • Applicability of THDA explored from SRU to stack level System model validated Low-level feedforward-feedback control loop designed A dynamic model of Diamond C system has been developed and validated: The model is being exploited to design the control and diagnostic strategies; Control-oriented models are being developed for real-time monitoring. FSM development procedure through FTA and model simulations has been defined.
AIP 2013	System life > 10 years for smaller-scale applications	> 10 years for smaller-scale application	10 years	No system test done yet



- Isolated components (validated at month 6) are integrated within a comprehensive DIAMOND-C system model

- Experimental inputs are reduced and replaced by isolated (or single) component models outputs
- Good accuracy is granted even with global system model

Don Quichote

Demonstration of New Qualitative Innovative Concept of Hydrogen Out of Wind Turbine Electricity

AIP / APPLICATION AREA	AIP 2011 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2011.2.1: Demonstration of MW capacity hydrogen production and storage for balancing the grid and supply to a hydrogen refuelling station
START & END DATE	01 Oct. 2012 - 30 Sep. 2017
TOTAL BUDGET	€ 4,946,134
FCH JU CONTRIBUTION	€ 2,954,846
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Hydrogenics Europe NV

Partners: Hydrogen Efficiency Technologies (HyET) BV, WaterstofNet vzw, Etablissementen Franz Colruyt NV, TUV Rheinland Industrie Service GmbH, Joint Research Centre – European Commission, Thinkstep, Icelandic New Energy Ltd, Federazione delle Associazioni Scientifiche e Techniche (FAST)

PROJECT WEBSITE/URL

http://www.don-quichote.eu/

PROJECT CONTACT INFORMATION

Johan Seykens (Hydrogenics Europe NV)
jseykens@hydrogenics.com

MAIN OBJECTIVES OF THE PROJECT

The Don Quichote project complements and expands existing hydrogen refuelling system in Halle, Belgium, with innovative, components: a PEM electrolyser, a fuel cell re-electrification unit and an electrochemical compressor. Integration with a windmill, realizes hydrogen based energy storage. The hydrogen refuels forklifts at 350bar or produces electricity. The whole system is evaluated in terms of performance, carbon footprint, regulation issues and business potential. It combines targets on increasing renewable electricity, grid balancing, sustainable mobility and using 100% green hydrogen in an obvious way.

PROGRESS/RESULTS TO-DATE

- Regular performance and cost monitoring via validated LCA (Life Cycle Analyses) software
- Development, construction, delivery and site operation of a PEM electrolyser (30 Nm^3/h, 10 bar)
- Development and construction of a Fuel Cell outdoor system (120kW)
- LCA analysis performed
- Development of registration plan and operational diary for TCO (Total Cost of Ownership)

FUTURE STEPS

- Continuous monitoring of extension including PEM electrolyser and fuel cell stack
- Construction and on-site installation of the electrochemical compressor,
  60 kg/day, 450 bar
- Continuous performance monitoring of the system with electrochemical compression included (final Phase)
- Detailed yearly datasets on the performance of the plant

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Good view of regulatory hurdles
- Realistic costing of hardware and installation
- Excellent performance of PEM electrolyser and ease of operation
- Prospect on detailed data for TCO assessment

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 2011	efficiency (WtT; well to tank) > 55 %	> 10 years	electrolyser 69% compressor 85	Stack at 77% efficiency (full production). BOP: to be monitored
AIP 2011	cost of hydrogen delivered	<15€/kg	<13€/kg	Related to cost of renewable energy. Phase 2 TCO analysis in progress Phase 3 demo cost unclear
AIP 2011	Hydrogen production facility turn-key CAPEX (capital expenditures):	3.5 M€/(t/d) (i.e. 1.7 M€/MWel)	3.5 M€/(t/d) (i.e. 1.7 M€/MWel)	To be assessed during economical evaluation end project
AIP 2011	hydrogen quality	ISO/DIS 14786-2 compliant	ISO/DIS 14786-2 compliant	PEM unit qualified Compressor to be done
AIP 2011	Availability	>95%	>95%	Succesfull site acceptance test. Measurements phase II starting Q3,2015

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

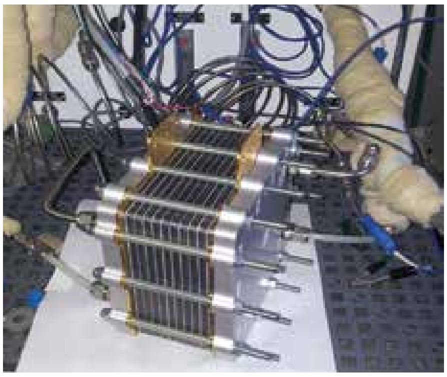
http://www.duramet.eu

PROJECT CONTACT INFORMATION

Dr. Antonino Salvatore Arico'
Tel. +39090624237

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.

EDEN

High Energy Density Mg-Based Metal Hydrides Storage System

AIP / APPLICATION AREA	AIP 2011 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2011.2.4: Novel H_2 storage materials for stationary and portable applications
START & END DATE	01 Oct. 2012 - 31 Jan. 2016
TOTAL BUDGET	€ 2,653,574.00
FCH JU CONTRIBUTION	€ 1,524,900.00
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Fondazione Bruno Kessler

Partners: MBN Nanomaterialia SPA, Cidete Ingenieros SL, Matres SCRL, Panco GmbH, Universidad de la Laguna, Joint Research Centre – Institute for Energy and Transport

PROJECT WEBSITE/URL

www.h2eden.eu

PROJECT CONTACT INFORMATION

Luigi Crema
Crema@fbk.eu

MAIN OBJECTIVES OF THE PROJECT

Main objective of EDen project: develop a new storage material with high hydrogen storage capacity, manageable in real-time, for distributed applications, on a storage tank. It will be interlinked to an energy provision system able to match intermittent sources with local energy demand. The target values are:

- Material: Storage capacity: >6.0 wt.%, Density : >80 g/l, Desorption rate : >3 g/min, Cost : <30€/kg;
- Tank: Storage capacity: 4.0 wt.%, Density : 40 g/l, Absorption heat recovery : 25%, Hydrogen stored : 600g, Desorption rate : 1,5g/min
- System : Heat recovery, Safety, SOFC performance : >300 mW/cm^2 , Performance loss : <10%/year

PROGRESS/RESULTS TO-DATE

- The improved material has been realized both with standard and sputtered catalysts added;
- Intermediate and full Storage Tanks realized, integrated of all thermal and hydrogen management components, able to release more than 1,5 litres per minute;
- System integration layout comprised of all auxiliaries to properly manage hydrogen and thermal power between the hydrogen tank and the SOFC;
- Full scale POWER TO POWER system, using HT electrolyzer / fuel cell and solid state integrated storage

FUTURE STEPS

- Test and validate the material in the full scale storage tank along long term tests
- Demonstrate the power to power technology in real environment

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The Mg-metal hydride has been demonstrated to have 7,1 % weight of storage capacity and a reaction kinetic able to release 2,0 litres per minute of hydrogen
- Innovative catalyst addition process realized, qualified and first samples realized and validated with improved reaction kinetic
- The tank has been realized integrating innovative layout with enhanced transfer medium as expanded natural graphite and heat pipes, with less than 1 °C of internal temperature gradient
- Full management and control of the power to power technology was realized

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 storage (of H_2 from renewable electricity), by 2015 Capacity per site / CAPEX per site	5 t / 1,5 M€ per t	NOT APPLICABLE	NOT APPLICABLE
AIP 2011	Hydrogen storage capacity	>6% w	>6% w	7,0% w
AIP 2011	Tank system storage capacity	>4% w	4% w	Around 2,0% w
AIP 2011	Compatibility with FC systems	Any FC	SOFC/SOE	confirmed
AIP 2011	Long term run cost	<500€/kg	300€/kg	N/A (test not finalized)

ELECTRA

High Temperature Electrolyser with Novel Proton Ceramic Tubular Modules of Superior Efficiency, Robustness and Lifetime Economy

AIP / APPLICATION AREA	AIP 2013 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SPI-JTI-FCH-2013.2.4: New generation of high temperature electrolyser
START & END DATE	03 Mar. 2014 - 02 Mar. 2017
TOTAL BUDGET	€ 4,007,084.60
FCH JU CONTRIBUTION	€ 2,240,552.00
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: University of Oslo (NO)

Partners: CSIC (ES), SINTEF (NO), MARION (FR), PROTIA (NO), Abengoa Hidrigeno (ES), CRI (IC)

PROJECT WEBSITE/URL

http://www.mn.uio.no/smn/english/research/projects/chemistry/electra/index.html

PROJECT CONTACT INFORMATION

Professor Truls Norby, Univ. Oslo
truls.norby@kjemi.uio.no

MAIN OBJECTIVES OF THE PROJECT

This project seeks to design, build and test a kW size multi-tubular proton ceramic high temperature electrolyser for production of hydrogen from steam and renewable energy. The project also aims to develop efficient and stable oxygen side electrodes with integrated current collection, segmented-in-series proton ceramic tubular cells, and design of a multi-tubular module with its necessary peripherals. The project will test the multi-tubular unit for production of 250 L_n/h hydrogen, and test the single tube unit in co-ionic mode for production of syngas and di-methyl ether (DME) from CO_2 and steam.

PROGRESS/RESULTS TO-DATE

- Successful production of 1st and 2nd gen. tubes
- Stable and compatible component materials identified
- Anode layers with required performance have been developed
- Single-tube and multi-tube module designs conceived
- Techno-economic modelling on integration with renewable energy sources initiated

FUTURE STEPS

- Further development and production of 2nd and 3rd generation, segmented tubes
- Deposition and characterization of anode electrodes and interconnects on tube segments
- Electrolysis tests of fully assembled 1st , 2nd, and/or 3rd generation cells
- Development of compatible current collection layers
- System design and techno-economic studies for process integration with renewable power sources

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Work progresses as planned at month 16
- 1st generation tubes fabricated and in use
- 2nd generation stacked tubes demonstrated
- Oxygen electrodes (anodes) identified and tested OK
- 3rd generation segmented tubes challenging

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	Unit capacity	~1.5 t/day	250 L_n/hour	Test not scheduled yet
MAIP 2008-2013	Efficiency	68 %	68 %	Test not scheduled yet
AIP 2013	Cell and stack properties	I > 1 Acm^{-2} Area Specific Resistance < 1 Ωcm^2	I > 1 Acm^{-2} ASR < 1 Ωcm^2	Individual MEA layers OK
AIP 2013	Degradation rate	< 0.5% per 1,000 hours	< 0.5% per 1,000 hours	Test not scheduled yet
AIP 2013	Durability	Pressure tolerance under realistic conditions	Long term operation at 20 bar. Robust solutions for lifetime economy.	Design conceived for individual tube monitoring and replacement. Pressure and long term test not scheduled yet.
AIP 2013	Module power	kW range	Multi-tubular module of ~1kW	Design conceived. Not built or tested yet.
AIP 2013	Co-electrolysis proof-of-concept	85-90 % efficiency	Syngas and DME production -> 85% efficiency	Test not scheduled yet.

ELECTROHYPEM

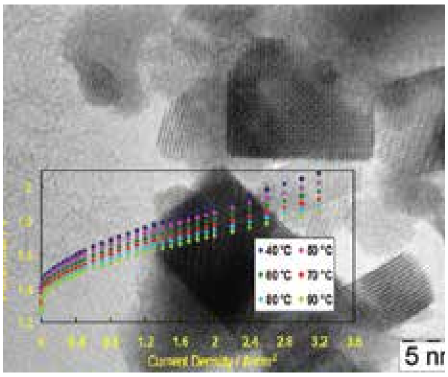
Enhanced Performance and Cost-Effective Materials for Long-Term Operation of PEM Water Electrolysers Coupled to Renewable Power Sources

AIP / APPLICATION AREA	AIP 2011 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2011.2.7: Innovative Materials and Components for PEM electrolysers
START & END DATE	01 Jul. 2012 - 30 Jun. 2015
TOTAL BUDGET	€ 2,842,312
FCH JU CONTRIBUTION	€ 1,352,771
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CONSIGLIO NAZIONALE DELLE RICERCHE (CNR-ITAE)

Partners: JOINT RESEARCH CENTRE, INSTITUTE FOR ENERGY AND TRANSPORT (JRC-IET), CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE (CNRS), SOLVAY SPECIALTY POLYMERS ITALY S.P.A. (SLX), ITM Power (Trading) Ltd (ITM), TOZZI RENEWABLE ENERGY (TRE)



PROJECT WEBSITE/URL

http://www.electrohypem.eu

PROJECT CONTACT INFORMATION

Dr. Antonino Salvatore Arico'
Tel. +39090624237

MAIN OBJECTIVES OF THE PROJECT

The overall objective of the ELECTROHYPEM project is to develop cost-effective components for PEM electrolysers with enhanced activity and stability in order to reduce stack and system costs and to improve efficiency, performance and durability. The focus of the project is on low-cost electrocatalyst, low-noble metal loading electrodes and membrane development. The project addresses the development of PEM electrolysers based on such innovative components for residential applications in the perspective of a suitable integration with renewable power sources. The aim is to contribute to the road-map addressing the achievement of a wide scale decentralised hydrogen production infrastructure.

PROGRESS/RESULTS TO-DATE

- Innovative membranes with enhanced conductivity and reduced hydrogen cross over for wide temperature operation have been developed
- Enhanced nanosised solid solution mixed oxide electrocatalysts demonstrated
- Membrane-electrode assembly (MEA) performance of 1.8 V at 3 A cm^{-2} achieved at 130 °C (0.5 mg cm^{-2} noble metal loading)
- MEA performance decay with time ~8 μV/h (1200 hrs test)
- Power consumption of 3.53 kWh/Nm^3 H_2 for 1.2 Nm^3/h capacity water electrolysis stack

FUTURE STEPS

- Use the developed components in 100 Nm^3/h capacity electrolysers
- Achieving similar efficiencies in large size PEM stacks (0.5 MW)
- Set-up of processes for volume manufacturing of the membranes and electro-catalysts
- Scaling-up of the MEA active area
- Dissemination and exploitation of project results

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- In order to be competitive within the field of decentralised hydrogen production, the PEM electrolyser must be reasonably cheap; moreover, it should be compact, characterised by high durability and capable of producing hydrogen at high efficiency and at suitable pressure.
- Enhanced materials and components (catalyst, membranes, MEAs and stacks) have been developed providing performance better than the state of the art at lower precious metal loading
- Novel materials have been validated in stacks of 1.2 Nm^3 H_2/h capacity and promising efficiency levels have been achieved
- These devices are promising for small scale applications especially under operation with renewable power sources and for grid-balancing service

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-competitive, high energy efficient and sustainable hydrogen production	Cost-efficient low-temperature electrolysers	Development of enhanced performance and cost-effective materials for long-term operation of PEM water electrolysers coupled to renewable power sources	High performance novel membranes and electrodes with cost effective characteristics have been demonstrated
AIP 2011	PEM electrolyser capacity	Hydrogen production capacity > 1 Nm^3/h	Innovative electrolyser with rated production capacity > 1 Nm^3/h	Innovative electrolyser with production capacity 1.2 Nm^3/h
AIP 2011	PEM electrolyser stack efficiency/ energy consumption	Efficiency of 75% (LHV)	Stack energy consumption < 4 kWh/Nm^3 H_2 @ 1 Nm^3 h^{-1}	Stack energy consumption 3.53 kWh/Nm^3 H_2 at 1.2 Nm^3 h^{-1}
AIP 2011	PEM electrolyser durability/ stability	High stability at constant load	Voltage increase < 15 µV/h at 1 A cm^{-2}	Stability > 1200 hrs, 8 µV/h at 1 A cm^{-2}
AIP 2011	PEM electrolyser capital costs	Stack cost <2.500 €/Nm^3 H_2 in series production;	Aimed stack cost <<2.500 €/Nm^3 H_2 using novel membranes and electrocatalysts	Cost effective novel membranes and electrocatalysts demonstrated

ELYGRID

Improvements to Integrate High Pressure Alkaline Electrolysers for Electricity/H_2 Production from Renewable Energies to Balance the Grid

AIP / APPLICATION AREA	AIP 2010 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2010.2.1: Efficient alkaline electrolyzers
START & END DATE	01 Nov. 2011 - 31 Dec. 2014
TOTAL BUDGET	€ 3,701,178.33
FCH JU CONTRIBUTION	€ 2,105,017
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: FHA

Partners: IHT, EMPA, AREVA, JÜLICH, VITO, LAPESA, INYCOM, INGETEAM, CEA

PROJECT WEBSITE/URL

www.elygrid.com

PROJECT CONTACT INFORMATION

Coordinator: Foundation for Hydrogen in Aragon
info@hidrogenoaragon.org

MAIN OBJECTIVES OF THE PROJECT

ELYGRID project aims at contributing to the reduction of the Total Cost of hydrogen produced via electrolysis coupled to Renewable Energy Sources, mainly wind turbines, and focusing on mega watt size electrolyzes (from 0,5 MW and up). The objectives are to improve the efficiency related to the complete system by 20% and to reduce costs by 25%. The work will be structured in cell improvements, power electronics and balance of plant (BOP).

PROGRESS/RESULTS TO-DATE

- New materials for separator developed and tested
- Full BOP containerized redesign (cost reduction)
- Long term tests at real scale (1.600 mm membrane diameter)
- Dynamic model for electrolyser coupled to RE
- Improved control system for the electrolyser

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Redesign of BOP: 20% of cost reduction (against baseline case)
- High capacity units could be produced increasing the current density
- New power electronics based on IGBTs
- New plug&play design and control system could reduce the Total Cost of Ownership (TCO)

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 target: Unit capacity	1.5 Ton/d	3 Ton/d	3 Ton/d
AIP 2013	Efficiency	80% HHV (0,75 A/cm^2)	90%HHV (0,5 A/cm^2)	78% HHV (0,4 A/cm^2)
AIP 2013	Durability	10 years lifespan	10 years lifespan	Critical factor: membrane. AST or extrapolation of behaviour needed
AIP 2013	Modular system cost	3000€/Nm^3	25% cost reduction	Final cost reduction 20% taking into account the baseline of the previous technology at the beginning of the project

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

Paolo Piccardo
paolo.piccardo@unige.it

MAIN OBJECTIVES OF THE PROJECT

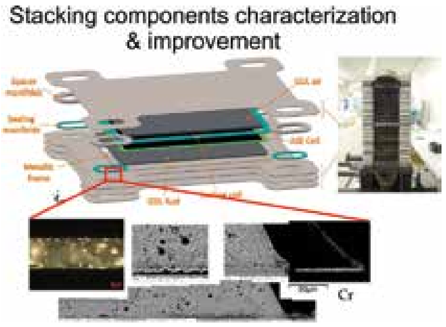
Based on SoA SOFC stack a descriptive model is refined to become a trustworthy predictive model for the stack life. The stack is then described with its minimum number of elements called «minima phenomena». Specific microsamples representative of a well defined zone of the stack are used to test improved 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
- 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 microscructural 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.

ene.field

European Wide Field Trials for Residential Fuel Cell Micro-CHP

AIP / APPLICATION AREA	AIP 2011 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2011.3.7 Field demonstration of small stationary fuel cell systems for residential and commercial applications
START & END DATE	1 Sep. 2012 - 31 Aug. 2017
TOTAL BUDGET	€ 52,351,061.70
FCH JU CONTRIBUTION	€ 25,907,168,77
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: COGEN Europe

Partners: Bosch Thermotechnik, Dantherm Power, Elcore, RBZ, SOLIDpower, Vaillant, Hexis, SenerTec, Viessmann, GDF, Dolomiti Energia, British Gas, Element Energy, Hyer, Imperial College, DCHT, Envirpark, Politecnico, DBI, EST, GWI, DTU, Eifer, DONG,

PROJECT WEBSITE/URL

www.enefield.eu

PROJECT CONTACT INFORMATION

Ms Fiona Riddoch
Fiona.riddoch@cogeneurope.eu

MAIN OBJECTIVES OF THE PROJECT

The main aim is to remove barriers to the roll-out of technically mature fuel cell micro-CHP systems through a large scale deployment. This will trigger important first steps in the establishment of genuine product support networks, well-developed supply chains and the growth of new skills to support commercial micro-CHP rollout.

The deployment of large numbers of micro-CHP devices will also help to drive costs down, increase consumer awareness and establish new routes to markets, in preparation for commercial rollout.

PROGRESS/RESULTS TO-DATE

- The field trials started on September 2013 and at August 2015 over 250 units installed across 8 field trials Information packs for householders in 12 different languages, ene.field website and regular communications (press releases, newsletters)
- Different Regional Workshops took place (Spain, Italy and Germany)
- Establishment of: Utility Working Group and Regulations Codes and Standards working group; and production of position papers (RCS, Grid connection, smart grid)
- Data collected for 8 different systems and 1st reports produced (field trial support, supply chain analysis).

FUTURE STEPS

- 2015-2016-2017 – Deployment of approx. 500 units in field trials in Austria, Belgium, Germany, Luxembourg, Italy, Netherlands, Denmark, Switzerland, Slovenia and the UK
- 2015-2016-2017 – Data reporting and analysis: monthly aggregation of the data from the trials first report
- 2015 – Analysis of the field support and barriers: study in progress
- 2015 – Development of an environmental life cycle and costs assessment: studies under peer review (September 2015)
- 2016 - Establish a commercialization framework

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Key learnings around the practical implications of installing, operating and supporting a fleet of fuel cells with real world customers
- An implementable consistent monitoring scheme has been put in place.
- Awareness of the project has been built up (and will continue) with outreach to a range of target groups and potential supporters.
- Production volume is a serious limiting factor for the successful development of the supply chain
- New relationships have been developed to strengthen the supply chain and reduce costs of mCHP systems in Europe

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	Number of units	1000	1000	250 (installations ongoing)
AIP 2011	Efficiency (electrical) (%)	>35	>35	Achieved – to be confirmed by data analysis
AIP 2011	overall efficiency (LHV)	>85	>85	Achieved – to be confirmed by data analysis

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

Dr. Alexander Dyck
info@project-eureca.com

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
remi.costa@dlr.de

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

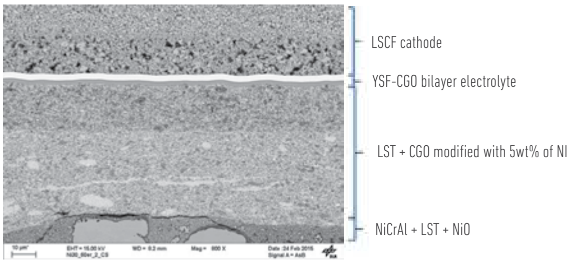
- Prototype showing 350 m W/cm^2 at 0.7V and 750°C demonstrated.
- Proven stable against 10 redox cycles without quantifiable degradation.

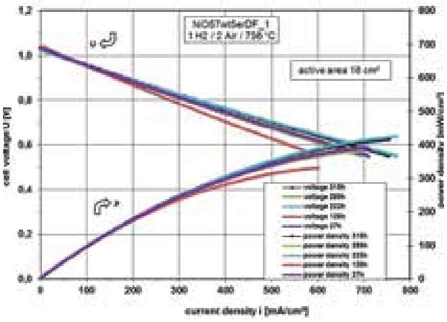
FUTURE STEPS

- 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 m W/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.

FCGEN

Fuel Cell Based Power Generation

AIP / APPLICATION AREA	AIP 2010 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2010.1.5 Auxiliary Power Units for transportation applications
START & END DATE	01 Nov. 2011 - 31 May 2015
TOTAL BUDGET	€ 9,309,998
FCH JU CONTRIBUTION	€ 4,010,884
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Jožef Stefan Institute

Partners: Powercell Sweden AB, Forschungszentrum Juelich GMBH, Volvo Technology AB, Fraunhofer-Gesellschaft zur Foerderung der angewandten Forschung E.V, Johnson Matthey PLC, Modelon AB

PROJECT WEBSITE/URL

www.fcgen.com

PROJECT CONTACT INFORMATION

Boštjan Pregelj
bostjan.pregelj@ijs.si

MAIN OBJECTIVES OF THE PROJECT

The main objective of the Fuel Cell based Power Generation (FCGEN) project is to develop and demonstrate a proof-of-concept diesel-powered PEM fuel cell based 3 $kW_{(net\ el.)}$ auxiliary power unit (APU) in the laboratory in close to real conditions.

Other objectives are to produce PEFC quality reformate, high efficiency, size /weight reduction and very clean exhaust (less, CO, NMHC).

Moreover, the project also seeks to further develop key components and subsystem technologies that have been advanced by the project partners in previous collaborations and move them closer towards commercially viable solutions.

PROGRESS/RESULTS TO-DATE

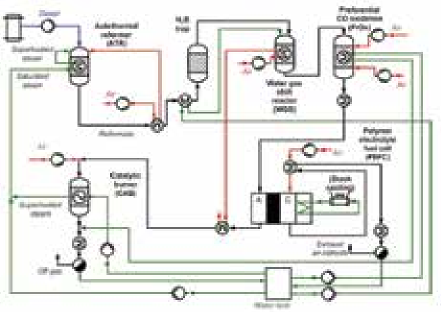
- Fuel processor developed and operation demonstrated with required reformate quality (10ppm CO, 1 ppm NHC, 1ppm S)
- High efficiency, designed to cost power conditioning and control system developed and integrated
- BoP components for maximizing efficiency and cost reduction found or prototypes obtained
- Complete APU built and autonomous APU operation demonstrated (~3kW net electric, battery charging, self sustained start-up & shutdown)

FUTURE STEPS

- increase TRL to high level,
- increase efficiency and lifetime
- further reduce cost, size & weight,
- implement serviceability

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- 25 % efficiency achieved, means identified to reach above 35%
- good operability, fast power level change, clean exhaust
- startup time still slow
- system still size & weight still need to be reduced
- refined complete system design-to-cost approach required for next generation



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	APU system efficiency	Demonstrations of increased efficiency of on-board power generation and reduce CO_2 emissions and local pollutions	System efficiency ~ 30% ;	Demonstrated 25% efficiency over entire operating range, required means for reaching above 35% identified and planned for future work. Compared to engine-idling cca 80% consumption (and consequently pollution emissions) reduction
MAIP 2008-2013	Development of Fuel cell based APU systems for mobile applications	Research, development and proof-of-concept demonstration of APU systems for on-board power generation	Develop and demonstrate a PEMFC-APU in laboratory.	Diesel powered PEMFC-APU development successfully finished. A working prototype was built and tested
MAIP 2008-2013	Fuel processing of logistic fuels	*Demonstrated fuel processing technology for logistic fuels*	Design the fuel processor module to handle logistic fuels Emissions: Sulphur < 10 ppb Carbon monoxide < 25 ppm Non-methane hydrocarbons < 1 ppm	Fuel processor module with sulphur tolerant reformer and desulphurization unit downstream the reformer is developed with required operation parameters demonstrated using standard commercially available diesel fuel: Sulphur: Demonstrated during single component testing CO (verified during APU test) NMHC 0-2 ppm (verified during APU test)
AIP 2010	Vehicle demonstration of auxiliary power units	• Research, development and proof-of-concept demonstration of APU systems for on-board power generation. • demonstrated feasibility of using logistic fuels and demonstrated fuel processing technology for logistic fuels • defined requirements for fully integrated systems in the specific application. • full APU system evaluation with respect to application specific requirements and multifunctional usage of fuel cells (heat and water), including cost analysis	Develop and build a stand-alone PEMFC-APU system which can handle low sulphur logistic fuels and demonstrate the performance of the system on-board a truck *Truck demonstration goal has been removed with amendment since the truck-demonstration partner has left consortium and no suitable replacement was found.*	An APU system consisting of a fuel processor module, a PEM FC module and a control module was developed and the complete autonomous operation demonstrated in laboratory environment. The fuel processor as well as fuel-cell modules have been tested separately and finally as a complete APU has been demonstrated. The vehicle integration parameters (mechanical, fuel, electrical, communication) have been defined. The study has been performed, providing the pay-off proof as a truck-anti-idling-application. Furthermore a cost analysis has been performed, showing cost ~ 1500€/kW in high production with current not fully-optimized design.

FCpoweredRBS

Demonstration Project for Power Supply to Telecom Stations Through FC Technology

AIP / APPLICATION AREA	AIP 2010 / AA 4: Early Markets
CALL TOPIC	SP1-JTI-FCH.2010.4.2: Demonstration of industrial application readiness of fuel cell generators for power supply to off-grid stations, including the hydrogen supply solution
START-DATE	01 Jan. 2012 - 31 Dec. 2015
TOTAL BUDGET	€ 10,591,649
FCH JU CONTRIBUTION	€ 4,221,270
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Ericsson Telecommunication Italy

Partners: Ericsson Telecommunication Italy, Dantherm Power AS, GreenHydrogen DK APS, Joint Research Centre, Università degli Studi di Roma Tor Vergata

PROJECT WEBSITE/URL

www.fcpoweredrbs.eu

PROJECT CONTACT INFORMATION

Giancarlo.Tomarchio
giancarlo.tomarchio@ericsson.com

MAIN OBJECTIVES OF THE PROJECT

Field trials in 14 live Radio Base Station sites and Lab test in 2 research centers. Demonstrate to the TLC operators the possible advantage, in term of TCO, associated to power off-grid RBS with a new system combining renewable sources in substituting the Diesel generator.

PROGRESS/RESULTS TO-DATE

- Benchmarking test executed and provisional TCO calculated in Lab;
- Authorization process defined for installation rollout
- Solution and smart metering O&M completed;
- H_2 supply solution and safety procedures implemented
- 11 live site up and running in main TLC Italian operator network;

FUTURE STEPS

- Integration with O&M TLC processes
- Field Tests and TCO consolidation
- Dissemination in TLC industry
- FC Certification procedures TLC compliant

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The project results will give an immediate answer with respect to the market readiness of the proposed solution.
- The Consortium would expect that if the TCO will demonstrate to be in line with expectation a proper market proposition may be already available
- O&M processes and procedures are essential for the successful penetration of the FC technology into TLC market
- Off-grid sites usual setup limits this FC based solution penetration.

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	Number of kw installed	100MW	About 80kw	About 53 kW installed in filed and labs.
AIP 2010	H_2 based solution to replace diesel/Life cycle assessment	TCO comparison	TCO calculation based on a Real Business Case model	TCO tool completed and preliminary business case ready
AIP 2010	Live TLC Sites powered with FC	-	15 sites	11 live sites in operation within two large TLC operators radio network
AIP 2010	FC deployed according to TLC operational requirements	-	Installations compliant with official regulation and TLC constraints	All the live sites have been assessed according to standard certification rules and Operators requirements

FERRET

A Flexible Natural Gas Membrane Reformer for M-CHP Applications

AIP / APPLICATION AREA	AIP 2013 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2013.3.3 Stationary Power and CHP fuel cell system improvement using improved balance of plant components/ sub-systems and/or advanced control and diagnostics systems.
START & END DATE	01 Apr. 2014 - 31 Mar. 2017
TOTAL BUDGET	€ 3,202,767
FCH JU CONTRIBUTION	€ 1,730,663
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Eindhoven University of Technology

Partners: Fundación Tecnalia Research & Innovation, Politecnico di Milano,
ICI caldaie S.P.A., HyGear BV, Johnson, Matthey PLC

PROJECT WEBSITE/URL

http://www.ferret-h2.eu/

PROJECT CONTACT INFORMATION

Fausto Gallucci
F.Gallucci@tue.nl

MAIN OBJECTIVES OF THE PROJECT

Within the FERRET project, the consortium will improve the technology based on membrane reactors and test a fully functional reactor for use in a current m-CHP unit from HyGear.

FERRET project will:

- Design a flexible reformer in terms of catalyst, membranes and control for different natural gas compositions
- Use hydrogen membranes to produce pure hydrogen and help with shifting all the possible H_2 production reactions towards the desired products, thus reducing side reactions.
- Scale up the new H_2 selective membranes and catalyst production
- Introduce ways to improve the recyclability of the membrane

PROGRESS/RESULTS TO-DATE

- First membranes developed
- First generation catalyst developed

FUTURE STEPS

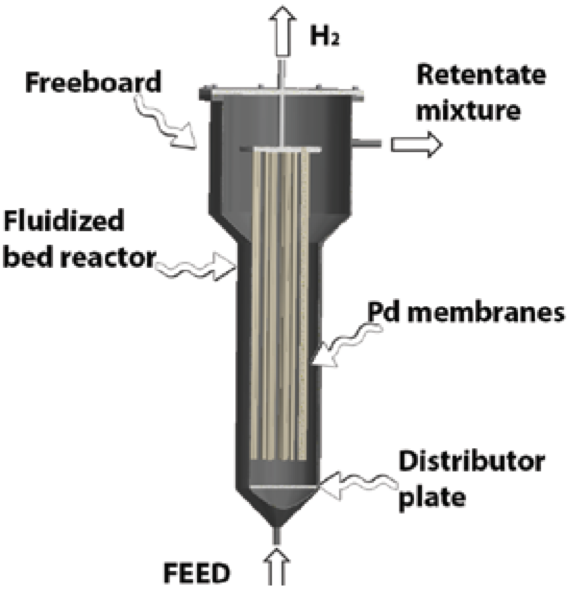
- Further development of the catalysts and high performance Pd-based membranes.
- Prototype reactor testing and validation.
- Proof of concept of the novel micro-CHP system. The new m-CHP will integrate the new reactor prototype and FC stacks with an optimised BoP.
- Modelling and simulation of both reactor and complete system

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- FERRET gives an answer to the segmented energy market in Europe
- FERRET will develop a flexible reformer that can cope with the differences in natural gas quality around Europe
- Proof of Concept of an advanced high performance, flexible and cost effective NG based micro-CHP system.

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	Overall efficiency CHP units	> 80%	> 90%	40%
MAIP 2008-2013	Emissions and fuels	Lower emissions and use of multiple fuels	Flexibility to use different natural gas qualities. Reduced CO_2 emissions compared to conventional reformers.	40%
MAIP 2008-2013	Cost per system (1kWe + household heat).	2015 target: Cost 10,000 € per system (1kWe + household heat). 2020 target: 5,000 € per system (1kWe + household heat).	5,000 € (1kWe + house heat)	50%
AIP 2013	Proof-of-Concept of CHP applications at laboratory scale.	Proof-of-Concept of CHP applications within laboratory.	TRL 4 – technology validated in lab	15%
AIP 2013	Durability	several hundreds of continuous operating hours	1000h of operation at nominal power output	N/A



FireComp

Modelling the Thermo-Mechanical Behaviour of High Pressure Vessels, Made of Composite Materials when Exposed to Fire Conditions

AIP / APPLICATION AREA	AIP 2012 / AA 5: Cross-Cutting Activities
CALL TOPIC	SP1-JTI-FCH.2012.5.4: Pre-normative research on fire safety of pressure vessels in composite materials
START & END DATE	01 Jun. 2013 - 31 May 2016
TOTAL BUDGET	€ 3,543,498
FCH JU CONTRIBUTION	€ 1,877,552
PANEL	Panel 6- Cross-Cutting

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Air Liquide

Partners: CNRS, University of Edinburgh, Raufoss Fuel Systems, INERIS, Health and Safety Laboratory, LMS Samtech, Alma CG

PROJECT WEBSITE/URL

www.firecomp.info

PROJECT CONTACT INFORMATION

Béatrice Fuster
Beatrice.fuster@airliquide.com

MAIN OBJECTIVES OF THE PROJECT

The main objective of the FireComp project is to better characterize the conditions that need to be achieved for improving the performance to fire of composite cylinders.

- Experimental work will be carried out to improve the understanding of heat transfer mechanisms, thermal degradation, combustion and the loss of strength of composite high-pressure vessels in fire conditions.
- Then the modelling of the thermo-mechanical behaviour of these vessels will be set up. The model will be validated by full scale fire tests.

Different applications will be considered: automotive application, stationary application, transportable cylinders, bundles and tube trailers.

PROGRESS/RESULTS TO-DATE

- A thermal degradation model has been developed; based upon an energy balance (to determine temperature through the composite depth) and thermo-gravimetric analysis data (to assess mass loss at each depth)
- Coupled thermo-mechanical tests have shown there is no significant influence of load on temperature evolution
- The material identification has been performed, and a temperature dependent damage model is now available within SAMCEF code
- All parameters for fire calibration have been defined and bonfire tests have started

FUTURE STEPS

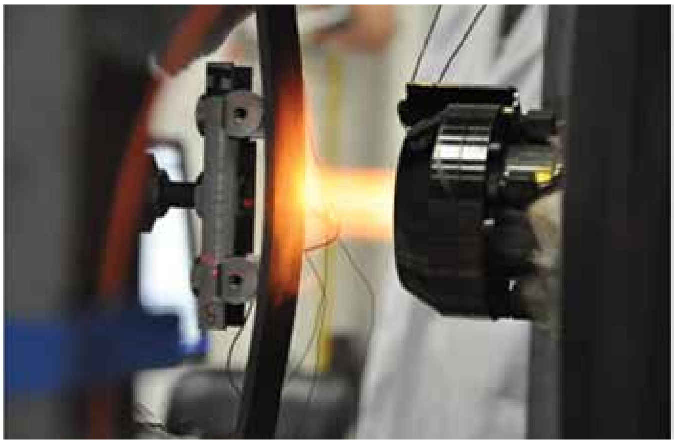
- Work on heat flux measurement during bonfire test: methods tested so far not satisfactory. Possibilities with a thin nickel sensor, with measurements of temperatures on both faces, complete heat transfer model and inverse problem solution (December 2015)
- Update of quantitative risk analysis with bonfire tests results: comparison with currently used technology (December 2015)
- Further development of damage models, involving the char & Coupled thermo-mechanical simulations (December 2015)
- Numerical prediction of vessels lifetime in fire and comparison with bonfire test results (March 2016)

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The atmosphere (i.e. oxygen from air) has a critical influence in the decomposition mechanism of composite in fire.
- Measurement of the radiation properties of the composite showed that the emissivity coefficient of the composite is 0.91 (no transmission and thus no internal radiation) at high temperature.
- The fibre orientation does not seem to influence the surface temperature during the degradation process
- The temperature of glass transition of the resin has a critical role in the decay of the mechanical properties of composite at high temperature
- Hydrogen gas fire selected for bonfire tests: characterisation of the test is quite easy (mass flow, injector diameter, distance...) and repeatability is better than with pool fire

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 AIP 2012	Model integrating the thermo-mechanical behaviour of the pressure vessel in fire conditions	1	1	On going
AIP 2011	Experimental validation of the model	1	1	On going. In the last phase of decisive experiments
AIP 2011	Proposed approach for standardization	1	1	Under construction. Formalized into final guidelines
AIP 2011	Recommendations for implementation in international standards	1	1	Under construction. Formalized into final guidelines and liaisons with ISO TC58/SC3/WG24



FluidCELL

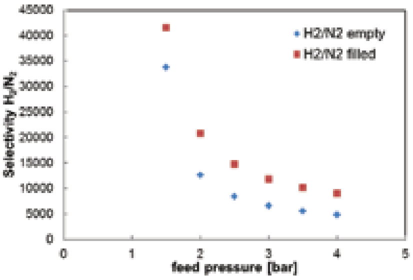
Advanced m-CHP Fuel CELL System Based on a Novel Bio-Ethanol Fluidized Bed Membrane Reformer

AIP / APPLICATION AREA	AIP 2013 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2013.3.4 Proof of concept and validation of whole fuel cell systems for stationary power and CHP applications at a representative scale. SP1-JTI-FCH.2013.3.3 Stationary Power and CHP fuel cell system improvement using improved balance of plant components/sub-systems and/or advanced control and diagnostics systems.
START-DATE	01 Apr. 2014 - 31 Mar. 2017
TOTAL BUDGET	€ 4,193,548.92
FCH JU CONTRIBUTION	€ 2,492,341
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Fundación Tecnalia Research & Innovation

Partners: Eindhoven University of Technology, Commissariat à l'Energie Atomique et aux Energies Alternatives, Politecnico di Milano, University of Salerno, Porto University, ICI caldaie S.P.A., HyGear BV, Quantis Sàrl



PROJECT WEBSITE/URL

www.fluidcell.eu

PROJECT CONTACT INFORMATION

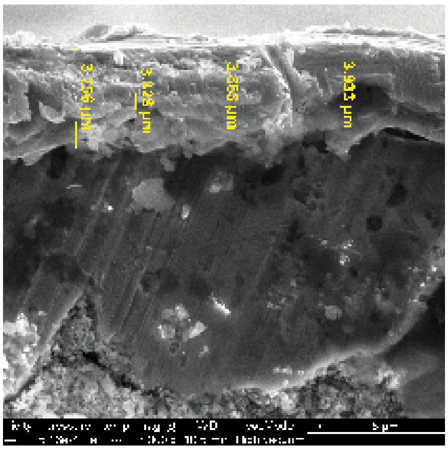
José Luis Viviente
Joseluis.viviente@tecnalia.com

MAIN OBJECTIVES OF THE PROJECT

FluidCELL aims the Proof of Concept of an advanced high performance, cost effective bio-ethanol micro-CHP cogeneration FC system for decentralized off-grid applications.

The system will be based on:

- Design, construction and testing of an advanced bio-ethanol reformer for pure hydrogen production (3.5 Nm3/h) based on Catalytic Membrane Reactor in order to intensify the process of hydrogen production through the integration of reforming and purification in one single unit and
- Design and optimization of all the subcomponents for the BoP with particular attention to the optimized thermal integration and connection of the membrane reformer to the FC stack.



PROGRESS/RESULTS TO-DATE

- First generation catalyst and membranes developed.
- Reference fixed bed membrane reactor performance completed with membranes from TECNALIA and commercial catalyst.
- State-of-the-art of PEM FCs for stationary applications completed.
- CHP performance simulation with membrane fuel processor completed.
- Screening Life Cycle Assessment.

FUTURE STEPS

- Development of novel catalysts and high performance Pd-based membranes.
- Prototype reactor assembling, testing and validation.
- Proof of concept of the novel micro-CHP system. The new m-CHP will integrate the new reactor prototype and FC stacks with an optimised BoP.
- Technical economic assessment and optimization of both reactors and complete system
- Life Cycle Analysis and safety analysis

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- FluidCELL gives an answer to the large number of off-grid decentralized energy consumers that actually depend on expensive and high polluting sources such as LPGs, bottle gas, heating oil or solid fuels.
- Proof of Concept of an advanced high performance, cost effective bio-ethanol micro-CHP system.

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	Overall efficiency CHP units	> 80%	> 90%	40%
MAIP 2008-2013	emissions and fuels	Lower emissions and use of multiple fuels	Bio-ethanol as fuel (instead of natural gas). Reduced anthropogenic CO_2 emissions compared to conventional fossil fuels.	30%
MAIP 2008-2013	Cost per system (1kWe + household heat).	2020 target: 5,000 € per system (1kWe + household heat).	5,000 € (1kWe + house heat)	40% • Cost could be achieved for mass production. • The industrial requirements of the m-CHP system have been completed. • First generation catalyst developed. • First generation of membranes developed. • Reference commercial fixed bed membrane reactor performance completed with membranes from TECNALIA and commercial catalyst. • State-of-the-art of PEM FCs for stationary applications completed. • Benchmark case definition with conventional fuel processor completed. • CHP performance simulation with membrane fuel processor completed. • Screening Life Cycle Assessment.
AIP 2013	Proof-of-Concept of CHP applications within laboratory.	Proof-of-Concept of CHP applications within laboratory.	TRL 4 – technology validated in lab	15%
AIP 2013	Durability	several hundreds of continuous operating hours	1000h of operation	N/A

FLUMABACK

Fluid Management Component Improvement for Back Up Fuel Cell Systems

AIP / APPLICATION AREA	AIP 2011 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2011.3.3: Component Improvement for stationary power applications
START & END DATE	01 Jul. 2012 - 30 Jun. 2015
TOTAL BUDGET	€ 3,999,005
FCH JU CONTRIBUTION	€ 2,482,969
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Electro Power Systems S.p.A.

Partners: Domel, Tubiflex, Environment Park, Jožef Stefan Institute, Foundation for the Development of New Hydrogen Technologies in Aragon, NedStack Fuel Cell Technology BV, Onda, University of Ljubljana – Faculty of Mechanical Engineering, Joint Research Centre – Institute for Energy and Transport

Air Blower

PROJECT WEBSITE/URL

www.flumaback.eu

PROJECT CONTACT INFORMATION

Ilaria Rosso
ilaria.rosso@electropowersystems.com

Mitja Mori
mitja.mori@fs.uni-lj.si

MAIN OBJECTIVES OF THE PROJECT

The project focuses on new design and improvement of balance of plant (BoP) components, specifically:

- Air and fluid flow equipment, including subcomponents and more specifically air and hydrogen blower;
- Humidifier;
- Heat exchanger.

The goals of the project:

- Improving BoP components performance, in terms of reliability;
- Improving the lifetime of BoP components at both component and system levels;
- Reducing cost in a mass-production perspective;
- Simplifying the manufacturing/assembly process of the entire system.

Hydrogen recirculation blower

PROGRESS/RESULTS TO-DATE

- Three iterations of air blower, hydrogen pump and humidifier developed and tested singularly and on 3kW and 6kW fuel cell systems
- Air blower almost fully achieved project targets in terms of cost, efficiency and lifetime; hydrogen recirculation blower, novel product developed within the FluMaBack project achieves specified pressure-flow requirements; but some further development needed to achieve higher level of reliability; humidifier, a novel product developed within the FluMaBack project as well, achieve the expected technical performance and cost target but some further development needed in terms of manufacturing process.
- Increase of efficiency at system level achieved.
- RCS, LCA and End-of-life assessment performed
- Market analysis performed.

FUTURE STEPS

Project concluded on 30th June 2015

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Air blower developed shows significant improvements respect to SoA in terms of cost, efficiency and lifetime. It is is ready to be used in comercial fuel cell system products.
- Hydrogen blower developed in the project enables good foundations for further development to improve lifetime. Since there is only limited publically available information on the subject, further research must be made on identifying advantages or disadvantages of different working principles used for hydrogen recirculation pumps/blowers.
- Humidifier developed in FluMaBack Project is very promising in terms of identified material (alternative to Nafion), design and manufacturing costs. Further development acitivites are required in the manufacturing process to improve lifetime.
- Fuel cell system with improved BoP components has higher efficiency and it is more cost effective.

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 system €/kW – midterm 2015	€ 1,500/kW	214 €/kW total cost of BoP components to be developed	Achieved for the 6 kW fuel cell system if the production samples consist of 100 pieces (159 €/kW) . If the production samples are 800 pieces each, the total target cost/kW has been achieved for both 3 kW (220 €/kW) and 6 kW (124 €/kW) fuel cell system.
MAIP 2008-2013	Durability/reliability	10,000 h	10,000 h	Verified 10,000h lifetime of air blower and confirmed the same perfomances in comparison with the BoL. Degradation of humidifier observed in long term tests. No ageing test on the hydrogen blower because of reliability issues.
AIP 2011	Component life time and maintenance cycle	Component life and maintenance cycle consist with system life up to 10 years for small-scale application	Life time BoP components: 10,000 hours, durability, reliability and robustness of single developed BOP components in order to provide maintenance cycles consistent with system life up to 10 year.	Same results of point above.
AIP 2011	BoP electrical efficiency	BOP Electrical efficiency > 90% for system < 10 kWe	BOP Power consumption relative to 6 kW fuel cell system output power of 8,3%	BOP Power consumption relative to 6 kW fuel cell system output power of 11%.
AIP 2011	Novel design and optimisation of non-stack components		Novel design and optimisation of air blower, hydrogen pump and humidifier.	Optimisation of air blower, novel design of both hydrogen pump and humidifier achieved.

H2Sense

Cost-Effective and Reliable Hydrogen Sensors for Facilitating the Safe Use of Hydrogen

AIP / APPLICATION AREA	AIP 2012 / AA 5: Cross-Cutting Activities
CALL TOPIC	SP1-JTI-FCH.2012.5.1: Hydrogen safety sensors
START & END DATE	01 Jun. 2013 - 31 Aug. 2014
TOTAL BUDGET	€ 785,290
FCH JU CONTRIBUTION	€ 380,348
PANEL	Panel 6- Cross-Cutting

PARTNERSHIP/CONSORTIUM LIST

Coordinator: BAM Federal Institute for Materials Research and Testing

Partners: European Commission – Joint Research Centre (JRC) – Institute for Energy and Transport (IET), AppliedSensor GmbH, Sensitron S.r.l., UST Umweltsensortechnik GmbH, Zentrum für Sonnenenergie und Wasserstoff-Forschung Baden-Württemberg (ZSW).

PROJECT WEBSITE/URL

http://www.h2sense.bam.de/

PROJECT CONTACT INFORMATION

Dr. Thomas Hübert
thomas.huebert@bam.de

MAIN OBJECTIVES OF THE PROJECT

H2Sense has been initiated to promote the effective deployment and safe use of reliable hydrogen sensors, primarily but not exclusively for applications using hydrogen as an alternative fuel. The main objectives of the project are:

- Evaluation of existing and anticipated sensors and sensor platforms
- Identification of existing and key near-term hydrogen applications and sensor performance requirements
- Identification of commercialisation barriers and approaches in R&D, regulation and standardisation to overcome these barriers
- Performance tests and validation of promising commercial off-the-shelf hydrogen sensors
- Interaction and knowledge transfer with US partner NREL

PROGRESS/RESULTS TO-DATE

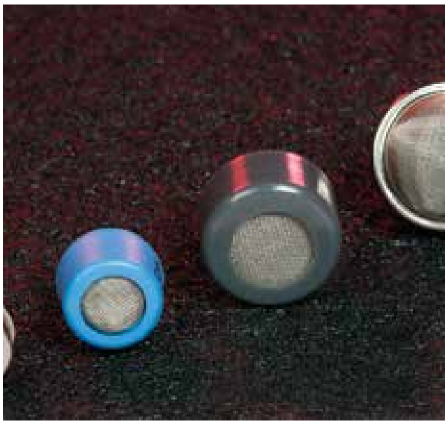
- Market survey on commercial hydrogen sensors and sensor platforms http://www.h2sense.bam.de/en/home/index.htm
- Brochure "Hydrogen sensors for the safe and reliable use of hydrogen"
- Classification of hydrogen sensor applications and identification of correlated performance requirements is performed
- Approaches to overcome commercialisation barriers have been suggested
- Inter-laboratory testing of commercial off-the-shelf hydrogen sensors and comparison of results has been carried out

FUTURE STEPS

- Dissemination of results in brochure, book, and other publications
- Promoting the use of hydrogen sensors, advice on effective deployment and safe use
- R&D on sensor performance regarding sensor lifetime prognosis, cross sensitivities and time response
- Webinar on hydrogen sensors

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- A large variety of hydrogen sensors are commercially available for safety issues, leak detection and process control
- Further sensor development is needed in order to achieve desired target specifications
- Commercialisation can be promoted by exploiting market potentials, considering the complete H_2 supply chain, adapting and harmonising regulations, increasing functional safety, reducing costs, and dissemination of sensor knowledge to stakeholders
- RCS are needed for specific sensor applications, e.g. leak detection, harmonisation desirable for facilitating commercialisation
- Laboratory testing shows general suitability of commercial off-the-shelf sensors for safety applications



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	Priority of the cross-cutting activities application area	Evaluate the socio-economic, environmental and energy impact of FCH technologies Support the growth of the European industry, particularly SMEs	Support of the safe use of hydrogen and the transition to a hydrogen inclusive economy Contribution to minimizing the release of hydrogen into the atmosphere Saving and increase of working places with sensor manufactures Creating an opportunity to translate suggested approaches to overcome barriers of new technology commercialisation	Ongoing
AIP 2012	Assessment of commercially available hydrogen safety sensors in terms of e.g. performance and cost-effectiveness for near-term applications	Assessment of (i) state-of-the-art hydrogen sensor technologies (ii) recommendations for effective deployment for near-term applications (iii) cost-effective manufacture and barriers to commercialisation; implications and recommendations for sensor requirements in RCS	Evaluation of existing and anticipated sensors and sensor platforms Identification of existing and key near-term hydrogen applications and sensor performance requirements Identification of commercialisation barriers and approaches in R&D, regulation and standardisation to overcome these barriers	Fulfilled
AIP 2012	Assessment of safety issues related to fuel cell and hydrogen applications	R&D, testing, validation in laboratory and field conditions to address critical gaps in safety sensor technology	Performance tests and validation of promising commercial off-the-shelf hydrogen sensors	Fulfilled
AIP 2012	Assessment of safety issues related to fuel cell and hydrogen applications	Compendium of existing applications, feedback on sensor performance, experiences and best practices to identify recommendations for more effective deployment	Brochure "Hydrogen sensors for the safe and reliable use of hydrogen"	Fulfilled

H_2TRUST

Development of H_2 Safety Expert Groups and Due Diligence Tools for Public Awareness and Trust in Hydrogen Technologies and Applications

AIP / APPLICATION AREA	AIP 2012 / AA 5: Cross-Cutting Activities
CALL TOPIC	SP1-JTI-FCH.2012.5.5: Assessment of safety issues related to fuel cells and hydrogen applications
START & END DATE	01 Jun. 2013 - 28 Feb. 2015
TOTAL BUDGET	€ 1,208,416.22
FCH JU CONTRIBUTION	€ 796,678
PANEL	Panel 6- Cross-Cutting

PARTNERSHIP/CONSORTIUM LIST

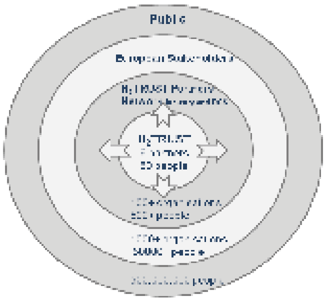
MATGAS 2000 AIE (coordinator), Air Products PLC, European Hydrogen Association (Federazione delle Associazioni Scientifiche e Techniche), Solvay Speciliaty Polymers Italy S.P.A., Politecnico di Milano, McPhy Energy SA, SOL S.p.A., Ciaotech S.r.l, Technische Universiteit Eindhoven.

PROJECT WEBSITE/URL

h2trust.eu

PROJECT CONTACT INFORMATION

Lourdes F. Vega
vegal@matgas.org



MAIN OBJECTIVES OF THE PROJECT

1. Assess industry efforts to assure FCH technology is safe, adequate regulation, hazard awareness, incident readiness, and ability to respond to public concerns.
2. Hazard & risk assessment in FCH industry in each of the main application areas.
3. Systematically map safety issues and assess how they are addressed.
4. Compile information demonstrating safety due diligence and best practices.
5. Make recommendations for further safety efforts by FCH community.
6. Develop communications network to manage public reaction to incidents and give documented responses.
7. Disseminate the results creating a culture of safety practices.

PROGRESS/RESULTS TO-DATE

- An info gathering process has been carried out in WP3, taking into account data from existing industries in different sectors. The data collected from stakeholders (questionnaires, surveys, interviews, etc.) was analysed together with additional information from desk research and results from EU-funded projects and other initiatives, to map the safety issues, identify best practices, and make a safety risk assessment as well as a public safety assessment and recommendations (WP4).
- The methodology for risk assessment (Task 4.3) was designed and developed, taking into account all the areas for hydrogen applications considered in the project. The online H_2 safety due-diligence tool (Task 5.2) was based on it.

- The dissemination of this project was done through the participation in different conferences, press releases, newsletters, publications, lectures, and the project website (h2trust.eu/).
- The on-line portal was implemented with additional features and tools such as a crawler for an advanced search, an on-line forum, an online library, a news section and the risk assessment tool.
- Dissemination: in addition to the website and the participation in conferences, a kit (book, brochure, banner and video) was prepared, as well as an online tool enabling FCH stakeholders to rapidly analyze and assess a particular H_2 application.

FUTURE STEPS

- Further dissemination activities at different levels.
- Looking for future collaborations related to hydrogen safety and social awareness, including similar initiatives outside Europe.
- Active search of similar initiatives to leverage the work done in the H_2TRUST. Work to build a permanent structure with EU support.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- A website has been created to disseminate the results of the project.
- The main outcomes of the project are the report of best practices, safety risk assessment and public safety assessment, and recommendations. Moreover, the risk assessment tool is made available for whoever wants to use it to assess its safety readiness/adequacy.
- The project has concluded according to the Description of Work of the Grant Agreement (taking into account the amendment sent in October 2014).
- Dissemination activities have been carried out in order to maximize the diffusion of this knowledge to the widest possible audience, including stakeholders, industries and the society in general. A dissemination book was published.
- A good acceptance of the project objectives and results by H_2 researchers, stakeholders & partners of related projects has been detected along the execution of the project. Further work in this topic should be encouraged and supported by the JU and the EU.

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	Awareness.	Education and public awareness.	Assess FCH industry, make recommendations, develop communications network to manage public reaction to incidents, and give documented responses.	Best practices, safety risk assessment, public safety assessment and final recommendations were reported. A website and kit for demonstrations, was created to disseminate the results of this project.
MAIP/AIP	Regulations, Codes and Standards (RCS) and Pre-normative Research (PNR) needs.	Identify and prioritize RCS and PNR needs. Coverage by standards and/or regulations of the relevant safety requirements.	Data collection from the regulatory and safety stakeholders, consumers and incident response bodies associated with FCH industries. Make recommendations for further safety efforts by FCH community.	RCS were considered for the whole project. WP4 included reporting on the regulatory and safety state of the art, in order to define the recommended actions required to assure the successful and incident free development of the industry.
AIP 2012	Lessons learnt.	Application of existing knowledge and lessons learnt from past experience. Implementation of product concepts that are inherently safe; assurance of fitness for service; and control of accidental situations, and mitigation of impacts.	Compile information demonstrating safety due diligence and best practice. Seek inputs from other projects and similar international activities.	In WP3 an info gathering process was carried out. An online literature database has been prepared, available online at h2trust.eu.
AIP 2012	Hazards.	Identification and understanding of hazards.	Hazard and risk assessment. Systematically map safety issues and assess how they are addressed.	Best practices, safety risk assessment, public safety assessment, as well as recommendations have been reported.
AIP 2012	Best practices.	Preparedness to emergency situation and effectiveness of emergency response measures; ability of safety officials to exercise their responsibility; and operators and end-users awareness of hazards.	Develop communications network to manage public reaction to incidents and give documented responses. Disseminate the results so as to create a long lasting culture of safety practices in the industry and a legacy of tools and knowledge serving to reinforce best practices and assure public confidence.	An online tool was created to analyse and assess a particular application area for safety hazard, risk and preparedness. Participation in numerous dissemination activities:28 conferences, 22 press appearance, 4 newsletters, 1 exhibitor, 2 papers in international journals and 1 dissemination book. 25 websites links lead to the H_2TRUST website.

HAWL

Large Scale Demonstration of Substitution of Battery Electric Forklifts by Hydrogen Fuel Cell Forklifts in Logistics Warehouses

AIP / APPLICATION AREA	AIP 2012 / AA 4: Early Markets
CALL TOPIC	SP1-JTI-FCH.2012.4.1 - Demonstration of fuel cell powered material handling equipment vehicles including infrastructure
START & END DATE	01 Sep. 2013 - 31 Aug. 2016
TOTAL BUDGET	€ 8,523,185.00
FCH JU CONTRIBUTION	€ 4,278,555.00
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Air Liquide

Partners: FM Logistic, Hypulsion SaS, Crown Galbelstapler GmbH, Toyota Material Handling Europe, Diagma Group

PROJECT WEBSITE/URL

www.hawl-project.eu

PROJECT CONTACT INFORMATION

laurent.ferenczi@airliquide.com
charline.dubois@airliquide.com

MAIN OBJECTIVES OF THE PROJECT

HAWL project aims at deploying 200 fuel cells powered forklift trucks on 2 or 3 logistics warehouses and demonstrating competitiveness (productivity), technical maturity and user acceptance of the technology in Europe, as an alternative to battery powered trucks operation.

PROGRESS/RESULTS TO-DATE

- HRS commissioned and installed at site 1 (February 2015)
- 4 types of forklifts qualified to be used with fuel cells (reach trucks and pallet trucks)
- Phase test started at Site 1 (10 forklifts demonstrated) – 5 months to date (July 2015)
- > 1700 fillings performed - Average filling time: 150 seconds
- Official opening took place in March 2015 at FM Logistic premises

FUTURE STEPS

- Decision milestone in September 2015: additional deployment of site 1 in case of productivity and economic business case demonstration
- Phase Test & deployment at site 2
- Phase Test & deployment at site 3

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- MS1 (site 1 identification), MS4 (permiting) and MS7 (Acceptance) have been passed
- Workers satisfied with the innovative solution - improvement of the working conditions
- Valuable return of experience helping to improve the products
- Interest of the solution and cost evaluation to be assessed for a large scale deployment
- A Reference Code on HRS installation and H_2 in warehouse distribution might be published by French administration in Autumn 2015, thus facilitating and accelerating local authorizations for permitting or the next 2 sites

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	Total cost of FC system (at early volume production) for FC > 3kW:	< 50 units / < 3,500 €/kW	< 3,000 €/kW	Achieved (2,000€/kW for class 2 10 kW fuel cell)
AIP 2012	System lifetime (with service/stack refurbishment)	Not defined	> 7,500 hours	Not demonstrated in the project yet
AIP 2012	FC system efficiency (%)	>40	>45	FC Class 2 (for reach trucks): Project and Program objectives: Achieved FC Class 3 (for Pallet trucks): 40%: inferior to Project objectives (45%) The 45% Project objective is maintained and should be reached thanks to improvements both at the level of the stack and at the level of the software.
AIP 2012	Refuelling time	3 min	3 min	Achieved

HELMETH

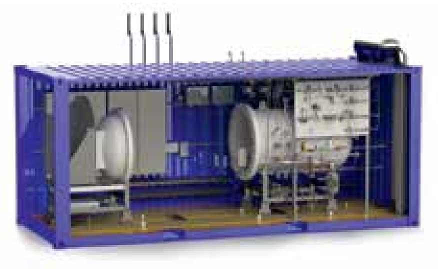
Integrated High-Temperature Electrolysis and Methanation for Effective Power to Gas Conversion Sources

AIP / APPLICATION AREA	AIP 2013 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2013.2.4: New generation of high temperature electrolyser
START & END DATE	01 Apr. 2014 - 31 Mar. 2017
TOTAL BUDGET	€ 3,809,972.00
FCH JU CONTRIBUTION	€ 2,529,352.00
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Karlsruhe Institute of Technology (Germany)

Partners: Politecnico di Torino (Italy), Sunfire GmbH (Germany), European Research Institute of Catalysis A.I.S.B.L. (Belgium), Ethos Energy Italy (Italy), National Technical University of Athens (Greece), DVGW - German Technical and Scientific Association for Gas and Water (Germany)



PROJECT WEBSITE/URL

www.helmeth.eu

PROJECT CONTACT INFORMATION

Dimosthenis Trimis
dimosthenis.trimis@kit.edu

MAIN OBJECTIVES OF THE PROJECT

The objective of the HELMETH project is the proof of concept of a highly efficient Power-to-Gas (P2G) technology with methane as a chemical storage and by thermally integrating of high temperature electrolysis (SOEC technology) with CO_2 methanation. The aim is to prove and demonstrate that high temperature electrolysis and methanation can be coupled and thermally integrated towards highest conversion efficiencies > 85 % from renewable electricity to methane by utilizing the process heat of the exothermal methanation reaction in the high temperature electrolysis process.

PROGRESS/RESULTS TO-DATE

- System specifications of SOEC and methanation module fixed
- Pressurised high-temperature electrolysis system is completed and already realised. First test results with preliminary SOEC stack correspond to the expectations
- Tests on co-electrolysis conducted. Results will be published in September 2015 as Deliverable 2.2
- Novel design of SOEC heat exchangers by using Direct Laser Metal Sintering technology is almost finished
- Decision of optimal methanation module concept consisting of 3 reactors, combined in one pressure vessel (86% process simulation efficiency)

FUTURE STEPS

- Results of pressurized catalytic tests will be published in September 2015 as Deliverable 3.2
- Construction of methanation module starts in autumn 2015
- Hazard and operability study is currently ongoing in order to assure the SOEC and methanation module safety concept

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Total efficiency of coupled SOEC and methanation module is expected to exceed 85 % at a SOEC steam conversion of 80 %
- Higher efficiencies can be reached with higher SOEC steam conversions and/or with SOEC co-electrolysis
- Optimal reaction temperature concerning the methanation is 300°C for an integrated system (SOEC + Methanation)
- Minimal heat losses can be reached by combining catalytic reactors in one pressure vessel

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 2013	Development of cells and stacks designed for high-temperature and high current density, pressurised conditions	High-temperature (800-1000 °C), high current density (>1 A/cm^2), pressurised conditions	High-temperature (800-1000 °C), high current density (>1 A/cm^2), pressurised conditions	Electrodes and interconnector protection layers feasible for HTE under pressurized conditions
AIP 2013	Manufacture of dedicated HTE cells and stacks for use in large systems for the conversion of electricity from renewable sources and from nuclear power, i.e. large-area cells	Manufacture of dedicated HTE cell	HELMETH will deliver a proof of concept towards this direction. Large systems are the development focus of the involved industrial partners and especially of SUNFIRE. Concerning large area cells a modular approach with more cell elements on a common interconnector frame is followed.	For non-pressurized operation, sunfire has already produced a system in the 100 kW range; scalability can be reached effectively with the common sunfire cell size, which is applied within the HELMETH project also for pressurized conditions. The durability for pressurized conditions has to be proven by the ongoing pressurized tests.
AIP 2013	Demonstration of a HTE system of kW size under realistic conditions	Demonstration of a HTE system of kW size under realistic conditions with degradation rates around 1 %/1000 h (0,5 %/1000 h for short stack tests)	HELMETH will demonstrate the feasibility of a 10-15 kW class system with degradation rates around 1 %/1000 h (0,5 %/1000 h for short stack tests)	First pressurized test is ongoing @ 10 bar (g) and 700°C with stack in 5 kW power range; current density target and fluctuating production not evaluated yet; degradation prediction not yet possible in this state of preliminary testing
AIP 2013	Proof-of-concept for co-electrolysis, syngas production and final chemical product, and validation of efficiency figures. Total efficiencies are expected in the 85-95% range	Total efficiencies are expected in the 85-95% range	Conversion efficiencies > 85 % from electricity to methane	Detailed process simulations including all BoP components for the chosen reactor concept predict a total conversion efficiency of 86%. (Efficiency of prototype plant will be lower due to heat losses, which are dependent on size of plant; the difference is predictable)

High V.LO City

Cities Speeding up the Integration of Hydrogen Buses in Public Fleets

AIP / APPLICATION AREA	AIP 2010 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2010.1.1 Large-scale demonstration of road vehicles and refuelling infrastructure III
START & END DATE	01 Jan. 2012 - 31 Dec. 2018
TOTAL BUDGET	€ 31.586.671
FCH JU CONTRIBUTION	€ 13.491.724
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Van Hool

Partners: Riviera Trasporti, Dantherm, Solvay, De Lijn, Waterstofnet, Hyer, DITEN, Regione Liguria, FIT, Aberdeen City Council, CNG Net.

PROJECT WEBSITE/URL

www.highvlocity.eu

PROJECT CONTACT INFORMATION

Flip Bamelis
flip.bamelis@vanhool.be

MAIN OBJECTIVES OF THE PROJECT

High V.LO City aims to present the readiness of hydrogen technology for sustainable public transport in 3 European sites through the demonstration of 14 FC buses and 3 hydrogen refueling infrastructures and subsequently disseminate the results to engage stakeholders. These stakeholders are public transport companies, local authorities and the public.

PROGRESS/RESULTS TO-DATE

- 14 FC Buses are delivered
- 2 HRI's are operational (Aberdeen and Antwerp)
- 9 FC Buses are operational in real life circumstances
- data sets required to calculate the KPI's are calculated
- practical experience up to the start of the operations is documented

FUTURE STEPS

- activate the Sanremo site after the manufacturing and startup of the local HRS
- increase FCBus availability at all sites up to the project objective (85%)
- present bus performances, the evolution since the start and the measures to increase them
- further disseminate the project results

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The legal framework on different plans is only limited ready for FC Buses
- The introduction of HRS and FCB should go combined.
- Local technologic knowledge is a key issue to make FC Buses a success story.
- With the entrance of FC Buses, a complete new technology enters into public transport workshops, depots and drivers. This requires a change of mind of all partners involved.

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 Buses operational	500 @ 10 new sites	14 @ 3 sites	9 @ 2 sites (4 in Aberdeen, 5 in Antwerp)
MAIP 2008-2013	System cost	<3.500€/kW	2500€/kW	Achieved
MAIP 2008-2013	Durability of the FC System	>5.000h	15.000h guaranteed by supplier	In test
MAIP 2008-2013	Roadmap for the establishment of a commercial HRI	Roadmap for the establishment of commercials HRI	2 new HRI's operational, a third one should come	2/3 achieved
MAIP 2008-2013	Production of hydrogen	Free or carbon lean	2/3 of the hydrogen in High V.LO City is produced lean	In test

HYACINTH

Hydrogen Acceptance in the Transition Phase

AIP / APPLICATION AREA	AIP 2013 / AA 5: Cross-Cutting Activities
CALL TOPIC	SP1-JTI-FCH.2013.5.3: Social acceptance of FCH technologies throughout Europe
START & END DATE	01Sep. 2014 - 28 Feb. 2017
TOTAL BUDGET	€ 1,002,288
FCH JU CONTRIBUTION	€ 661,584
PANEL	Panel 6- Cross-Cutting

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Centro Nacional de Experimentación de Tecnologías de Hidrógeno y Pilas de Combustible (CNH2)

Partners: I Plus F France SARL (IPLUSF FRANCE), Fraunhofer Gesellschaft zur Förderung der Angewandten Forschung E.V. (FRAUNHOFER), Aberdeen City Council (ABERDEEN), Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), Fundación Cidaut (CIDAUT), Razvojni Center Za Vodikove Tehnologije (RCVT), Norstat Deutschland GmbH (NORSTAT), University of Leeds - Center for Integrated Energy Research (LEEDS), University of Sunderland (SUNDERLAND), Consultoría de Innovación y Financiación S.l.(IPLUSF ESPAÑA)

PROJECT WEBSITE/URL

www.hyacinthproject.eu

PROJECT CONTACT INFORMATION

Daniel Esteban Bechtold
daniel.esteban@cnh2.es

MAIN OBJECTIVES OF THE PROJECT

The overall purpose of HYACINTH is to gain a deeper understanding of the social acceptance of hydrogen technologies across Europe in the transition phase, between demonstration projects and a full market deployment, by combining specific qualitative and quantitative methods and samples of European citizens and stakeholders. The main aims are to: identify and understand awareness and acceptance and the perceived potential benefits, identify the main drivers of social awareness and acceptance and support stakeholders by providing a social acceptance research toolbox, enabling a regional understanding of the acceptance process and providing tools to manage expectations and to increase acceptance.

PROGRESS/RESULTS TO-DATE

- Context analysis: former projects and studies, list of potential stakeholders, methodologies and factors

FUTURE STEPS

- Methodological design
- Data collection
- Data analysis and interpretation
- Development of management toolbox

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Levels of acceptance found in previous research are quite theoretical and only of limited validity.
- The research of acceptance in the transition phase has to differentiate between technology performance and operational, organizational or economic challenges.
- Research on acceptance has to acknowledge its process character and identify means to understand and manage the acceptance process.

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 2013	Current state of public awareness and public acceptance of FCH technologies in Europe?	N/A	Interviews of up to 7,000 European citizens and 455 stakeholders in 7 different countries with different degree of penetration of H_2&FC technologies.	To be done the 2nd year
AIP 2013	What kind of fears is associated with FCH technologies to date? How is hydrogen safety perceived by the general public?	N/A	To identify bottlenecks for H_2&FC technologies commercialization. To discern handicaps that may be geographically linked or appear for a certain H_2&FC technology.	To be done the 2nd year
AIP 2013	How can a successful transition towards the use of hydrogen in the mobility sector be achieved?	N/A	Development of a specific toolbox	To be done the 3rd year

Hycarus

Hydrogen Cells for Airborne Usage

AIP / APPLICATION AREA	AIP 2012 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2012.1.6: Fuel Cell systems for airborne application
START & END DATE	01 May 2013 - 30 Apr. 2016
TOTAL BUDGET	€ 10,515,603.60
FCH JU CONTRIBUTION	€ 5 219 265,00
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Lothar Kerschgens (Zodiac Cabin & Control)

Partners: Commissariat à l'énergie atomique et aux énergies alternatives, DASSAULT Aviation, Air Liquide, Joint Research Centre - Institute for Energy and Transport, Spanish National Institute for Aerospace Technology, ARTTIC, Zodiac Aeroelectric, Zodiac Galleys Europe sro, Zodiac Aerotechnics

PROJECT WEBSITE/URL

www.hycarus.eu

PROJECT CONTACT INFORMATION

Christophe Elleboode
Christophe.Elleboode@zodiacaerospace.com

MAIN OBJECTIVES OF THE PROJECT

HYCARUS develops a Generic Fuel Cell System (GFCS) in order to power non-essential aircraft applications such as a galley in a commercial aircraft or to be used as a secondary power sources on-board business jets. Demonstration of GFCS performances in relevant and representative cabin environment (TRL 6) will be achieved through flight tests on-board a Dassault Falcon aircraft.

Moreover, HYCARUS will assess how to valorise the by-products (especially heat and Oxygen Depleted Air - ODA) produced by the fuel cell system to increase its global efficiency.

PROGRESS/RESULTS TO-DATE

- Completion of specifications and sizing of the GFCS
- Design of the different sub-systems and components of the GFCS, (Fuel cell stack, Battery, Hydrogen High Pressure Storage, Hydrogen Low Pressure Supply, Air supply, Electrical Power Management, Monitoring and Control, etc.)
- Preliminary Safety analysis
- Detailed integration of the GFCS for the flight test configuration and for the galley configuration
- Preparation for the "permit to Fly" including Qualification Program Plan and Test Flight conditions

FUTURE STEPS

The next part of the project will be focused on the verification of the whole Generic Fuel Cell System. Two configurations will be tested:

1. "Flight test" configuration: in addition to the development tests, performance tests, environmental tests and flight tests on-board a Falcon aircraft will be performed.
2. "Galley" configuration: In addition to the development tests, only performance tests on ground will be performed with the Generic Fuel Cell system integrated in the Galley.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The Consortium will build on the first results to provide and test the GFCS in a representative aircraft environment, in accordance with the TRL6 level.
- The consortium members are engaged into a challenging development and demonstration project
- HYCARUS will contribute to establishment of certification process for on board Fuel Cell system in a cabin environment
- HYCARUS will accelerate market introduction of Fuel Cell systems on board aircraft.

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 2011	Fuel cell system technology maturity	TRL6	TRL6 Fuel cell system with flight tests on-board an aircraft	Fuel cell system Demonstrator development in progress. Qualification Program Plan and Test Flight conditions defined
AIP 2011	Representativeness of demonstrator against application	Power range 20-100 kW	Fuel cell system rated power 20-25 kW	Fuel Cell system demonstrator development in progress. Simulated performances for both Galley and Secondary power source applications.
AIP 2011	Durability with cycling hours	2,500 hours under flight representative load profiles	2,500 hours durability tests under flight representative load profiles	Fuel Cell system test not performed yet. 2000 hours Fuel Cell stack durability test performed under flight representative load profiles.
AIP 2011	Fuel cell system efficiency (LHV)	55% @ 25% of rated power:	55% @ 25% of rated power:	46% system electric efficiency under airborne operating conditions (simulation results, test to be performed in 2016)
AIP 2011	System Power density	Fuel Cell system power density (EOL): 0,4kW/L	Fuel Cell system density (EOL): 0,4kW/L based on the fuel-cell stack value 1,7kW/L	Not yet achieved as the priority is given to the airborne requirements compliance so as TRL6 maturity objective for the demonstrator with flight tests on-board an aircraft is achieved.
AIP 2011	System Specific Power	Fuel Cell system specific power (EOL): 0.65kW/kg	Fuel Cell system specific power (EOL): 0,65kW/kg based on the fuel-cell stack value 1,2kW/kg	Not yet achieved as the priority is given to the airborne requirements compliance so as TRL6 maturity objective for the demonstrator with flight tests on-board an aircraft is achieved.

HyCoRA

Hydrogen Contaminant Risk Assessment

AIP / APPLICATION AREA	AIP 2013 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2013.1.5: Fuel Quality Assurance for Hydrogen Refuelling Stations
START & END DATE	01 Apr. 2014 - 31 Mar. 2017
TOTAL BUDGET	€ 3,906,912.00
FCH JU CONTRIBUTION	€ 2,159,024.00
PANEL	Panel 6- Cross-Cutting

PARTNERSHIP/CONSORTIUM LIST

Coordinator: VTT Technical Research Centre of Finland

Partners: CEA, JRC, Protea ltd, SINTEF, Powercell Sweden AB

PROJECT WEBSITE/URL

http://hycora.eu

PROJECT CONTACT INFORMATION

Jari Ihonen, project coordinator,
jari.ihonen@vtt.fi

MAIN OBJECTIVES OF THE PROJECT

The main objective of HyCoRA project is to provide information to reduce cost of hydrogen fuel quality assurance (QA). However, it will also provide recommendations for revision of existing ISO 14687-2:2012 standard for hydrogen fuel in automotive applications.

PROGRESS/RESULTS TO-DATE

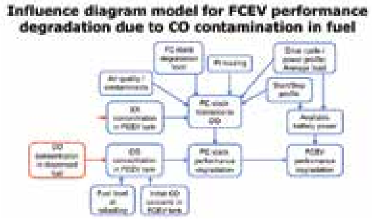
- A recirculation single cell hardware has been developed, enabling anode gas humidification by recirculation and fuel utilisation of 99.5%.
- The results showing the effect of drive cycle with CO as contaminant has been recorded.
- Acquisition of hydrogen pre-concentration device through collaboration with Argonne/Dept. of Energy.
- A first sampling campaign at hydrogen refuelling stations has been completed and results have been disseminated.
- The first version of qualitative risk model for hydrogen fuel contamination has been developed.

FUTURE STEPS

- The results from a single cell with recirculation and an automotive type PEMFC system are compared to define applicability of single cell measurements for Task 1.3
- Evaluation of analytical techniques with focus on challenging/cost driving analyses (ie. Total sulphur and halogenates).
- Conduct and analyse hydrogen samples from second measurement campaign from hydrogen refuelling stations.
- Quantitative risk model for hydrogen fuel contamination will be developed with focus on carbon monoxide.
- The effect of formic acid and formaldehyde will be studied using the cells and systems with anode gas recirculation.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Hydrogen fuel contamination studies require high fuel utilisation and development of experimental techniques for that both in single cell and PEMFC system level.
- A pre-concentration device may be necessary for reducing the analytical techniques in hydrogen quality assurance.
- The limits of formic acid and formaldehyde in ISO 14687-2:2012 may be conservative and more research on the effect of these contaminants is needed.
- A first sampling campaign at hydrogen refuelling stations shows that the use of CO canary species may be problematic when contaminant levels are very low.


Influence diagram model for FCEV performance degradation due to CO contamination in fuel

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	Hydrogen delivered to retail station	cost under 5 €/kg	To reduce cost of hydrogen fuel quality assurance (QA) so that 5 €/kg is possible to reach.	Work is progressing as planned.
AIP 2013	Understanding the effect of contaminants in automotive PEMFC systems.	Completing current knowledge by identifying the impurity limits of PEMFCs for various poisonous species under actual automotive drive cycles	Understanding hydrogen contaminant research in PEMFC system level	Literature review has been completed. Critical contaminants for the quality assurance (formic acid, formaldehyde) have been identified and work is focused on those in addition to carbon monoxide.
AIP 2013	Impurity levels in HRS.	Providing technical data on fuel composition and impurity concentrations at HRS	The objective of is to find out quality variation for automotive grade hydrogen in production and HRS nozzle for different fuel feedstock and production technologies. The work will provide technical and statistically relevant data for impurity concentrations at HRS nozzle.	The first measurement campaign has been completed.
AIP 2013	Understanding the effect of contaminants in automotive PEMFC systems.	Build on existing knowledge, through extensive use of results achieved in previous and on-going European projects as well as international networking and exchange.	Work is performed International co-operation with USA (LANL, Argonne NL), Japan (Japan, Automotive Research Institute, JARI) and Korea (KIST) will be established, as this type of work requires international co-operation.	Contacts have been established and practical co-operation have been started with LANL and ANL.
AIP 2013	The cost of hydrogen quality assurance.	Establishing a simplified and diversified set of requirements for hydrogen fuel quality depending on fuel feedstock and production technologies (biogas, reforming, electrolysis, by-product etc.)	The objective of is to construct a probabilistic risk assessment model that integrates the data on hydrogen quality variation and correlations between impurity concentrations, hydrogen impurity analysis methods and instrumentation, and the susceptibility of fuel cells to hydrogen fuel contaminants.	Work started and first version of qualitative risk model is completed.
AIP 2013	The cost of hydrogen quality assurance.	Simplifying fuel quality control by enhance knowledge of correlations between gas impurity concentrations based on extensive in field measurements at HRS fuel nozzle	The objective of is to construct a probabilistic risk assessment model that integrates the data on hydrogen quality variation and correlations between impurity concentrations, hydrogen impurity analysis methods and instrumentation, and the susceptibility of fuel cells to hydrogen fuel contaminants.	The first measurement campaign has been completed and results have been analysed.
AIP 2013	The cost of hydrogen quality assurance.	Assessing ways to reduce the number of analysis methods required for complete QA	The objective of is to construct a probabilistic risk assessment model that integrates the data on hydrogen quality variation and correlations between impurity concentrations, hydrogen impurity analysis methods and instrumentation, and the susceptibility of fuel cells to hydrogen fuel contaminants.	The work with quantitative risk model has been started.
AIP 2013	The cost of hydrogen quality assurance.	Establishing new analytical methodology relevant for gas impurity quantification	Simplify and reduce cost of analysis by reducing the number of analytical techniques required, partly through the establishment and validation of a pre-concentration device.	Work started and numbers of methods have been evaluated.
AIP 2013	The cost of hydrogen quality assurance.	Designing and verifying of gas sampling instrumentation applicable to HRS operation, including e.g., novel sensors for identification of ultra-low impurity concentrations.	Simplify and reduce cost of analysis by reducing the number of analytical techniques required, partly through the establishment and validation of a pre-concentration device.	Work started
AIP 2013	Understanding the effect of contaminants in automotive PEMFC systems and true need of quality assurance level.	Providing feedback to ISO TC 197/WG 12 and to equipment manufacturers	Validate the performance and accuracy of methods for the quality assurance of hydrogen fuel which are currently used by industry.	Work started and numbers of methods have been evaluated.

HYDROSOL-PLANT

Thermochemical Hydrogen Production in Solar Monolithic Reactor: Construction and Operation of a 750 kWth Plant

AIP / APPLICATION AREA	AIP 2012 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2012.2.5: Thermo-electrical-chemical processes with solar heat sources
START & END DATE	01 Jan. 2014 - 31 Dec. 2016
TOTAL BUDGET	€ 3,480,806
FCH JU CONTRIBUTION	€ 2,265,385
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: APTL/CPERI/CERTH

Partners: DLR, CIEMAT, HYGEAR, HELPE

PROJECT WEBSITE/URL

http://hydrosol-plant.certh.gr

PROJECT CONTACT INFORMATION

souzana@cperi.certh.gr

MAIN OBJECTIVES OF THE PROJECT

The HYDROSOL-PLANT project comes as the natural continuation of the successful HYDROSOL and is expected to develop and operate all of the tools required to scale up solar H_2O splitting to the 750 kWth scale.

Main objectives:

• Define all key components and aspects

• Develop tailored heliostat field technology that enables accurate temperature control of the solar reactors.

• Construct a 750 kWth solar hydrogen production demonstration plant to verify the developed technologies for solar H_2O-splitting.

• Operate the plant and demonstrate hydrogen production and storage on site.

• Techno-economic study for the commercial exploitation of the solar process.

PROGRESS/RESULTS TO-DATE

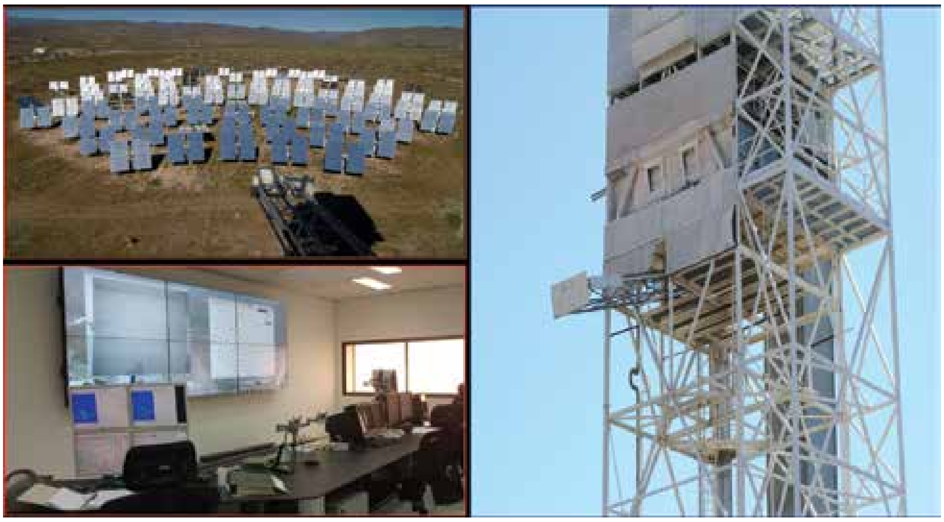
- Definition of key components
- Completion of process flowsheet layout and piping/ instrumentation diagram

FUTURE STEPS

- Construction of H_2 production reactor
- Completion of BoP and subBoP units
- Completion of adaptation of solar tower platform including reactor, peripherals and components integration
- Thermal-only and solar hydrogen production campaigns of prototype plant

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- A flow sheet of the H_2 production plant was elaborated involving all necessary components for the operation of the plant by taking into account also existing facilities on the PSA in Almeria.
- A P&ID diagram was elaborated in order to define the control strategy of the plant. Within the current period changes were implemented in the process layout, mainly related to the addition of one more reactor (a total of 3 parallel reactors), as well as to the feeding of nitrogen in the process.
- The design of the reactor was revisited to cover certain specifications (such as platform space and weight limitations, reactor volume, scalability of the redox porous structures, and also budget limitations). The final reactor design involves a set-up of 3 reactors put in a triangular arrangement.
- Honeycomb as well as foam monolithic structures consisting entirely of the redox material were considered as possible structures for the building of the reactor body and were developed and evaluated. Within the current project period a redox monolithic structure was subjected to more than 450h of consecutive splitting and regeneration cycles in the laboratory with no significant degradation in each redox activity being observed.
- The main process BoP and sub-BoP components were described while the solar platform is prepared to host the HYDROSOL-plant (structural improvements at the 27m height platform, renovation of the heliostat facets, new control program etc.).



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	Materials with performances suitable for economic operation, i.e. life times in the range of more than 1000 operational hours	1000 h	1000 h	450 h
AIP 2012	Solar hydrogen generator in a demonstration range @ 0.5-2 MW scale for high temperature water splitting	0.5-2MW	0.75 MW	construction in preparation
AIP 2012	Demonstration of hydrogen production and storage on site (>3kg/week)	3 kg H_2/week	3 kg H_2/week	3.3 (average-based on lab scale experiments)

HyFIVE

Hydrogen for Innovative Vehicles

AIP / APPLICATION AREA	AIP 2013 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2013.1.1 Large-scale demonstration of road vehicles and refuelling infrastructure VI
START & END DATE	01 Apr. 2014 - 30 Sept. 2017
TOTAL BUDGET	€ 38,445,634.82
FCH JU CONTRIBUTION	€ 17,970,566.00
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Greater London Authority

Partners: BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT (BMW), Daimler AG, Honda Europe, Hyundai Motor Europe, Toyota Europe, Air Products, Danish Hydrogen Fuel, ITM Power, Linde, Danish Partnership for Hydrogen and Fuel Cells, ISTITUTO PER INNOVAZIONI TECNOLOGICHE BOLZANO SCRL, Element Energy, Thinkstep, OMV

PROJECT WEBSITE/URL

www.hyfive.eu

PROJECT CONTACT INFORMATION

Simona Webb
Simona.Webb@london.gov.uk

MAIN OBJECTIVES OF THE PROJECT

To deploy and monitor 110 next generation FCEVs from leading global OEMs (BMW, Daimler, Honda, Hyundai and Toyota) from summer 2014.

To place vehicles with end users representative of the likely earliest commercial adopters, study their behaviour and attitudes towards hydrogen transport to inform subsequent roll-out strategies for the technology.

To create viable hydrogen refuelling station (HRS) networks in 3 regions by deploying 6 new 700 bar HRS and incorporating 12 existing HRS in the project.

To spread a positive and accurate message about the status of FCEV and HRS technology and industry plans for commercialisation via a well-targeted dissemination strategy.

PROGRESS/RESULTS TO-DATE

- Orders placed for 69 vehicles with 38 vehicles operational in the three clusters.
- Sites identified for the Copenhagen Cluster: Aarhus and Korsor.
- Work on one of the sites ongoing over summer 2015 and work done on site identification for other 2 stations in London.
- Station deployed in the Southern Cluster (Innsbruck) in May 2015.
- Ongoing activities linking the HyFIVE project with other existing FCHJU projects as well as National Projects and Initiatives like the CEP.

FUTURE STEPS

- Organising test drives across the three clusters to identify end users and place more FCEVs orders.
- Finalising discussions on the sites for London and Copenhagen and beginning the build of stations.
- Using milestones in the project to disseminate information about it to local and national government, decision makers, potential early adopters and members of the public.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- More work needs to be done to ensure acceptance and understanding of the technology from early responders (fire brigade, etc) as well as insurers and local planning teams.
- More work needs to be done to prepare and inform potential end users about the positives and benefits of the technology.
- More work needs to be done to improve regulations around the use of the technology in vehicles and refuelling as well as to ensure this technology becomes mainstream.

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	Durability in car propulsion systems 5,000 hours	Durability in car propulsion systems 5,000 hours	Vehicle Operation lifetime (>2,000 hrs initially, min. 3,000 hrs as programme target)	On track: vehicles have operated on avg. ~180 hours /~ 72 hours / ~ 23 hours for Southern / Copenhagen / Greater London Clusters. (as of March 31st 2015). 2.000 hrs will not be reached but utilisation and availability of the FCEV are high.
MAIP 2008-2013	Roadmap for the establishment of a commercial European hydrogen refueling infrastructure	Roadmap for the establishment of a commercial European hydrogen refueling infrastructure	Deployment of six new HRS, linking with 12 existing stations and task forces to resolve all remaining pre-commercial hydrogen retailing issues	We expect to reach this target. These HRS are tracking data within HyFIVE: Southern Cl.: OMV Stuttgart Apt, OMV Innsbruck and IIT Bolzano; Copenhagen Cl.: Sydhavnen and Gladsaxe; London Cluster: no data available yet
AIP2013	Vehicle Operation lifetime	(>2,000 hrs initially, min. 3,000 hrs as programme target)	> 2,000 hours initially and minimum 3,000 hours as project target	On track, current operating hours/vehicle: Copenhagen Cl. 71,5 / 22,8 / 180 h for Copenhagen/ London / Southern Cl.
AIP2013	Minimum vehicle operation during the project	12 months or 10,000 km	12 months or 10,000 km	Avg distance/vehicle (as of March 31st 2015): 2.578/ 714 / 4.903 km for Copenhagen / London / Southern Cluster
AIP2013	Mean time between failures (>1,000km)	>1,000km	>1,000km	On track, currently Southern and Copenhagen Cluster achieved an MDBF of 8683 km.
AIP2013	Vehicle availability	>95%	>95%	On track: Achieved availability on the first 6 month of the project: 99,8%
AIP2013	HRS refuelling capacity	min. 50kg/day at start of project, extended to 200kg/day (50 FCEVs/day), with concept for modular upgrade to 100 FCEVs/day	All HRS will have a capacity of >80kg/day initially and the network in each cluster will exceed the 200kg/day target	We expect to reach this target • Swindon: 61kg/d (upgrade possible) • Temple Mills 320kg/d • Hatton Cross 50 kg/d (upgrade: tbc) • Central London 80kg/d upgrade: tbc) • IIT Bolzano: 150 kg/d (upgrade poss.) • OMV Stuttgart Airport 356 kg/d (upgrade: tbc) • OMV Innsbruck no data available yet • Sydhavnen, Koge, Gladsaxe, Aarhus, Konsor: 100 kg/d (upgrade: tbc)
AIP2013	Hydrogen purity and vehicle refuelling process	according to SAE J2601 and 2719 and ISO specifications. IR Communication according to SAE TIR J 2799	H_2 purity and refuelling time according to SAE J2601 & J2719 spec. IR communication to SAE TIR J2799 included on all stations	Achieved. Current average refueling time of 2 min 48 sec.

HYINDOOR

Pre-normative Research on Safe Indoor Use of Fuel Cells and Hydrogen Systems

AIP / APPLICATION AREA	AIP 2010 / AA 4: Early Markets
CALL TOPIC	SP1-JTI-FCH.2010.4.6: Pre-normative research on the indoor use of hydrogen and fuel cells
START & END DATE	02 Jan. 2012 - 01 Jan. 2015
TOTAL BUDGET	€ 3,657,760
FCH JU CONTRIBUTION	€ 1,528,974
PANEL	Panel 6- Cross-Cutting

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Air Liquide

Partners: Commissariat à l'Energie Atomique et aux energies alternatives (CEA), Karlsruhe Institute of technology (KIT), University of Ulster (UU), The CCS Global Group (CCS), Joint Research Center (JRC), Hygear Fuel cell Systems (HFCS), Health and Safety Laboratory (HSL), National Center for Scientific Research Demokritos (NCSRD), LGI consulting (LGI)

PROJECT WEBSITE/URL

http://hyindoor.eu

PROJECT CONTACT INFORMATION

Béatrice Fuster L'Hostis
Beatrice.fuster@airliquide.com

MAIN OBJECTIVES OF THE PROJECT

This project addresses the issue of safe indoor use of hydrogen and fuel cells systems (priority 4.6 of the call FCH-JU-2010-1) for early markets (forklift refuelling and operation, back-up power supply, portable power generation, etc.): It aims to provide scientific and engineering knowledge for the specification of cost-effective means to control hazards specific to the use of hydrogen indoors or in confined space and developing state-of-the-art, guidelines for European stakeholders including specific engineering tools supporting their implementation and recommendations with regards to evolutions needed in the RCS framework .

PROGRESS/RESULTS TO-DATE

- Public deliverables for end users and policy makers: Widely accepted guidelines on Fuel Cell indoor installation and use and RCS recommendations
- Contribution to technical educational training
- International dissemination workshop Paris, December 11th

FUTURE STEPS

- Concerning RCS, since project partners (AL, UU, CCS, CEA) are also members to the ISO/IEC committees, they will attempt to push forward so that the HyIndoor recommendations may be implemented in the new international norms
- Dissemination within specific events like ICHS 2015, Oct. Japan

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The four following main topics were identified and treated experimentally, analytically and/or numerically:
  - Hydrogen release inside semi-confined enclosure,
  - Indoor hydrogen-air deflagration,
  - Jet fire and under-ventilated fire,
  - Hydrogen detection for confined spaces.
- In conclusion of the work performed in HyIndoor project, research results obtained in each work package were critically analysed and translated in easily understandable and usable general rules and calculation means for consequences and mitigation assessment and/or sizing.
- Thus this Guidelines document presents recommendations to integrate safety through the applications.
- For the design and for consequences or mitigation effectiveness assessment several calculation means are proposed and possible, nomograms were built for easy and quick handling of phenomena consequences assessment.
- Simple engineering approaches are proposed as well, and recommendations are given for proper use of the numerical simulation tools.

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 2010	Safe indoor use of hydrogen and fuel cells systems for early markets, forklift refuelling and operation, back-up power supply, portable power generation, etc.)	4	4	Public guidelines, public RCS recommendations and final report are delivered and available in the web site. Final dissemination workshop was organized in Paris, December 11th with international and a diversity of large participants Update educational training course at UU)
AIP 2010	Provide scientific and engineering knowledge for the specification of cost-effective means to control hazards specific to the use of hydrogen indoors or in confined space and developing state-of-the-art guidelines for European stakeholders. Safety guidelines with criterias.	1	1	Preparation of guidelines for installation: • methodologies for calculation of risk assessment considering different phenomena: dispersion, deflagration and under-ventilated fires) • useful trends and criteria when total validation is not possible (experimental vs. modelling) • proposition of mitigation strategies RCS recommendations towards ISO/TC 197 and IEC/ TC 105. Several publications and participation to different international conferences • Realization of the advanced research workshop in September 2013 in Bruxelles, • Realization of the final dissemination workshop in Paris, the 11st of December 2014
AIP 2010	Definition of an RCS transfer strategy	1	1	Strategy defined- liaisons with different international standards groups ISO/TC 197 CEN/ TC 268 and IEC/TC 105, Hysafe and EIGA
AIP 2010	Dissemination, contribution to technical educational trainings	1	1	HyIndoor project staff participated in the work of different sessions of technical School of H_2FC European Infrastructure organized by University of Ulster within H_2FC project. Project outcomes in areas of hydrogen releases, dispersion and ventilation, as well as in mitigation of deflagrations and dealing with hydrogen jet fires indoors will be introduced to teaching and training programs at the University of Ulster: • PGCert/PGDip/MSc in Hydrogen Safety Engineering • Short courses "Progress in Hydrogen Safety" • Teaching hydrogen safety within UK EPSRC Centre for Doctoral Training "Fuel Cells and their Fuels – Clean Power for the 21st Century".

HyLIFT-EUROPE

Demonstration of Fuel Cell-Powered Materials Handling Vehicles Including Infrastructure

AIP / APPLICATION AREA	AIP 2011 / AA 4: Early Markets
CALL TOPIC	SP-JTI-FCH.2011.4.1: Demonstration of fuel cell-powered Material Handling Equipment vehicles including infrastructure
START & END DATE	01 Jan. 2013 - 31 Dec. 2017
TOTAL BUDGET	€ 22,318,685.20
FCH JU CONTRIBUTION	€ 9,263,194.00
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Ludwig-Bölkow-Systemtechnik GmbH (LBST)

Partners: STILL GmbH (STILL), MULAG Fahrzeugwerk Heinz Wössner GmbH (MULAG), Air Products GmbH (AP; exit JUN 2014), Copenhagen Hydrogen Network AS (CHN; exit JUN 2014), Element Energy Ltd. (EE), Federazione delle Associazioni Scientifiche e Tecniche / European Hydrogen Association (FAST/EHA), European Commission – Directorate-General Joint Research Centre – Institute for Energy and Transport (JRC), Heathrow Airport Ltd. (HAL), H_2 Logic A/S (H_2L; exit JUL 2014), Air Liquide Advanced Business (AL; entry JUL 2014), Dantherm Power A/S (DTP; entry AUG 2014), Prelocentre (PRE; entry FEB 2015)

PROJECT WEBSITE/URL

www.hylift-europe.eu

PROJECT CONTACT INFORMATION

coordinator@hylift-europe.eu

MAIN OBJECTIVES OF THE PROJECT

- Demonstration of more than 200 units of hydrogen powered fuel cell materials handling vehicles at vehicle-user sites across Europe
- Demonstration of state-of-the-art supporting hydrogen refuelling infrastructure at 5-20 vehicle-user demonstration sites throughout Europe
- Validation of Total Cost of Ownership (TCO) & path towards commercial targets
- Planning and ensuring initiation of supported market deployment beyond 2015
- Preparation of best practice guide for hydrogen refuelling station installation
- European dissemination and supporting of the European industry

PROGRESS/RESULTS TO-DATE

- HyLIFT-EUROPE will become one of the leading projects in Europe
- As the project has had to overcome some hick-ups in the beginning no vehicles are in demonstration yet
- Several contacts to potential vehicle users are established and discussions are ongoing
- Tests, trials and demo operations are under preparation
- The first hydrogen refuelling station in the framework of the HyLIFT-EUROPE project will start its operation in Q4 2015

FUTURE STEPS

- As one of the first steps test trials for potential customers will be performed
- The consortium will prepare a package comprising vehicles, hydrogen refuelling station and hydrogen supply to be offered to potential customers
- Focus will be on customers with large fleets, three-shift operation and cheap hydrogen available
- As soon as demonstration has started Total Costs of Ownership (TCO) calculations will be performed to identify the real TCO in comparison with conventional technology

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- In USA the number of hydrogen powered fuel cell materials handling vehicles has reached 8,500 units
- The USA success factors are not easily to be transferred to Europe
- Substantial financial support will be required until supply chains are fully established and enable competitive cost structures compared to conventional technologies

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 target: number of industrial and off-highway vehicles	500	> 200	0
AIP 2011	Number of FC-systems	>50 units	> 200 units	0
AIP 2011	FC system life time (h)	>7,500 hours	10,000 hours	No vehicles in demo yet
AIP 2011	FC system efficiency (%)	>45%	45-50%	No vehicles in demo yet
AIP 2011	FC-Systems sales price	<3,000 €/kW	< 2,300 €/kW	No agreements with vehicle-users signed yet
AIP 2011	Refuelling time	3 minutes	~3 minutes	First HRSs under construction
AIP 2011	HRS availability	--	98%	First HRSs under construction
AIP 2011	H_2 price at pump	<10 €/kg	8-12 €/kg (average <10€/kg)	No hydrogen prices disclosed yet

HyPactor

Pre-Normative Research on Resistance to Mechanical Impact of Composite Overwrapped Pressure Vessels

AIP / APPLICATION AREA	AIP 2013 / AA 5: Cross-Cutting Activities
CALL TOPIC	SP1-JTI-FCH.2013.5.6: Pre-normative research on resistance to mechanical impact of pressure vessels in composite materials
START & END DATE	01 Apr. 2014 - 31 Mar. 2017
TOTAL BUDGET	€ 4,049,293
FCH JU CONTRIBUTION	€ 2,143,665
PANEL	Panel 6- Cross-Cutting

PARTNERSHIP/CONSORTIUM LIST

Coordinator: COMMISSARIAT A L'ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES

Partners: L'AIR LIQUIDE S.A, HEXAGON RAUFOSS AS, INSTITUT DE SOUDURE ASSOCIATION, POLITECHNIKA WROCLAWSKA, NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET, ALMA CONSULTING GROUP SAS

PROJECT WEBSITE/URL

http://www.hypactor.eu/

PROJECT CONTACT INFORMATION

Fabien Nony
Fabien.nony@cea.fr

MAIN OBJECTIVES OF THE PROJECT

HYPACTOR aims at providing recommendations for Regulation Codes and Standards (RCS) regarding the qualification of composite overwrapped pressure vessels (COPV) and the procedures for periodic inspection in service of COPV subjected to mechanical impacts.

- Build a database gathering data from literature and from experience (~100 cylinders to be tested) to link well characterized damages induced by impact with residual performance
- Determine the consequences of the different kinds of impacts on vessels' properties and safety
- Define criteria for standardisation organisms in order to optimize vessels' use and safety
- Disseminate the results / make recommendations to the scientific and normalisation communities

PROGRESS/RESULTS TO-DATE

- Review of international impact related incidents on pressure composite cylinders
- Investigation of industrial constraints for the use of NDT in industrial sites
- Definition of project impact test matrix
- Review of NDT techniques and protocols to characterize impact damage
- First results of impact campaign on 36L 70MPa tanks with first estimation of immediate failure level, influence of internal load (unpressurized, 20bar/700bar/875bar gas, water), impact testing on vessel with 700 bars water inside will be done at the end of 2015
- Definition of NDT protocols
- First results of NDT characterisation on impacted COPV

FUTURE STEPS

- Technical report on impact testing with characterization of induced tank damage
- Choice of 2-3 relevant impact conditions from preliminary study (WP2) to study residual performance at short and long term (WP3)
- Definition of WP3 test matrix on the impact testing and residual performance assessment; technical report on short/long term residual performance of impacted tanks
- Definition of NDT protocols
- Modelling of residual performance of impacted COPV with given damage.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

Major results:

- First experimental database with impact parameters and characteristics of induced damage (WP2 step1, 15 impacted tanks which accounts for ~90 impacts under various impact parameters like speed/weight/energy/internal load/drop tower or pneumatic canon...)
- First assessment of impact conditions that lead to immediate failure on 36L 70MPa COPV as a function of internal load (empty, 20bar up to 875bar gaz)
- First comparative assessment of NDT techniques and protocols to characterize impact damage

Main perspectives:

- Conclusions on short/long term residual performance of impacted tanks
- Define most appropriate NDT and pass/fail criteria for periodic inspection or qualification
- Provide normative committees with scientific feedback

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 2013	Identify types of alterations produced by mechanical impacts and develop an understanding of their consequences on short and long term structural integrity	-	• To determine damage characteristics induced by impacts • To identify impact conditions that produce short term failure	On-going (WP2 and WP3) Conditions that lead to immediate failure as a function of internal load First database filled with 90 impacts
AIP 2013	Through a combination of experimental, analytical and/or modelling approaches, establish a relation between severity of impact, level of damage, and effect on structural integrity.in order to determine which impacts may cause a pressure vessel to fail in service.	-	• To identify impact conditions that produce short term failure; by testing, immediate failure (leakage or burst) has been studied • To determine residual burst performance after impact, and long term influence of damage induced by impact • To develop numerical model to predict the influence of well-characterized damage induced by impact on tank performance and safety	On-going
AIP 2013	Apply the results of the above to assess the reliability of composite pressure vessels in the foreseen applications and potential needs of protection and/or opportunities of design optimization.	-	• identify most relevant impact conditions • assess reliability of COPV with respect to field/in-service experience.	Not started
AIP 2013	Evaluate non-destructive examination methods, such as analysis of acoustic emissions, and associated pass/fail criteria for controlling pressure vessels in service with regards to potential damage from impact	-	• assess non-destructive techniques and define protocols to inspect composite damaged by impact • define critical damage and pass/fail criteria	On-going on WP2 impacted tanks
AIP 2013 MAIP 2008-2013	Recommendations to industry and for international standards development	-	• dissemination of experimental results, revised methodology for qualification, inspection and testing to RCS committees	Not started
MAIP 2008-2013	International cooperation strategy /safety	-		Consortium contacted by DoE for exchange

HYPER

Integrated Hydrogen Power Packs for Portable and Other Autonomous Applications

AIP / APPLICATION AREA	AIP 2011 / AA 4: Early Markets
CALL TOPIC	SP1-JTI-FCH.2011.4.4: Research, development and demonstration of new portable fuel cell systems
START & END DATE	03 Sept. 2012 - 02 Sept. 2015
TOTAL BUDGET	€ 3,9 million
FCH JU CONTRIBUTION	€ 2,2 million
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Orion Innovations (UK) Ltd

Partners: PaxiTech SAS, University of Glasgow, Airbus Group Innovations (AGI), Institute of Power Engineering, McPhy Energy SA, Joint Research Centre.

PROJECT WEBSITE/URL

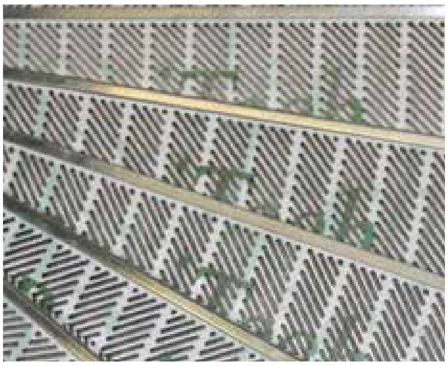
www.hyperportablepower.com

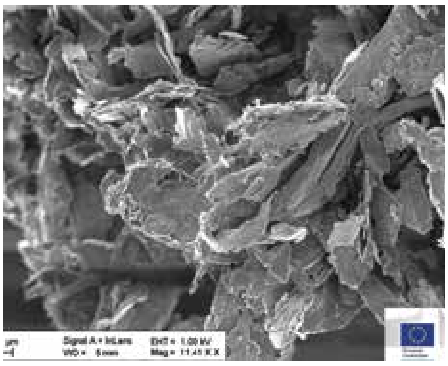
PROJECT CONTACT INFORMATION

Dr Juliet Kauffmann
Juliet.kauffmann@orioninnovations.co.uk

MAIN OBJECTIVES OF THE PROJECT

Development and demonstration of a market ready, portable power pack comprising an integrated modular FC and hydrogen storage system that is flexible in design, cost effective and readily customised for application across multiple low power markets.





PROGRESS/RESULTS TO-DATE

- Developed nanostructured ammonia borane composite H_2 storage material with >5 wt% and no release of toxic gases
- Developed low temperature hydride tank to demonstrate interoperability of HYPER system
- Integrated 20 W_e FC modules into complete 100 W_e FC system (including controls and cooling) incorporating results from thermodynamic modelling
- Initiated field testing of application specific 100 W_e alpha prototypes with both solid and gaseous storage modules
- First beta prototype design with full safety features, in preparation for CE marking and end user trials.

FUTURE STEPS

- Complete field testing of alpha prototypes and incorporate results into future design development.
- Complete beta design with focus on cost-efficient manufacturing optimised for different power outputs
- Build beta prototypes and complete CE marking process
- Trial with independent end users
- Follow through with the project's commercialisation strategy to reach early sales of FC system

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Ammonia borane composite could provide step change in terms of gravimetric density, but requires more research before integration into storage tank
- Two working 100 W_e HYPER prototype systems with alternative fuelling are being tested within specific applications.
- Detailed market analysis and validation exercise showed remote monitoring and control particularly attractive for HYPER System, which can offer a reliable low power (<20 W), grid-independent power source
- Independent end users have expressed interest in trialling the complete system as soon as possible

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	Demonstrate technology readiness of specific applications	12,000 - 13,000 portable & micro FC's in the market by 2015	Field demonstration as 100 W_e portable power pack and 500 W_e UAV range extender	Field testing of 100 W_e systems for specific applications are underway, using interchangeable H_2 storage.
AIP 2011	Develop application specific prototypes ready to be used by specified end users	Demonstration of complete systems	Field demonstration as 100 W_e portable power pack and 500 W_e UAV range extender	Field testing of 500 W_e UAV range will not be achieved during the lifetime of the project due to technical difficulties with scale up.
AIP 2011	Weight and volume	<35 kg/kW and 50 l/kW	100 W_e system: 65 kg/kW and 60 l/kW 500 W_e system: 20 kg/kW and 20 l/kW	100 W_e system, 85 kg/kW and 250 l/kW. High weight and volume due to BoP requirements, use of off-the-shelf casing, incorporation of fans to meet safety regulations and spacing of FC modules to ensure cooling by natural convection. Call targets will readily be met at lower powers where BoP and need for cooling reduced (<40 W).
AIP 2011	Final system cost	<5,000 €/kW	<5,000 €/kW	Current high volume costs anticipated at > 5000 €/kW. However, cost per kW rises significantly for small FC systems. Composed of compact 20 W modules with limited BoP, the HYPER system is expected to be very competitive at small scales (<40 W).
AIP 2011	System efficiency	>30%	FC efficiency >50%	FC efficiency of 50% achieved.
AIP 2011	Lifetime:	1000h, 100 start stop cycles	1000h, 100 start stop cycles	Targets for lifetime and start stop cycles will be exceeded by the end of the project for the 20 W_e FC module.
AIP 2011	Operating temperature	-20°C to 60°C	-20°C to 60°C	FC demonstrated from -20°C to 40°C. 40°C is a maximum operating temperature, but cooling triggered at 41°C.

HyResponse

European Hydrogen Emergency Response Training Programme for First Responders

AIP / APPLICATION AREA	AIP 2012 / AA 5: Cross-Cutting Activities
CALL TOPIC	SP1-JTI-FCH.2012.5.3 : First responder educational and practical hydrogen safety training
START & END DATE	01 Jun. 2013 - 31 May 2016
TOTAL BUDGET	€ 2,640,284.40
FCH JU CONTRIBUTION	€ 1,858,453.00
PANEL	Panel 6- Cross-Cutting

PARTNERSHIP/CONSORTIUM LIST

Coordinator: ENSOSP

Partners: AIR LIQUIDE BUSINESS, UNIVERSITY OF ULSTER, AREVA ENERGY STORAGE, FAST, CCS GLOBAL GROUP, CRISE

PROJECT WEBSITE/URL

www.hyresponse.eu

PROJECT CONTACT INFORMATION

Major Sébastien BERTAU (ENSOSP)
sebastien.bertau@ensosp.fr

Dr Franck VERBECKE (AREVA)
franck.verbecke@areva.com

MAIN OBJECTIVES OF THE PROJECT

The HyResponse project set itself six main objectives:

1. Define emergency scenarios and first response strategies,
2. Create an educational training material,
3. Build an operational training facility as a plateform with with multiple workshops exercises,
4. Imagine and develop an virtual reality training platform (reproduce a nerve center for crisis management to simulate frames exercises),
5. Execute three pilot training sessions to 50 first responders,
6. Promote recommandations and dissemination all around Europe (also in US and Japan countries)

PROGRESS/RESULTS TO-DATE

- Definition of risks associated with the use of hydrogen in professional and industrial areas (leak, fire, explosion, etc.),
- For each risk, definition of strategic and tactical maneuvers to eliminate the hazard or due incidents / accidents to the use of responders (firemen or industrial sites security guards),
- For each risk, definition of educational training scenarios using the above defined tactical maneuvers,
- Creating the educational matrix of a training week nesting theoretical courses (risk knowledge, standards, feedback), the practical training sequences on a physical platform and virtual reality exercises,
- Definition of the training platform plans (5 modules) / exercise scenarios in virtual reality / main courses.

FUTURE STEPS

- Construction of the physical platform with the 5 modules (clarinets, explosion area, simulating hydrogen vehicules, mikados, refuelling station),
- Construction of the virtual reality plateform (informatic network (computers, software) allowing simultaneous teamwork in separate box),
- Implementation of a best practices guide
- Animation of the three pilot training sessions

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- This project will be the first European training center at the discretion of the hydrogen risk,
- It will regularly offer to all European stakeholders training sessions mixing theorical courses, practical exercises and educational and scientific approaches through virtual reality,
- This program also aims to create and meet together a community of experts in this domain,
- After the project, in a logical sequence, creation of multi level operational and virtual training exercices

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	Developing training programmes at all levels	2 levels: regulators and technical project managers.	3 levels: discovery, advanced (as regulators), and expert	Lectures, practical training scenarios and 2 exercises in virtual reality for each level have been developed
MAIP 2008-2013	Dissemination of the programme results through public awareness events and initiatives	Qualitative	2 international worhshops for European firefighters and decision makers of the crise 3 advisoring consultating panel meetings Events participations	1 internationalworkshop realised in 2014 (September) and 2 ACP meetings (2014 and 2015) Participation to several international events on hydrogen (e.g. ICHS 2015 in Japan)
AIP 2012	Develop and disseminate first-responder hydrogen safety educational materials in Europe		A full week training session will be developed with lectures, practical training scenarios and 2 exercises in virtual reality. This week will allow learner progress through three levels: discovery, advanced (as regulators), and expert	The plan of the training week is ready, some lectures and RCS (regulations, codes and standards) also. A matrix is used to identify each application using hydrogen, the possible risk for maneuver and response (reduction in risk) tactical or strategic. Within this context on the risk, of the tool (application) created and the expected response, at each time some exercises scenarios are determined, both on the operational platform but also with virtual reality.
AIP 2012	Build and disseminate hydrogen safety response approach based on feedback and responders' best practices		A full week training session will be developed with lectures, practical training scenarios and 2 exercises in virtual reality. This week will allow learner progress through three levels: discovery, advanced (as regulators), and expert	The plan of the training week is ready, some lectures and RCS (regulations, codes and standards) also. A matrix is used to identify each application using hydrogen, the possible risk for maneuver and response (reduction in risk) tactical or strategic. Within this context on the risk, of the tool (application) created and the expected response, at each time some exercises scenarios are determined, both on the operational platform but also with virtual reality.
AIP 2012	Develop and disseminate first-responder intervention guide		idem	At the end of the three experimental training sessions planned in the project (the last in June 2016) and their feedback, the good practice guide will be finalized
AIP 2012	Install an European Hydrogen Training Platform on which will be realised full scale exercises		Construction of the physical platform with the 5 modules (clarinets, explosion area, simulating hydrogen vehicles, mikados, refuelling station), Construction of the virtual reality platform (informatic network (computers, software) allowing simultaneous teamwork in separate box),	The deposite of the building permit of this platform is being investigated. Work will begin in November 2015 and it will be operational with tests phase in February 2016 The virtual reality platform already exists but it will be improved and better dimensioned at the end of this year 2015
AIP 2012	Perpetuate practical training using the platform disseminate best practices using online tools		After the project, the EHSTP (European hydrogen safety training platform) will survive and will propose trainings sessions with lectures, practical and virtual exercise scenarios	A part of the online tools are ready on website site of HyResponse but not publicly available yet

HyTEC

Hydrogen Transport in European Cities

AIP / APPLICATION AREA	AIP 2010 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2010.1.1: Large-scale demonstration of road vehicles and refuelling infrastructure III
START & END DATE	01 Sept. 2011 - 31 Aug. 2015
TOTAL BUDGET	€ 29,2 million
FCH JU CONTRIBUTION	€ 11,95 million
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Air Products

Partners: Element Energy, HyER, LTI Ltd (Note that LTI is no longer part of the HyTEC project. However, the organisation contributed greatly to the first half of the project), Cenex, Greater London Authority, hySOLUTIONS, Matgas, LBST, Copenhagen Hydrogen Network, Kobenhaven Kommune, Foreningen Hydrogen Link, Intelligent Energy, Heathrow Airport Ltd, London Bus Services Ltd, Fraunhofer Gesellschaft, Hyundai Motor Europr

PROJECT WEBSITE/URL

http://hy-tec.eu/

PROJECT CONTACT INFORMATION

Emma Guthrie
guthriej@airproducts.com

MAIN OBJECTIVES OF THE PROJECT

The HyTEC project was tasked with creating new hydrogen vehicle deployment centers in London, Copenhagen and Oslo. Each city adopted trialled different vehicle types and approaches to refuelling infrastructure rollout, allowing diverse concepts to be tested:

- In Copenhagen passenger were trialled alongside a refuelling station dispensing green hydrogen.
- In London passenger cars and taxis were deployed alongside a state-of-the-art refuelling station using innovative delivered hydrogen technology.
- In Oslo passenger cars were deployed, utilising existing infrastructure

The experience acquired by the cities is being shared with other cities and communities.

PROGRESS/RESULTS TO-DATE

London:

- Installation and operation of the UK's first publicly accessible hydrogen fuelling station.
- Vehicle test and shakedown, driver training and certification of five fuel cell taxis and creation of their operations base in London.

London and Oslo:

- Deployment and operation of fuel cell passenger cars in both cities.

Copenhagen:

- Completion of the tendering process for the procurement of FCEVs, resulting in the delivery and operation of 15 Hyundai ix35 FCEVs (9 of these vehicles are supported by HyTEC, with 6 coming via another project).
- Installation and operation of three hydrogen fuelling stations based on green hydrogen.

FUTURE STEPS

- Continued operation and data collection from hydrogen vehicle fleets and the associated fuelling infrastructure in Copenhagen and London, through the HyFIVE project.
- Disseminating the results of the project, considering the full well to wheels life cycle impact of the vehicles and associated fuelling networks, demonstrating the technical performance of the vehicles and uncovering non-technical barriers to wider implementation.
- Dissemination of analysis on future commercialisation of the vehicles, as well as providing an approach for the rollout of vehicles and infrastructure, building on the demonstration projects.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The HyTEC project implemented stakeholder inclusive vehicle demonstration programmes that specifically address the challenge of transitioning hydrogen vehicles from running exemplars to fully certified vehicles and moving along the pathway to providing competitive future products.
- HyTEC's work led to the creation of networks in each country for the ongoing co-ordination of the process leading to hydrogen vehicle rollout in the UK and Denmark.
- These networks will be used beyond the end of the project, providing a lasting legacy and supporting continued commercialisation efforts in the hydrogen transport sector.

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	Light Duty Vehicles deployment	~500	~20	27
MAIP 2008-2013	Additional sites and stations	2 additional sites with 3 new stations	2 additional sites with 4 new stations	2 additional sites with 4 new stations
MAIP 2008-2013	Vehicle lifetime	> 5,000 hours	> 2,000 hours	This has already been achieved for the passenger cars. For the taxis and scooter, this has been demonstrated in test stands in the laboratory and taxis will achieve this target during the project.
MAIP 2008-2013	Establishment of a commercial European hydrogen refuelling Infrastructure	Roadmap for the establishment of a commercial European hydrogen refuelling Infrastructure	Rollout strategies / partnerships developed in the UK and Denmark. Creation of links between demonstration sites	Rollout strategies reports for Copenhagen and London Development of partnerships with key stakeholders
AIP 2010	Vehicle reliability	Mean Time Between Failure (MTBF) >1,000 km	Vehicle reliability - MTBF >1,000 km	Achieved
AIP 2010	Vehicle availability	>95%	>95%	95% - 99% (average - depending on vehicle type and location)
AIP 2010	Vehicle efficiency	Efficiency >40% (NEDC)	Efficiency >40% (NEDC)	Real-world (non-NEDC) consumption of 70 km/kg H_2 - 74 km/kgH_2 (average - depending on vehicle type and location)
AIP 2010	Refuelling capacity	Stations refuelling at 35 and 70 MPa, with refuelling capacity of 50 kg and potential for extension to 200 kg	Stations refuelling at 35 and 70 MPa, with refuelling capacity of 50 kg and potential for extension to 200 kg	35 and 70 MPa, with potential for extension to 200 kg
AIP 2010	Station availability	98%	98%	95% - > 99% (average - depending on site)
AIP 2010	Station hydrogen production efficiency	Efficiency of 50-70%	Will be achieved at each station (>55% for onsite), the overall efficiency of the logistics based energy chains can exceed 70% (well to tank)	N/A (Not tested as yet)
AIP 2010	H_2 price at pump (€/kg)	10 €/kg or price that matches cost per driven km on gasoline	10 €/kg or price that matches cost per driven km on gasoline	10 €/kg or price that matches cost per driven km on gasoline

HyTIME

Low Temperature Hydrogen Production from Second Generation Biomass

AIP / APPLICATION AREA	AIP 2010 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2010.2.4: Low temperature H_2 production processes.
START & END DATE	01 Jan. 2012 - 30 Jun. 2015
TOTAL BUDGET	€ 3,057,249
FCH JU CONTRIBUTION	€ 1,606,900
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: DLO-FBR

Partners: Awite, ENVIPARK, Heijmans, RWTH, TUW, HyGear, Veolia Water (Wiedemann-Polska left in Month 27)

PROJECT WEBSITE/URL

www.hy-time.eu

PROJECT CONTACT INFORMATION

Pieternel Claassen
pieternel.claassen@wur.nl

MAIN OBJECTIVES OF THE PROJECT

The target of HyTIME is to construct a prototype process for the production of 1-10 kg H_2/day from second generation biomass. The strategy is to employ thermophilic bacteria, growing at 70 °C, which have superior yields in H_2 production from grass and straw hydrolysates, or molasses. Dedicated bioreactors and gas upgrading devices will be constructed with the aim to increase productivity. The effluent of the H_2 reactor will be used for biogas production to cover the energy demand of the system.

PROGRESS/RESULTS TO-DATE

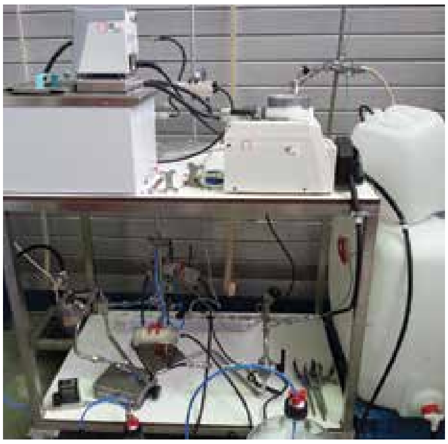
1. Productivity increase was proportional to decrease of hydraulic retention time during stable fermentation for > 37 days
2. On pure sugar max productivity was 66 mg H_2/L.h with 26 % H_2 in off gas at 53% yield
3. On steam exploded and enzymatically hydrolysed straw hydrolysate max productivity was 3.6 mg H_2/L.h with 44% H_2 in off gas
4. Subsequent anaerobic digestion was 6.3 CH_4/L.h with 47% CH_4 in off gas
5. In a 255 L packed bed reactor 110 g H_2/day was achieved using pure sugars at 25% yield

FUTURE STEPS

1. Further fundamental R&D aimed at management of bacterial population dynamics
2. Selection of robust hydrogen producers
3. Verification of new strategies with mixed product portfolios

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

1. Biomass is a potential source for hydrogen production
2. Combination of hydrogen fermentation with anaerobic digestion is successful starting from straw
3. Selection pressure in hydrogen fermentation by applying thermophilic conditions seems insufficient



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 2010	Biomass availability and mobilization of sugars with dedicated fractionation processes	Efficient, easy to handle biological systems shall be developed with digestion systems based on 2nd generation biomass feedstock	75% mobilization of sugars from biomass	71% from straw 36% from verge grass <10% from kitchen waste
AIP 2010	Increase of hydrogen productivity	Low temperature H_2 production process	0.08 g H_2/L.h with high H_2 yield (75%)	On glucose: 0.034 g H_2/L.h with H_2 yield of 80%; On grass hydrolysate 0.04 g H_2/L.h with H_2 yield of 90%.
AIP 2010	Upscaling hydrogen production	Stable continuous hydrogen production in large scale reactor	1-10 kg H_2/day at 75% efficiency in large scale bioreactor on molasses	In the 5L reactor: 9 g H_2/day on glucose at 68 % efficiency; 6 g H_2/day on grass hydrolysate at 90% efficiency In the 50L reactor: 23.4 g H_2/day atx 88% efficiency on sucrose and 18,3 at 20% on molasses, respectively In the 225L reactor: 108 g H_2/day at circa 25% efficiency
AIP 2010	System integration to produce hydrogen and methane	Development of bio H_2 production systems	n.a.	No data yet available

HyTransfer

Pre-Normative Research for Thermodynamic Optimization of Fast Hydrogen Transfer

AIP / APPLICATION AREA	AIP 2012 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2012.2.6: Pre-normative research on gaseous hydrogen transfer
START & END DATE	01 Jun. 2013 - 31 Jul. 2016
TOTAL BUDGET	€ 3,095,956
FCH JU CONTRIBUTION	€ 1,608,684
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Ludwig-Bölkow-Systemtechnik GmbH

Partners: Ludwig-Bölkow-Systemtechnik GmbH, Air Liquide S.A., The CCS Global Group Limited, Hexagon Raufoss AS, Honda R&D Europe (Deutschland) GmbH, JRC – Joint Research Centre – European Commission, Centre National de la recherche scientifique, Testnet Engineering GmbH

PROJECT WEBSITE/URL

www.hytransfer.eu

PROJECT CONTACT INFORMATION

Sofia Capito, Coordinator
info@HyTransfer.eu

MAIN OBJECTIVES OF THE PROJECT

HyTransfer aims to develop and experimentally validate a more practical approach for optimized fast filling of compressed hydrogen, meeting the material temperature limits of the tanks taking into account the container and system's thermal behaviour.

This project aims to create conditions for an uptake of the approach by international standards, for wide-scale implementation into refuelling protocols. The new approach will be thus evaluated and its benefits quantified with regards to performance, costs, and safety. Finally, recommendations for implementation into international standards will be proposed.

PROGRESS/RESULTS TO-DATE

- Tanks with temperature measuring devices (thermocouples) in the tank walls were manufactured by two different tank manufacturers. Thermocouples were strategically placed according to Computational Fluid Dynamics (CFD) calculations.
- 65 filling and emptying experiments on two different kinds of small tanks have been performed at three different labs in Europe. Temperature was measured inside the tank in the gas, inside the tank wall between liner and composite wrapping and on the outside of the tank wall.
- Results show a significant temperature difference between hydrogen gas and tank wall at the end of fast-fills
- A simple model predicting all temperatures is in very good agreement with the experiments. The error is in the magnitude of 3°C.
- Existing RCS and opportunities for improvements by the project are continuously monitored.

FUTURE STEPS

- Experiments on tank systems with up to 5 tanks of different sizes will be performed in autumn and winter 2015/2016
- Further optimization of CFD and simple model to match experiments even better
- Development and validation of simple model sustaining energy based fuelling process control criteria
- Techno-economical evaluation of results
- Prepare recommendations for RCS

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

Perspectives:

- Optimized and more efficient refuelling protocol
- Guidance and simple model for optimized temperature control during hydrogen transfer
- Reduction of HRS operational expenditures (OPEX) and capital expenditures (CAPEX)
- Increased reliability and life time of technical HRS components
- Recommendations for international RCS

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	Identification of opportunities for optimization	Not specified	Not specified	Optimization by focussing on heat transfer
AIP 2012	Identification of existing RCS and opportunities for improvement	Not specified	Not specified	Work in progress
AIP 2012	Improved approaches for carrying out the transfer with less pre-cooling	Not specified	Not specified	Work in progress
AIP 2012	Recommendations for implementation in international standards	Not specified	Not specified	This will be the final result of HyTransfer
AIP 2012	Evaluate the influence of tank construction on the maximum allowable filling speed	Not specified	Not specified	Tanks of three different sizes from two different manufacturers with two different liner materials were purchased and will be evaluated in three different labs concerning their thermal behaviour under a variety of filling conditions.

HyTransit

European Hydrogen Transit Buses in Scotland

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.1 - Large-scale demonstration of road vehicles and refuelling infrastructure IV
START & END DATE	01 Jan. 2013 - 30 Jun. 2017
TOTAL BUDGET	€ 16,3 million
FCH JU CONTRIBUTION	€ 7 million
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: BOC Ltd

Partners: Van Hool N.V., Aberdeen City Council, Stagecoarch Bus Holdings Ltd., Hydrogen, Fuel Cells and Electro-mobility in European Regions, Planet Planumgsgruppe Energie und Technik GBR, Dantherm Power A.S., Element Energy Ltd.

PROJECT WEBSITE/URL

http://aberdeeninvestlivevisit.co.uk/Invest/Aberdeens-Economy/City-Projects/H2-Aberdeen/Hydrogen-Bus/Hydrogen-Bus-Project.aspx

PROJECT CONTACT INFORMATION

Dr Hamish Nichol
hamish.nichol@boc.com
+44(0)7554437269

MAIN OBJECTIVES OF THE PROJECT

The overall project objective is to prove that a hybrid fuel cell bus is capable of meeting the operational performance of an equivalent diesel bus on demanding UK routes (including urban and inter-urban driving), whilst considerably exceeding its environmental performance.

This will be achieved by bringing together a primarily industrial consortium from five member states to develop, deploy a state of the art refuelling station and bus fleet and then monitor the buses in day to day service, with an overarching aim to demonstrate an operational availability for the buses equivalent to diesel (over 90%).

PROGRESS/RESULTS TO-DATE

- All six hydrogen buses operational on a commercial route.
- State of the art hydrogen production and refuelling station commissioned and operational.
- Hydrogen safe maintenance facility built and operational.

FUTURE STEPS

- Continue operation of buses and collect data on usage
- Continue operation of hydrogen production plant and refuelling station and collect data
- Analyse usage data
- Disseminate data and knowledge to wider community
- Techno-economic feasibility study based on real data.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

Too early to conclude on findings.

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 2011	Large-scale demonstration of road vehicles and refuelling infrastructure IV	Fuel cell life: > 4,000h initially, with a min. of 6,000h lifetime as target	System with > 12,000h warranty.	Lifetime not yet reached
AIP 2011	Large-scale demonstration of road vehicles and refuelling infrastructure IV	Availability of over 85%, with maintenance as for conventional buses	Availability > 90%(Availability is defined as in the CHIC and HyFLEET:CUTE project: "the ratio of time that the unit is operational (i.e. operating or on stand-by) to the total time of the project". www.global-hydrogen-bus-platform.com), maintenance regime based on that for a conventional bus.	*Still in 'teething' period of bus operation.*
AIP 2011	Large-scale demonstration of road vehicles and refuelling infrastructure IV	Fuel consumption < 11–13 kg H_2/100 km	< 10 kg of hydrogen /100 km.	*Data yet to be analysed*
AIP 2011	Large-scale demonstration of road vehicles and refuelling infrastructure IV	Refuelling capacity > 50kg/day (at the beginning of the project) to be extended to min. 200kg/day	System peak fuelling capacity : 300kg/day, compatible with modular expansion to > 1,000kg/day with minimal modification to the on-site H_2 storage system.	Peak fuelling is currently 360kg/day. We are regularly refuelling ~200kg/day
AIP 2011	Large-scale demonstration of road vehicles and refuelling infrastructure IV	Ensure that 1–2 buses can be refuelled per hour	Station design incorporates ionic compressors in a booster configuration allowing continuous dispensing at 120g/s (> AIP targets).	Each bus fuelling takes <10 minutes and the system can manage all six buses back to back.
AIP 2011	Large-scale demonstration of road vehicles and refuelling infrastructure IV	The refuelling station concept must include a modular expansion to 100/vehicles per day	Refuelling station modular design - can dispense up to 1,000 kg/day, (50 buses or 250 cars).	Design is modular - compliant and exceeding AIP targets
AIP 2011	Large-scale demonstration of road vehicles and refuelling infrastructure IV	The refuelling station must prove an availability of ≥98% (usable operation time of the whole station)	Target achievable by the refuelling technology proposed.	So far, 7 months of running the station at 100% availability.
AIP 2011	Large-scale demonstration of road vehicles and refuelling infrastructure IV	Hydrogen purity and refuelling time according to SAE and ISO specifications	SAE and ISO specs as contractual requirements for H_2 supplied by the fuelling station.	Compliant
AIP 2011	Large-scale demonstration of road vehicles and refuelling infrastructure IV	Hydrogen Opex cost < 10 €/kg (excluding tax), and individuation of a suitable strategy to achieve 5 €/kg	Opex + H_2 production costs basis (200 Kg/day): 6 €/kg. For 1,000kg/day, the price could fall to < 5 €/kg.	*Data yet to be analysed (but €/GBP exchange rate changed considerably since 2011)*
AIP 2011	Large-scale demonstration of road vehicles and refuelling infrastructure IV	H_2 production efficiency 50% to 70%	Initially: H_2 sourced within BOC's merchant network (> 60% SMR). To be replaced by on-site water electrolysers linked to the grid (expected efficiency > 60%)	All H_2 currently used is produced on site by electrolysis. Efficiency data not analysed yet.

IMMEDIATE

Innovative Automotive MEA Development – Implementation of IPHE-GENIE Achievements Targeted at Excellence

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.5: Next generation European MEAs for transportation application
START & END DATE	01 Jan. 2013 - 31 Mar. 2016
TOTAL BUDGET	€ 3,685,553
FCH JU CONTRIBUTION	€ 2,087,390
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: IRD Fuel Cells A/S

Partners: ICPF, CNRS, FUMA-TECH, SHANGHAI JIAO TONG UNIVERSITY, VOLVO TECHNOLOGY, SGL CARBON, JRC, Imerys Graphite & Carbon.

PROJECT WEBSITE/URL

www.immediate.ird.dk

PROJECT CONTACT INFORMATION

Madeleine Odgaard
mod@ird-fuelcell.com

MAIN OBJECTIVES OF THE PROJECT

The overall objective of the IMMEDIATE project is to develop a medium temperature PEM MEA °C that will fulfil the OEM requirements with respect to cost, performance and durability. The prime focus of Immediate to develop MEAs aimed for transportation applications is through material R&D & process oPGMimization and to screen and test precursor materials such as ionomers, membranes, catalyst, catalyst supports and gas diffusion layers aiming to demonstrate an oPGMimized MEA and accomplish the target with performance > 1.0 W/cm^2 @ η_{El}> 55%, T≥95°C, RH≤30%, P≤1.5 bar (abs).

PROGRESS/RESULTS TO-DATE

1. A range of carbon supports with a variety of surface properties and oPGMimised mesoporosity have been developed
2. A range of 60wt% PGM/C catalyst fabricated and evaluated (activity, AST, MEA performance)
3. New cross-linkable ionomers based on PFSA polymer have been developed.
4. A route has been developed to incorporate radical scavenger/hydrogen peroxide degradation catalysts in the membrane
5. First steps towards an improved gas diffusion layer with enhanced conductivity and water retention were taken

FUTURE STEPS

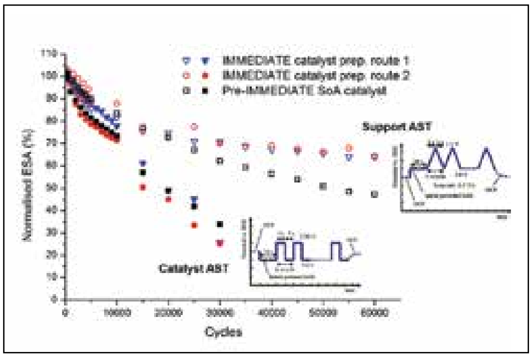
1. Development of low PGM MEA with developed catalyst and supports
2. Fabrication and validation of the developed MEA's in short stack
3. Demonstrate MEA performance > 1W/cm2
4. Reduce PGM content < 0.15 g/kW

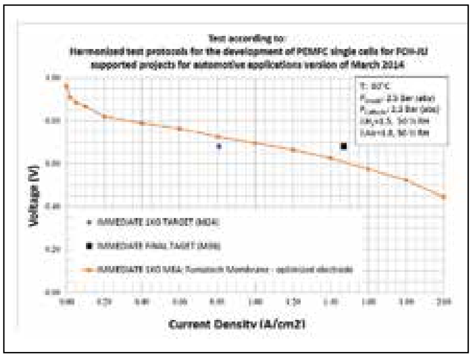
CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

1. Through extensive characterisation as well as electrochemical screening of the various supports and catalysts, a synthesis methods have been developed and oPGMimised.
2. New membrane has been developed and demonstrated in single-cell test
3. Improved GDL has shown superior performance at low relative humidity
4. Performance > 0.75 W/cm2 of MEAs with improved electrodes resulted in reduced PGM-content from 0.9 g/kW to 0.45 g/kW

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	*Busses Vehicle* PEM-FC System:	<3,500€/kW	The overall aim is to develop Membrane Electrode Assemblies with significant specific cost reduction (i.e. cost/power) through development of processes and materials a) catalysts b) membrane and c) gas diffusion layers (GDLs). 2015 target: MEA with PGM-loading of < 0.15 g PGM/kW	MEA with <0.45 gPGM/kW
AIP 2011	2015: Membrane with proton conductivity ≥ 100mS/cm at ≤ 25% RH, 120°C	Membrane with proton conductivity of at least 0.1S/cm at 120°C & 25% RH	Membrane with proton conductivity of at least 0.1S/cm at 95°C & 25% RH	90 mS/cm at 100 °C and 50% RH
AIP 2011	2015: Membrane with thermal stability up to 160°C	Membrane with thermal stability up to 160°C	Membrane with thermal stability up to 120°C	Glass transition temperature *(Tg)* of 140–150 °C
AIP 2011	GDL with area conductivity (through plane) >2 S/cm at operating conditions	GDL with through plane conductivity >2 S/cm at nominal operating conditions	GDL with through plane conductivity >2 S/cm at nominal operating conditions	GDL with conductivity of 4.4 mOhm*cm2
AIP 2011	2015. MEA with PGM-loading of < 0.15 g PGM/kW	2015. MEA with PGM-loading of < 0.15 g PGM/kW	2015. MEA with PGM-loading of < 0.15 g PGM/kW	MEA with < 0.45 gPGM/kW
AIP 2011	MEA BOL of > 1.0 W/cm^2 @ U_{Cell}=0.68 V	MEA BOL of > 1.0 W/cm^2 @ U_{Cell}=0.68 V	MEA BOL of > 1.0 W/cm^2 @ U_{Cell}=0.68 V	MEA BOL of > 0.9 W/cm^2 @ U_{Cell}=0.68 V





IMPACT

Improved Lifetime of Automotive Application Fuel Cells with Ultra-Low Pt-Loading

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.6 Investigation of degradation phenomena SP1-JTI-FCH.2011.1.5 Next generation European MEAs for transportation applications
START & END DATE	01 Nov. 2012 - 31 Oct. 2016
TOTAL BUDGET	€ 9,144,498
FCH JU CONTRIBUTION	€ 3,902,403
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

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

Partners: Commissariat à l'Energie Atomique (CEA), European Commission, Directora¬te-General Joint Research Centre, Institute for Energy (JRC-IE), Consiglio Nazionale delle Ricerche, Johnson Matthey Fuel Cells Limited, Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW), University of Applied Science Esslingen, TU Berlin, Institut National Polytechnique de Toulouse, Gwangju Institute of Science and Technology, Solvay Specialty Polymers Italy S.p.A.

PROJECT WEBSITE/URL

http://www.eu-project-impact.eu/

PROJECT CONTACT INFORMATION

Prof. Dr. K. Andreas Friedrich
Andreas.Friedrich@dlr.de

MAIN OBJECTIVES OF THE PROJECT

Identify the relevant degradation mechanisms of polymer electrolyte fuel cells at ultralow Pt content (< 0.2 mgcm-2) and derive mitigation strategies to obtain a lifetime of 5,000 hours in dynamic operation, with a degradation rate below 10 µVh-1, by material development, structural design of cells and materials, and integration of improvements into a best MEA. The results of the improved durability of the cell technology will be demonstrated in a relevant stack environment.

PROGRESS/RESULTS TO-DATE

- In-situ and ex-situ investigation of reference MEA
- In-situ and ex-situ investigation of improved MEAs (generation I – IV)
- Determination of reversible and permanent degradation in single cell and stack
- Locally resolved analysis of cell performance
- First stack durability tests ongoing

FUTURE STEPS

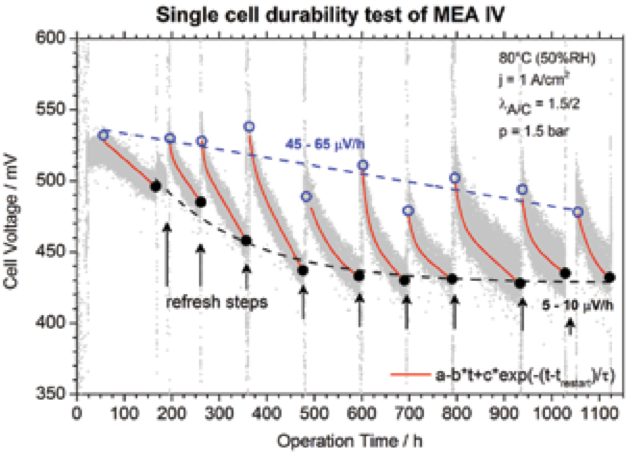
- Fabrication of next generation improved MEA
- Test of improved MEA in single cell and stack
- Selection of best materials for final MEA
- Start of final durability stack test (2500-5000 h)

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Performance of 0.82 W/cm2 at 1.5 A/cm2 reached for overall Pt loading of 0.4 mg/cm2
- Performance of 0.57 W/cm2 at 1.5 A/cm2 reached for overall Pt loading of 0.25 mg/cm2
- For generation IV MEA (0.25 mgPt/cm2) irreversible degradation rate is ~10 – 65 µVh-1 Target cell performance durability (10 µVh-1 decay rate) will be probably reached in 2016

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	Demonstration of long-term stability under automotive fuel cell conditions	lifetime of 5,000 hours in dynamic operation, with a degradation rate below 10 µVh-1,	lifetime of 5,000 hours in dynamic operation, with a degradation rate below 10 µVh-1,	test with >1000 h with regular refresh steps shows degradation rates of few tens of µVh-1 at
AIP 2011	Degradation	Irreversible and reversible degradation mechanism categorization	Irreversible and reversible degradation mechanism categorization	Methods to determine irreversible degradation rate and procedures for performance recovery analyzed
AIP 2011	MEA developement	Development of catalysts and electrode layers allowing for significant reduction in precious metal catalyst loadings	Pt loadings < 0.2 mgPt/cm2	Overall Pt loading of 0.25 mgPt/cm2 (anode+cathode)
AIP 2011	Development of durable ultra-low loaded MEAs for automotive applications	1 W/cm2 at 670mV (1.5 A/cm2) single cell performances	1 W/cm2 at 670mV (1.5 A/cm2) single cell performances	0.57 W/cm2 at 1.5 A/cm2 for Pt loading of 0.25 mgPt/cm2, 50%RH, stoich. 1.5/2, and 1.5 bara



IMPALA

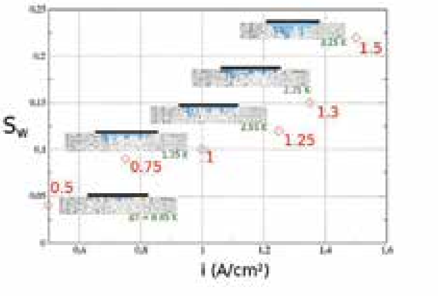
Improve PEMFC with Advanced Water Management and Gas Diffusion Layers for Automotive Application

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.5: Next generation European MEAs for transportation applications
START & END DATE	01 Dec. 2012 - 30 Nov. 2015
TOTAL BUDGET	€ 5,081,586,8
FCH JU CONTRIBUTION	€ 2,640,535
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA (French Alternative Energies and Atomic Energy Commission)

Partners: DLR (Germany), PSI (Switzerland), JRC, (The Netherlands), INPT (France), SGL (Germany), NDSTK (The Netherlands)



Variation of overall water saturation as a function of current density for RH = 50% together with corresponding condensation invasion patterns (shown for i =0.5, 0.75, 1.25, 1.3 and 1.5 A/cm²). Each little square corresponds to a pore. Liquid phase in blue, gas phase in grey. The temperature difference across the GDL corresponding to the imposed current density is indicated for each pattern shown.

PROJECT WEBSITE/URL

www.impala-project.eu

PROJECT CONTACT INFORMATION

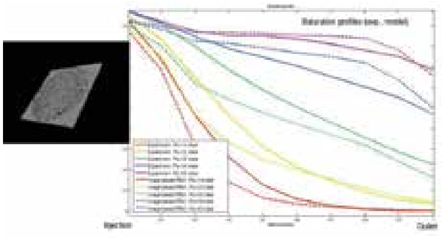
Joël Pauchet
joel.pauchet@cea.fr

MAIN OBJECTIVES OF THE PROJECT

The aim of IMPALA is to produce improved GDL to increase performance (up to 1 W/cm^2) of PEMFC by a twofold approach: a) modification of homogeneous GDL (MPL, wettability, additives…); b) development of innovative non-uniform GDL.

This technological work is supported by a deep water management analysis combining the most advanced two-phase models (Pore Network Modelling) and experimental diagnostics (X-Ray liquid visualisation). This will help better understand the link between GDL properties and performance and propose design recommendations.

The project is focused on automotive conditions but the improvements will be checked for different stack designs and back-up application.



Comparison between Pore Network Modeling and experimental X-Ray during a capillary intrusion experiment. PNM is based on real 3D X-Ray images (left) and liquid saturation in the thickness of the GDL is compared (right) for increasing injection pressure (from red to purple) between experiments (continuous lines) and simulations by PNM (dashed lines).

PROGRESS/RESULTS TO-DATE

- First two targets have been reached by modifying GDL: reference/MEA Level 0 (0.75 W/cm^2) and MEA Level 1 (0.90 W/cm^2)
- Numerous modifications of GDL have been done: MPL, chemical grafting, structuration, combination of improvements…
- Pore Network Modelling of GDL has been improved: use of real 3D images, condensation effect
- Comparison has been done on two-phase pattern between PNM and X-Ray experiments

FUTURE STEPS

- Check increase of performance with improved GDL at stack level
- Introduce some last modifications of GDL and check (single-cell 25 cm^2) increase of performance
- Include in performance models some transfer properties from PNM (one-phase situation)

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Performance has been increased by modifying properties of the backing and/or of the MPL of commercial reference GDL
- Final target (1W/cm^2) will most probably not be reached only by tuning the GDL properties but could be reached with a matching combination of improved membrane, electrodes, and GDL
- Improvements of GDL are not additive
- Pore Network Modelling of GDL has been improved: transfer properties based on real 3D images, condensation effect, successful comparison to X-Ray images of 3D liquid pattern
- Multiscale coupling of models in the case of two-phase flows inside the GDL is difficult and remains as a future step

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 2011	Increase of performance	Reach power density > 1 W/cm^2 at 1.5 A/cm^2 (BoL) and > 0.9 W/cm^2 at 1.4 A/cm^2 (EoL).	MEA Level 0: 0.75 W/cm^2 MEA Level 1: 0.9 W/cm^2 MEA Level 2: 1.0 W/cm^2 Operating conditions for automotive: H_2/air, gas hydration 50%, Stoe 1.2/2, 80°C, 1.5 bara	MEA Level 0 is reached MEA Level 1 is reached
AIP 2011	Improvement of material	Improve performance of ref GDL (SGL 24BC) at RH 20% for automotive operating conditions (see below)	Improve performance at standard automotive conditions (MEA Level 0-2) and check improvement at other conditions	Specific hydrophobic treatments can improve performance significantly at RH 20% or RH 100%, but not whatever the RH is. IMPALA#30 leads to lower increase of performance but for every RH.
		Conductivity > 2 S/cm (in-plane) and > 100 S/cm (through-plane)	Reduce through-plane resistance by 10%	Reached
AIP 2011	Durability	Demonstration of long term stability under automotive fuel cell conditions.	Verify that degradation rate of MEA Level 1 and 2 is not lower than the one of MEA Level 0 (ref)	Durability stack tests are planned in October/November 2015 with improved GDL.
AIP 2011	Industrialization	Optimization and demonstration of MEA processing at pilot scale based on these innovative GDL	Analyze the trade-off between increase of market thanks to improvement of performance, and new investments due to process modifications	This work has started in the frame of the cost analysis task
AIP 2011	Modeling	Development and improvement of multiscale and multiphenomena modelling tools for increased understanding of performance and degradation phenomena.	Pore Network Modeling (PNM): include condensation effect	Condensation has been included in PNM
			Performance modeling (PM) of MEA: improve predictability with better inputs (upscaling of PNM, experiments)	PM has been updated with more reliable properties of SGL24BC (from the project and literature). Active layer has been meshed to improve predictability. Inclusion of transfer properties of GDL from PNM is on-going (one-phase)
			3D tomography of liquid invasion during operation	3D images of liquid invasion have been obtained during capillary invasion and during operation
			Intensive characterization (modeling at pore scale, single and two-phase characterization) of GDL to propose more reliable inputs for performance models	Characterization of structural properties (geometry, pores, chemical structure), transport properties (electrical & thermal conductivity, diffusion, permeation) and two-phase properties. In-plane properties and inner surface wettability could not be characterized reliably.
			Comparison between models and experiments	Comparison between PNM and X-Ray liquid visualization has been done.
AIP 2011		Contribute to the development of European Industry solutions	Improve materials of SGL and PEMFC systems of NDSTK	SGL materials have been improved. Tests are planned at NDSTK

IRMFC

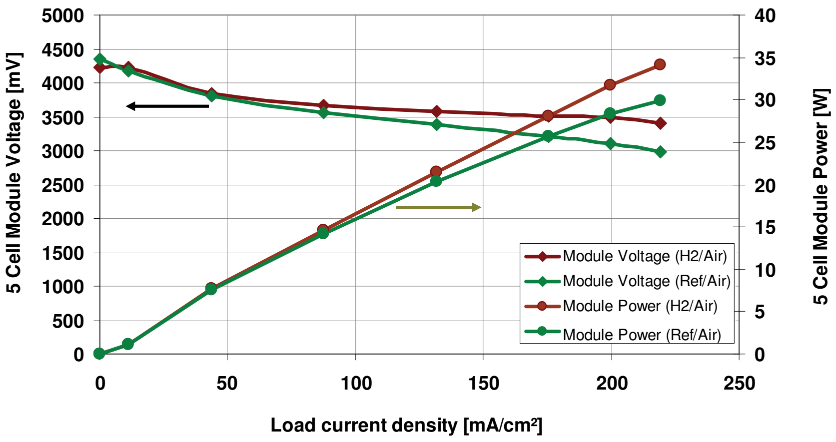
Development of a Portable Internal Reforming Methanol High Temperature PEM Fuel Cell System

AIP / APPLICATION AREA	AIP 2012 / AA 4: Early Markets
CALL TOPIC	SP1-JTI-FCH.2012.4.4: Demonstration of portable fuel cell systems for various applications SP1-JTI-FCH.2012.4.2: Demonstration of portable generators, back-up power and Uninterruptible Power Systems Energy
START & END DATE	01 May 2013 - 30 Apr. 2016
TOTAL BUDGET	€ 3,440,043.65
FCH JU CONTRIBUTION	€ 1,586,038.00
PANEL	Panel 6- Cross-Cutting

PARTNERSHIP/CONSORTIUM LIST

Coordinator: FORTH/ICE-HT (Greece)

Partners: Advent (Greece), UMCS (Poland), Fraunhofer ICT-Fraunhofer ICT-IMM (Germany), UPAT (Greece), ZBT (Germany), JRC-IET (Belgium), ARPEDON (Greece)



PROJECT WEBSITE/URL

irmfc.iceht.forth.gr

PROJECT CONTACT INFORMATION

George Avgouropoulos
geoavg@iceht.forth.gr

MAIN OBJECTIVES OF THE PROJECT

Development/demonstration of 100 W internal reforming methanol high temperature PEM fuel cell system for portable applications. Main goals to be accomplished: Scale-up synthesis and optimization of the main components (HT-MEAs, methanol reforming catalysts, BoP) developed within the framework of previous FCH-JU IRAFC 245202 project.

PROGRESS/RESULTS TO-DATE

- Scale-up synthesis and long term testing of ultra thin Cu-based methanol reformer; highly active at 210°C; double reformer arrangement; easy embedding in the cell
- Polymer electrolyte membranes operating at 210-220°C with high stability (>500 h fuel cell testing)
- New metal- and graphite-based bipolar plates operating at 200-230°C
- Successful single cell testing of new materials at 0.2 A/cm^2 at 210°C; 5-cell IRMFC modules testing under run
- BoP design done; all main components delivered; further simplifications in BoP architecture are under way

FUTURE STEPS

- 5-cell modules testing
- All BoP components tested, integrated and delivered
- 100 W stacks integrated and tested
- Self-sustaining operation at 100 W net power output (no external power supply) for 1000 h (including startup/shutdown cycles)

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The first 24 months results clearly demonstrate the IRMFC project progress, feasibility and future success
- Crosslinking methodology adopted herein for the first time has demonstrated some excellent results leading to MEAs operating at 210-220°C under reformate conditions
- New-type methanol reformer (ultrathin and lightweight) and bipolar plates (operation at 200-230°C) have been successfully prepared (scale-up) and tested for >1000 h
- Promising results from single cell testing with a new double reformer arrangement gives high perspective to achieve the objectives of the project

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)	<5,000	<5,000	N/A (components being scaled up and tested)
AIP 2012	FC stack life time (h)	>1,000	>1,000	N/A (main components under testing / optimization)
AIP 2012	FC system electrical efficiency (%)	>30%	>30	N/A (Integration/testing of the final system will start at the end of 2015)

KnowHy

Improving the Knowledge in Hydrogen and Fuel Cell Technology for Technicians and Workers

AIP / APPLICATION AREA	AIP 2013 / AA 5: Cross-Cutting Activities
CALL TOPIC	SP1-JTI-FCH.2013.5.2: Training on H_2&FC technologies for operation and maintenance
START & END DATE	01 Sep. 2014 - 31 Aug. 2017
TOTAL BUDGET	€ 1,437,062.40
FCH JU CONTRIBUTION	€ 1,000,000.00
PANEL	Panel 6- Cross-Cutting

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Technical University Delft

Partners: Fundacion para el Desarollo de las Nuevas Tecnologias del Hidrogeno en Aragon, Fundacion San Valero, Technische Universitat Munchen, Environment Park, Campus Automobile, University of Birmingham, Instituto Superior Tecnico – Universidade Tecnica de Lisboa, Federazione delle Associazioni scientifiche e tecniche, Vetigo Games B. V., ONO Consultants B. V., Kiwa Netherlands, McPhy Energy S.A.

PROJECT WEBSITE/URL

www.knowhy.eu

PROJECT CONTACT INFORMATION

P.V. Aravind
p.v.aravind@tudelft.nl
knowhy@tudelft.nl

MAIN OBJECTIVES OF THE PROJECT

To train technicians in the field of fuel cells and Hydrogen with theoretical as well as hands-on learning. The course will be offered in 7 languages throughout Europe. It is desired to make the course self sustainable to the point that the only personal contact is during the practical sessions. Rest of the time will be spent on e-learning complimented by serious game. After undertaking this course successfully, the technicians would be able to have the basic knowledge as well as in depth knowledge of one specialization such as Fuel Cells based transport.

PROGRESS/RESULTS TO-DATE

- Target group and training module definition
- Teaching methodology set up
- Specification for the on-line platform, set-up and validation of the platform
- Performance indicators and protocols definition
- Development, validation and translation of the contents

FUTURE STEPS

- Development, validation and translation of the contents
- Trial and Evaluation of KnowHy curriculum
- Running of the training
- Monitoring of progress
- Fostering project promotion, liaison establishment and dissemination to stakeholders

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- E-learning cum hands-on sessions can be used to train technicians
- Serious games are a valid tool for teaching
- Uniqueness of the program allows the technicians to have basic knowledge accompanied by in-depth knowledge of one specialisation
- Consortium collaboration comes in handy allowing sharing of resources

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 AIP 2013	projects that will ensure the human capital necessary in deploying FC & H_2 technology in the mid-term is developed		providing the technicians with the required training in the field of Fuel Cells and Hydrogen with foremost importance on the safety aspects	• Target group and training module of KnowHy curriculm defined • Teaching methodology and the specification for the online platform hosting KnowHy course determined • Contents of KnowHy course and the didactic resources are being developed • The partners have started with the dissemination of the project






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

http://www.laser-cell.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.

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 H_2Logic)

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

MATHRYCE

Material Testing and Recommendations for Hydrogen Components Under Fatigue

AIP / APPLICATION AREA	AIP 2011 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2011.2.8: Pre-normative research on design and testing requirements for metallic components exposed to H_2 enhanced fatigue
START & END DATE	01 Oct. 2012 - 30 Sep. 2015
TOTAL BUDGET	€ 2,446,372.60
FCH JU CONTRIBUTION	€ 1,296,249
PANEL	Panel 6- Cross-Cutting

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA/LITEN

Partners: L'Air Liquide SA, Teknologian Tutkimuskeskus VTT, Joint Research Center Petten, The CCS Global Group Limited, Centro Sviluppo Mateiali SPA, Dalmine SPA.

PROJECT WEBSITE/URL

www.mathryce.eu

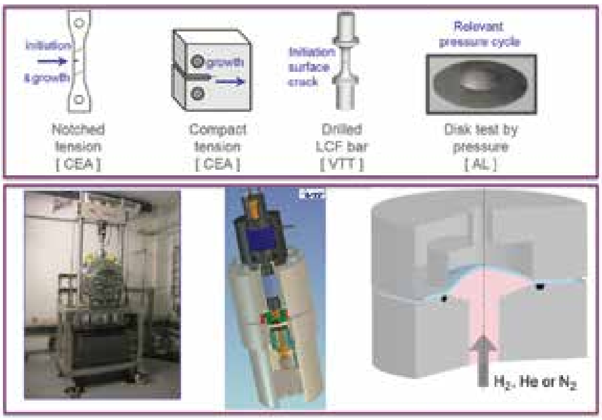
PROJECT CONTACT INFORMATION

Laurent Briottet
Laurent.Briottet@cea.fr

MAIN OBJECTIVES OF THE PROJECT

The MATRHYCE project aims to develop an easy to implement vessel design and service life assessment methodology based on lab-scale tests under hydrogen gas. The main outcomes are:

1. The development of a reliable testing method to characterize materials exposed to hydrogen-enhanced fatigue,
2. The experimental implementation of this testing approach, generating extensive characterization of metallic materials for hydrogen service,
3. The definition of a methodology for the design of metallic components exposed to hydrogen enhanced fatigue; this methodology being liable to be recognized for pressure equipment regulation,
4. The dissemination of prioritized recommendations for implementations in international standards.



PROGRESS/RESULTS TO-DATE

- Comparison of existing codes on a given case, highlighting the main differences (advantages and drawbacks)
- 3 types of lab-scale tests under hydrogen pressure have been developed to address both fatigue crack initiation and fatigue crack propagation.
- Hydraulic as well as hydrogen pressure cyclic tests on full components performed.
- Preliminary analysis of the results at lab-scale and full scale, helped by numerical simulations.
- Preliminary methodology proposal.

FUTURE STEPS

- Finalising, the last lab-scale results on a specific type of test (fatigue discs tests) in which the cycling loading is closer to the real life of a cylinder than in other types of tests.
- Identify the lab-scale test the most appropriate to be used in the design methodology.
- Methodology development. The proposal will be discuss with international experts during September 18 workshop dedicated to hydrogen enhanced fatigue.
- Validation of the methodology from both lab-scale and full-scale tests.
- Organisation of a workshop (September 21) to disseminate the RCS recommendations to ISO and CEN groups.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The results obtained favour the use of a fracture mechanics approach to design cylinders under hydrogen cyclic pressure.
- In presence of a defect, it appears that the fatigue crack initiation step under hydrogen can be neglected.
- For initially low ΔK loadings, it has been shown that it is necessary to use the fatigue crack growth rate law including the change of behaviour at such low values, in order to not to be too conservative.
- Development of an ISO standard is tentatively considered possible within 5 years following the project.

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	RCS strategy	Development of RCS to avoid major barriers for the commercialisation of FCH products	To propose dedicated RCS	The RCS proposals will be presented to the ISO and CEN experts on the September 21 workshop.
AIP 2011	Metallic material characterization for hydrogen service	-	Three types of tests are developed and applied to the metallic material AISI 4130	The experimental tests are achieved at 90%.
AIP 2011	Experimental implementation of design approach and design testing approach	-	Development of service life assessment methodology based on lab-scale tests under hydrogen gas and taking into account fatigue.	The experimental data are used to select the appropriate testing method (or methods) that will be proposed in the methodology.
AIP 2011	Design code for pressure equipment with metallic components in hydrogen service	-	Development of a design methodology taking into account hydrogen enhanced fatigue.	The methodology is still under discussion but a first draft has been circulating. The final proposal will be discussed with international expert on the September 21 workshop.

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

Jérémy Allix
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. H_2/O_2, H_2/Air and reformate H_2/Air

PROGRESS/RESULTS TO-DATE

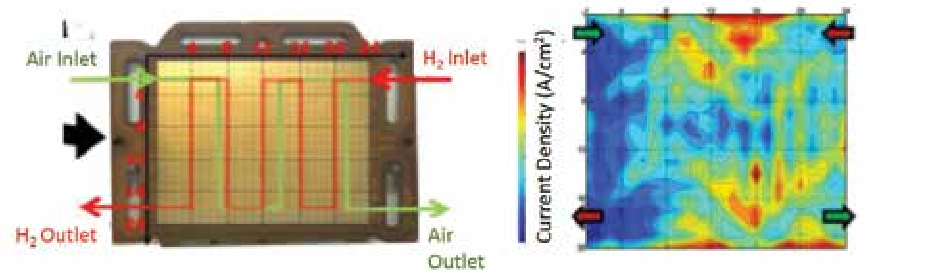
- Anti-wicking
- Mapping of MEA reference
- Gasket deposition on MEA

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

MEGASTACK

Stack Design for a Megawatt Scale PEM Electrolyser

AIP / APPLICATION AREA	AIP 2013 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2013.2.3: Large capacity PEM electrolyser stack design
START & END DATE	01 Oct. 2014 - 30 Sep. 2017
TOTAL BUDGET	€ 3,912,286
FCH JU CONTRIBUTION	€ 2,168,543
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Stiftelsen SINTEF

Partners: Fraunhofer Gesellschaft zur Förderung der angewandten Forschung e.V., ITM Power Trading Limited, Commissariat A L'Energie Atomique et Aux Energies Alternatives

PROJECT WEBSITE/URL

www.megastack.eu

PROJECT CONTACT INFORMATION

Magnus Thomassen
Magnus.s.thomassen@sintef.no

MAIN OBJECTIVES OF THE PROJECT

The main objective of MEGASTACK is to develop a cost efficient stack design for MW sized PEM electrolysers and to construct and demonstrate a prototype of this stack. The prototype will demonstrate a capability to produce hydrogen with an efficiency of at least 75% (LHV) at a current density of 1.2 Acm-2 with a stack cost below €2,500/Nm3h-1 and a target lifetime in excess of 40,000 hours (< 15 µVh-1 voltage increase at constant load).

PROGRESS/RESULTS TO-DATE

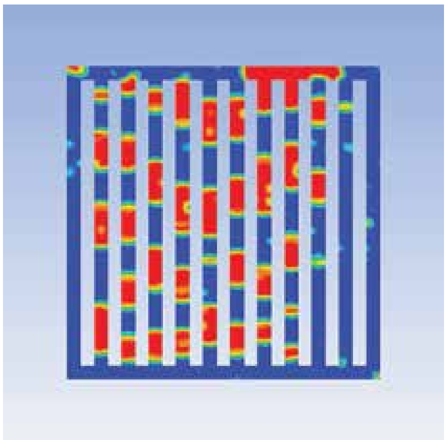
- Organised PEM electrolyser cost workshop
- Selection of supplier of MEA for MW stack concluded
- Multiphase flow model established
- 1st generation stack model completed
- 1st generation stack design completed

FUTURE STEPS

- Considerations of stack costs vs. markets
- Validation of multiphase flow model by bubble flow imaging
- Evaluation of stack design by mathematical models
- Component level testing on single cell and short stack level

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- MW scale PEM electrolyser design launched by ITM Power
- Further cost reductions possible through manufacturing and supply chain improvements



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 2013	Hydrogen production capacity of single stack	> 100 Nm3/h	60 Nm3/h	60 Nm3/h
AIP 2013	Stack efficiency	Current density @ 1.2 A/cm^2 with η > 80% on LHV basis up to @ 2.4 A/cm^2 with η > 70% on LHV basis	Current density @ 1.2 A/cm^2 with η > 75% on LHV basis	No stack tests or single cell tests (in stack size) performed yet
AIP 2013	Modular stack cost	< € 2 500/Nm3/h capacity	€ 2 500/Nm3/h capacity	Not available, no cost estimation performed to date.
AIP 2013	Stack availability	> 99%	> 99%	Not available, no stack constructed for testing.
AIP 2013	Lifetime	> 40 000h	> 40 000h	Not available, no stack constructed for testing.

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. BTi02, 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

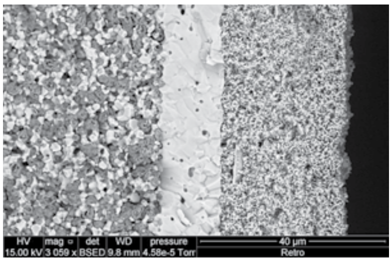
- Well performing electrode/electrolyte materials dedicated to a service temperature range between 550-650°C have been developed:
  - Electrodes: BSCF-BCYZ/BCY composite cathodes with an Area Specific Resistance (ASR) down to 0.44 ohm.cm^2; BCYZ-NiO anodes with ASR down to 0.07ohm.cm^2 and σ_e >1000 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•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 €/kgH_2 @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: δV/V= +3,6%/1000h; • Micro-cogeneration (dynamic) profile: δV/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

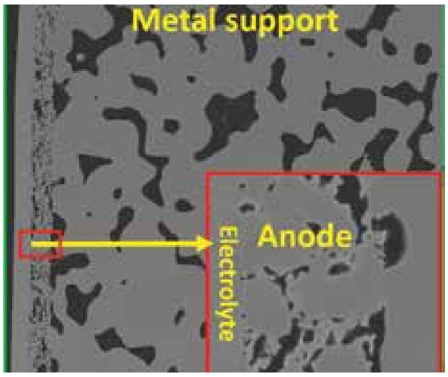
Metal Supported SOFC Technology for Stationary and Mobile Applications

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

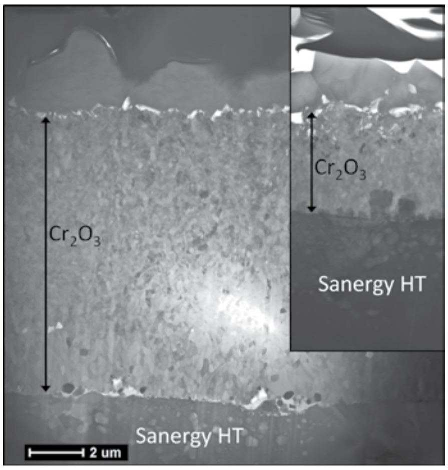
PROJECT CONTACT INFORMATION

Severine Ramousse
rase@dtu.dk

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.

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

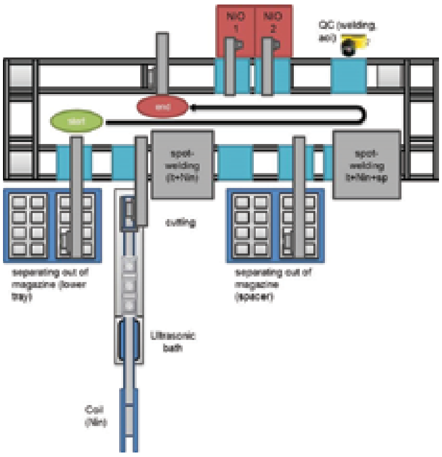
www.mmlcr-sofc.eu

PROJECT CONTACT INFORMATION

Prof Robert Steinberger-Wilckens
r.steinbergerwilckens@bham.ac.uk

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

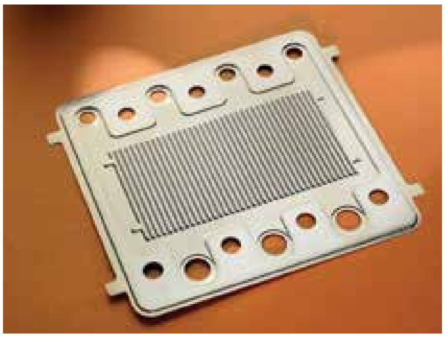
- D1.0 design updates implemented and first prototype stacks tested
- D 2.0 accomplished and manufactured, testing initiated
- more power and better cycling capability implemented in D2.0
- D2.n improvements designed and ready for implementation
- design of automated manufacturing line completed; one 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

MobyPost

Mobility with Hydrogen for Postal Delivery

AIP / APPLICATION AREA	AIP 2009 / AA 4: Early Markets
CALL TOPIC	SP1-JTI-FCH.2009.4.1 Demonstration of fuel cell powered materials handling vehicles and infrastructure
START & END DATE	01 Feb. 2011 - 30 Nov. 2015
TOTAL BUDGET	€ 8,257,272.60
FCH JU CONTRIBUTION	€ 4,251,064.21
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Université de Technologie de Belfort Montbéliard

Partners: Steinbeis Europa Zentrum der Steinbeis Innovation GmbH, EUROPAISCHES INSTITUT ENERGIEFORSCHUNG ELECTRICITE DE FRANCE/ UNIVERSITAT KARLSRUHE (EIFER), Mahytec SARL, La Poste SA, MES SA, Institut Pierre Vernier, H_2Nitidor SRL, Ducati energia SPA

PROJECT WEBSITE/URL

www.mobypost-project.eu.com

PROJECT CONTACT INFORMATION

Michel Romand
Michel.romand@utbm.fr

MAIN OBJECTIVES OF THE PROJECT

MobyPost aims at testing a unique autonomous and sustainable mobility concept based on solar to wheel solution for postal delivery: 2 fleets of 5 FCEV specifically designed for improving ergonomics of postal delivery and 2 related solar hydrogen production and refuelling stations.

PROGRESS/RESULTS TO-DATE

- Metal hydride tanks used to store and deliver H_2 on board to a 1kW low temperature FC
- 10 vehicles built and homologated despite of missing regulations
- One infrastructure built and producing 1,5 kg H_2 per day
- Demonstration under real conditions running with 5 vehicles and one infrastructure since May 2015

FUTURE STEPS

- Finish the second infrastructure
- Analyse the demonstration data
- Exploitation and business plan under work

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- niche market on which FCEV could have a high impact
- solar-to-wheel concept as well as the metal-hydride technology used could improve the general public acceptance of the fuel cell technologies. Technology already well accepted by the postmen using it
- legal frame as well as standards are at the moment inexistent for such technologies (hydrides), which could delay the general entry on the market

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 2009	Number of vehicles	10	10	10
AIP 2009	Refueling time	< 5 min	~ 3 hours	~ 3hours according to technology chosen
AIP 2009	FC system efficiency (%)	>40	>40	32 (measure on test bench)
AIP 2009	H_2 price at pump (€/kg)	<13	<13	Not already measured
AIP 2009	FC price	<4000€/kW	<5000€/kW	<5000€/kW

Nano-CAT

Development of Advanced Catalysts for PEMFC Automotive

AIP / APPLICATION AREA	AIP 2012 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FHC.2012.1.5: New catalyst structures and concepts for automotive PEMFCs
START & END DATE	01 May 2013 - 30 Apr. 2016
TOTAL BUDGET	€ 4,394,330
FCH JU CONTRIBUTION	€ 2,418,439
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA

Partners: DLR, Armines, Tecnalia, JRC, C-Tech, Nanocyl, Volvo

PROJECT WEBSITE/URL

http://nanocat-project.eu/

PROJECT CONTACT INFORMATION

Pierre-André JACQUES
pierre-andre.jacques@cea.fr

MAIN OBJECTIVES OF THE PROJECT

Nano-CAT aims at developing new catalysts to decrease the amount of Pt needed in PEMFC electrode. For that 2 routes are followed. One more fundamental dedicated to the synthesis of bio-inspired compound to produced Pt-free catalyst. A second, less risky, based on the deposition of Pt alloys on resistant supports (carbon nanotube and doped metal oxide). The MEA integrating the project catalysts are tested under conditions required for bus application.

PROGRESS/RESULTS TO-DATE

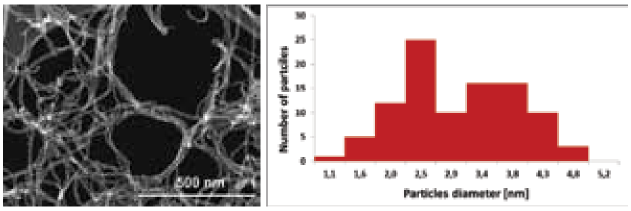
- 80 mV overvoltage for Pt catalyst for ORR (Vs Pt).
- 23 mA/mgPt @ 0.9 V/RHE with Pt3Co by Physical Vapor Deposition.
- Structuration of Pt alloy on Carbon NanoTubes.
- 0.22 gPt/kW @ 750 mw/cm^2

FUTURE STEPS

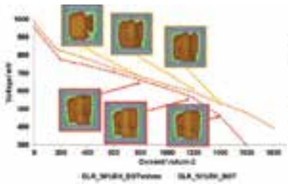
- Integration of Pt free catalyst in MEA and test in Single Cell
- Integration of catalyst supported on Carbon Nanotubes in MEA at anode and test in single Cell
- Test of reference catalysts using protocol for bus application in short stack.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

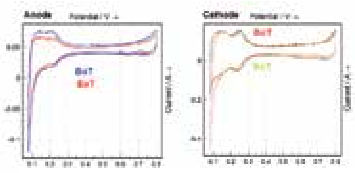
- Use of innovative catalyst and supports to reduce Pt loading and decrease degradation for buses application.



Pt on modifed CNT



Polarisation curves between BOT and EOT (300h) of the synthetic buse cycle
Degradation: 60 µV/h @ 1A/cm² reference MEA



CVs on the anode and cathode at the BoT and EoT (300h), ECSA Changes: anode side (27%) cathode side (11%).

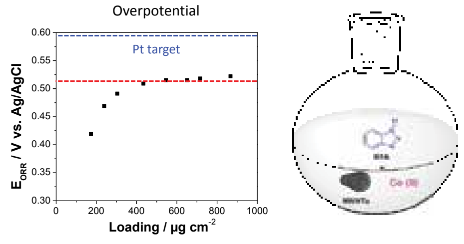
CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE
MAIP 2008-2013	Reduce Pt cost in automotive PEMFC	< 0.1 gPt/kw	< 0.1 gPt/kW	0.22 gPt/kW
AIP 2012	Increase specific power for automotive PEMFC	1 W/cm^2 @ 1.5 A/cm^2	1 W/cm^2 @ 1.5 A/cm^2	750 mW/cm^2 @ 1.6 W/cm^2 (MEA 0.2 mgPt/cm^2) BoL.
AIP 2012	Increase lifetime of automotive PEMFC	h Lifetime: 5 000 hrs	10% loss after 5000 hours	53 µV/h @ 1 A/cm^2 on 300 hrs (aged with synthetic buses cycle) (MEA 0.6 mgPt/cm^2)

○SnO_2 (Nb, Sb)

- ✓ Doped : **rutile under Air, 600 °C**
- ✓ S_{BET} close to **90 m²/g**
- ✓ PSD centerd around **20 & 50 nm**
- ✓ **Airy texture**
- ✓ **Homogeneous distribution of Sb**
- ✓ High « bulk » conductivity : **0,95 S/cm** (SnO_2:Sb 5at.%)
- ✓ Stability vs corrosion

Metal oxyde characterisation as catalyst support



Ex situ characterisation of Pt free catalyst for ORR

NELLHI

New All-European High-Performance Stack: Design for Mass Production

AIP / APPLICATION AREA	AIP 2013 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	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 May 2014 - 30 Apr. 2017
TOTAL BUDGET	€ 2,858,447.20
FCH JU CONTRIBUTION	€ 1,633,895.00
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: ENEA (ITA)

Partners: Elcogen AS (EST), Elcogen Oy (FIN), VTT (FIN), Flexitallic (GBR),
Borit (BEL), Sandvik Materials Technology (SWE), CUTEC (GER)

PROJECT WEBSITE/URL

www.nellhi.eu

PROJECT CONTACT INFORMATION

Stephen McPhail
stephen.mcphail@enea.it

MAIN OBJECTIVES OF THE PROJECT

NELLHI combines European know-how in single cells, coatings, sealing, stack designs and manufacturing technology to produce an innovative and modular 1 kW SOFC stack, together with the proof of concept of a 10 kWe SOFC stack module. Improvements over the state of the art in cost, performance, efficiency, and reliability will be proven, as a combined result of high-performance cells and manufacturability designed for mass production at high yield.

The project target is an off-the-shelf, modular stack assembly that can be integrated in stationary CHP applications of various sizes fed by natural gas – from single kilowatt to multi-megawatt scale.

PROGRESS/RESULTS TO-DATE

- First-generation stack has been assembled and sent out for testing
- Second-generation components are being frozen
- In-depth characterization of cell processes carried out
- Website running and first scientific results presented

FUTURE STEPS

- Repeatability of cell validation and further cell process mapping
- Flow field modelling and experimental validation
- Component assembly to 2nd generation stack
- Testing of stack and feedback to design process

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Sealing properties massively improved
- Outstanding quality, robustness and volume-driven cost effectiveness of the interconnect production process envisaged
- In-depth and full-range assessment of cell characteristics expected to cross-correlate to modelling outcome
- Robustness, leakage rate and degradation characteristics significantly improved in SOFC 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	Efficiency for mCHP system stacks	35-45 % (elec) 75-85 % (tot)	Cell voltage ca. 850 mV @ 0.5 Acm-2 at 650°C	Cell voltage ca. 870 mV @ 0.5 Acm-2 at 650°C
AIP 2013	increase robustness and lifetime	Beyond SoA	Less than 0.2% voltage loss in 1000 hours and 0.5% after 10 thermal cycles (enables >25000 hours life-time)	Less than 5mOhm.cm2 in 1000 hours (9000 hours experiment) demonstrated with unit cells (better than project targets). Less than 0.5 % degradation after 10 thermal cycles. demonstrated.
AIP 2013	increase performance, power density, and efficiency	Beyond SoA	Stack's performance at 900mV with 0.3 Acm-2 current density at 650 °C with increased cell footprint. The stack's fuel utilization capabilityshould be at least 65%.	Stack voltage ~910 mV @ 0.3 Acm-2 at 650°C Demonstrated stack fuel utilization capacity of 85%.
AIP 2013	reduce materials and manufacturing cost	Beyond SoA	Cost target for cells less than 300 €/ kWe. Target for ready interconnect ~ 200 €/kW The price target for the final sealing materials is 30€/kWe	Manufacturing process intrinsically upscalable to mass production, so in line with targets, based on production volume

NEMESIS2+

New Method for Superior Integrated Hydrogen Generation System 2+

AIP / APPLICATION AREA	AIP 2010 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2010.2.2: Development of fuel processing catalysts, modules and systems
START & END DATE	01 Jan. 2012 - 30 Jun. 2015
TOTAL BUDGET	€ 3,393,341
FCH JU CONTRIBUTION	€ 1,614,944
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

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

Partners: HyGear B.V., Johnson Matthey PLC., Abengoa Hidrógeno, S.A., Abengoa Bioenergía San Roque, S.A., Centre for Research and Technology Hellas, Instituto Superior Técnico

PROJECT WEBSITE/URL

www.nemesis-project.eu

PROJECT CONTACT INFORMATION

Stefan Martin
stefan.martin@dlr.de

MAIN OBJECTIVES OF THE PROJECT

Within the 3.5-year project NEMESIS2+ a small-scale hydrogen generator capable of producing 50 $m^3 \cdot h^{-1}$ hydrogen (purity: 5.0) from biodiesel and diesel has been developed.

With the envisaged process concept, a system efficiency (based on the lower heating value of hydrogen related to the lower heating value of liquid fuel) > 65 % was targeted. Hydrogen production costs of 4 €/kg were targeted.

PROGRESS/RESULTS TO-DATE

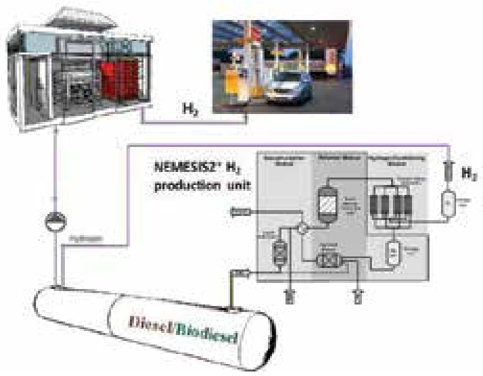
- Stable steam reforming of diesel and biodiesel shown on laboratory scale (100 hours) + Successful development pre-commercial prototype H_2 generator
- Stable water gas shift performance in the presence of 1 ppm H_2S and 100 ppm hydrocarbons (100 hours)
- Liquid desulphurization (< 2 ppm S) achieved in an adsorption bed of activated carbon
- Improved catalyst formulations (reformer, water gas shift) developed

FUTURE STEPS

- Project has been finalized

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Stable operation of pre-commercial hydrogen generator based on feedstock diesel and biodiesel has been shown
- Hydrogen production cost of the envisaged 50 Nm^3/h system (5.8 Euro/kg H_2 for biodiesel) is competitive with renewable hydrogen production in Europe
- Stable steam reforming of diesel and biodiesel is possible! We were the first to publish respective results for feedstock biodiesel.



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	Supply of 50 % of the anticipated hydrogen energy demand (expected to come mainly from transport and early market applications) from renewable energy sources by 2020	NEMESIS2+ will contribute to reach this target by using biodiesel as an environmentally friendly resource with high energy density.	Stable and cheap hydrogen production from biodiesel	Successful and stable steam reforming of biodiesel and diesel shown on lab scale and prototype level
AIP 2010	System efficiency (Higher Heating Value H_2/Higher Heating Value Fuel)	80	70	This target was not met
AIP 2010	Catalyst durability	stable long-term operation	1000 hours	1000 hours
AIP 2010	Scalability	Scalable from 2 to 750 Nm3/h	Scalable from 2 to 750 Nm3/h	Scalable beyond 1000 Nm3/h (due to modular set-up)
AIP 2010	Catalyst efficiency	reforming catalyst system should exhibit enough shift activity to reduce CO concentration below 10vol% (dry basis) to reduce shift catalyst quantity	CO-conc. < 10 vol.-%	achieved
MAIP 2008-2013	H_2 production costs (€/kg)	<5	<4	~5.8
AIP 2010	Material costs (after 6 years)	< 5000 Euro/Nm^3 for a capacity of 50 Nm^3/H > plant costs should not exceed 250 000 Euro	Plant costs < 250 000 Euro (assuming 2 5 units/year)	227 000 Euro per plant

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

NOVEL

Novel Materials and System Designs for Low Cost, Efficient and Durable PEM Electrolysers

AIP / APPLICATION AREA	AIP 2011 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2011.2.7: Innovative Materials and Components for PEM electrolysers
START & END DATE	01 Sep. 2012 - 31 Aug. 2016
TOTAL BUDGET	€5,743,445
FCH JU CONTRIBUTION	€2,663,357
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Stiftelsen SINTEF

Partners: Fraunhofer Gesellschaft zur Förderung der angewandten Forschung e.V., Commissariat A L'Energie Atomique Et Aux Energies Alternatives, AREVA H_2 Gen, Johnson Matthey Fuel Cells Limited, Teer Coatings Limited, Paul Scherrer Institute

PROJECT WEBSITE/URL

www.novelhydrogen.eu

PROJECT CONTACT INFORMATION

Magnus Thomassen
Magnus.s.thomassen@sintef.no

MAIN OBJECTIVES OF THE PROJECT

The main objective of NOVEL is to develop and demonstrate an efficient and durable PEM water electrolyser utilising the new, beyond the state of the art materials developed within the project. The electrolyser will demonstrate a capability to produce hydrogen with an efficiency of at least 75% (LHV) at rated capacity with a stack cost below €2,500/Nm^{3}h^{-1} and a target lifetime in excess of 40,000 hours (< 15 μVh^{-1} voltage increase at constant load)

PROGRESS/RESULTS TO-DATE

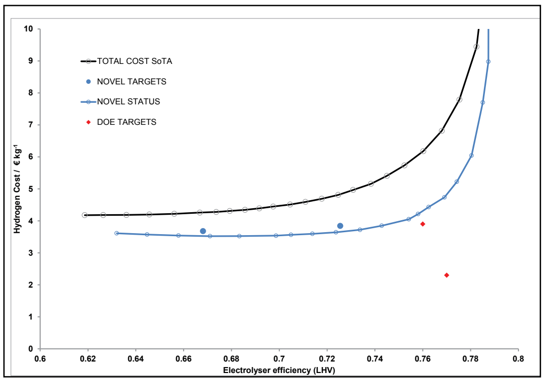
- Identified degradation mechanisms in PEM electrolysers
- Developed membranes with lower H_2 crossover and lower costs
- Supported electrocatalysts with higher activity developed
- Oxide coatings for Ti bipolar plates developed
- AREVA electrolyser stack tested more than 6000h

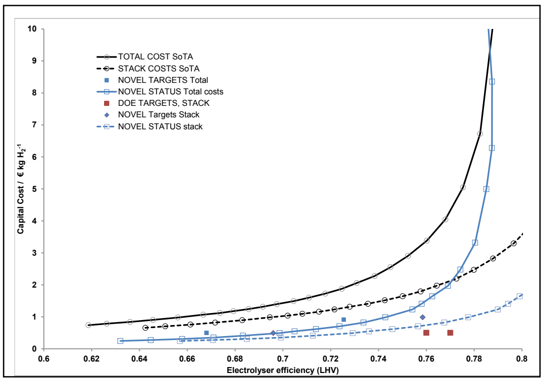
FUTURE STEPS

- Integration of catalysts and membranes to new MEAs
- Upscaling of process optimisation of bipolar plate coating process
- Lifetime evaluation of PEM electrolysers

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- A new generation polyaromatic membranes for PEM electrolysers with significant potential for cost reduction
- New oxygen evolution catalysts with improvement in catalytic activity and potential for noble metal thrifting.
- Increased understanding of degradation issues in PEM electrolysers and parameters affecting overall lifetime which can contribute to increasing the lifetime of these units.
- Novel stack design, reducing construction material costs and easing assembly.





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 2011	More efficient catalysts for the oxygen evolution reaction presenting lower activation overpotential as well as new catalyst structures or metal alloys resulting in lower noble metal loadings	N/A	Improved catalysts with 200% mass activity vs. state of the art demonstrated. Fibrous catalyst supports and the use of alternatives to Pt for hydrogen evolution is being evaluated	Catalysts with 300% mass activity vs. state of the art demonstrated ex situ. Fibrous catalyst supports and the use of alternatives to Pt for hydrogen evolution has been evaluated
AIP 2011	Polymer membranes with improved conductivity, low gas crossover and high mechanical stability at operating conditions such as hydrocarbon membranes or other novel membrane concepts, including composite structures	N/A	• Thinner, more conductive and reinforced PFSA membranes • Radiation grafted membranes • More advanced concepts, such as structured radiation grafted membranes and hybrid membranes	Membranes with a higher ratio of conductivity vs hydrogen crossover has been developed and tested for hydrogen crossover and conductivity ex situ. First tests of electrolyser MEAs are ongoing
AIP 2011	Alternative materials for bipolar plates and current collectors, replacing the use of titanium as construction material, e.g. novel coatings for stainless steel capable of withstanding potentials up to 2 V and pressurised oxygen	N/A	Development of coatings using several coating processes. The goals of the coatings are either to reduce the contact resistance of Titanium or, preferably to coat lower costs materials such as stainless steel.	N/A

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

Marco Ferraro
marco.ferraro@itae.cnr.it

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.

PECDEMO

Photoelectrochemical Demonstrator Device for Solar Hydrogen Generation

AIP / APPLICATION AREA	AIP 2013 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2013.2.5: Validation of photoelectrochemical hydrogen production
START & END DATE	01 Apr. 2014 – 31 Mar. 2017
TOTAL BUDGET	€ 3,394,010.00
FCH JU CONTRIBUTION	€ 1,830,644.00
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)

Partners: Ecole Polytechnique Federale de Lausanne (EPFL), Technion – Israel Institute of Technology (IIT), Deutsches Zentrum für Luft- und Raumfahrt (DLR), Universidade do Porto, Evonik Industries AG, Solaronix SA

PROJECT WEBSITE/URL

www.pecdemo.eu

PROJECT CONTACT INFORMATION

Roel van de Krol: roel.vandekrol@helmholtz-berlin.de,
Daniela Kaden: daniela.kaden@helmholtz-berlin.de

MAIN OBJECTIVES OF THE PROJECT

To address the challenges of solar energy capture and storage in the form of a chemical fuel, we will develop a hybrid photoelectrochemical-photovoltaic tandem device for light-driven water splitting with an active area of ≤50 cm^2 and a solar-to-hydrogen (STH) efficiency of 8-10% that is stable for more than 1000 h. In parallel, our partners from industry and research institutions will work together on an extensive techno-economic and life-cycle analysis based on actual performance characteristics. This will give a reliable evaluation of the application potential of photoelectrochemical hydrogen production, and further strengthen Europe's leading position in this growing field.

PROGRESS/RESULTS TO-DATE

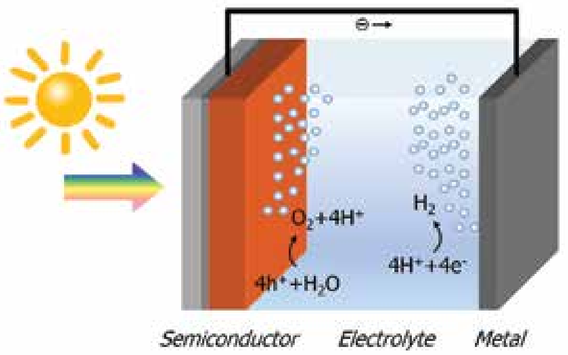
- Photoactive BiVO^4 films made with reactive magnetron sputtering
- ALD protection layers significantly reduce photocorrosion
- First stand-alone water splitting device with Cu2O/perovskite cell shows STH efficiency of 2.1%
- Process flow sheets worked out for three H_2 production scenarios, first simulations on energy flows completed.
- First CFD simulations on temperature profiles in angled PEC cell design completed

FUTURE STEPS

- Further optimization of magnetron sputtering process
- Development of nanostructured composite photoanodes
- Experimental studies on optimal PEC/PV combinations
- Experimental validation of CFD simulations

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Stability and efficiency of individual components continue to be improved
- Initial results on innovative cell architectures look promising
- The consortium is on track to reach overall goals.



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	New hydrogen production pathway	Development and testing of new hydrogen production pathways (the MAIP does not specify quantitative targets for these pathways).	Development of a hybrid photoelectrochemical-photovoltaic tandem device for light-driven water splitting with an active area of at least 50 cm^2 and a solar-to-hydrogen efficiency of 8% that is stable for more than 1000 h.	Concept has been demonstrated by applicants, the best efficiency achieved so far is 6.5% (HHV) for a <1 cm^2 device.
AIP 2013	Hydrogen cost	Estimate feasibility to meet EU target cost of 5 €/kg H_2.	Cost estimation for photoelectrochemically produced hydrogen through economic analysis (Task 5.4).	Process flow sheets worked out for three H_2 production scenarios, first simulations on energy flows completed.
AIP 2013	Development and integration of prototypes	Demonstrate prototypes that allow easy integration in small to medium scale applications ranging from 100 W to 100 kW.	Demonstration of a prototype module of 4 devices, each larger than 50 cm^2 having an efficiency of 8%.	Construction of prototype module is scheduled to start in M28.
AIP 2013	Development of new architectures	To design innovative device architectures that combine efficient sunlight harvesting.	Development of effective light management strategies for tandem devices based on wavelength-selective mirrors and filters.	First dichroic mirrors fabricated, simulations show positive impact on overall cell performance. Film transfer method developed for making Fe_2O_3 photoanodes with reflecting back-contact.
AIP 2013	Development of diagnostic methods	To develop diagnostic methods to identify the energy loss and material degradation mechanisms limiting performance.	Modeling of optical and electrical coupling of PEC-PV tandem devices and development of diagnostic methods to identify and quantify losses.	Intensity-modulated photocurrent spectroscopy has revealed that surface recombination is an important loss mechanism in $BiVO_4$.
AIP 2013	Development of new technology with a higher large area	To develop technologies that enable controlled, reproducible and potentially large-scale production of large-area (>50 cm^2) stable solar hydrogen production devices.	To evaluate and develop the deposition technology that is needed for fabricating large-area hybrid PEC-PV devices.	Photocurrents of 2.9 mA/cm^2 achieved for BiVO4 photoanodes made with reactive magnetron sputtering.
AIP 2013	Durability	Laboratory and field tests of ≥1000 h duration.	Performance and stability test ≥1000 h.	Tests will start in M28.

PEMBeyond

PEMFC System and Low-Grade Bioethanol Processor Unit Development for Back-Up and Off-Grid Power Applications

AIP / APPLICATION AREA	AIP 2013 / AA 4: Early Markets
CALL TOPIC	SP1-JTI-FCH.2013.4.4 Development of 1-30 kW fuel cell systems and hydrogen supply for early market applications
START & END DATE	01 May 2014 - 30 Apr. 2017
TOTAL BUDGET (EUR)	€ 4,586,324.90
FCH JU CONTRIBUTION (EUR)	€ 2,315,539.00
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: VTT Technical Research Centre of Finland

Partners: PowerCell Sweden Ab, Genport srl, Fraunhofer ICT-IMM, University of Porto

PROJECT WEBSITE/URL

http://pembeyond.eu

PROJECT CONTACT INFORMATION

Henri Karimäki, project coordinator
henri.karimaki@vtt.fi

MAIN OBJECTIVES OF THE PROJECT

In PEMBeyond project a cost-competitive, energy-efficient and durable integrated PEMFC based power system operating on low-grade (crude) bioethanol will be developed for back-up and off-grid power generation.

The system will be:

- Using crude (80-90%) bioethanol as primary fuel
- Cost-competitive (complete system < 2 500 €/kW @ 500 units)
- Energy-efficient (> 30% overall system efficiency, > 45% PEMFC system efficiency)
- Durable (> 20 000 hours system lifetime)

Extensive techno-economic and environmental analyses will be carried out throughout the project to ensure attractiveness of the concept. A roadmap to volume production will be one of the main deliverables of the project.

PROGRESS/RESULTS TO-DATE

- Definition of system specifications completed
- Market Analysis for Telecom back-up systems completed
- "Product version" PEMFC stack design ready and first stacks delivered
- System/subsystem development work (PEMFC system, bioethanol reformer, complete system) is in progress
- Experimental hydrogen impurity studies ongoing to determine final hydrogen quality specifications used.

FUTURE STEPS

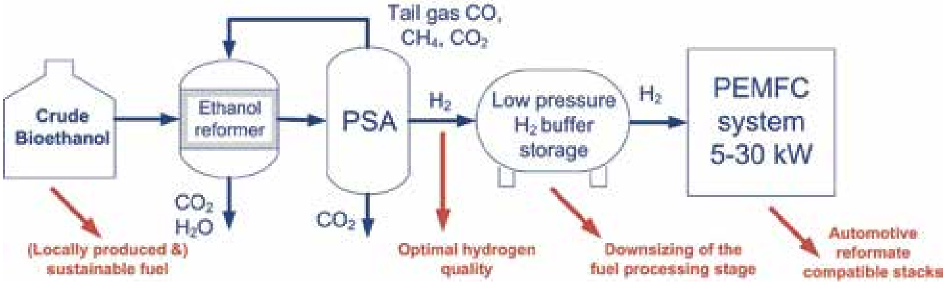
- Hydrogen quality specifications frozen
- Completion of component/subsystem (PEMFC stack & system, bioethanol reformer, PSA) development
- Functional testing of components/subsystems separately
- Complete system integration, testing and field-trial
- Completing the techno-economic & Environmental analyses

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Very high interest from potential end-user companies (telecom) to the project and system to be developed
- Both local and EU level regulation affect significantly the telecom back-up market and the system requirements
- According to the Market Analysis conducted within the project, a significant portion of the telecom backup market (60%) can be served by the PEMBeyond system (Served Available Market).
- No major technical obstacles are foreseen at this point in developing a back-up power system to reach the set targets and system specifications

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	Number of new UPS/back-up power units in the EU market	1000 units	1 new back-up power unit installed during the project	System and subsystems design work in progress
MAIP 2008-2013	Cost of industrial/commercial units	1,500 - 2,500 €/kW	< 3,300 €/kW (@>500 units & 5 kW) < 2,500 €/kW (@>500 units & 25 kW)	9,000 €/kW, estimated with current existing subsystem and component designs in the beginning of the project
AIP 2013	Fuel cell and hydrogen system cost (including H_2 generator)	€2,500/kW (@ >500 units)	< 3,300 €/kW (@>500 units & 5 kW) < 2,500 €/kW (@>500 units & 25 kW)	9,000 €/kW, estimated with current existing subsystem and component designs in the beginning of the project
AIP 2013	Fuel cell system (FCS) efficiency	45%	> 45%	> 45% according to first FCS simulations. Experimental data not available yet.
AIP 2013	System life-time	20,000 hours (fuel cell stack 20,000 hours)	> 20,000 hours	N/A, not sufficiently data available yet from stack development
AIP 2013	System efficiency when working with an integrated hydrogen generator	> 30%	> 30%	~30% according to first system simulations. Experimental data not available yet.



PHAEDRUS

High Pressure Hydrogen all Electrochemical Decentralized Refueling Station

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	"SP1-JTI-FCH.2011.1.8: Research & Development of 700 bar refuelling concepts & technologies"
START & END DATE	01 Nov. 2012 – 31 Oct. 2015
TOTAL BUDGET	€ 6,309,832
FCH JU CONTRIBUTION	€ 3,566,343
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Hydrogen Efficiency Technologies (Netherlands)

Partners: ITM power Limited (UK), H_2 Logic (Denmark), Raufoss Fuel Systems (Norway), Daimler (Germany), Shell Global Solution (Netherlands), Bundesanstalt fuer Materialforschung und Pruefung (Germany), Association pour la recherche et le développement des méthodes et processus industriels – ARMINES (France), Hochschule Esslingen (Germany), Uniresearch (Netherlands).

PROJECT WEBSITE/URL

www.phaedrus-project.eu/

PROJECT CONTACT INFORMATION

Technical coordinator: Peter Bouwman peter.bouwman@hyet.nl
Project Management: Anna Molinari a.molinari@uniresearch.com

MAIN OBJECTIVES OF THE PROJECT

The project objective is to develop and validate a new concept for 70 MPa hydrogen refuelling retail stations enabling self-sustained infrastructure roll-out for early vehicle deployment volumes, showing the applicability of the novel electrochemical hydrogen compression technology in combination with a PEM electrolyser, storage units and dispensing system. A step change is expected in both the efficiency and cost of ownership of an integrated hydrogen refuelling system. The applicability will be demonstrated in a fuelling system producing 5 kg hydrogen per day, while a design is made for a fuelling system capable of producing 200 kg hydrogen per day.

PROGRESS/RESULTS TO-DATE

- Construction of electrolysis unit delivering 8MPa
- Construction electrochemical compression unit with new membrane capable of pressures exceeding 90MPa.
- Storage tank configuration mainly targeting medium (50 MPa) pressure and smaller capacity at high pressure (100 MPa)
- A dispensing system equipped with a pre-cooling unit, with a capacity of 5 kg/3 min enabling back-to-back refuelling

FUTURE STEPS

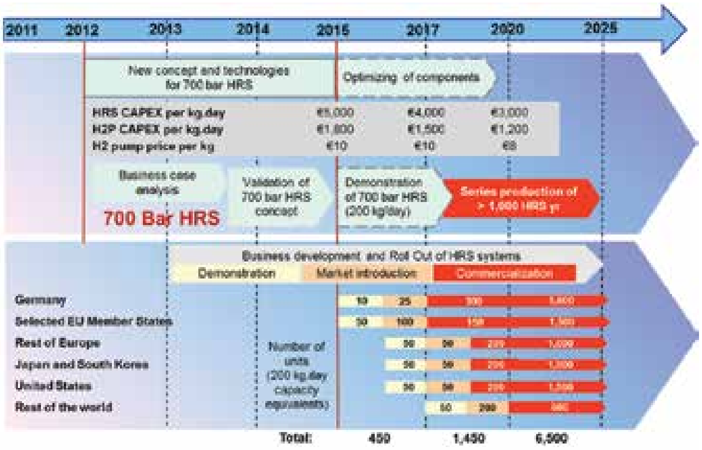
- Design 200 kg/day HRS based on new technology
- Integrate new technology into 5kg/day system
- Validate technology and cost efficiency improvement

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- New catalyst and membrane materials appear promising
- Model shows advantages of new system design, but significant costs are yet incurred due to multitude of state-of-art high pressure couplings, which are apparently still expensive specialty products.
- Measurement data being accumulated

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	HRS CAPEX (design 200kg/day)	2015 target: <1M€	Optimal system configuration with new technology	Model ready, accumulating data / awaiting system integration
MAIP 2008-2013	H_2P CAPEX	2015: €3500 per Nm3/hr	Cost reduction and scalable design	Modular compression unit system, low membrane costs and catalyst loadings
AIP 2011	Optimisation of compression & storage systems with respect to cost, efficiency and capacity.	CAPEX and OPEX costs enabling self- sustained roll-out	Balance between component specifications in final system configuration	Components are being sized through modeling, tested separately anticipating integration, data being generated.
AIP 2011	Compliancy	SAE J2601, SAE J2799 and ISO 20100	Standardised compliance verification involving BAM evaluation	New SAE J2601refueling control system under development
AIP 2011	Hydrogen price	2015 target 10-15€/kg	Meeting target of 10€/kg	OPEX production/compression : €5.6/kg. Including depreciation and interest a price close to €10/kg



POWER-UP

Demonstration of a 500 kWe Alkaline Fuel Cell System with Heat Capture

AIP / APPLICATION AREA	AIP 2012 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2012.3.7: Field demonstration of large-scale stationary power and CHP fuel cell systems
START & END DATE	1 Apr. 2013 - 30 Jun. 2017
TOTAL BUDGET	€ 11,552,448
FCH JU CONTRIBUTION	€ 6,137,565
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: AFC Energy PLC (UK)

Partners: Air Products PLC (UK) GB Innomech Ltd (UK), Zentrum für Brennstoffzellen-Technik GmbH (DE), Paul Scherrer Institut (CH), FAST - Federazione Delle Associazioni Scientifiche E Tecniche (IT)

PROJECT WEBSITE/URL

http://project-power-up.eu/

PROJECT CONTACT INFORMATION

Mr Christopher TAWNEY
ctawney@afcenergy.com

MAIN OBJECTIVES OF THE PROJECT

A 500 kWe alkaline fuel cell system will be demonstrated at Air Product's industrial gas plant in Stade, Germany. Performance, cost, social, economic and environmental impacts will be independently assessed, and certification for the post-funding period will be prepared. In addition, a prototype high-volume manufacturing line will be achieved through the introduction of automation.

PROGRESS/RESULTS TO-DATE

- Demonstration site permitted; utilities and buildings complete.
- Scaled-up alkaline fuel cell system complete. System constructed, tested and shipped to demo site *(being commissioned at the time of writing)*
- Fuel cell production line upgraded; extrusion now replaces blade mixing
- Automated stack assembly complete
- Recycling/re-use targets for catalyst and system components achieved

FUTURE STEPS

- Power production by Q3 2015
- Connection to the grid by Q3 2015
- Operational data to confirm cost of ownership, system performance, and economic/environmental/social impacts
- Automation of stack disassembly
- Certification

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Automation of fuel cell production has increased volumes without reducing quality
- Project targets are achievable
- Scaled-up system design will be basis of future commercial product
- Huge commercial interest in system from beyond Europe
- Connection to grid will be achieved by Q3 2015

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	Power generated in the field	*>5 MW by 2015*	240 kW by end 2015	N/A (test not finalized)
MAIP 2008-2013	Cost	*3,000 €/kW Assuming supported deployment from 2013+*	3,000 €/kW is the target cost (CapEx and OpEx), using demonstration systems. Target cost for the post-funding period will be significantly lower	The first system had a number of one-off high-cost items which will not be repeated. We now believe that this target is realistic for initial systems
AIP 2012	Conversion efficiency	58% (elec)	58 – 59%	On track to achieve by end of project
AIP 2012	Lifetime / duration of	15,000 hrs	15.000	On track to achieve by end of project

PROSOFC

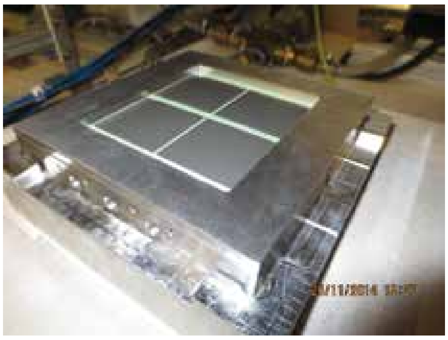
Production and Reliability Oriented SOFC Cell and Stack Design

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

Martin Hauth
martin.hauth@avl.com

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.

PUMAMIND

Physical Bottom-Up Multiscale Modelling for Automotive PEMFC Innovative Performance and Durability Optimization

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.3 - Improvement of PEMFC performance and durability through multi-scale modelling and numerical simulation
START & END DATE	17 Dec. 2012 - 16 Dec. 2015
TOTAL BUDGET	€ 4,092,629.69
FCH JU CONTRIBUTION	€ 2,294,106
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA

Partners: ENSL, LRCS, DLR, HSO, JRC, CSIC, UNISA, VODERA, SFU, IDIADA

PROJECT WEBSITE/URL

www.pumamind.eu

PROJECT CONTACT INFORMATION

Pascal Schott and Manuelle Quinaud
Pascal.schott@cea.fr , Manuelle.quinaud@cea.fr

MAIN OBJECTIVES OF THE PROJECT

In order to improve the PEMFCs systems durability, efficiency and to decrease the cost, time ofdevelopment, design of new diagnostic tools is crucial.

The project PUMAMIND will enhance the understanding of interaction, competitions and synergies among the mechanisms at multiple scales and lead to the development of robust dynamic macroscopic models for control-command purposes with predictive capabilities.

PROGRESS/RESULTS TO-DATE

- So far, a proof of concept has been reached by coupling the various scales from the nano to the system-level scale and permitted to develop new methodologies in the field of multi-scale simulation for fuel cells for optimization of both design and management of fuel cell systems. Therefore, the main objective of PumaMind has been reached.
- The direct use of activation energies for catalyst degradation in the local degradation model leads to a new physical bottom-up model, with results in good agreement with experimental data.
- Atomistic approaches at the nanoscale are key to understand the degradation mechanisms and to investigate the effect of material properties.
- PumaMind mitigation strategies at the system level rely on design observers at the cell level to estimate the key parameters that have to be considered for the control of the system.

FUTURE STEPS

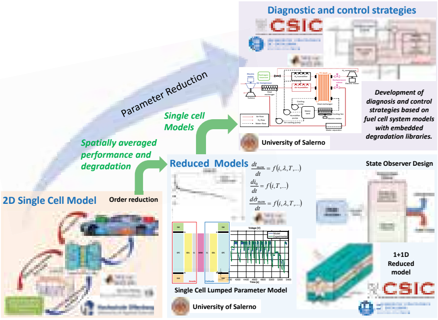
- Going-on with the fine understanding at the nanoscale of electrochemical mechanism, both in term of performance oxygen reduction reaction and degradation.
- Coupling of both the membrane degradation model and the catalyst degradation model with a performance model to simulate the effect of the operating conditions on global degradation of the PEMFC.
- Development of a simple tool to analyse the impact of both the design of the PEMFC and the operating conditions.
- Determination of mitigation strategies based on physical models in order to optimize both performance and durability.

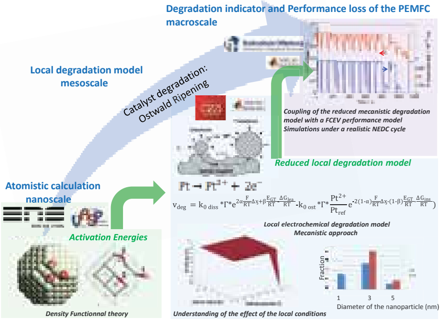
CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- PumaMind is the unique on-going European project that focuses specifically on multi-scale modelling of PEMFC in Europe in order to bridge the gaps between the many different scales that have to be considered for a realistic overall picture of FC systems operation
- The new multiscale modelling approach brings key elements for an optimal design and management of PEMFCs by providing new insights on the physics behind these complex systems.
- Nanoscale models of catalyst performance and degradation in the context of the FC complex environment require intensive further efforts of computational and methodological developments, in order to offer accurate predictions.
- Phenomenological approaches are also needed to simplify several complex phenomena towards a mathematical modelling representation being able to run on-board of real systems; such an achievement is the basis of, e.g., lifetime prediction, quantitative diagnostics, advanced, robust and adaptive control;
- A special care has to be paid on experimental validation at all the working scales, including the lower scales. For example, local experimental electrochemical data about the composition of the electrochemical interface are promising to help in determining the most relevant degradation mechanisms by identifying intermediate species.

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	Development of modeling tools for PEMFC performance and durability	"Development of multi-scale modeling and numericalsimulation tools for increasing the performance anddurability of PEM fuel cells. These computer-based tools are to be validated through experimental work"	DFT calculation of adsorption energies on a Pt_{201} nanoparticule (Nano scale).	Linear relationships for the estimation of the adsorption energies.
			Kinetic Monte Carlo description of the adsorbed species in the electrochem. double layer (mesoscale).	Coupling of Kinetic Monte Carlo and transport model. Ready for the comparison between Kinetic Monte Carlo and the Mean Field approaches for the modelling of the electrochemical double layer.
			Integration of the modules at the mesoscale Study of the interplay (sensitivity study) Methodology for the reduction of the micromodel.	Development of a mechanistic catalyst degradation model (Ostwald Ripening) Ongoing: Coupling of the ab-initio electrochemical model with the local continuous model
			Bridge between the micromodel and the system-level models.	The reduced catalyst degradation model at the local scale has been coupled with a performance model corresponding to a fuel Cell Electric Vehicle.
			Real-time diagnostic model for optimum control-command strategies	Performance indicators for activation, diffusion and ohmic losses





PURE

Development of Auxiliary Power Unit for Recreational Yachts

AIP / APPLICATION AREA	AIP 2011 / AA 4: Early Markets
CALL TOPIC	SP1-JTI-FCH.2011.4.4 Research, development and demonstration of new portable Fuel Cell systems
START & END DATE	01 Jan. 2013 - 31 Dec. 2015
TOTAL BUDGET	€ 2,884,875.00
FCH JU CONTRIBUTION	€ 1,641,194.00
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: HyGear Fuel Cell Systems

Partners: Danmarks Tekniske Universitet, Centre for Research and Technology Hellas, Joint Research Centre, Scheepswerf Damen Gorinchem bv.

PROJECT WEBSITE/URL

www.pure-project.eu

PROJECT CONTACT INFORMATION

Ellart de Wit
ellart.de.wit@hygear.nl

MAIN OBJECTIVES OF THE PROJECT

The main objective in the PURE project is the development, construction and testing of a fuel cell system for maritime applications. The LPG based fuel processor produces reformate which is used to produced 500 W DC electricity in a high temperature PEM fuel cell.

Other objectives are:

- Weight target: 35kg/kW
- System volume target: 50l/kW
- Sulphur tolerant hydrogen production catalysts
- Improved sulphur adsorption materials
- Optimised MEA production methods for HT PEM stack
- System designed for maritime applications

Two prototypes are built for environmental testing at JRC and on board of a ship.

PROGRESS/RESULTS TO-DATE

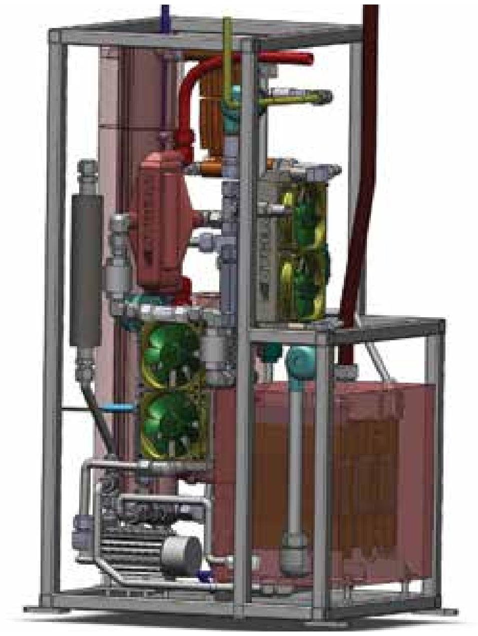
- System design and construction ready
- Optimised MEA's built into stacks
- Improved ATR catalysts delivered for integration in system
- System Modules (ATR, Stack, ATO) successfully tested
- 3D printed metal heat exchangers successfully tested

FUTURE STEPS

- Shock and vibration tests on Modules and system
- Environmental tests on system
- System testing in lab
- System testing on board of a ship.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Improved sulphur tolerance ATR catalysts shown
- 3D metal printing is a useful new manufacturing technology for small systems
- MEA production by environmental friendly processes and materials proven
- Small size system compared to SoA designed and constructed



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	Development of miniaturized BoP for specific devices	50l/kWe, 35kg/kWe	50l/kWe, 35kg/kWe	75 l/kWe, 52kg/kWe
MAIP 2008-2013	Assessment of fueling supply options	Logistics fuel	LPG based system	LPG fuel processing proven
AIP 2011	Stack power max. 50-500We net	Max 500 We	Max 500 We	Max power reached.
AIP 2011	On board fuel processing	Max conversion in LPG fuel processing	100% conversion vs chemical equilibrium reached & proven	Ready for implementation

ReforCELL

Advanced Multi-Fuel Reformer for CHP-Fuel Cell Systems

AIP / APPLICATION AREA	AIP 2010 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2010.3.3 Component improvement for stationary power applications
START & END DATE	01 Feb. 2012 - 31 Dec. 2015
TOTAL BUDGET	€ 5,546,194.57
FCH JU CONTRIBUTION	€ 2,857,211
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Fundación Tecnalia Research & Innovation

Partners: Eindhoven University of Technology, Commissariat à l'Energie Atomique et aux Energies Alternatives, Politecnico di Milano, SINTEF,
ICI caldaie S.P.A., HyGear BV, SOPRANO INDUSTRY, Hybrid Catalysis BV, Quantis Sàrl, JRC –JOINT RESEARCH CENTRE- EUROPEAN COMMISSION

PROJECT WEBSITE/URL

www.reforcell.eu

PROJECT CONTACT INFORMATION

José Luis Viviente
joseluis.viviente@tecnalia.com

MAIN OBJECTIVES OF THE PROJECT

ReforCELL aims at developing a high efficiency PEM fuel cell micro Combined Heat and Power system (net energy efficiency > 42% and overall efficiency > 90%) based on a novel, more efficient and cheaper pure hydrogen production unit (5 Nm3/h), together with optimized design of the subcomponent for the BoP. The target will be pursued with the integration of the reforming and purification in one single unit using Catalytic Membrane Reactors (CMR).

PROGRESS/RESULTS TO-DATE

- Metallic supported membranes working under 500°C have been developed with high selectivities (>150,000). Long term testing (~1200 h) has been demonstrated at 400°C.
- Reactor prototype has been assembled.
- PEM FC has been fully characterised and stack size, components manufacturing and integration have started.
- Test facility for the m-CHP system completed
- m-CHP designed.
- A preliminary LCA analysis for environmental impact assessment has been delivered

FUTURE STEPS

- Pilot scale CMR reformer validation
- Stack for the m-CHP
- Integration of the BoP and stack in the m-CHP.
- Testing the new m-CHP system.
- Complete Life Cycle Analysis and safety analysis

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

The incorporation of catalytic membranes reactors in the PEM fuel cell micro-CHP systems could improve the efficiency while reducing the cost due to the integration of the reforming and purification in one single unit (working at lower temperature) and the optimized design of the subcomponent for the BoP.

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	Overall efficiency CHP units	*> 80%*	> 90%	90 % can be achieved if the appropriate heat exchanger sizing and insulation is adopted (see D7.3)
MAIP 2008-2013	Micro-CHP (residential), natural gas based Cost per system (1kWe + household heat).	2015 target: Cost 10,000 € per system (1kWe + household heat). 2020 target: 5,000 € per system (1kWe + household heat).	5,000 € (1kWe + house heat)	• Cost could be achieved for mass production. However this is not the actual situation for some components. An estimated cost will be calculated when knowing the final components and theirs costs at the end of the project. • m-CHP system will be assembled end September / beginning October. • Stack is being built. To be delivered in September. • Reformer prototype has been assembled. It will be delivered in September after validation.
AIP 2010	Viable mass production	Viable mass production	Mass production technologies are considered in the development	-
AIP 2010	Electrical efficiency (%) >42%	> 42%	> 42%	According to the simulation techno-economic optimization of the lay-out for the ReforCELL system (D7.3) the target could be achieved. However, measuring it a real m-CHP is delayed.
AIP 2010	Recyclability	LCA and safety study	LCA and safety study	A preliminary LCA analysis for environmental impact assessment has been delivered (D8.1).

RESelyser

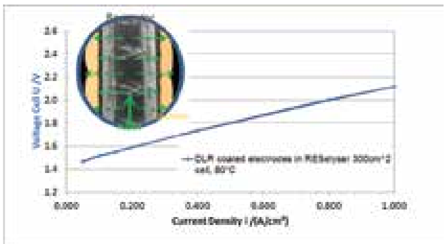
Hydrogen from RES: Pressurised Alkaline Electrolyser with High Efficiency and Wide Operating Range

AIP / APPLICATION AREA	AIP 2010 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2010.2.1: Efficient alkaline electrolysers
START & END DATE	01 Nov. 2011 - 30 Apr. 2015
TOTAL BUDGET	€ 2,888,957.40
FCH JU CONTRIBUTION	€ 1,484,358
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Deutsches Zentrum fuer Luft- und Raumfahrt eV. (DLR)

Partners: Vlaamse Instelling voor Technologisch Onderzoek N.V. (VITO), Hydrogenics Europe N.V., Danmarks Tekniske Universitet (DTU)



PROJECT WEBSITE/URL

www.reselyser.eu

PROJECT CONTACT INFORMATION

Regine Reissner
Regine.reissner@dlr.de

MAIN OBJECTIVES OF THE PROJECT

The project RESelyser develops high pressure, highly efficient, low cost alkaline electrolysers that can be integrated with renewable energy power sources (RES) using an advanced membrane concept, highly efficient electrodes and a new cell concept. Quantitative objectives: efficiency >80%, 1,000 on/off switching cycles; 3,000 €/(Nm^3/h) plant capacity.

PROGRESS/RESULTS TO-DATE

- Novel diaphragms with internal electrolyte bypass and properties for maximum benefit of the cell developed and produced in technical size
- 300 cm^2 cell and 10 kW stack up to 30 bar used for tests
- Electrode coatings with low-cost material developed with 411 mV overpotential reduction versus uncoated electrodes retaining 98% of their initial efficiency in 1100 on-off cycles
- Electrode coating porosity and degradation investigated with two and three dimensional electron microscopy
- Gas impurity at low current density very low: 48 ppm O_2 in H_2 and 247 ppm H_2 in O_2 at 5 bar

FUTURE STEPS

The project is terminated.

- Promising electrode coating needs further development and transfer to commercialisation.
- Double layer separator is ready for commercial licensing.
- High pressure stack technique will be used in future electrolyser development.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Key steps towards a next generation alkaline water electrolyser for higher pressure and highly fluctuating power supply were achieved: separators, electrodes, stack construction, and BoP construction

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 2010	Power level stack	Exceeding 5kW	10 kW	10 kW stack 30 bar
AIP 2010	Efficiency @current density 0.75 A/cm^2	>80% on HHV basis	η >80% on HHV basis 300 cm^2 electrodes, low-cost materials	Total efficiency η=76% on HHV basis at a current density of 0.75 A/cm^2 in a 300 cm^2 cell, 82% for smaller cell
AIP 2010	Electrolyser system operation at high pressure	15MPa=150 bar with compression or 3 MPa=30 bar without compression	100-150 bar concept, 25 bar realisation without compression	Tests up to 30 bar, stack ready for 50 bar
AIP 2010	Retention of ...% of initial efficiency over at least 1000 on/off switching cycles	>90%	>90% demonstrated with 10 kW electrolyser	Electrode potential 98% of initial efficiency over 1100 on/off switching cycles; higher degradation in stack
AIP 2010	Modular system cost	€1,000 per Nm^3/h plant capacity for the stack and €3,000 per Nm^3/h plant for a complete system	System costs €3,000 per Nm^3/h plant capacity for the complete system	Estimate 2,300 €/(Nm^3/h) plant capacity stack costs S2500 running at 65 bar, 7K€/(Nm^3/h) for a 6-stack-arrangement (1000 cm^2) 65barg reselyser system. Costs of electrolyser system for some application cases lower than state of the art

SAPIENS

Solid Oxide Fuel Cell Auxiliary Power in Energy/Noise Solutions

AIP / APPLICATION AREA	AIP 2011 / AA 4: Early Markets
CALL TOPIC	SP1-JTI-FCH.2011.4.4: Research, development and demonstration of new portable Fuel Cell systems
START & END DATE	01 Nov. 2012 - 31 Oct. 2015
TOTAL BUDGET	€ 2,369,507.20
FCH JU CONTRIBUTION	€ 1,591,590.00
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Adelan Ltd

Partners: Auto-Sleepers Group Ltd, Center for Abrasives and Refractories Research and Development, Clausthaler Umweelttechnik Institut GMBH, Joint Research Centre –European Commission, Fundacio Institut de recerca de L'Energia de Catalunya, Zachodniopomorski Uniwesytet Technologiczny w Szczecinie.

PROJECT WEBSITE/URL

http://sapiens-project.eu

PROJECT CONTACT INFORMATION

Jill Newton
jill.newton@adelan.co.uk

MAIN OBJECTIVES OF THE PROJECT

SAPIENS aims to design, optimize and build 100W micro-tubular solid oxide fuel cell (mSOFC) stacks, and to integrate them into hybrid power systems. These will form auxiliary power units to provide power for appliances found in recreational vehicles (RVs).

- Test the liquid petroleum gas (LPG) fuel
- Improve the mSOFC in terms of materials, lifetime, performance, noise reduction, emissions and costs
- To disseminate by getting users to apply the new device and report results across Europe. Also three special conferences will be organised to disseminate information, ten refereed publications will be submitted and patents will be published.

PROGRESS/RESULTS TO-DATE

- Cells tested
- Stack built
- Balance of plant complete
- CPOX experiments with LPG were successful
- Prototype installed in RV

FUTURE STEPS

- Complete field trials
- Demonstration of consumer/environmental performance and acceptability.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Good cell and substack performance has been achieved
- CPOX experiments with LPG were successful
- Prototype installed in RV

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	Development of miniaturized BoP for specific devices ...		As the fuel cell generator including fueling has to fit into a confined RV space, the BoP components have to be miniaturized	The fuel cell generator has been fitted in cofined space in RV
MAIP 2008-2013	Assessment of fueling supply options		On-board fueling with LPG for mission extension	The fuel cell generator runs on LPG
MAIP 2008-2013	Supportive actions for SME		Auto-Sleepers is customer and contributor in SAPIENS SME, producer of RV products, Adelan Ltd is developer of the core modules	Successful partnership

Sapphire

System Automation of PEMFCs with Prognostics and Health Management for Improved Reliability and Economy

AIP / APPLICATION AREA	AIP 2012 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2012.3.3: Robust, reliable and cost effective diagnostic and control systems design for stationary power and CHP fuel cell systems
START & END DATE	01 May 2013 – 30 Apr. 2016
TOTAL BUDGET	€ 3,269,417.10
FCH JU CONTRIBUTION	€ 1,745,140
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: SINTEF Foundation (Norway)

Partners: European Institute for Energy Research (Germany), FCLAB Research Federation (France), University of Split (FESB, Croatia), Center for Solar and Hydrogen Energy Research (German), Dantherm Power A/S (Denmark)

PROJECT WEBSITE/URL

www.sapphire-project.eu

PROJECT CONTACT INFORMATION

Federico Zenith
Federico.zenith@sintef.no

MAIN OBJECTIVES OF THE PROJECT

To develop an integrated prognostics and health management (PHM) system, including a health-adaptive controller to extend the lifetime and increase the reliability of low-temperature PEM fuel cell stacks in μCHP systems.

This is achieved by developing degradation and health assessment methods that can be applied on-line with existing or inexpensive additional sensors, prognostic algorithms to estimate the Residual Useful Life (RUL) of the stack given its current state and predicted usage, and a control system to maximise the RUL by manipulating the operating conditions of the system.

PROGRESS/RESULTS TO-DATE

- Performed extensive cell and stack testing
- Long-term system testing with current technology
- Developed prognostic and diagnostic algorithms
- Identified modes of operation with no degradation
- Synthesised advanced controllers

FUTURE STEPS

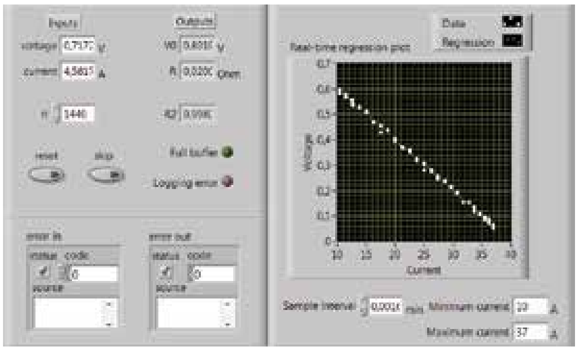
- Long-term testing with new technology
- Validation of prognostic algorithms
- Validation of control performance
- Evaluation of stack design influence on degradation

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Degradation can be strongly reduced with appropriate action
- Cost constraints will be achieved
- Prognostics without on-line EIS is possible

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 lifetime	30000 h	> 20000 h With current tech	> 9000 h tested ~ 50000 projected
AIP 2012	FC lifetime	20000 h With current tech	> 20000 h With current tech	> 9000 h tested ~ 50000 projected
AIP 2012	Extra cost for control system	100 €/kW	100 €/kW	136 €/kW



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
r.steinbergerwilckens@bham.ac.uk

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

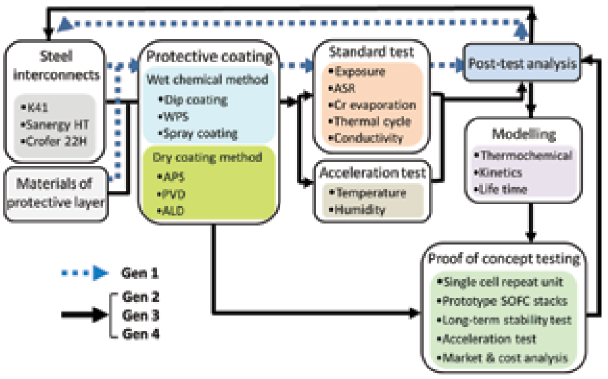
- sample choice & preparation
- test matrix established
- first and second generation test coatings
- systematic testing & analysis ongoing

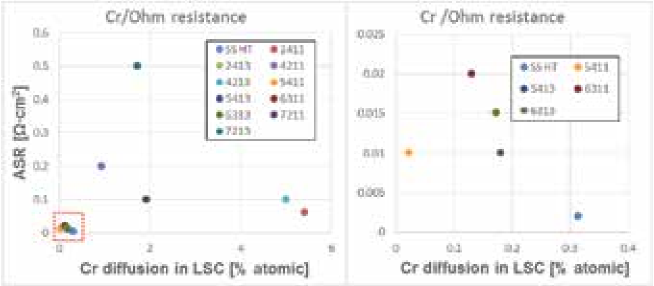
FUTURE STEPS

- 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

Sylvie Escribano
sylvie.escribano@cea.fr

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 H_2 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 (H_2 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.

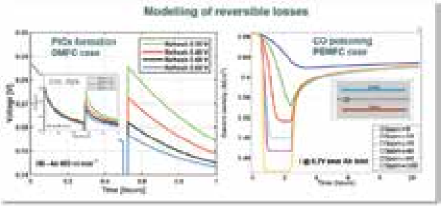
FUTURE STEPS

- 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 H_2 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 H_2 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.*

SMARTCat

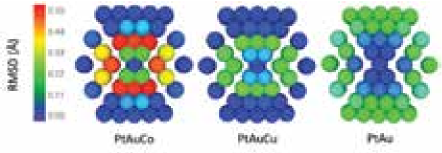
Systematic, Material-Oriented Approach Using Rational Design to Develop Break-Through Catalysts for Automotive PEMFC

AIP / APPLICATION AREA	AIP 2012 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2012.1.5: New catalyst structures and concepts for automotive PEMFCs
START & END DATE	01 Jun. 2013 - 31 May 2017
TOTAL BUDGET	€ 4,768,172.60
FCH JU CONTRIBUTION	€ 2,501,998.00
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CNRS

Partners: SINTEF, DTU, CEA, mxpolymers



PROJECT WEBSITE/URL

smartcat.cnrs.fr

PROJECT CONTACT INFORMATION

Pascal Brault
Pascal.Brault@univ-orleans.fr

MAIN OBJECTIVES OF THE PROJECT

- New and innovative electrodes using tri-metallic low Pt-content (0.01 mg^{-2}, 0.05g/kW)) based catalyst nanoparticles and nanostructured layers (CL) combined with new and corrosion resistant metal-doped oxide-based materials (CL-conductivity in the range from 1 to 10 S/cm).
- Upscaling HT membranes proton conductivity > 60 mS/cm @ 40 °C; > 200 mS/cm @ 180 °C.
- Enable to optimize and to automate the production of MEAs (60/day).
- Prove the viability of the new concept for automotive applications (220 cm^{-2}, 5000h durability).

PROGRESS/RESULTS TO-DATE

- PtNiAu tri-metallic catalysts gives FC performance of 733 mW/cm^2 at 80°C and 505 mW/cm^2 at 115 °C,
- synthetized (Sb,Nb)-doped SnO_2 support with conductivity > 0.1 Scm^{-1};pore size 20-100 nm, and active area above 80 m^2.g^{-1}.
- development of 1 kg polymer synthesis for new PYPO HT membranes with conductivity 0.5 Scm-1 at 110°C
- first automatized MEA fabrication (50 MEA processed per day)

FUTURE STEPS

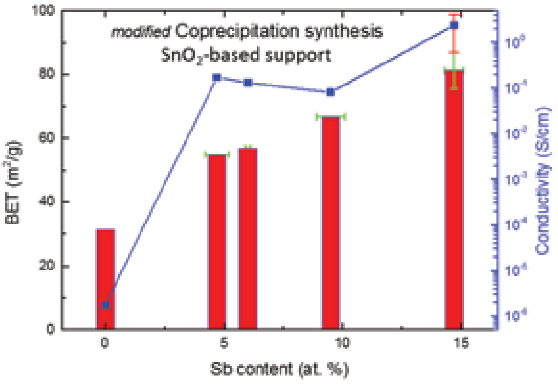
- optimization of deposition of trimetallic catalysts on SINTEF Antimony Tin Oxide (ATO) support
- optimization of the trimetallic catalyzed support in terms of improved corrosion resistance.
- optimized oxide support will be used to manufacture MEAs
- automatized MEA fabrication using SMARTCat materials

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Ongoing project is in time
- FC with tri-metallic electrodes power density > 700 mWcm^{-2}
- Support with expected conductivity reached around 0.1 Scm^{-1}
- 100 cm^2 HT membrane with 0.5 Scm^{-1} achieved
- Progress are expected for increasing FC performances and durability.

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	• new electrodes materials for fuel cell car • lowering cost with targeted performances • developing low cost process fabrication of low cost catalyst, support materials and automated high rate MEA fabrication at the pilot scale.	Not defined	25 cm^2 Single Cell performance of 1Wcm^{-2} 100 cm^{-2} Single Cell performance of 0.9 Wcm^{-2} at EoL 220 cm^{-2} short stack >2kWL-1	0.7 Wcm^{-2} with 0.025 mg.cm^{-2} loaded cathode with PtNiAu trimetallic catalyst on 25 cm2 electrode.
AIP 2012	Pt loading	0.1 g/kW	0.1 g/kW	0.036 g/kW
AIP 2012	Support + catalyst conductivity	n/a	> 1 S/cm	0.01 S/cm in non-optimized Pt/ATO catalyst



SOCTESQA

Solid Oxide Cell and Stack Testing, Safety and Quality Assurance

AIP / APPLICATION AREA	AIP 2013 / AA 5: Cross-Cutting Activities
CALL TOPIC	SP1-JTI-FCH.2013.5.4: Development of industry wide uniform performance test schemes for SOFC/SOEC cells & stacks
START & END DATE	01 May 2014 - 30 Apr. 2017
TOTAL BUDGET	€ 3,212,186
FCH JU CONTRIBUTION	€ 1,626,373
PANEL	Panel 6- Cross-Cutting

PARTNERSHIP/CONSORTIUM LIST

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

Partners: Commissariat à l'énergie atomique et aux énergies alternatives (CEA), Danmarks Tekniske Universitet (DTU), Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (ENEA), Joint Research Centre-European Commission (JRC), Europäisches Institut für Energieforschung EDF-KIT EWIV (EIFER), Nanyang Technological University (NTU)

Generic Test Modules		Applications			
		Stationary SOFC	Mobile SOFC	SOEC	Combined SOFC/SOEC
TM01	Leakage test	x	x	x	x
TM02	Start-up	x	x	x	x
TM03	Current-voltage characteristics	x	x	x	x
TM04	Electrochemical impedance spectroscopy	x	x	x	x
TM05	Current interruption	x	x	x	x
TM06	Cyclic voltammetry	-	-	-	-
TM07	Reactant utilisation	x	x	x	x
TM08	Reactant gas composition	x	x	x	x
TM09	Temperature sensitivity	x	x	x	x
TM10	Pressure sensitivity	-	-	x	x
TM11	Mechanical load sensitivity	x	x	x	x
TM12	Operation under constant current	x	x	x	x
TM13	Operation under varying current	x	x	x	x
TM14	Thermal cycling	x	x	x	x
TM15	Redox cycling	x	x	x	x
TM16	Shut-down	x	x	x	x
TM17	Vibration test	-	x	-	-
TM18	Emergency stop	x	x	x	x

PROJECT WEBSITE/URL

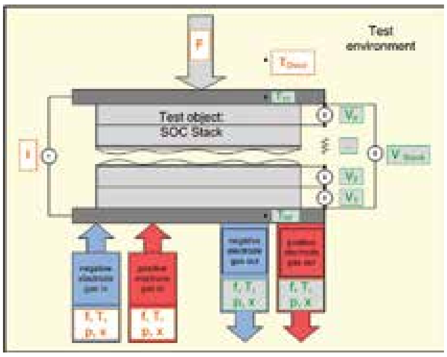
http://www.soctesqa.eu/

PROJECT CONTACT INFORMATION

Michael Lang
michael.lang@dlr.de

MAIN OBJECTIVES OF THE PROJECT

The main objective of the project is to develop uniform and industry wide test programs for solid oxide cell (SOC)/stack assembly units. The project will address three different operation modes, which are solid oxide fuel cell (SOFC), solid oxide electrolysis cell (SOEC) and combined SOFC/SOEC operations. Both stationary and mobile applications areas will be covered. Moreover, advanced characterization techniques, as electrochemical impedance spectroscopy, will be integrated in the test programs. The test modules will be experimentally validated on SOC short stacks. Moreover, the project will address safety aspects, liaise with standards developing organizations (SDO) and establish contact with industrial practice.



PROGRESS/RESULTS TO-DATE

- Project start phase (specifications, literature review, delivery of SOC short stacks...) finished
- Test matrix, test master document and first test program developed
- Application specific fact sheets were supplied by industries and active liaison with the most important standards developing organisations (SDOs) in the field were established
- Test stations specified and adapted for testing
- Five important test modules drafted and validated, e.g. current-voltage curve, electrochemical impedance spectroscopy and operation at constant current

FUTURE STEPS

- Optimization of test modules by future validation loops
- Development of further test modules, e.g. for dynamic operation of SOC stacks
- Data sensitivity analysis related to interfaces between a common stack and different test stations
- Synchronisation of the project outcome to SDO and industrial advisory board (IAB) in the frame of a joint liaison project workshop

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Proper definition and monitoring of all interfaces between short stack and test station are very important
- The first results between the partners shows a high consistency
- A high sensitivity of the stack behaviour towards operating temperatures and the process gases was found
- Even little changes/differences of the operating conditions at the interfaces can strongly influence the stack results
- These high sensitivity parameters have to be addressed properly in the test modules and programs

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	testing and certification procedures	Establishment of frameworks and schemes to support SMEs to develop a supply chain for fuel cell and hydrogen technologies (e.g. by facilitating testing and certification procedures).	Definition, development and experimental validation of commonly accepted testing procedures and test protocols for a selected number of SOFC/SOEC applications.	Altogether 18 test modules were identified in the test matrix, which cover a wide range of system applications. The most important test modules (TM02, TM03, TM04, TM12 and TM16) have been developed and a first test program was established. The validation of these test modules in the frame of the test station comparison was performed and is currently under optimization.
AIP 2013	standardisation	testing standards for SOFC and SOEC	Identification of the most relevant testing procedures and test protocols for Solid Oxide Cell technology based on fuel cell applications and electrolysis application.	This topic was addressed by the specifications in WP 2 and by the definition of the test matrix and the test program in WP 3.The definition of the test matrix is finalized. The Deliverable D3.1 (Test Matrix) has been uploaded to FCH-JU platform (SESAM).
AIP 2013	standardisation	testing standards for SOFC and SOEC	It is very important to identify the most relevant parameters to be included in the testing procedures and test protocols addressing performance and endurance.	This topic was addressed by the development of the test program in WP 3. The corresponding Deliverable 3.2 was uploaded on SESAM. In order to determine the conditions for this test program a fact sheet was developed. The SOC industrial stakeholders have given input to these fact sheets according to the different system applications.
AIP 2013	standardisation	testing standards for SOFC and SOEC	Description of the required test infrastructure (test benches, system environments, hardware in the loop installations etc.)	This objective was addressed by Tasks 4.1, Task 5.1 and Task 6.1: Adaptation and commissioning of test stations for SOFC, SOFC and combined SOFC/SOEC testing, respectively. The corresponding deliverables D4.1, D5.1 and D6.1 have been uploaded to FCH-JU platform (SESAM).
AIP 2013	standardisation	testing standards for SOFC and SOEC	Moreover, besides current voltage curves, more detailed electrochemical characterisation methods with improved technical methods are now possible, e.g. electrochemical impedance spectroscopy (EIS).	In WP3 a test module (TM04) was developed, which is dedicated to electrochemical impedance spectroscopy. It is being validated in the different testing campaigns.
AIP 2013	standardisation	testing standards for SOFC and SOEC	Establishment of methodologies for the uniform collection, analysis and presentation of test data	In WP3 a test module (TM00) was developed, which is dedicated to general testing guidelines. These guidelines describe methodologies, collection, analysis and presentation of test data.
AIP 2013	standardisation	testing standards for SOFC and SOEC	Establishing liaison to standards development organisations (SDOs),... is encouraged.	In Task 7.1of WP 7 the interaction and liaison with standards development organisations (SDO) was intensified. Up to now strong liaison with the International Electrotechnical Commission IEC and the European CEN/CENELEC was established. A joint liaison workshop with SDO and IAB will take place at 15.12.2015.

SOFCOM

SOFC CCHP with Poly-Fuel: Operation and Management

AIP / APPLICATION AREA	AIP 2010 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2010.3.4 - Proof-of-concept and validation of integrated fuel cell systems
START & END DATE	01 Nov. 2011 - 30 Apr. 2015
TOTAL BUDGET	€ 6,250,227.23
FCH JU CONTRIBUTION	€ 2,937,753.00
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Politecnico di Torino (Italy)

Partners: Teknologian Tutkimuskeskus VTT (Finland), Topsoe Fuel Cells A/S (Denmark), Società Metropolitana Acque Torino spa (Italy), Matgas 2000 A.I.E. (Spain), Consiglio Nazionale delle Ricerche (Italy), Instytut Energetyki (Poland), Ecole Polytechnique Fédérale de Lausanne (Switzerland), Technische Universitaet Muenchen (Germany), Università di Torino (Italy)

PROJECT WEBSITE/URL

www.sofcom.eu (http://areeweb.polito.it/ricerca/sofcom/en/)

PROJECT CONTACT INFORMATION

Massimo Santarelli
massimo.santarelli@polito.it

MAIN OBJECTIVES OF THE PROJECT

SOFCOM is an applied research project devoted to demonstrate the technical feasibility, the efficiency and environmental advantages of CHP systems based on SOFC fed by biogenous primary fuels (biogas and bio-syngas) integrated by a process for the CO_2 separation and Carbon reutilization.

The Demonstration is implemented in the context of other 2 axes:

Lab-scale: fuel production section; fuel cleaning section; fuel processing section; SOFC CHP section; carbon capturing module (oxy-combustion, CO_2 separation, C fixing in algae)

System Analysis: energy, economic, environmental analysis of the option of SOFC-based CHP plants as distributed systems using local biogenous energy sources; development of guidelines for the scale-up; development of pre-normative results; LCA analysis

PROGRESS/RESULTS TO-DATE

- Analysis of biogas contaminant effects on SOFC anodes: halogens, siloxanes, sulphur, also with combined and synergetic effects

- DEMO of complete biogas-cleaning-SOFC-CO_2 recovery from anode exhaust
- DEMO of SOFC stack fed with lean fuel (syngas from biomass gasification)
- Biogas-SOFC-CO_2 recovery plants: scale-up and exploitation analysis

FUTURE STEPS

Done

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- SOFCOM demonstrates (through in-field DEMO) the high interest of electrochemical systems based on high temperature fuel cells to operate as the core of future energy systems with renewable fuels and multi-product configuration, with particular care on CO_2 management through C re-utilization in different processes (electrochemical, chemical, or biological as in SOFCOM).
- scale-up of the biogas-SOFC plant. New project **DEMOSOFC** (FCH2 JU Call 2014), providing a industrial size (175 kWe) DEMO of a SOFC system installed in a waste water treatment plant, fully fed by biogas from WWTP.
- deep analysis of biogas contaminant effects on SOFC anodes: combined and synergetic effects
- activities on SOFC fed by lean syngas and strong interest in going on with the activities on the contaminants effect on cells and elements of the stack
- CO_2 recovery from SOFC anode exhausts

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	High electrical efficiencies	45%+ for power systems and of 80%+ for CHP systems, with lower emissions and use of non-fossil fuels.	From the first analysis, the figures are as follows: a) 49.50% of the primary fuel is converted in high value electric power; b) 47.16% of the primary fuel is converted in low grade heat flow, but fully useful in the WWTU plant to supply the heat requirements of the thermo-phillic sewage digesters; c) 1.22% of the primary fuel is converted back in useful biomass, which can be re-inserted in the digester for biogas production, or used for other applications (e.g. bio-fuel productions). Also, it has to be considered that: a) the biogas is a completely sustainable fuel, b) the system provides a complete closed loop of the Carbon atoms	The DEMO has been tested in the industrial context. The electric efficiency has reached 53%.
MAIP 2008-13	Demonstration activities target proof-of-concept, technology validation or field demonstrations	NA	SOFCOM develops two final demonstration of complete biofuel-fed SOFC systems: DEMO 1 Torino (IT): field demonstration of WWTU biogas-fed SOFC with CO_2 recovery and reuse; real operating environment. DEMO 2 Helsinki (FI): technology validation within in-house test facility of bio-syngas-fed SOFC; in-house validation.	DEMO 2 Helsinki (FI): done. DEMO 1 Torino (IT): done.
MAIP 2008-13	Field demonstration activities are split into small (residential and commercial applications) and large (distributed generation or other industrial or commercial applications) scale.	NA	The DEMO 1 in Torino is a small scale demonstration activity but performed in a real industrial application scale. The DEMO 2 in Helsinki is a small scale demonstration activity but with emphasis on future scale-up (biomass gasification fuel).	DEMO 2 Helsinki (FI): done. DEMO 1 Torino (IT): done.
AIP 2010	Development of proof of concept prototypes that combine fuel cell units into complete systems, performing integration and testing with fuel delivery and processing subsystems; interface with devices featuring delivery of customer requirements (e.g. power, heat, cooling and CO_2 capture), also integrating renewable sources and other services wherever appropriate	NA	SOFCOM develops of two proof-of-concept demonstration plants, which integrates SOFCs into complete systems. The demonstration site in Torino (Italy) consists in SOFC generator fully integrated in a large waste-water treatment plant producing biogas; the generator works in a cogenerative mode, producing electrical power, plus heat; it is also integrated with a CO_2 separation and reutilization module (photo-bio-reactor for algae water and Carbon fixing). The demonstration site in Helsinki (Finland) is based on the integration of the SOFC with another fuel typology: a bio-syngas (from gasification) is used to feed the SOFC unit, which works in CCHP configuration.	DEMO 2 Helsinki (FI): done. DEMO 1 Torino (IT): done.
AIP 2010	Identification of technical and economic requirements in order to be competitive in the marketplace	NA	Analysis, following the real experience performed in the Demonstration Activity, with a scale-up analysis of the integrated SOFC systems studied.	Analysis done, to be used especially for next scale-up project in the area of biogas-fed FCs (DEMOSOFC, financed in the FCH2 JU Call 2014)
AIP 2010	Validation activities, performed in a real system environment or with real equipment in a simulated system environment	NA	The proof-of-concept validation of the tested systems on the demonstration sites is one of the main results of the project; this is followed by a close examination of the lessons learned, which will eventually enable us to identify the reliability of the SOFC integrated systems, weaknesses, and eventually to establish the market maturity.	Validation activities done in a real industrial site

SOFT-PACT

SOFT-PACT

Solid Oxide Fuel Cell Micro-CHP Field Trials

AIP / APPLICATION AREA	AIP 2010 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2010.3.5: Field demonstration of stationary fuel cell systems
START & END DATE	08 Jul. 2011 - 07 Oct. 2015
TOTAL BUDGET	€ 10,312,703
FCH JU CONTRIBUTION	€ 3,950,893
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: E.ON NEW BUILD & TECHNOLOGY LIMITED

Partners: CERAMIC FUEL CELLS GMBH, IDEAL BOILERS LIMITED, HOMA SOFTWARE BV

PROJECT WEBSITE/URL

www.soft-pact.eu

PROJECT CONTACT INFORMATION

Andrew Thomas
andrew.thomas@eon.com

MAIN OBJECTIVES OF THE PROJECT

SOFT-PACT has been established to undertake a large scale field demonstration of SOFC generators that can be utilised in residential applications. The objectives being to:

- Design, develop and deploy integrated fuel cell mCHP systems
- Long term reliability and life data from the systems
- Remote control and diagnostics of all the systems from a central point in real time
- Training and re-skilling of installation and maintenance engineers
- Identification and quantification of benefits to the homeowner

Key outputs (EU market study, data from two field trials, building of installation capability and completion of the development of an optimised integrated FC system)

PROGRESS/RESULTS TO-DATE

- EU FC Market Opportunities Study Report
- Deployment of Pathfinder BlueGen Systems in DE & UK
- Specification for Integrated Fuel Cell Appliance
- Cost Reduction and Component Optimisation of BlueGen
- Design, test, build and deployment of Integrated Fuel Cell Appliances in Field Trial

FUTURE STEPS

- Monitoring Data Analysis
- Decommissioning & removal of field trial units (Mid 2015)
- Final Reports

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Large opportunities for fuel cell deployment with EU @ right price
- Policy and incentive support must be maintained to aid volume production cost reductions
- Range of systems required to meet all EU markets (gas types and local regulations)
- Deployment of systems by local companies requires hybrid installation engineer training to reduce costs.
- Fuel Cell Start ups are extremely dependant on Investors – (CFC currently in administration – June 2015)

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 *life time* (h)	>5,000	>10,000	Ongoing (test not finalized)
AIP 2010	Deployment of fuel cel*ls* with Trial	10	Up to 100	39 BlueGen Systems 26 Integrated Fuel Cell Appliances (SIFC) 65 Fuel Cell Systems Total (ongoing)
AIP 2010	FC system Electrical efficiency (%) (HHV)	>40	>40	56 -> 42 Over lifetime
AIP 2010	Cost Reduction (€/kWe)	€5000 /kWe	25% Reduction on BlueGen	Achieved via Re-engineering & supply chain enhancements

SOL2HY2

Solar To Hydrogen Hybrid Cycles

AIP / APPLICATION AREA	AIP 2012 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2012.2.5: Thermo-electrical-chemical processes with solar heat sources
START & END DATE	01 Jun. 2013 - 31 May 2016
TOTAL BUDGET	€ 3,701,300
FCH JU CONTRIBUTION	€ 1,991,115
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: EnginSoft S.p.A.

Partners: Aalto-korkeakoulusäätiö, Deutsches Zentrum fuer Luft- und Raumfahrt e.V., Agenzia per le Nuove Tecnologie l'Energia e lo Sviluppo Economico Sostenibile, Outotec (Finland) Oy, Erbicol S.A., Oy Woikoski AB.

PROJECT WEBSITE/URL

sol2hy2.eucoord.com

PROJECT CONTACT INFORMATION

Stefano Odorizzi
stefano.odorizzi@enginsoft.it

Michael Gasik
michael.gasik@aalto.fi

MAIN OBJECTIVES OF THE PROJECT

1. Development of the key hybrid plant components (SO_2-depolarized electrolyzer (SDE), solar-powered H_2SO_4 cracker and heat storage)
2. Multi-objective design and optimisation and testing of improved critical materials solutions and processes
3. Designing and running field tests of key blocks of the hybrid cycles their performance analysis
4. Technical-economic evaluation of the new process concept
5. Development of the flexible centralised H_2 production plant options using interfaces to running industrial process as the starting point for renewable H_2 by-production

PROGRESS/RESULTS TO-DATE

- A multi-cell SDE stack was constructed and tested in the lab for hydrogen and sulphuric acid co-production.
- An acid decomposition chamber, acid evaporator and gas handling were designed for field demo tests using solar tower
- Hybrid solar plant flowsheets were analysed and optimized.
- Multi-objective design and optimization were performed on key units such as SDE and their optimal processing parameters were identified
- Balance of plant has been selected and prepared for the virtual plant model for specific locations

FUTURE STEPS

- Finalising tests of SDE in different conditions
- Field tests of efficient catalysts for sulphuric acid cracking
- Final multi-objective optimization of the plant
- Running demo activities in 2015 at the solar tower in Jülich
- Analysing feedback and update of the final steps of the project

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The hybrid plant design was demonstrated flexibility for selected locations and input parameters, able to adjust with solar input
- SO_2-depolarized electrolyzer was successfully designed and tested
- Molten salt technology is feasible to ensure continuous operation for hydrogen and acid production, where high-temperature solar power is only used for acid cracking and recycling
- Virtual plant model linked with multi-objective design and optimization provides opportunity for user-tailored solutions.
- Combination of closed (hybrid sulphur) and Outotec open cycles allows greater cost-efficiency at high power utilization.

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	Catalysts with activities	+30% vs. state of the art	>100% vs. known Pt/Pd loads	Good electrolyzer performance achieved with only 1-3 μg/cm^2 loads vs. known 100-1000 μg/cm^2
AIP 2012	Redox materials with conversion rate	+100% vs. state of the art	Redox materials not used	Use of redox materials eliminated
AIP 2012	Development of key components with enhanced efficiency in relevant scale	0.5-2.0 MW	>0.5 MW at daily input 20 MWh	Design according to the program objective

SOPHIA

Solar Integrated Pressurized High Temperature Electrolysis

AIP / APPLICATION AREA	AIP 2013 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2013.2.4: New generation of high temperature electrolyser
START & END DATE	01 Aprl 2014 - 31 Mar. 2017
TOTAL BUDGET	€6,080,105
FCH JU CONTRIBUTION	€3,325,751
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: HyGear BV

Partners: HTceramix SA, Commissariat à l'énergie atomique et aux énergies alternatives, Deutsches Zentrum fuer Luft- und Raumfahrt ev, Ecole polytechnique federale de Lausanne, Teknologian Tutkimuskeskus VTT, GdF Suez, SOFCpower Spa

PROJECT WEBSITE/URL

http://www.sophia-project.eu/

PROJECT CONTACT INFORMATION

Dr. Ellart de Wit
Ellart.de.wit@hygear.nl

MAIN OBJECTIVES OF THE PROJECT

Design, fabrication, and operation on-sun of a 3 kWe-size pressurized High Temperature Electrolysis (HTE) system, coupled to a concentrated solar energy source as proof of principle. Proof of concept of co-electrolysis at the stack level, and pressurized.

Development and manufacturing of optimized large area cells for HTE operation targeting at high performance, and improved durability. Degradation analysis. Design of a stack for pressurized operation.

PROGRESS/RESULTS TO-DATE

- PFD of system ready
- Concept P&ID of SOE sub-system ready
- Solar receivers build and tested, optimisation on going
- 1st Market analysis is done, case studies are defined (varying country, hydrogen or syngas pathway, definition of end use), the simulation model is in progress.
- Short stack experiments at 1 bar done

FUTURE STEPS

- Design of components and construction of BoP
- Stack design validation (self-clamping system validation) – Integration of SP cells; build of 3 kW SOE stack,
- Finalize design and build of Solar receiver/steam generator
- Continue cell and short stack tests according to the plan
- Electrode microstructure optimization and degradation analysis ongoing (H_2 electrode form SP to be well-characterized, electrode model calibration to be performed, co-electrolysis model validation to be continued)

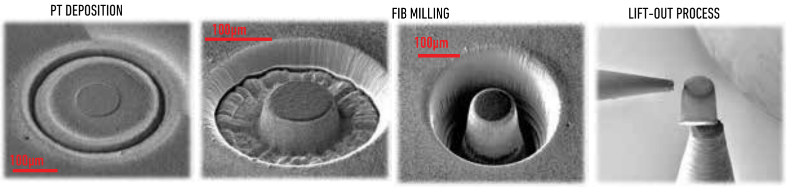
CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Tailor made test station validated for reversible operation of a SOE stack
- Current H_2 for industrial : huge market in EU, very high prices; mobility market by 2020 : might be huge for renewable in EU depending on regulation
- A complete numerical model considering two phase flow, radiative heat transfer, and natural convection is developed for evaluation and optimization of the solar receiver for cogeneration of high temperature steam and CO_2. Based on the model, parametric studies show that the current receiver prototype design has potential to be improved by changing the tube diameter, orientation and position of tubes and aperture, and operation strategies.
- First performance tests performed with SP button cells under pressurized conditions in electrolysis and co-electrolysis modes – At the thermoneutral voltage: positive impact of the pressure. The electrochemical model at P≥1 bar validated at the Single Repeat Unit. Simulations performed to identify the best operating conditions of this cell in pressurized electrolysis mode.

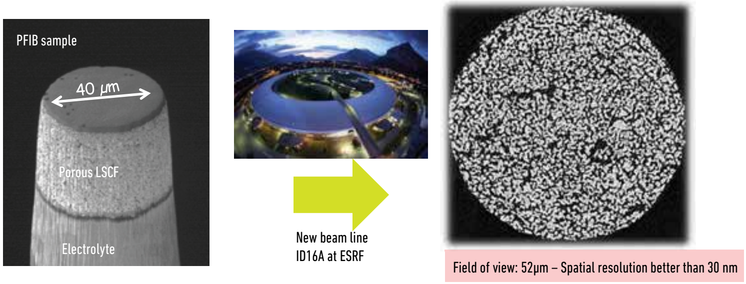
Model calibrated for the O2 electrode thanks to polarization curve obtain in symmetrical configuration and microstructure data input -> First recommendations/conclusions for microstructure optimization : (Because of a non-symmetrical behavior in both polarization, a specific microstructural optimization is required in electrolysis mode. A LSCF-CGO composite with fine and percolated phases has been recommended for electrolysis operation...) A sensitivity analysis on microstructural properties has shown that electrode performances could be improved in both polarization (i.e. fuel and electrolysis)

- More accurate characterization of the electrode of the electrolyzer and its transport properties is achieved by tomography-based direct numerical simulations, which increase the accuracy of the overall cell and stack models. Using the tomography-based direct numerical simulations, no significant difference in transport properties of the electrode is quantifiable for an electrode exposed to air for 3000 hours at 800°C

Sample preparation with FIB Xe for tomography



Holotomography on the new beam line



Development of a methodology for relevant 3D reconstruction for SOC electrodes with a high field of view and high spatial resolution

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	Carbon free/carbon lean H_2 production	10 – 20%	HT SOE system at kW size	System design is ready; cell and short stack stack experiments have been done.
AIP 2013	Low degradation rate	<0.5% per 1000 h		First degradation rate at the single cell level: 50 mV/kh during the first 500h and then 5 mV/kh between t=500 and t=2000h (850°C, i=-0.5 A/cm², SC=60%)
AIP 2013	Pressurized electrolysis	>1	15	At the thermoneutral voltage: positive impact of the pressure Electrochemical model validated. Identification of the best operating conditions under pressure

Stack-Test

Development of PEM Fuel Cell Stack Reference Test Procedures for Industry

AIP / APPLICATION AREA	AIP 2011 / AA 5: Cross-Cutting Activities
CALL TOPIC	SP1-JTI-FCH.2011.5.4: Development of EU-wide uniform performance test schemes for PEM fuel cell stacks
START & END DATE	01 Sep. 2012 - 31 Aug. 2015
TOTAL BUDGET	€ 5,637,780
FCH JU CONTRIBUTION	€ 2,909,898
PANEL	Panel 6- Cross-Cutting

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW)

Partners: CEA, DTU, DLR, ICRI, AAU, NEXT ENERGY, CITEDEC, Fraunhofer ISE, JRC-IE, SymbioFC

PROJECT WEBSITE/URL

http://stacktest.zsw-bw.de

PROJECT CONTACT INFORMATION

Ludwig Jörissen
Ludwig.joerissen@zsw-bw.de

MAIN OBJECTIVES OF THE PROJECT

- Propose and validate harmonized, and industrially relevant test procedures for PEM fuel cell stacks in form of generic test modules and application specific test programs.
- Address functional / performance, endurance, and safety testing,
- Interact with industry.

PROGRESS/RESULTS TO-DATE

- Generic test modules, and application specific test programs for performance, endurance and safety testing developed.
- Experimental validation completed.
- Four Stakeholder workshops held
- Feedback from workshops and industrial advisory group included into the documents.
- Test modules and test programs in their final versions publicly available starting from November 2015.

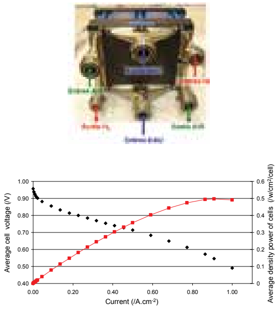
FUTURE STEPS

The project ends in August 2015, all tasks in the project will be closed by then.

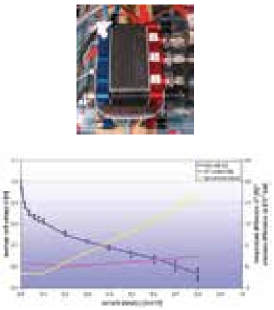
CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

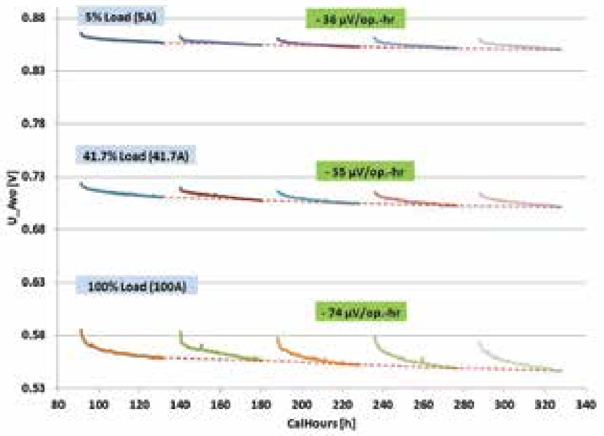
- Based on results from previous projects, the methodology of PEM fuel cell stack testing has been reviewed and improved.
- Generic test modules and application oriented test programs have been defined and finally validated after two iterations.
- Two different sets of stack test samples were supplied to the participants for validation purpose.
- Consistent results in performance testing were achieved using static and dynamic load.
- Endurance testing experiments have been carried out, however, understanding of the test results needs to be refined.

CEA Stack
representative for automotive



ZSW Stack
Representative for stationary





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	Provide a coherent framework to monitor progress	-	Provide a methodology of performance, endurance, and safety / environmental testing on a PEM-FC stack level	Generic test modules and application oriented test programs for performance, endurance and safety testing are ready for final release.
MAIP 2008-2013	Maintain, consolidate and disseminate results of RCS and PNR activities	-	Provide annually updated review of RCS relevant for PEM fuel cell stack testing	Basic assessment including 2 updated versions keeping track of changes are available.
AIP 2011	Development of harmonised testing protocols for PEM stacks, in order to achieve a set of testing procedures that provide a uniform look at their characteristics.	-	Provide experimentally validated test procedures for performance, endurance and safety / environmental testing	Generic test modules and application oriented test programs for performance, endurance and safety testing are available in for final release.

STAGE-SOFC

Innovative SOFC system layout for stationary power and CHP applications

AIP / APPLICATION AREA	AIP 2013 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2013.3.4: Proof of concept and validation of whole fuel cell systems for stationary power and CHP applications at a representative scale
START & END DATE	01 Apr. 2014 - 31 Mar. 2017
TOTAL BUDGET	€ 3,970,267
FCH JU CONTRIBUTION	€ 2,165,725
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: VTT Technical Research Centre of Finland Ltd

Partners: sunfire GmbH, ICI Caldaie S.p.A., Lappeenranta University of Technology, West Pomeranian University of Technology

PROJECT WEBSITE/URL

http://www.stage-sofc-project.eu/

PROJECT CONTACT INFORMATION

Matti Reinikainen
matti.reinikainen@vtt.fi

MAIN OBJECTIVES OF THE PROJECT

The project aims to develop a 5kWel Proof-of-Concept prototype of a new SOFC concept that achieves an electrical efficiency of ≥ 45% and a thermal efficiency of > 85% with a serial connection of stacks. The system combines the benefits of the simple and robust catalytic partial oxidation layout with the high efficiencies obtained by the steam reforming process. A staged cathode air supply allows an individual control of stack temperatures and saving of costly heat exchanger area. The system will be designed for small-scale CHP and off-grid applications in the power range of 5 to 50 kW.

PROGRESS/RESULTS TO-DATE

- System simulation proof the underlying idea of the project feasibility of reaching > 45 % efficiency
- Basic design of the reformer ready and operational window specified
- 3D construction of 1st PoC ready, purchasing of components ongoing

FUTURE STEPS

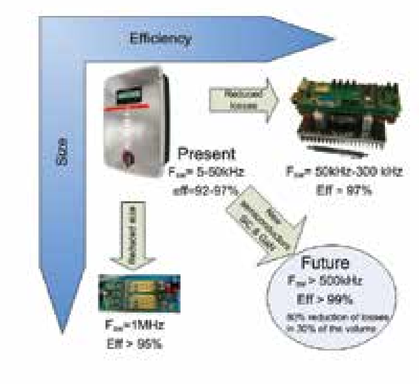
- Commissioning and test operation of 1st PoC system
- Industrial design of SOFC hotbox and coldbox
- Design and construction of final PoC prototype
- Analysis of business cases, exploitation strategy

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Based on extensive simulation work the optimal operation point has been defined
- Market analysis show great potential of technology in different applications
- Major barriers (stack costs, SOFC maturity) need to be addressed for product placement

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 FC system	> 45 for power only units, > 80% for CHP units	> 45 for power only units, > 80% for CHP units	System simulation shows that >45% AC efficiency achievable, reaching >80% overall efficiency depends on heat losses and load.
MAIP 2008-2013	Lifetime for cell and stack	> 40 000 h	> 40 000 h	Results of stack components tests and field testing of SOFC unit will be used to generate lifetime forecast. A proof is not possible within the project time.
AIP 2013	Development of PoC prototype systems that combine advanced components into complete, fully integrated systems	PoC tested	5 kWel prototype built and tested	The design of 5 kW prototype has been finished. Ordering of basic components have been started. Assembling will start in September.
AIP 2013	POC projects will be expected to show successful duration of run times for whole fuel cell systems of up to several hundred hours by the end of the project.	several hundreds of hours	≥3000h	Task not started yet.



STAMPEM

Stable and Low Cost Manufactured Bipolar Plates for PEM Fuel Cells

AIP / APPLICATION AREA	AIP 2011 / AA 1: Transportation and Refuelling Infrastructure
CALL TOPIC	SP1-JTI-FCH.2011.1.7: Research & development on Bipolar Plates
START & END DATE	01 Jul. 2012 - 30 Jun. 2015
TOTAL BUDGET (EUR)	€ 5,223,807
FCH JU CONTRIBUTION (EUR)	€ 2,576,505
PANEL	Panel 2- Transport RTD

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Stiftelsen SINTEF

Partners: Teer Coatings Ltd. Miba Coatings Group, ElringKlinger AG, Fraunhofer Gesellschaft zur Förderung der angewandten Forschung e.V., University of Birmingham, Fronius International GmbH

PROJECT WEBSITE/URL

www.stampem.eu

PROJECT CONTACT INFORMATION

Anders Ødegård
anders.odegard@sintef.no

MAIN OBJECTIVES OF THE PROJECT

The main objective of STAMPEM is to develop durable coating materials for metal based bipolar plates (BPP), that can be mass produced for less than 2.5 € /kW of rated stack power at mass production volumes of 500 000 pieces annually. Properties after extrapolated 10 000 hours from accelerated stress test (AST) single cell testing shall still be within the AIP specifications. The main parameters are interfacial contact resistance (ICR, < 25 mohm cm^2) and corrosion resistance (< 10 μA/cm^2).

PROGRESS/RESULTS TO-DATE

- Several coatings (Physical Vapour Deposition -(PVD), polymer- and carbon composite-based) show promising performance in ex-situ and small scale in-situ tests
- Best PVD based coatings perform well in full scale in-situ testing, also pre-coated BPPs (coated before stamping).
- More than 6000 hours of operation of a coated metal based stack, without significant degradation
- Full size segmented test cell developed and tested
- Plasma cleaning process for in-line cleaning of BPP substrates developed.

FUTURE STEPS

- Project completed

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Coated metal BPPs perform according to requirements, at a lower cost compared to carbon composite plates, however the cost is still higher than the target 2.5 € /kW.
- Full coating coverage of the metal substrate is not required, i.e. post-stamping of coated plates is possible.
- Several potential low cost materials show promising performance and may be applied after optimisation and production scale-up has been achieved.
- Existing test protocols not fully representative for real time, in-situ BPP degradation
- Still lack in available information/knowledge on MEA ion tolerance

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 target lifetime for vehicles	>5,000	Properties after extrapolated 10 000 hours from AST single cell testing shall still be within the AIP specifications.	A PEMFC stack based on coated metal BPPs has already operated for more than 6000 hours with a low degradation rate. On a smaller scale, several of the PVD-based coatings have shown promising properties/durability.
AIP 2011	BPP interfacial contact resistance	< 25 mohm cm^2	< 25 mohm cm^2 after 10 000 hours extrapolated from AST	Same as last year (< 10 mohm cm^2 after small scale in-situ AST) The project is finished but not yet reported, and the final evaluation of results is not yet completed. Once long term testing and analysis has been completed the results will be disseminated.
AIP 2011	BPP/coating corrosion resistance	< 10 μA/cm^2	< 10 μA/cm^2 after 10 000 hours extrapolated from AST	Same as last year (< 10 μA/cm^2 in ex-situ tests (Beginning of Life (BoL) , 1 mM H_2SO_4 at 0.8 V_{SHE} and 80 °C at BoL) The project is finished but not yet reported, and the final evaluation of results is not yet completed. Once long term testing and analysis has been completed the results will be disseminated.

S ofc
U nmanned
A erial
V ehicle

SUAV

Microtubular Solid Oxide Fuel Cell Power System Development and Integration into a Mini-UAV

AIP / APPLICATION AREA	AIP 2010 / AA 4: Early Markets
CALL TOPIC	SP1-JTI-FCH.2010.4.5: RTD on new portable and micro Fuel Cell solutions
START & END-DATE	01 Dec. 2011 - 30 Nov. 2015
TOTAL BUDGET	€ 3,873,401.02
FCH JU CONTRIBUTION	€ 2,109,514.00
PANEL	Panel 1- Transport Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: HyGear Fuel Cell Systems B.V.

Partners: Adelan Ltd., Catator AB, CNR-ITAE, Airbus Group Innovations UK and Germany, efceco, University of Birmingham, West Pomeranian University of Technology Szczecin, SURVEY Copter SAS

PROJECT WEBSITE/URL

www.suav-project.eu

PROJECT CONTACT INFORMATION

Dr. Ellart de Wit - ellart.de.wit@hygear.nl (coordinator contact)
Dr. Erich Erdle – efceco@efceco.com (technical contact)

MAIN OBJECTIVES OF THE PROJECT

The objective of the project is to design, optimise and build a fuel cell power generator for small Unmanned Aerial Vehicles (mini-UAV). The stack to be developed will be integrated together with the required fuel processor and mechanical as well as electrical balance of plant components. The fuel cell generator will be packaged and placed into a mini-UAV. The advanced mini-UAV will be tested in a flight mission with the goal to achieve three-times longer flight endurance compared to batteries.

PROGRESS/RESULTS TO-DATE

- Top level requirements for fuel cell system into UAV defined including battery sizing
- improvement of tubular cell power from 1 W to 7 W (hydrogen flow)
- design of tubular SOFC stack (micro-SOFC) and stress calculation and modelling of micro-SOFC-stack
- development of highly integrated fuel cell power system design and design to implement fuel cell power system into UAV
- Lab testing commercial micro-SOFC system

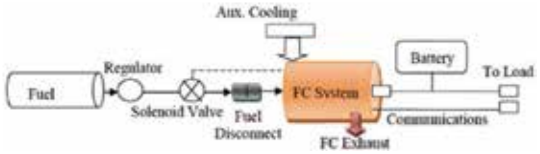
FUTURE STEPS

- Assembly fuel cell power system after successful stack manufacture
- Test of hybrid fuel cell power system(s)

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- sealing big challenge for tubular SOFC
- weight/volume constraints hard to tackle
- perspective to achieve European technology with higher energy densities compared to other technologies (e.g. batteries alone)

Exterior SOFC system



Schematic SUAV system

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	portable & micro FCs on EU market in 2012	400	Project started in 2011, targeted to mini-UAV	
MAIP 2008-2013	portable & micro FCs on the EU market in 2015	12,000 – 13,000		Not on market, SUAV will end in November 2015, targeted to a mini-UAV prototype
MAIP 2008-2013	Development of miniaturized BoP for specific devices	-	As the fuel cell generator including fueling has to fit into a mini-UAV the BoP components have to be miniaturized	stack and BoP miniaturized, development of special lightweight air valve (50 g in total)
MAIP 2008-2013	Assessment of fueling supply options	-	On-board fueling with Propane for long range missions	propane is the fuel to fly with
MAIP 2008-2013	Supportive actions for SME	-	SURVEY Copter is customer and contributor in SUAV SME, producer of mini-UAV and part of Airbus HyGear Fuel Cell Systems B.V., ADELAN Ltd. and CATATOR SA as developer and manufacturer of the core modules efceco as technical manager and advisor in all WPs	
MAIP 2008-2013	Pre-normative research on safety, emissions etc.	-	Is part of the Top Level Requirements task related to civil aviation	
AIP 2010	Stack power	200 W_e net	250 W_e	potentially 300 W_e
AIP 2010	On-board fuel storage		Propane on-board storage	
AIP 2010	Fuel Processing	-	Pre-reformer development	highly integrated CPOX-Fuel Cell system, manufactured
AIP 2010	Stack	-	stack development	Design ready; first stack assembled according to design, however it was broken during the FAT due to experimental circumstances
AIP 2010	Balance of Plant	-	Mechanical and Electrical Balance of Plant	highly integrated fuel cell power system manufactured
AIP 2010	Power electronics and controls	-	Controls development	development on-going with delay
AIP 2010	Proof-of-Concept unit		assembly of lab test and UAV unit	Delayed due to stack failure
AIP 2010	System validation through testing		lab testing and flight mission of UAV version	Delayed; commercial FC system tested in lab and combined with battery pack. Lab testing of the original SUAV system to be performed at later stage of the project

SUSANA

Support to Safety Analysis of Hydrogen and Fuel Cell Technologies

AIP / APPLICATION AREA	AIP 2012 / AA 5: Cross-Cutting Activities
CALL TOPIC	SP1-JTI-FCH.2012.5.2: Computational Fluid Dynamics (CFD) model evaluation protocol for safety analysis of hydrogen and fuel cell technologies
START & END DATE	01 Sep. 2013 - 31 Aug. 2016
TOTAL BUDGET	€ 2,119,669.90
FCH JU CONTRIBUTION	€ 1,159,124.00
PANEL	Panel 6- Cross-Cutting

PARTNERSHIP/CONSORTIUM LIST

Coordinator: KIT

Partners: UU, NCSRD, JRC, HSL, EE, AREVA

PROJECT WEBSITE/URL

www.support-cfd.eu

PROJECT CONTACT INFORMATION

Olaf Jedicke
Olaf.Jedicke@kit.edu

MAIN OBJECTIVES OF THE PROJECT

The project is built on the complementarities of expertise of leading European experts in the field of CFD use for provision of hydrogen safety to achieve the synergy and consolidate the CFD excellence in application to safety design of FCH systems and infrastructure.

The project aims to support all stakeholders using CFD for safety engineering design and assessment of FCH systems and infrastructure, especially those who have no specialised knowledge in hydrogen safety and associated CFD modelling/simulations practice, through the development of the CFD Model Evaluation Protocol, specialised databases, etc.

PROGRESS/RESULTS TO-DATE

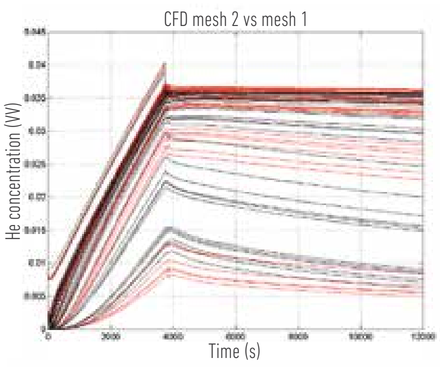
- Report on 1st CFD benchmarking exercice
- Database of verification problems
- Model validation database part I
- Best practice in numerical simulation – Interim Report
- State of the art review concerning FCH technologies
- SUSANA database and multitude of data sets

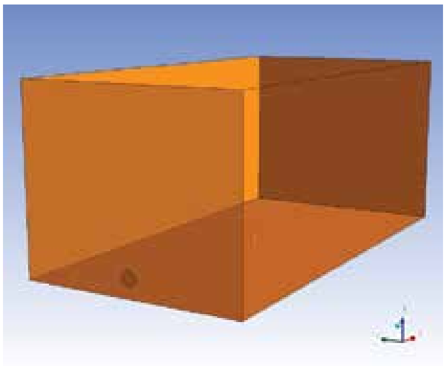
FUTURE STEPS

- 2nd CFD benchmarking exercice
- Critical analysis and requirements to models
- Final report on verification and validation procedures
- Final «The CFD model evaluation protocol
- Dissemination seminar to the database 2016 (by workshop or webinar)
- Development of further data sets and experiments for CFD database

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Intermediate report on best practice
- Database of verification problems
- State of the art review on CFD protocols
- Running Database and multitude data sets





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	Support to numerical simulation on FCH	Support to CFD applicable in FCH simulation	Database for CFD to support numerical simulation in FCH	Structure on database and provision to free access database related to CFD modelling and simulation in FCH Collection of protocols (50%)
AIP 2012	Support to CFD model evaluation protocols for safety analysis of hydrogen and fuel cell technologies	Development of a CFD model evaluation protocol for safety analysis and fuel cells	Development of a CFD model evaluation protocol for safety analysis	State of the art review on international level (achieved). Development of protocols for safety analysis. Database of the suitable experiments created (~70%)
AIP 2012	Protocol containing procedures, recommendations and criteria	See above	Critical analysis and requirements to physical and mathematical models, verification and validation procedures, best practice in CFD	Protocols containing procedures, recommendations and criteria to be discussed with international experts. Validation and Verification procedure. Best practice procedure ready to be discussed with international experts.
AIP 2012	Simulation Benchmarking	See above	Benchmarking on specific numerical simulation	Benchmarking exercise and 1st report on the benchmarking

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

Dimitrios Tsiplakides
dtsiplak@cperi.certh.gr

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

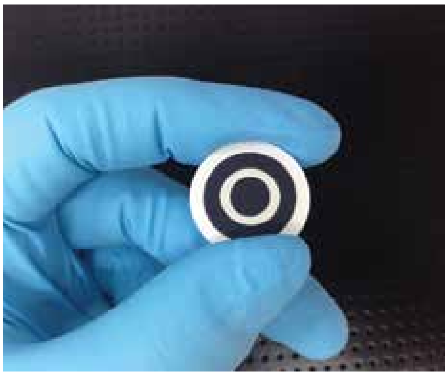
- Preparation of complete triode cells with standard and modified anodes
- Complete physicochemical characterization of modified powder and electrodes
- Preparation of Ni-YSZ thin film anodes by magnetron sputtering
- Assessment of the effect of triode operation on cell performance and carbon deposition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

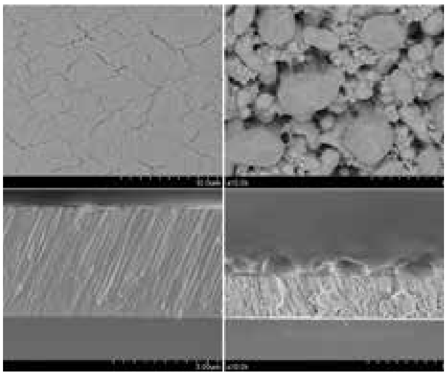
FUTURE STEPS

- 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

TriSOFC

Durable Solid Oxide Fuel Cell Tri-Generation System for Low Carbon Buildings

AIP / APPLICATION AREA	AIP 2011 / AA 3: Stationary Power Generation & Combined Heat and Power
CALL TOPIC	SP1-JTI-FCH.2011.3.4 - Proof of concept fuel cell systems
START & END DATE	01 Aug. 2012 - 31 Jul. 2015
TOTAL BUDGET	€ 2,727,219.06
FCH JU CONTRIBUTION	€ 1,481,391.00
PANEL	Panel 3- Stationary Heat and Power Demonstration

PARTNERSHIP/CONSORTIUM LIST

Coordinator: The University of Nottingham, UK

Partners: The Royal Institute of Technology- Sweden (KTH), The University of Birmingham-UK (UBHAM), IDMEC – Polo FEUP-Portugal (IDMEC), GETT Fuel Cells International AB-Sweden (GETT), Vestel Savunma Sanayi A.S-Turkey (VSS), Complex Ltd-Poland (COMPLEX), Swerea IVF-Sweden (IVF), INEGI -Polo FEUP, Portugal (INEGI)

PROJECT WEBSITE/URL

www.trisofc.com

PROJECT CONTACT INFORMATION

Saffa.riffat@nottingham.ac.uk

MAIN OBJECTIVES OF THE PROJECT

TriSOFC aims to design, optimise and build a 1.5 kW low-cost durable LT-SOFC tri-generation prototype, based on the integration of a novel LT-SOFC stack and desiccant unit. The system will include a fuel processor to generate reformate gas when natural gas utilized and other equipment for the electrical, mechanical and control balance of plant. All components will be constituents of an entire fuel cell tri-generation prototype system to supply cooling, heat and power, which will first be tested in the lab and after further optimisation, under real-life context in the Creative Energy Homes platform built at the University of Nottingham.

PROGRESS/RESULTS TO-DATE

- Desiccant unit simulation complete
- Desiccant cooling COP 0.7-1.1
- LT-single component SOFC membranes developed with 1100mW/cm^2 achieved from single cell 6cm x 6cm and 12W power output from 2 cell stack@530°C.
- Integration of 250We microtubular SOFC tri-generation system.
- Electrical efficiency 11%, overall efficiency 48%

FUTURE STEPS

- Prove durability of LT single component membranes and stacks
- Conduct extensive field trials of LT-SOFC tri-generation system
- Commercialise individual components

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Potassium formate was found to be the most suitable desiccant for the system
- A novel combined dehumidifier/cooler/regenerator has been developed and will provide a basis for compact, light-weight and low cost tri-generation for fuel cells and other generation systems
- Single component fuel cells working at low temperatures (500-600C) will enable cost reductions in BoP and improvement in performance
- Demonstrated integration of 250We microtubular SOFC tri-generation system. Elec efficiency 11%, overall efficiency 48%.

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 2008-13	Power range	1-5kWe	200-1500We	200We
AIP 2011	efficiency	35% to 45% (elec) 75% to 85% total	Expect 40-45% elec-85-95% total	Testing of microtubular SOFC tri-generation 12% elec – 48% total.
AIP 2011	durability	30,000hrs	40,000 hours	100hours
AIP 2011	costs	2,000€/kW		Costs dependent on stack and BoP.

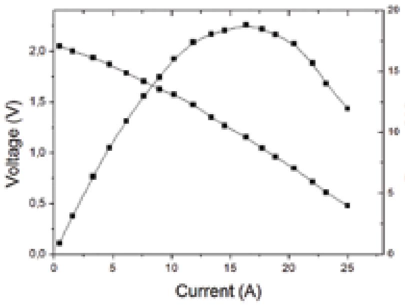


Figure 1. Variation in voltage and power output with current for 2-cell stack LT-SOFC @ 530C. Each cell is 6cm x 6cm.

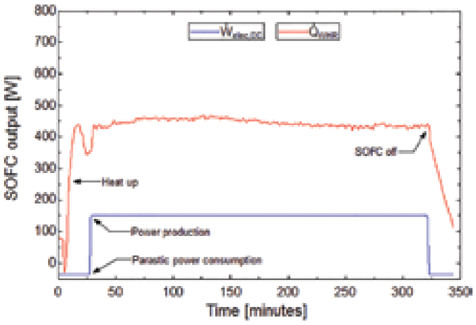


Figure 2. Electrical power and heat output from micro-SOFC tri-generation prototype.

UNIfHY

UNIQUE Gasifier for Hydrogen Production

AIP / APPLICATION AREA	AIP 2011 / AA 2: Hydrogen Production and Distribution
CALL TOPIC	SP1-JTI-FCH.2011.2.3 - BTH - Biomass-to-hydrogen (thermal conversion process)
START & END DATE	01 Sep. 2012 - 31 Dec. 2015
TOTAL BUDGET	€ 3,438,061.36
FCH JU CONTRIBUTION	€ 2,203,599.00
PANEL	Panel 5 - Hydrogen Production, Distribution and Storage

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Università degli Studi Guglielmo Marconi (USGM) - Italy

Partners: Università Degli Studi Di Roma La Sapienza (DIMA) - Italy, Università degli Studi Dell'aquila (UNIVAQ) - Italy, HyGear B.V (HyGear) - Netherland, Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (ENEA) - Italy, Universite de Strasbourg (UNISTRA) - France, Engineering, Procurement & Construction (EPC) - Germany, Pall Filtersystems Gmbh (PALL) - Germany, Air Liquide Hydrogen Energy (ALAB) - France

Third Parties: HyGear Fuel Cell Systems B.V. (HyGear FCS)- Netherland, Hygear Technology and Services (BV - HyGear TS) - Netherland

PROJECT WEBSITE/URL

www.unifhy.eu

PROJECT CONTACT INFORMATION

Enrico Bocci
e.bocci@unimarconi.it, info@unifhy.eu

MAIN OBJECTIVES OF THE PROJECT

By exploitation of the results obtained in past R&D EU projects on hot gas catalytic conditioning, UNIfHY aims to develop a continuous process for pure hydrogen production from biomass, for fuelling vehicles in a low-cost and effective way, by the integration of: (i) biomass gasification with catalytic hot syngas cleaning and conditioning integrated in the gasifier vessel (UNIQUE gasification concept); (ii) Water-Gas Shift (WGS) performed with catalysts impregnated on ceramic foams; (iii) Pressure Swing Adsorption (PSA) for hydrogen separation from syngas; (iv) High thermal integration and efficiency, by means of utilization of the H_2-depleted syngas within the conversion process.

PROGRESS/RESULTS TO-DATE

- Iron and copper WGS catalysts supported on ceramic alumina foams have been developed and characterized, showing good lifetime, low pressure drop and resistance to sintering
- Gasification bench scale tests allowed to evaluate the performance of new types of catalytic candle filters
- Extensive gasification test campaigns have been started and are due to be completed shortly in order to evaluate the performance of the two prototype gasifiers, without and with the candle filters, utilizing nut shells as biomass feedstock
- Portable Purification System (PPS) has been realized and is ready to be connected to the 1000 kWth gasifier for the final test of the entire system
- An analysis of the economical requirements and the hydrogen target cost (5€/kg) for UNIfHY-based-hydrogen production has been done

FUTURE STEPS

- Achievement of new results on the modelling at different scales
- Final testing on the 1000 kWth system to demonstrate that pure hydrogen (PEM grade) can be produced by thermo-chemical way starting from biomass wastes
- Long term testing with the prototype reactor
- Finalization of Life Cycle Assessment (LCA) and business exploitation

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The tests of fluidized bed steam biomass gasifiers integrating the hot gas cleaning system in the freeboard have verified the realization of compact, high efficiency and cost-effective gasification systems.
- New materials, as Fe-Cu/Foams, have permitted to obtain high efficient WGS also at atmospheric pressure that is a constraint for more sustainable small plant sizes, and modified PSA permits to obtain continuous hydrogen production at PEMFC grade even with reduced (> 34%) hydrogen content in the feed flow.
- By the analysis of economical requirements and the operative plant scenarios, according to preliminary evaluations UNIfHY is a profitable solution to match the hydrogen target cost of 5€/Kg.
- The integrated system is able to produce hydrogen from various biomass feedstocks in the forecourt size range for a hydrogen filling station (from 100 to 500 kg/day) with: (i) Energy and cost savings; (ii) reduction of space and components up to 50% ; (iii) overall hydrogen efficiency greater than 50% in comparison to standard systems (70% vs 45%).
- Due to the variety and complexity of problems, expertise and know-how, either scientific or technological, which are necessary for implementation of the UNIFHY technology, the project combines the efforts and capabilities available in Europe in order to maintain competitiveness on the global market.

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	H_2 price at pump (€/kg)	Cost of H_2 delivered at refueling station = €5/kg (€ 0.15/kWh)	Cost of H_2 delivered at refueling station < € 5/kg (€ 0.15/kWh)	Hydrogen cost <5 €/kg is obtainable if: 1) CAPEX: ~3000 €/kW, efficiency ~66% (steam to biomass 1-2, gasification temperature 850 °C, all PSA off gas used for the plant energy requirement), plant utilization index ≥ 6000 h/year 2) OPEX: automatic control to avoid on site daily operation necessary at small size (<MW), reduction of energy plant requirements, low cost biomass waste (<100 €/t)
AIP 2011	Demonstration of the technical and economic viability of hydrogen production from biomass	Development and scale-up activities on materials and reactor design to demonstrate the technical and economic viability of the global process: Technology Readiness Level (TRL): TRL 3 to TRL 6)	100 and 1000 kWth biomass gasifiers integrating filter candles. New materials to realize WGS also at atmospheric pressure. PSA integrated. All to increase efficiency and reduce cost and plant complexity allowing the technical feasibility and reliability.	Catalytic filter tested (TRL 4) showing tar <0.3 g/Nm3. Foam tested (CO conversion up to 43%) and integrated in a WGS reactor (TRL 5). Gasifiers in operation (gas yield up to 2 Nm3/kg of dry biomass, Hydrogen content up to 40% vol dry, tars ~10 g/Nm3, 0 particulate; others 50 ppmv) with filter candle inserted in (TRL 5). PSA tested (performs well down to H_2 concentrations of 34% at purity 5.0 with about 65% H_2 yield). 1MWth plus PPS connected (TRL 6).
AIP 2011	Global efficiency	Efficiency > 66% (gas/feedstock heating value)	Efficiency = 67% (gas/feedstock heating value)	At steam to biomass 2, gasification temperature 850 °C, all PSA off gas used for the plant energy requirement seems achievable 67% efficiency.
AIP 2011	Evaluation of the scalability	Scalability minimum to 500 kg/day	UNIFHY 100 (kWth input) can produce 50 kg/day. UNIFHY 1000 about 500 kg/day.	The scalability, owing to the fluidized bed gasifier technology and the two prototypes developed is achievable (up to now the only limit is the PPS designed to a flow corresponding to about 200 kWth input)
AIP 2011	Durability and availability	Durability > 10 years (80,000 h) with availability > 95%	Durability = 15 years. Availability = 80% (7000 hours)	The stability of the reactors, filter candles, catalyst seems to confirm the durability. 7000 annual operative hours seems achievable.
AIP 2011	LCA analysis	LCA/LCI analysis (ILCD compliant) compatible with green-H_2 fuel-cell requirements	LCA analysis (ILCD compliant) compatible with green-H_2 fuel-cell requirements	The preliminary results on the prototypes are negative but the full use of the PSA off gas and other improvements should obtain a positive LCA

EG-AA-16-001-EN-N

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING
Avenue de la Toison d'Or 56-60, B-1060 Brussels
Follow **@fch_ju** on Twitter and **FCH JU** on LinkedIn
Tel.: +32 2 221 81 28 – Fax: +32 2 221 81 26 – fch-ju@fch.europa.eu

Publications Office

ISBN 978-92-9246-140-9
doi:10.2843/79560