FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

PROGRAMME REVIEW
REPORT 2016

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FCH JOINT UNDERTAKING

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PROGRAMME REVIEW REPORT 2016

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LIST OF ACRONYMS

ACA	Alternating current
AFC	Alkaline fuel cell
AE	Alkaline electrolyser
AIP	Annual Implementation Plan
APU	Auxiliary power unit
AWP	Annual Work Plan
BoP	Balance of plant
BUP	Back-up power
CAPEX	Capital up-front expenditure (investment)
CGH_2	Compressed gas hydrogen
CHP	Combined heat and power
CO_2	Carbon dioxide
DC	Direct current
DoW	Description of work
EU	European Union
FP7	European Union's 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: FCH1 JU (2008-2014); FCH2 JU (2014-2020)
GDL	Gas diffusion layer
GHG	Greenhouse gas
H_2	Hydrogen
H2020	Horizon 2020
HFP	European Hydrogen and Fuel cell Platform

HRS	Hydrogen refuelling station
HT	High temperature
ICE	Internal combustion engine
IPHE	International Partnership for Hydrogen and fuel cells in the Economy
ISO	International Organisation for Standardization
KPI	Key performance indicator
kW	Kilowatt
LCA	Life-cycle assessment
MAIP	FCH JU's Multi-Annual Implementation Plan (2008-2013)
MAWP	FCH 2 JU's Multi-Annual Work Plan (2014-2020)
MEA	Memb rane electrode assembly
MHV	Materials handling vehicles
MW	Megawatt
NOx	Nitrogen oxides
PEM	Proton exchange membrane
PEME	Proton exchange membrane electrolyser
PEMFC	Proton exchange membrane fuel cell
PM	Particulate matter
PNR	Pre-normative research
PoC	Proof-of-concept
PRDs	Programme Review Days
RCS	Regulations, codes and standards
RIA	Research and innovation action
RTD	Research and technological development
SET-Plan	Strategic Energy Technology Plan
SME	Small and medium-sized enterprise
SoA	State of the art
SOEC	Solid oxide electrolyser cell
SOFC	Solid oxide fuel cell

SOx Sulphur oxides

TRL Technology readiness level

TRL 1 – basic principles observed

TRL 2 – technology concept formulated

TRL 3 – experimental PoC

TRL 4 – technology validated in lab

TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)

TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)

TRL 7 – system prototype demonstration in operational environment

TRL 8 – system complete and qualified

TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

UAV Unmanned aerial vehicle

USA United States of America

SECTION 01

PROGRAMME REVIEW

01 INTRODUCTION

1.1 FUEL CELL AND HYDROGEN TECHNOLOGIES CONTRIBUTING TO EU GOALS

The European Union (EU) is a signatory of the Paris Agreement which came into force in November 2016. The aim of the agreement is to enhance implementation of the United Nations Framework Convention on Climate Change by, for instance, limiting temperature increases to below 2 °C above pre-industrial levels and actually aiming to remain within a 1.5 °C rise.

Prior to this, the EU had already been active in targeting reductions in carbon dioxide (CO_2) emissions by setting increasingly ambitious objectives, the latest figures being those included in the 2030 Energy Strategy published in 2015:

- 40 % reduction in greenhouse gas emissions compared to 1990 levels;
- 27 % share of renewable-energy consumption;
- 27 % energy savings compared to a 'business as usual' scenario.

In parallel, the EU is aware of its extreme dependence on oil and gas imports, largely from unstable countries, and has set targets to reduce the related risks. This is voiced in the European Commission's 2014 Energy Security Strategy which again puts the focus on the need for improved energy efficiency, as well as the necessity to increase the EU's own energy production, to diversify supply sources and routes, to consolidate its internal energy system, and to protect its critical infrastructure.

Last, but not least, the EU aims to reduce air pollutants, with the latest objectives set out in the 2013 Clean Air Policy Package.

Fuel cell and hydrogen (FCH) technologies can play a major role in achieving these goals for climate change, energy efficiency, pollution mitigation and internal energy sourcing. Fuel cells (FCs) enable the production of electricity with improved efficiency when compared to internal combustion engines (ICEs), thereby reducing the CO_2 emissions when fuelled with traditional fuels, and eliminating them altogether when fuelled with hydrogen, while releasing very limited amounts of NOx, SOx and particulate matter (PM) pollutants.

Although the production of hydrogen (H2) itself, traditionally from hydrocarbons, does release CO_2, a hydrogen FC-powered engine will still emit less CO_2 globally than its ICE counterpart. Better still, the development of technologies for producing hydrogen from renewable energies would further improve this aspect and make hydrogen fuel cell power units totally carbon neutral. Furthermore, such so-called 'green hydrogen' can act as a store for renewable electricity and allow the instability caused by the fluctuating nature of renewable electricity production to be offset.

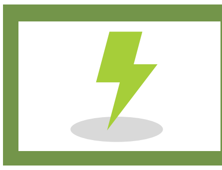
The European Commission had already identified this potential in 2004 when it set up the European Hydrogen and Fuel cell Platform (HFP). In 2008, this was transformed into the FCH JU, which was further renewed as FCH2 JU in 2014. In parallel, since the onset of Strategic Energy Technology Plan (SET-Plan), FCH technologies have been listed among the eight technologies with a potentially important role in the setting up of a successful European sustainable energy system.

1.2 THE ROLE OF THE FCH JU

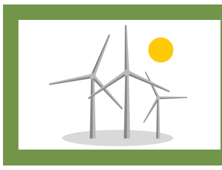
The overall objective of the FCH JU is to implement an optimal research and innovation programme at EU level in order to develop a portfolio of clean and efficient solutions that exploit the properties of hydrogen as an energy carrier and fuel cells as energy converters to the point of market readiness. This will enable support for EU policies on sustainable energy and transport, climate change, the environment and industrial competitiveness, as enshrined in the Europe 2020 strategy, job creation, and will also help to achieve the EU's overarching objective of smart, sustainable and inclusive growth. The core objectives are described in Figure 1.

FIGURE 1 I THE CORE OBJECTIVES OF THE FCH JU PROGRAMME

Reduce the production cost of fuel cell systems to be used in transport applications, while increasing their lifetime to levels which can compete with conventional technologies

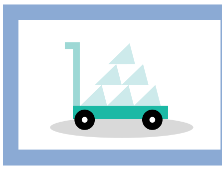


Increase the electrical efficiency and the durability of the different fuel cells used for power production to levels which can compete with conventional technologies while reducing costs



Increase the H_2 production energy efficiency mainly from water electrolysis & renewable sources while reducing costs, so that the combined system of the H_2 production and the conversion using the fuel cell system can compete with the alternatives for electricity production available on the market

Demonstrate on a large scale the feasibility of using H_2 to support renewable energy sources integration into the energy systems, incl. through its use as a competitive energy storage medium for electricity produced from renewables



Reduce the use of the EU-defined "critical raw materials", for instance through low-platinum or platinum-free resources and through recycling or reducing or avoiding the use of rare earth metals

The overall direction of the programme is guided by the multi-annual plans: MAIP for 2008-2013 under FP7 and MAWP for 2014-2020 under Horizon 2020. These plans specify targets for the state of FCH technologies in Europe (covering cost, durability and performance) and specific key performance indicators (KPIs). The progress of the programme is judged by progress towards achieving these targets and KPIs, and for the current review the most relevant are those for 2023 and interim ones for 2017 and 2020. The programme described in the MAWP places greater emphasis on near-market pre-commercialisation activities and particularly on increasing the number of units in demonstration projects.

These serve several broad aims: to provide real-world performance data on statistically significant numbers of units; to contribute to raising the scale of manufacturing and consequent reduction in costs; and to increase public awareness of the benefits of FCH technologies. The shift in emphasis in the programme is reflected in an increase in the technology readiness levels (TRLs) required of the projects. For example, currently, research and innovation projects are expected normally to have a starting TRL of 3 to 5 and demonstration projects a starting TRL of 6 to 8.

1.3 THE FCH JU PROGRAMME REVIEW 2016

In 2011, the interim evaluation of the FCH JU recommended periodic reviews of its portfolio of projects to ensure their alignment with the strategy and objectives set out in the MAIP. Annual reviews began in November 2011 and the 2016 review is the sixth in the series.

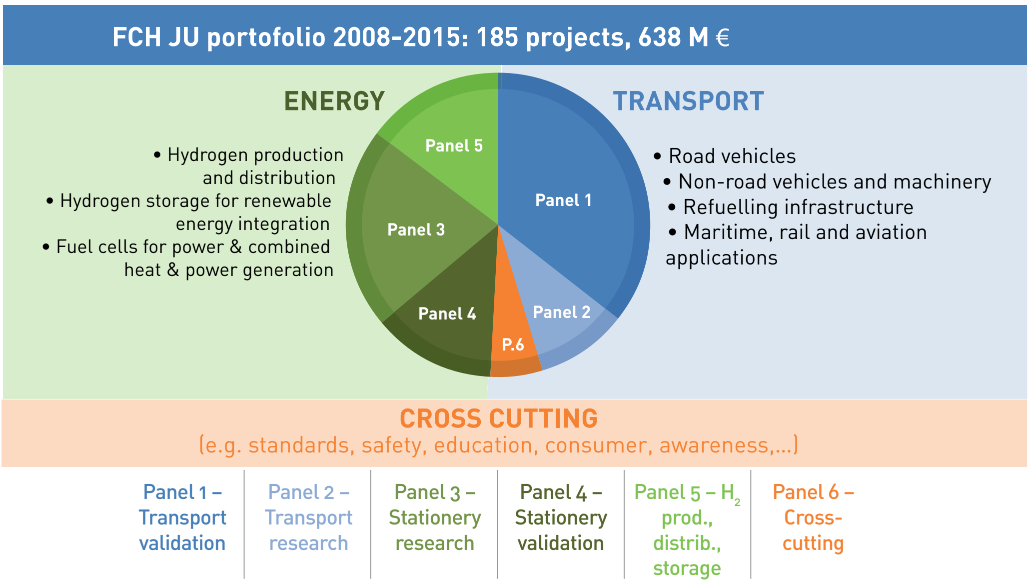
The review process begins each summer and involves a team of international experts in the FCH field. The team assesses and evaluates the portfolio against three primary criteria:

- 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 regulations, codes and standards (RCS), pre-normative research (PNR), safety, life-cycle and socio-economic analyses, education, training and public awareness;
- The extent to which interactions and cooperation 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

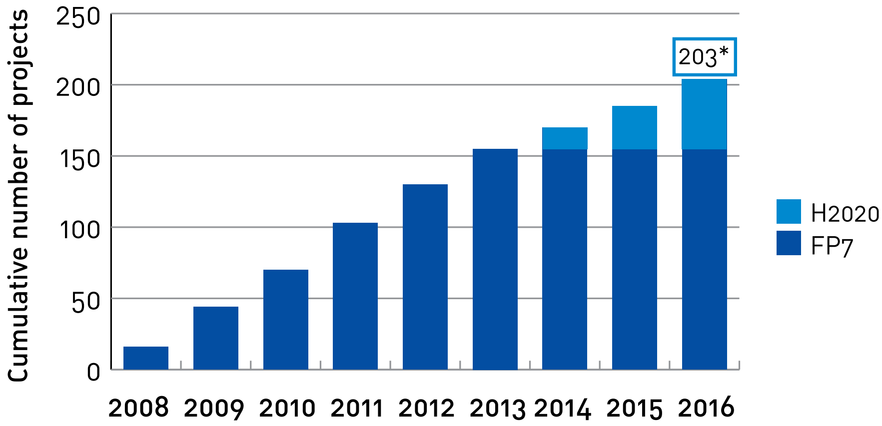
The structure of the FCH JU programme is illustrated in Figure 2 and emphasises the main division into two pillars (transport and energy) and the cross-cutting activities relevant to both.

FIGURE 2 | THE OVERALL STRUCTURE OF THE FCH JU PROGRAMME AND THE PANELS FOR THE 2016 REVIEW



Development of the cumulative number of projects supported by the programme is shown in Figure 3.

FIGURE 3 I CUMULATIVE NUMBER OF PROJECTS SUPPORTED IN THE FCH JU PROGRAMME



*projects signed at 01/03/2017

The 2016 review followed the same format as in 2015, with 100 projects divided into the six 'panels', as shown in Figure 2. These represent over half of the total of 185[1] projects supported by the FCH JU to date, of which 155 originated under FP7 and 30 as part of Horizon 2020 (calls 2014 and 2015).

The Programme Review 2016 covered those projects that were active in the period July to November 2015.

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 topic areas included in the six panels are shown in Table 1 below and, for the transport and energy pillars, distinguish between projects mainly concerned with demonstration and those mainly concerned with research. Projects with activities relevant to both pillars (overarching) are placed in the panel that best reflects their main focus although these projects also touch upon activities covered by other panels.

1 The 19 projects selected within the 2016 call for proposals had not been announced at the time of the Programme Review Days (PRDs), but if they were counted the total number of FCH JU projects rises to 204 – at date of going to press (March 2017) only 18 of the 19 projects selected in 2016 had been signed.

TABLE 1 | PANELS FOR THE 2016 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

A team of 20 international experts in FCH technology 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) both before (on the basis of the other experts' reports) and during the PRDs held in Brussels at the Charlemagne building on 21 and 22 November 2016. Each project was reviewed remotely by at least three experts (including the rapporteur acting initially as an individual reviewer) using information provided by the projects themselves and a report template designed by the FCH JU Programme Office (PO), along with publicly available information.

Each reviewer compiled a written report, which was sent to the PO and rapporteur for each panel. The rapporteurs (one per panel) also attended the PRDs and complemented their reviews based on the presentations and discussions as well as on the project posters exhibited during the PRDs, which had been prepared by the PO based on public information and figures received from the projects.

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

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

This 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 greenhouse gas (GHG) and other emissions such as SOx, NOx and 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 demonstration projects focus 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, the research and innovation projects focus on delivering better-performing fuel cells and hydrogen refuelling station (HRS) systems whilst also lowering costs. Together, these projects 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).

2.3 FOCUS AREAS AND ACHIEVEMENTS

The main thrust of this part of the programme is to reduce FC system costs for transport applications while increasing their lifetime and reducing the use of critical raw materials such as platinum group metals.

2.3.1 TECHNOLOGY VALIDATION (DEMONSTRATION)

Focus areas

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

- Cars – build up the number of FC 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 across a range of road, air and marine applications;
- Refuelling infrastructure – develop necessary infrastructure networks with redundancy at a competitive cost.

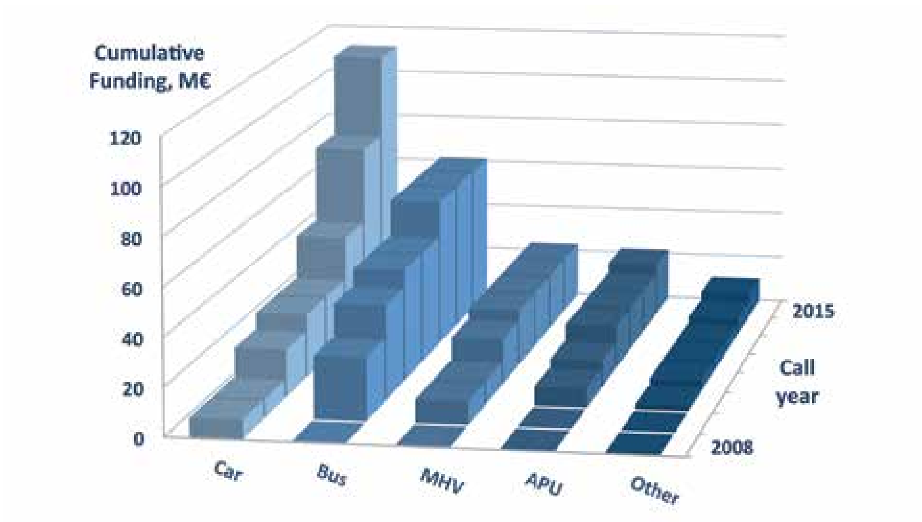
The emphasis of the transportation demonstration actions is to prove technology readiness, reliability, robustness, fuel efficiency and sustainability, together with confirmation of customer acceptance and ease of use, to enable full commercialisation in the medium term with a target market of EUR 1.5 billion in 2020.

The strategy in the four key segments is complemented by:

- FC cars – the opportunity to work alongside Europe's FCH-leading Member States' hydrogen mobility initiatives, namely in France, Germany, Scandinavia and the UK, among others;
- FC buses – advancing the case for FC 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.

In the calls between 2008 and 2015, the FCH JU supported 26 projects relevant to this panel with a total FCH JU contribution of EUR 228 million and a contribution from partners of EUR 323 million[2]. The distribution of cumulative FCH JU financial contributions to the different project categories is shown in Figure 4.

FIGURE 4 I CUMULATIVE FCH JU FINANCIAL SUPPORT FOR TECHNOLOGY VALIDATION PROJECTS IN DIFFERENT CATEGORIES WITHIN THE TRANSPORT PILLAR

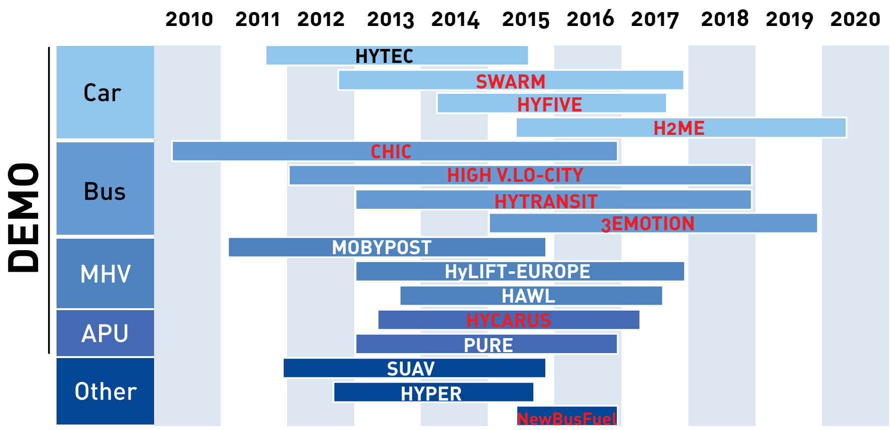


2 These figures include the overarching project H2ME2 which draws EUR 8 million (from a total of EUR 35 million) from the energy pillar.

Achievements

The 2016 review covered 16 projects with a total FCH JU contribution of EUR 162 million – their distribution is shown in Figure 5. The projects indicated in red gave presentations at the PRDs.

FIGURE 5 | DATE RANGES OF TECHNOLOGY VALIDATION PROJECTS WITHIN THE TRANSPORT PILLAR INCLUDED IN THE 2016 REVIEW. PROJECTS THAT GAVE PRESENTATIONS AT THE PRDs ARE SHOWN IN RED



Further information on the project titles can be found in Table 2.

TABLE 2 | TITLES OF THE TECHNOLOGY VALIDATION PROJECTS IN THE TRANSPORT PILLAR REVIEWED IN PANEL 1

SEGMENT	PROJECT ACRONYM	PROJECT TITLE
Cars	HYTEC	Hydrogen transport in European cities
	SWARM	Demonstration of small 4-wheel fuel cell passenger vehicle applications in regional and municipal transport
	HYFIVE	Hydrogen for innovative vehicles
	H2ME	Hydrogen mobility Europe
Buses	CHIC	Clean hydrogen in European cities
	HIGH V.LO-CITY	Cities speeding up the integration of hydrogen buses in public fleets
	HYTRANSIT	European hydrogen transit buses in Scotland
	3EMOTION	Environmentally friendly, efficient electric motion
MHVs	MOBYPOST	Mobility with hydrogen for postal delivery
	HYLIFT-EUROPE	Large scale demonstration of fuel cell powered material handling vehicles
	HAWL	Large scale demonstration of substitution of battery electric forklifts by hydrogen fuel cell forklifts in logistics warehouses
APUs	HYCARUS	Hydrogen cells for airborne usage
	PURE	Development of auxiliary power unit for recreational yachts
	SUAV	Micro-tubular solid oxide fuel cell power system development and integration into a mini-UAV
Other	HYPER	Integrated hydrogen power packs for portable and other autonomous applications
	NEWBUSFUEL	New bus refuelling for European hydrogen bus depots

The demonstration activities involving **cars** concern over 1500 vehicles (of which 250 are already in operation, the others being planned within the running projects). Since the FCH JU started, these have accumulated a total of over 1 million kilometres driven and consumed over 13 300 kilograms of hydrogen (average fuel consumption 1.3 kg hydrogen per 100 km) at an average availability of 99.2 %. In 2015, there were over 4400 refuelling operations and driving range was increased to 594 km. The 2017 targets for tank-to-wheel efficiency (42 %) and availability (98 %) have been met, while those for FC system cost (150 €/kW), mid-executive class vehicle cost (EUR 70 000) and FC system lifetime (5000 hours) are ongoing. The current state of progress is summarised in Tables 3 and 4.

TABLE 3 I FCH JU PROJECT RESULTS VS OBJECTIVES FOR CARS

	FCH JU PROJECT RESULTS 2015	MAWP TARGET 2017
Specific FC systems cost, €/kW	⚒	< 150
FC vehicle cost, k€ (C-segment)	⚒	< 70
Tank-to-wheel efficiency, %	✔	> 42
Availability, %	✔	> 98
FC system lifetime, h	⚒	> 5000

To meet the refuelling requirements for further uptake, a network of hydrogen refuelling stations is being created across Europe. To date, this covers eight countries and in 2015 delivered 130 000 kg of hydrogen in 17 500 refuelling operations at 96 % availability. These installations meet the 2017 targets for station CAPEX of EUR 1-2.5 million (200-1000 kg/day) and the price of hydrogen at the pump of 5 €/kg (from hydrocarbons) to 11 €/kg (from renewables). These values are slightly lower (better) than the international state of the art.

TABLE 4 I FCH JU PROJECT RESULTS VS OBJECTIVES FOR HYDROGEN REFUELLING STATIONS

	FCH JU PROJECT RESULTS 2015	MAWP 2017 OBJECTIVES
Price of H_2 at pump, €/kg	✔	5[1]-11[2]
CAPEX (M€)[3]	✔	1-2.5

[1] Hydrogen produced from hydrocarbones
[2] Hydrogen produced from renewables
[3] 700 bars HRS, 200-1000 kg/day capacity includong on-site storage

Demonstrations with **buses** concern 67 vehicles in 12 cities (41 vehicles in seven cities already in operation) and the technology is now close to commercial reality at TRL 8. The demonstrations have now accumulated a total driven distance of over 446 000 km and consumed over 42 900 kg of hydrogen (average fuel consumption 9.8 kg hydrogen per 100 km) at an average availability of 86 % since the FCH JU started. In 2015, there were over 2500 refuelling operations and the buses have proved able to meet the daily duty cycle. One vehicle has accumulated 22 000 h run time. The 2017 target for fuel consumption has been met (fuel economy doubled with respect to the previous generation of vehicles), while those for vehicle cost (EUR 700 000), availability (90 %) and FC system lifetime (8000 h) are still ongoing as most buses have not yet been able to operate the targeted number of hours (Table 5).

TABLE 5 I FCH JU PROJECT RESULTS VS OBJECTIVES FOR BUSES

	FCH JU PROJECT RESULTS 2015	MAWP 2017 OBJECTIVES
FC bus system lifetime, h	⚒	> 15 000 2 x 8000
FC bus cost, k€	⚒	< 700
Fuel consumption, kg/100km	✔	< 8.51
Availability, %	⚒	> 90

Demonstrations of **material handling vehicles** have involved 48 forklifts covering six models from three manufacturers on 10 sites. These vehicles are ready for commercialisation. They have accumulated approximately 45 000 h of operation, consuming over 4000 kg of hydrogen in 11 300 refuellings. The 2017 targets for lifetime (10 000 h), efficiency (50 %), availability (95 %) and cost of on-board hydrogen storage (1000 €/kg hydrogen) have all been achieved. Only the target for the FC system cost (1500 €/kW at 10 kW scale) remains to be met (Table 6).

TABLE 6 I FCH JU PROJECT RESULTS VS OBJECTIVES FOR FORKLIFTS

	FCH JU PROJECT RESULTS 2015	MAWP 2017 OBJECTIVES
Specific FC system cost, €/kW @ 10kW	⚒	< 1 500
H_2 storage system cost, €/kg H_2	✔	< 1 000
Lifetime, h	✔	< 10 000
Efficiency, %	✔	> 50
Availability, %	✔	> 95

From the above achievements it can be seen that FC system cost is the main outstanding issue in the transport pillar. Durability is still to be confirmed in real-life operations, although it is particularly encouraging that this has been demonstrated in some good individual cases. The challenge is to meet these requirements together (not individually) without compromising the targets already achieved.

2.3.2 RESEARCH AND INNOVATION

Focus areas

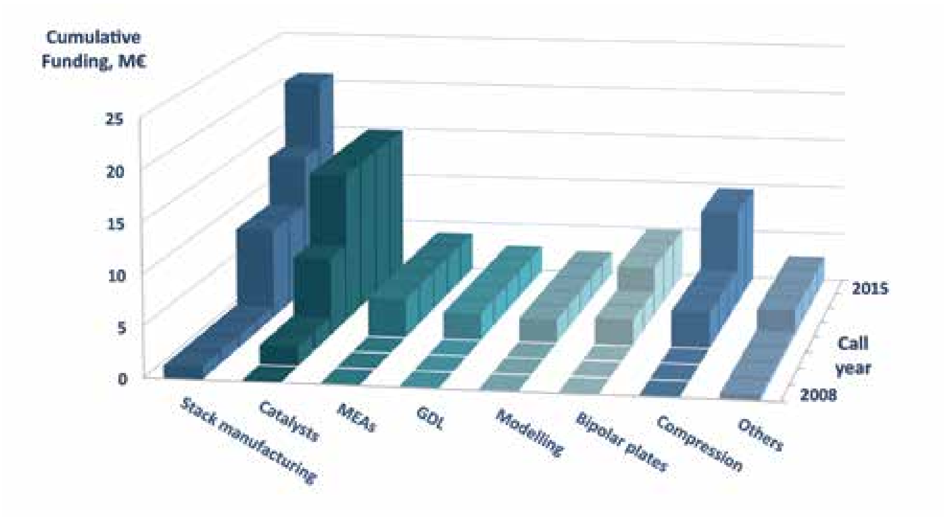
The portfolio of transportation RTD projects is very similar to preceding years with a focus on the following research areas:

- Membrane electrode assembly (MEA) – activities to develop and improve FC membranes for transportation;
- Catalysts – improvements to raise performance levels and reduce costs;
- Gas diffusion layer (GDL) - optimisation of gas distribution at the electrode 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.

Between 2008 and 2015, the FCH JU supported 20 projects with a total FCH JU contribution of EUR 61 million and a contribution from partners of EUR 40 million. The distribution of cumulative FCH JU financial contribution to the different project categories is shown in Figure 6.

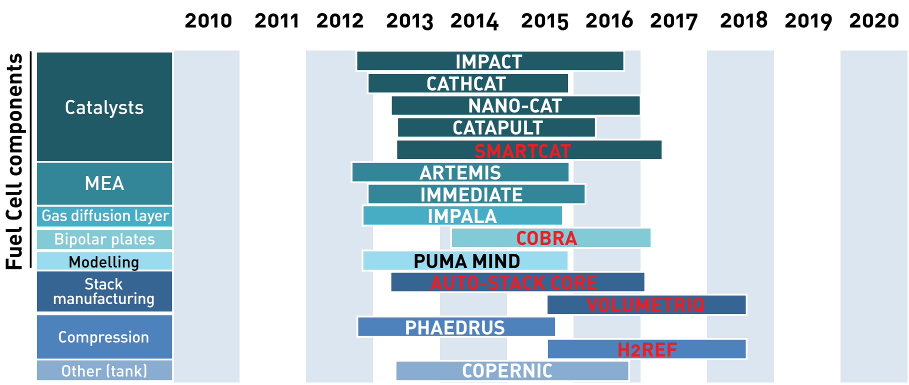
FIGURE 6 I CUMULATIVE FCH JU FINANCIAL SUPPORT FOR RESEARCH AND INNOVATION PROJECTS IN DIFFERENT CATEGORIES WITHIN THE TRANSPORT PILLAR



Achievements

The 2016 Review covered 15 projects with a total FCH JU contribution of EUR 48 million; their distribution is shown in Figure 7. The projects indicated in red gave presentations at the PRDs.

FIGURE 7 I DISTRIBUTION OF RESEARCH AND INNOVATION PROJECTS WITHIN THE TRANSPORT PILLAR INCLUDED IN THE 2016 REVIEW. PROJECTS THAT GAVE PRESENTATIONS AT THE PRDs ARE SHOWN IN RED



Further information on the project titles can be found in Table 7.

TABLE 7 I TITLES OF THE RESEARCH AND INNOVATION PROJECTS IN THE TRANSPORT PILLAR REVIEWED IN PANEL 2

TOPIC AREA	COMPONENT TYPE	PROJECT ACRONYM	PROJECT TITLE
Fuel cell components	Catalysts	IMPACT	Improved lifetime of automotive application fuel cells with ultra-low Pt-loading
		CATHCAT	Novel catalyst materials for the cathode side of MEAs suitable for transportation applications
		NANO-CAT	Development of advanced catalysts for PEMFC automotive applications
		CATAPULT	Novel catalyst structures employing Pt at Ultra Low and zero loadings for automotive MEAs
		SMARTCAT	Systematic, material-oriented approach using rational design to develop breakthrough catalysts for commercial automotive PEMFC stacks
	MEA	ARTEMIS	Automotive PEMFC range extender with high temperature improved MEAs and stacks
		IMMEDIATE	Innovative automotive MEA development – implementation of IPHE-GENIE achievements targeted at excellence
	Gas diffusion layer	IMPALA	Improve PEMFC with advanced water management and gas diffusion layers for automotive application
	Bipolar plate	COBRA	Coatings for bipolar plates
	Modelling	PUMA MIND	Physical bottom up multiscale modelling for automotive PEMFC innovative performance and durability optimization
Stack manufacturing		AUTO-STACK CORE	Automotive fuel cell stack cluster initiative for Europe II
		VOLUMETRIQ	Volume manufacturing of PEMFC stacks for transportation and in-line quality assurance
Refuelling (compression)		PHAEDRUS	High pressure hydrogen all electrochemical decentralised refueling station
		H2REF	Development of a cost effective and reliable hydrogen fuel cell vehicle refuelling system
On-board tank		COPERNIC	Cost and performances improvement for CGH_2 composite tanks

Most of the projects in this part of the programme concern improvements in PEMFC cells and stack components. The 2017 KPIs have been met for electrical efficiency (55 %), power density (1 W/cm2 at 1.5 A/cm2), durability (6000 h) and operating temperature (-25 to +95 °C). However, no project has yet been able to meet all the KPIs simultaneously. The KPI for platinum loading (0.1 g/kW) remains elusive.

TABLE 8 | FCH JU PROJECT RESULTS VS OBJECTIVES FOR PEMFC MEMBRANE ELECTRODE ASSEMBLIES (MEAs)

	FCH JU PROJECT RESULTS 2015	OBJECTIVES 2017*
Pt loading, g/kW	⚒	< 0.1
Electrical efficiency, %	✔	> 55
Power density (BoL), W/cm^2	✔	> 1
Durability, h	✔	> 6 000
Min./ max. operating temperature, °C	✔	-25/+95

** Based on AWP2014*

Novel hydrogen compression and storage systems have been developed to increase HRS availability and performance. New materials and improved components have enabled integrated on-board hydrogen storage tank systems to meet the 2017 KPIs for volumetric capacity (0.022 kg/l) and gravimetric capacity (4 %). However, despite the introduction of low-cost robotic manufacturing methods, the storage system cost is still greater than the 2017 target (800 €/kg hydrogen). Further reductions in cost are anticipated through optimisation of the storage system design for the mass production processes.

TABLE 9 | FCH JU PROJECT RESULTS VS OBJECTIVES FOR ON-BOARD VEHICLE STORAGE TANKS

	FCH JU PROJECT RESULTS 2015	OBJECTIVES 2017**
Hydrogen storage system cost, €/kg H_2	⚒	< 800
Volumetry capacity*, kg/l	✔	> 0.022
Gravimetric capacity*, %	✔	> 4

** H_2 tank system*
*** Based on AWP2014*

2.4 REVIEW FINDINGS

2.4.1 TECHNOLOGY VALIDATION

Relevance to programme objectives

The reviewers considered the portfolio of 16 projects for the demonstration of buses, cars, APUs and forklifts to be notable in the strength and focus of its collective activities and in the quality of its output, being well aligned with FCH JU objectives and targets. In the majority of projects, project management seems strong, and contingency plans have been brought into play where needed which has meant that, even in cases where an industrial partner strategy has changed or a partner has withdrawn, most of the objectives have been reached, sometimes after revisions to the original plan. The number of partners participating in demonstration projects shows a significant commitment to FCH technology and a buy-in for commercialising the technology. On the downside, the participation of research organisations and universities is conspicuously low, which is not surprising considering the high TRL in these projects.

Current projects give every confidence that Europe will catch up with Japanese technology, thanks to, among others, its large demonstration projects for cars and the flagship project H2ME which has started well. Nonetheless, it should be noted that several of the passenger vehicles deployed are not European made. Road transport HRS projects are a huge success; they have excellent visibility, strong management and are on track to reach their objectives. Building on the current network of HRS will enable widespread adoption of the technology, while many projects already share hydrogen infrastructure that will increase station utilisation.

Europe has gained a lead position internationally for technology validation of FC buses with, encouragingly, more countries and regions becoming involved. 3EMOTION, CHIC and HIGH V.LO-CITY all report significant progress. The bus projects in the portfolio are extremely comprehensive, following past demonstrations and building a consortium of industry partners able to contribute significant results to move to full commercial products with wide acceptance. The projects are showing impressive improvements with respect to fuel efficiency and availability. A greater sharing of results would be very useful for the FCH JU itself as well as for the larger industry (outside the group of EU-funded projects) so that it can learn of the achievements and benefit from them. However, better communication has recently become a reality with the launch, at the end of 2016, of the fuelcellbuses.eu website (managed by the High V.LO-CITY project with the ambition of providing an information platform on FC buses in Europe).

The smaller number of participants and issues with consortium stability have affected progress in the MHV and APU projects. Despite the fact that the MHV projects have now met their performance targets, the final step to commercialisation is proving difficult in Europe. These projects might benefit from interacting with projects outside the EU, since MHVs show a cost benefit over incumbent technologies in other areas of the world (particularly the USA). The projects developing APUs for application in airborne vehicles and personal power packs clearly need more research to resolve application-specific issues. FCH technology is newer to these applications and understandably needs more time and funding. These issues should feed back into future projects.

Complementarity with other projects and programmes

There does not appear to be any overlap between individual projects, and the majority of projects interact with similar projects. There is some information sharing across all projects. Nevertheless, in general, connections between projects should be strengthened and more networking/joint workshops are recommended. The level of integration with other national initiatives is good, with H2ME, CHIC, HIGH V.LO-CITY, HY-FIVE and HYTRANSIT standing out as having excellent relationships/interactions with national and regional programmes.

Horizontal and dissemination activities

External publicity from the majority of the projects is ensured professionally and is generally of a very high standard, which provides the projects with the requisite level of visibility. Beyond this however, much of what has been accomplished in terms of actual technical and economical results is often not available to those outside the project. More openness about such data would be helpful to industry and research providers outside of the project itself, although confidentiality concerns can in part be justified when it comes to costs. Sharing such information with the FCH JU is strongly recommended so that the state of the art can be effectively assessed and anonymised data can be communicated more widely without breaching the confidentiality of projects or partners.

Although training and education achievements are patchy, there are some excellent accomplishments such as the training programme for employees of bus operator Stagecoach dedicated to the safe operation of HRS and safe practice for the operation and maintenance of the buses. There are good examples of proactivity in the further development of relevant codes of practice, such as in HYTRANSIT.

Exploitation plans

For many of the partners of Panel 1 projects, deployment and commercialisation must come next. The exploitation plans are generally clear with 'next steps' identified and some have well-outlined plans to fully commercialise the technology in a particular application.

2.4.2 RESEARCH AND INNOVATION

Relevance to programme objectives

The activities of the 15 projects in Panel 2 are summarised in Table 7. The project consortia demonstrate good balance between the industry and research sectors, with greater industry participation in the two FCH2 JU projects, which aim to reach higher TRLs (TRL 6 in H2REF and TRL 7 in VOLUMETRIQ), and are closer to commercialisation.

In this panel, five projects aim to reduce the Pt content (cost) and maintain, or increase, the durability of PEMFC catalysts. In general, the projects are making significant progress at the individual component level, but are encountering problems when they are scaled up and incorporated into MEAs and stacks. For example, in SMARTCAT, although the 2017 KPI for Pt loading (0.1 g/kW) was surpassed at the cell level (0.03 g/kW), the loading had to be increased to 0.15 g/kW to meet performance targets at stack level. Nevertheless, since the achievements are sufficiently impressive, the target KPI should probably be reviewed to examine whether or not it is too demanding. Although the goals of these projects are similar, they use different approaches and therefore do not duplicate effort. In earlier projects, there was little evidence of meaningful interaction between projects, for example in the form of shared workshops, exchange of information about testing procedures and protocols or development of accelerated tests. It has been noted that this aspect is significantly better in the more recent projects.

A long-term objective in this part of the portfolio is to establish a European stack-manufacturing capability for transport applications. This started in the AUTO-STACK CORE project in which stacks have been developed that are comparable in performance with commercially available ones from Toyota, Nissan or Honda, with an estimated cost for mass production of 37 €/kW. In VOLUMETRIQ, successful component developments from other FCH JU projects (MAESTRO, IMPACT and STAMPEM) are being incorporated and taken to TRL 7. The prospects for achieving this strategic manufacturing objective are very promising.

Complementarity with other projects and programmes

Some projects have strong interactions with other national initiatives, particularly in France (NANO-CAT, IMPALA and COBRA) and Finland (CATAPULT). There are also some interactions outside Europe, such as in CATAPULT with the USA and IMPACT with Canada.

Horizontal and dissemination activities

The projects have strong dissemination activities in terms of journal publications and conference presentations, and there is some 'on the job' training for postdoctoral researchers and PhD students and other young scientists. Public awareness activities are increasing although they tend to be limited to project websites.

Exploitation plans

Direct commercial exploitation of the results of research and innovation projects is mainly not possible because further research is usually required to increase the TRL. Nevertheless, this further development is seen in the transfer of results to follow-on projects, as in VOLUMETRIQ. However, a larger patenting activity would be expected at the lower TRLs. The review reports indicate only 11 patents either granted or applied for.

Other issues identified in the review included: more attention to durability required in real-world conditions; clarification of the future role of high-temperature PEMFCs; and improved comparison with the international state of the art.

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. In particular, it aims to increase the efficiency and the durability of FCs and electrolysers for sustainable power and hydrogen production, while reducing costs. The widespread deployment of competitive FCH technologies will deliver substantial benefits in terms of energy efficiencies, emissions and security, together with maximising the integration of renewables into the energy system. As such, the FCH JU programme supports activities in three main areas, reflected in the choice of programme review panels:

- Stationary fuel cells (power and heat) demonstrations and proof-of-concept (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 renewable energy sources, handling, distribution and storage technologies to enable hydrogen to become a major energy vector for Europe.

3.2 BUDGET

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.

The budget under FCH1 JU was 44-49 % of the total FCH JU funds, with 34-37 % earmarked for stationary FCs 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.

The total budget for the energy pillar under the FCH2 JU is set at 47.5 % of the total FCH2 JU budget for the period 2014-2020.

To date (November 2016), 108 projects in the energy pillar have received financial contributions from the FCH JU totalling more than EUR 314 million across several types of technologies. The distribution of projects in the three main activity areas is shown in Table 10, with about EUR 135 million for stationary FC demonstration and PoC projects, EUR 84 million for stationary FC research and innovation actions, and EUR 93 million for hydrogen production, distribution and storage[3].

3 These figures include the full budget of overarching project (BIG HIT) which draws half of its EUR 5 million funding from the transport pillar and one project (HYUNDER) dedicated to hydrogen storage and financed with EUR 1.7 million in FP7 under a cross-cutting budget. These projects have been allocated to panel 5: Hydrogen production, storage and distribution, as this is the most appropriate.

TABLE 10 I FCH JU FINANCIAL CONTRIBUTION (EUR) FOR THE THREE MAIN ACTIVITY AREAS IN THE ENERGY PILLAR

Technology validation in stationary FC applications	136 447 302
Research activities for stationary FC applications	83 772 485
Hydrogen production, distribution and storage: research and validation	93 447 441
Total	**313 667 228**

3.3 FOCUS AREAS AND ACHIEVEMENTS

3.3.1 TECHNOLOGY VALIDATION IN STATIONARY FUEL CELL APPLICATIONS

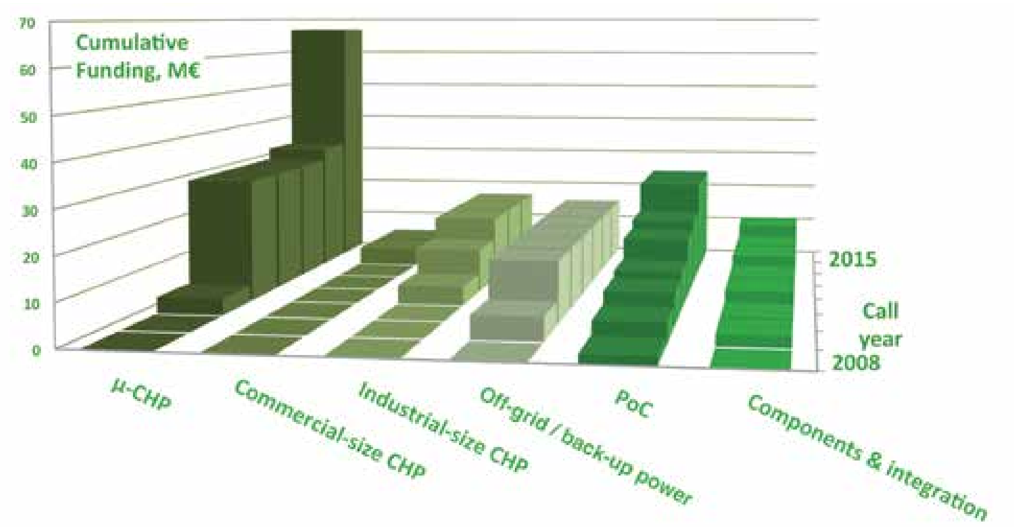
Focus areas

Stationary FC systems for distributed or centralised flexible baseload power and heat generation and back-up power at different levels need sustained innovation activities to reduce capital and operational costs, and improve system durability. The focus is on those applications with the greatest potential to contribute to the achievement of the EU energy policy objectives for power, combined heat and power (CHP) and combined cooling, heat and power (CCHP) production by stationary FCs through:

- Improved efficiency;
- Reduced degradation;
- Reduction of total cost of ownership (TCO in €/kWh);
- Development of European FC markets and competitiveness of the industry;
- Reduction of harmful emissions (CO_2, SOx, NOx, PM), noise, vibrations, etc.;
- Improved power supply security.

FCH2 JU has seen increased support for these activities which have now encompassed 27 projects with a cumulative value of EUR 288 million (FCH JU contribution of EUR 140 million and EUR 148 million from partners). The breakdown of cumulative FCH JU funding into different categories is shown in Figure 8. As the projects are technology neutral, 55 % are based on PEMFC, 39 % on solid oxide fuel cells (SOFC) and 6 % on alkine fuel cells (AFC).

FIGURE 8 I CUMULATIVE FCH JU FINANCIAL SUPPORT FOR TECHNOLOGY VALIDATION PROJECTS IN DIFFERENT CATEGORIES FOR STATIONARY FUEL CELL APPLICATIONS WITHIN THE ENERGY PILLAR



Demonstrations involve all sizes of CHP units and aim to establish operational performance capabilities, prove technology readiness to potential end-users, and develop the knowledge and expertise for installing, operating and maintaining units in real applications. Demonstration projects also include portable, back-up power (BUP) and uninterruptible power supply (UPS) systems.

PoC projects are seeking to validate and test whole-system concepts, usually around TRL. In addition, there are projects aiming to improve the performance, reliability, durability and cost of BoP components for the FC systems, alongside control subsystems.

Achievements

The 2016 review covered 14 projects in panel 3 with a total FCH JU contribution of EUR 72 million; their distribution is shown in Figure 9. The projects indicated in red gave presentations during the PRDs. The project titles are given in Table 11.

FIGURE 9 I DISTRIBUTION OF TECHNOLOGY VALIDATION PROJECTS FOR STATIONARY APPLICATIONS WITHIN THE ENERGY PILLAR INCLUDED IN THE 2016 REVIEW. PROJECTS THAT GAVE PRESENTATIONS AT THE PRDs ARE SHOWN IN RED

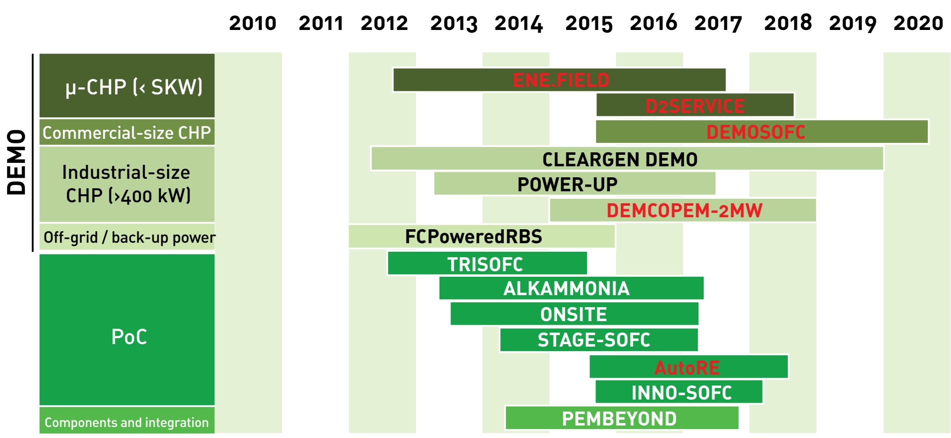


TABLE 11 I TITLES OF THE TECHNOLOGY VALIDATION PROJECTS FOR STATIONARY FUEL CELL APPLICATIONS IN THE ENERGY PILLAR REVIEWED IN PANEL 3

	Topic area	Project acronym	Project title
Demontration	m-CHP (< 5 kW)	ENE.FIELD	European-wide field trials for residential fuel cell micro-CHP
		D2SERVICE	Design of two technologies and applications to service
	Mid-size CHP	DEMOSOFC	Demonstration of large SOFC system fed with biogas from WWTP
	Large-size CHP (>400 kW)	CLEARGEN DEMO	The integration and demonstration of large stationary fuel cell systems for distributed generation
		POWER-UP	Demonstration of 500 kWe alkaline fuel cell system with heat capture
		DEMCOPEM-2MW	Demonstration of a combined heat and power 2 MWe PEM fuel cell generator and integration into an existing chlorine production plant
	Off-grid/back-up	FCPOWEREDRBS	Demonstration project for power supply to telecom stations through FC technology
Proof-of-concept		TRISOFC	Durable solid oxide fuel cell tri-generation system for low carbon buildings
		ALKAMMONIA	Ammonia-fuelled alkaline fuel cells for remote power applications
		ONSITE	Operation of a novel SOFC-battery integrated hybrid for telecommunication energy systems
		STAGE-SOFC	Innovative SOFC system layout for stationary power and CHP applications
		AUTORE	Automotive derivative energy system
		INNO-SOFC	Development of innovative 50 kW SOFC system and related value chain
Integration		PEMBEYOND	PEMFC system and low-grade bioethanol processor unit development for back-up and off-grid power applications

Close to 700 m-CHP systems have been installed so far in 11 countries across the field trials by 10 active manufacturers. These have shown that by generating their own electricity homeowners can cut energy costs by EUR 800-1300 per year and reduces exposure to rising electricity prices. The aim is to have 3000 units installed by 2020, providing a pathway to competitive market products. Field trials have revealed that the EC labelling system for these devices is more stringent than for incumbent domestic heating systems, which acts as a barrier to the take-up of FC systems. The 2017 KPIs have been met for electrical efficiency (reaching as much as 60 % for some systems) and total efficiency. However, 2017 KPIs for capital cost (14 000 €/kW at present manufacturing volumes) have yet to be achieved, while durability (12 years lifetime) performance testing is ongoing. The main routes being pursued for cost reduction are to reduce system complexity, increase use of standardised components, further automate manufacturing, and increase production volumes.

TABLE 12 I FCH JU PROJECT RESULTS VS OBJECTIVES FOR μ-CHP

	FCH JU PROJECT RESULTS 2015	MAWP TARGETS 2017
CAPEX, €/kW	⚒	< 14 000
Durability, y	⚒	> 12
Electrical efficiency, %	✔	33-60
Thermal efficiency, %	✔	25-55
LCOE, €/kWh	–	< 2.5* grid parity
NO_x emissions, ppm	–	< 2

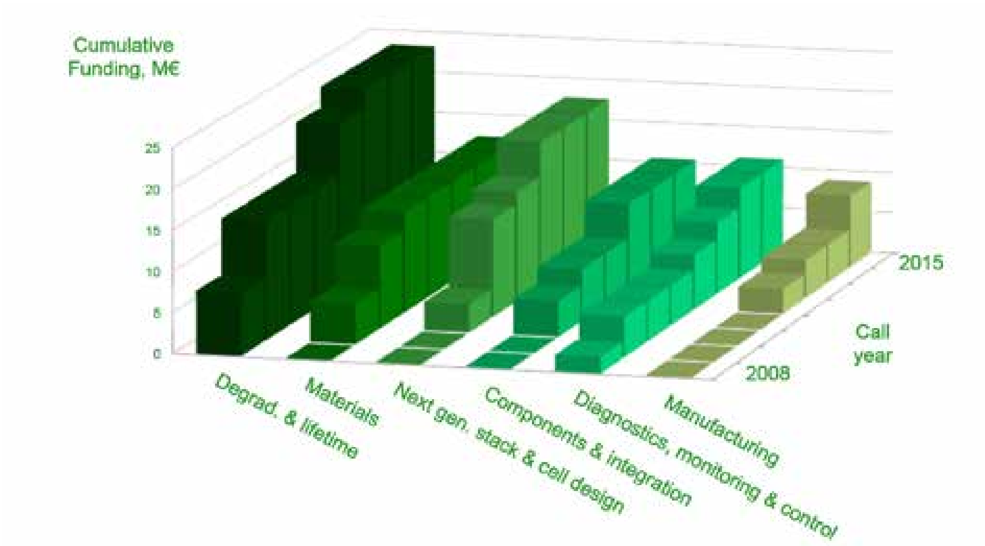
In the case of larger systems, the DEMOSOFC project is achieving particular success in integrating a 170 kW FC system with a biogas supply from a wastewater-treatment plant. This will be the largest SOFC in Europe. Project DEMCOPEM is constructing a 2 MW CHP installation in China using excess hydrogen from a chlor-alkali plant. On a smaller scale, tens of off-grid and back-up power supplies have been installed in remote areas and emerging economies.

3.3.2 RESEARCH AND INNOVATION FOR STATIONARY FUEL CELLS

Focus areas

The research activities serve the same overall goals as the demonstration activities. To date, 40 projects have been funded supported by EUR 84 million from FCH JU and EUR 76 million from partners. The breakdown of cumulative FCH JU financing in terms of topic area is shown in Figure 10. The main focus areas are extending FC lifetime and enabling cost reductions for technologies in the demonstration projects. More recently, there has been increased activity in diagnostics and manufacturing methods.

FIGURE 10 I CUMULATIVE FCH JU FINANCIAL SUPPORT FOR RESEARCH AND INNOVATION PROJECTS IN DIFFERENT CATEGORIES FOR STATIONARY FUEL CELL APPLICATIONS WITHIN THE ENERGY PILLAR



Achievements

The 2016 review covered 20 projects in panel 4 with a total FCH JU contribution of EUR 48 million; their distribution is shown in Figure 11. The projects indicated in red gave presentations at the PRDs. The titles of the projects are given in Table 13.

FIGURE 11 I DISTRIBUTION OF RESEARCH AND INNOVATION PROJECTS FOR STATIONARY FC APPLICATIONS WITHIN THE ENERGY PILLAR INCLUDED IN THE 2016 REVIEW. PROJECTS THAT GAVE PRESENTATIONS AT THE PRDs ARE SHOWN IN RED

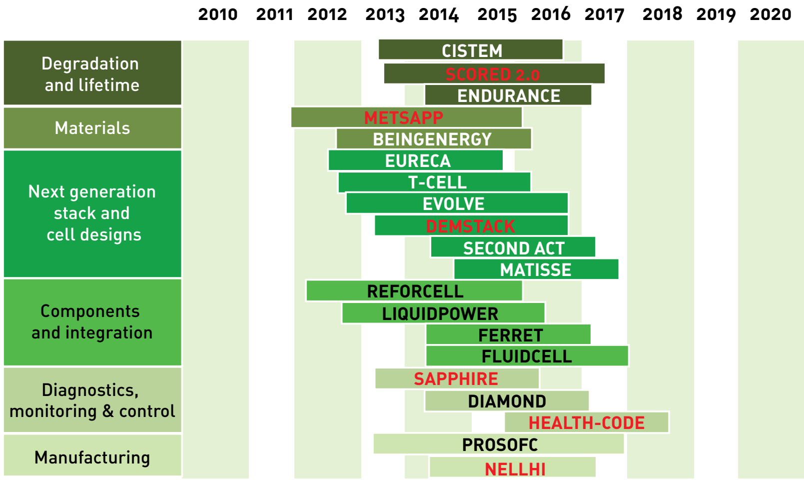


TABLE 13 I TITLES OF THE RESEARCH AND INNOVATION PROJECTS FOR STATIONARY FUEL CELL APPLICATIONS IN THE ENERGY PILLAR REVIEWED IN PANEL 4

Topic area	Project acronym	Project title
Degradation and lifetime	CISTEM	Construction of improved HT-PEM MEAs and stacks for long-term stable modular CHP units
	SCORED 2:0	Steel coatings for reducing degradation in SOFC
	ENDURANCE	Enhanced durability materials for advanced stacks of new solid oxide fuel cells
Materials	METSAPP	Metal supported SOFC technology for stationary and mobile applications
	BEINGENERGY	Integrated low temperature methanol steam reforming and high-temperature polymer electrolyte membrane fuel cell
Next-generation stack and cell designs	EURECA	Efficient use of resources in energy converting applications
	T-CELL	Innovative SOFC architecture based on triode operation
	EVOLVE	Evolved materials and innovative design for high-performance, durable and reliable SOFC cell and stack
	DEMSTACK	Understanding the degradation mechanisms of a high-temperature PEMFC stack and optimization of the individual components
	SECOND ACT	Simulation, statistics and experiments coupled to develop optimized and durable µCHP systems using accelerated tests
	MATISSE	Manufacturing improved stack with textured surface electrodes for stationary and CHP applications
Components and integration	REFORCELL	Advanced multi-fuel reformer for fuel cell CHP systems
	LIQUIDPOWER	Fuel cell systems and hydrogen supply for early markets
	FERRET	A flexible natural gas membrane reformer for m-CHP applications
	FLUIDCELL	Advanced m-CHP fuel cell system based on a novel bio-ethanol fluidized bed membrane reformer
Diagnostics, monitoring and control	SAPPHIRE	System automation of PEMFCs with prognostics and health management for improved reliability and economy
	DIAMOND	Diagnosis-aided control for SOFC power systems
	HEALTH-CODE	Real operation PEM fuel cells health-state monitoring and diagnosis based on dc-dc converter embedded EIS
Manufacturing	PROSOFC	Production and reliability oriented SOFC cell and stack design
	NELLHI	New all-European high-performance stack: design for mass production

The projects on FC stacks have accumulated over 76 000 h of FC operation and the stacks have demonstrated an average availability of 92 %. Average stack costs are 4200 €/kW for SOFC and 5300 €/kW for PEMFC. Average stack lifetimes now exceed the 2017 KPI of 30 000 h with total system efficiencies exceeding the 2017 KPI of 82 %. However, the average system electrical efficiency remains below the 2017 target of 57 %, even though some efficiencies as high as 60 % have been reported for some systems.

TABLE 14 I FCH JU PROJECT RESULTS VS OBJECTIVES FOR CHP SYSTEMS

	FCH JU PROJECT RESULTS 2015	OBJECTIVES 2017*
System electrical efficiency, %	🛠	> 57
Total system efficiency, %	✔	> 82
Stack lifetime, kh	✔	> 30

*Based on AWP2014

As expected for activities dominated by research, professional dissemination has been substantial with over 380 conference presentations and more than 220 journal publications. 'On the job' training for young engineers has been provided for approximately 17 post-doctoral researchers, 15 PhD students and five MSc students.

Strong emphasis on the issue of degradation of the research projects early on in the programme has achieved an increase in lifetime by two orders of magnitude. This has been key in enabling the success of demonstration projects such as ENE.FIELD. The ENDURANCE project is continuing to tackle this major issue and has already provided enhanced understanding of degradation mechanisms for SOFCs. In HT-PEMFC technology, project CISTEM has developed an innovative solution for MEAs which have demonstrated a degradation rate of only 4µV/h over more than 12 000h in operation, which goes beyond the state of the art.

Considering next-generation stack and cell design, project T-CELL has demonstrated very positive results with a new concept of triode operation for SOFC. Encouraging results are showing a 40-50 % reduction in carbon deposition on commercial anodes operating on hydrocarbon fuels.

In the area of diagnostics, monitoring and control, project SAPPHIRE has demonstrated two systems in which this has led to 6000h in operation with minimal or no degradation, and in fact managed to achieve a rejuvenation rate of 4µV/h.

Finally, the increasing interest in research into manufacturing has produced good results through the automation and streamlining of processes with the aim of reducing costs at large volumes. For example, project NELLHI has designed an all-European stack which is suitable for mass manufacturing and can lead to a stack cost of 1000€/kW.

3.3.3 HYDROGEN PRODUCTION, DISTRIBUTION AND STORAGE: RESEARCH AND VALIDATION

Focus areas

The overall aim of this part of the portfolio is to demonstrate on a large scale hydrogen's capacity to harness power from renewables and support its integration into the energy system. In addition, it will increase efficiency and reduce the costs of hydrogen production, mainly from water electrolysis and renewables.

The focus areas can be grouped into four categories:

- Hydrogen production through electrolysis – this covers development of a range of electrolysis technologies, with current effort in the areas of alkaline and proton exchange membrane (PEM) electrolysis for use in the shorter term, and high-temperature electrolysis for the longer term;

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

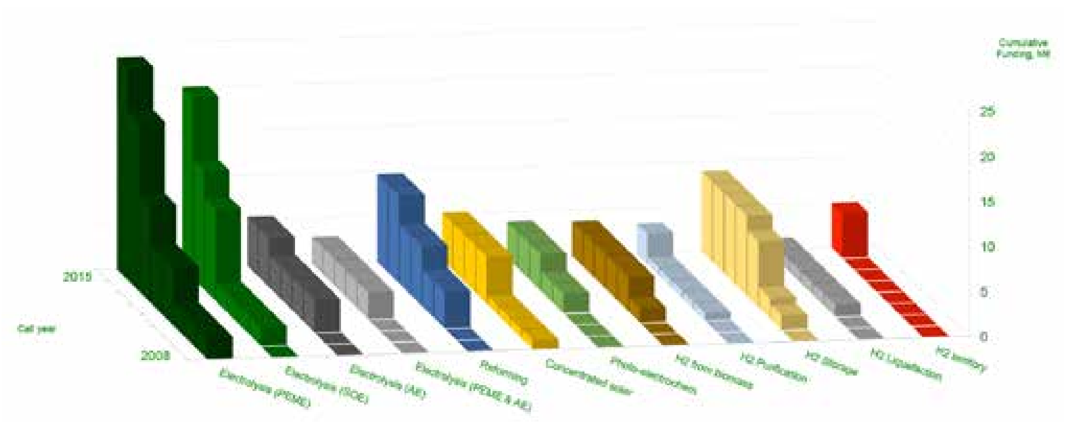
- Innovative reformers – reformer development for distributed hydrogen production from a number of feedstocks, including biogas and biodiesel;

- 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 essentially focus on better performance, e.g. higher efficiencies, greater capacities, increased daily hydrogen production rates and lower costs, while minimising their environmental footprint.

Since 2008, 41 projects have been undertaken in this area at a total cost of EUR 153 million, of which EUR 93 million is from FCH JU and EUR 60 million is from partners3. The distribution of cumulative FCH JU financial contribution to the different project categories is shown in Figure 12. This illustrates how the emphasis has shifted towards electrolysis as the programme has matured.

FIGURE 12 I CUMULATIVE FCH JU FINANCIAL SUPPORT FOR PROJECTS IN DIFFERENT CATEGORIES FOR HYDROGEN PRODUCTION, DISTRIBUTION AND STORAGE WITHIN THE ENERGY PILLAR



Achievements

The 2016 review covered 21 projects in panel 5 with a total FCH JU contribution of EUR 55 million; their distribution is shown in Figure 13. The projects indicated in red gave presentations on the PRDs and the project titles are given in Table 16.

Progress in PEM and alkaline electrolyser technology has been particularly strong and has served to maintain Europe's leading position in this area. Eight demonstration units have been installed and have produced 100 tonnes of hydrogen with 93 % availability. The 2017 KPIs for response time (< 10 s) and durability (< 2 % efficiency degradation per year) have been met for both PEM and alkaline electrolyser types. Energy consumption at 57 kWh/kg is very close to the target of 55 kWh/kg H_2. However, the capital cost of PEM electrolysers is still above target (3.7 M€/t/day), as it is for PEMFC in transport applications.

TABLE 15 I FCH JU PROJECT RESULTS VS OBJECTIVES FOR ELECTROLYSERS

	PEME	AE	MAWP TARGETS 2017
CAPEX, M€ (t/d)	⚒	✔	< 3.7
Energy consumption, kW/kg	⚒	⚒	< 55
Efficiency degradation, %/y	✔	✔	< 2
Min. load, % of nominal capa.	✔	–	< 5
Max. load, % of nominal capa.	⚒	–	> 150
Hot start, seconds	✔	✔	< 10
Cold start, seconds	⚒	⚒	< 120

The NOVEL project has successfully incorporated new materials into PEM electrolyser stacks which can produce hydrogen at 5 €/kg, thereby meeting the 2017 KPI. The developments are now being fed into MEGASTACK for a prototype demonstration at the MW scale and to reduce capital cost by improved cell design, manufacturability and supply chains. The projected cost using the current technology is below (75 %) the 2017 KPI.

Larger-scale demonstrations are now planned for concentrated and direct solar hydrogen production as a result of successful developments on smaller scales. Low-concentration (1 µg/cm²) gold catalysts have been developed for high-temperature water splitting using concentrated solar heat input, and promising new configurations and catalysts for photo-electrolysis are being scaled up.

Solid-state storage of hydrogen in metal hydrides was demonstrated in integrated systems, but issues of complexity and hydrogen density still remain.

FIGURE 13 I DISTRIBUTION OF PROJECTS FOR HYDROGEN PRODUCTION, DISTRIBUTION AND STORAGE WITHIN THE ENERGY PILLAR INCLUDED IN THE 2016 REVIEW. PROJECTS THAT GAVE PRESENTATIONS AT THE PRDs ARE SHOWN IN RED

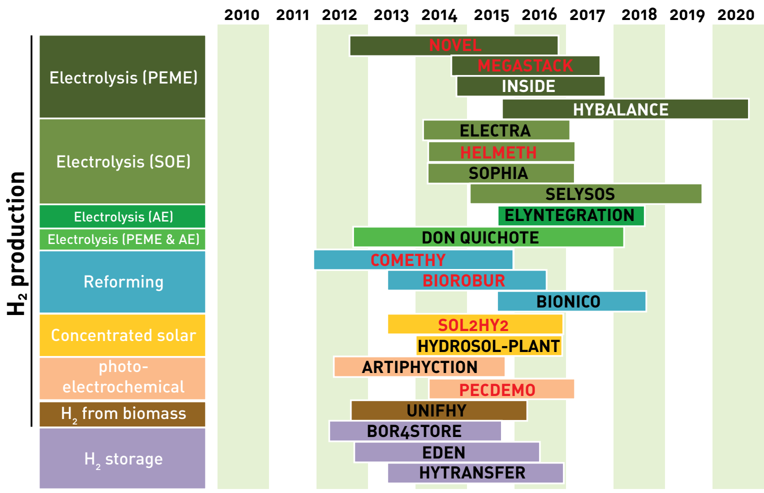


TABLE 16 I PROJECTS FOR HYDROGEN PRODUCTION, DISTRIBUTION AND STORAGE IN THE ENERGY PILLAR REVIEWED IN PANEL 5

SEGMENT	PROJECT ACRONYM	PROJECT TITLE
Electrolysis (PEME)	NOVEL	Novel materials and system designs for low cost, efficient and durable PEM electrolysers
	MEGASTACK	Stack design for a megawatt scale PEM electrolyser
	INSIDE	*In-situ* diagnostics in water electrolysers
	HYBALANCE	Grid balancing by water electrolysis
Electrolysis (SOE)	ELECTRA	Tubular high temperature proton electrolyser
	HELMETH	Integrated high-temperature electrolysis and methanation for effective power to gas conversion
	SOPHIA	Solar integrated pressurized high temperature electrolysis
	SELYSOS	Development of new electrode materials and understanding of degradation mechanisms on solid oxide high temperature electrolysis cells
Electrolysis (AE)	ELYNTEGRATION	Grid integrated multi megawatt high pressure alkaline electrolysers for energy applications
Electrolysis (PEME+AE)	DON QUICHOTE	Demonstration of new qualitative concept of hydrogen out of wind turbine electricity
Reforming	COMETHY	Compact multi-fuel energy to hydrogen converter
	BIOROBUR	Biogas robust processing with combined catalytic reformer and trap
	BIONICO	Biogas membrane reformer for decentralized hydrogen production
Concentrated solar	SOL2HY2	Solar to hydrogen hybrid cycles
	HYDROSOL-PLANT	Thermochemical hydrogen production in a solar monolithic reactor: construction and operation of a 750 kWth plant
Photo-electrochemical	ARTIPHYCTION	Fully artificial photo-electrochemical device for low-temperature hydrogen production
	PECDEMO	Photo-electrochemical demonstrator device for solar hydrogen generation
H_2 from biomass	UNIFHY	Unique gasifier for hydrogen production
H_2 storage	BOR4STORE	Fast, reliable and cost effective boron hydride based high capacity solid state hydrogen storage materials
	EDEN	High energy density Mg-based metal hydride storage system
	HYTRANSFER	Pre-normative research for thermodynamic optimization of fast hydrogen transfer

3.4 REVIEW FINDINGS

3.4.1 TECHNOLOGY VALIDATION IN STATIONARY FUEL CELL APPLICATIONS

Relevance to programme objectives

The projects reviewed in panel 3 are given in Table 11.

The two flagship projects are ENE.FIELD and PACE (not formally reviewed as a separate project in the 2016 programme review since it only started in June 2016) which are field trials for domestic, and small commercial, micro-CHP FC systems. The ENE.FIELD field trial is designed to prove a range of products for early commercialisation. It has 27 partners and aims to assist initial deployment of up to 1000 units with EUR 26 million of FCH JU funding. It is on track for installation of over 800 units. PACE has nine partners and builds on ENE.FIELD, aiming for a larger demonstration of over 2500 units, supported by EUR 34 million FCH JU funding to help build the commercial market and reduce costs by increasing production volumes and standardisation of components. These activities benefit from close interaction with the German national projects CALLUX and KFW 433 which have similar aims and are projected to result in a market of 10 000 units per year in Germany from 2020. Despite the success achieved so far and the competitive level of European technology, Europe still lags a long way behind Japan in terms of deployment, where more than 150 000 FC m-CHP systems have been installed. Project AUTORE is working on the development of European PEMFC cells and stacks in which automotive-type PEMFCs will be adapted and integrated into a 50 kWe CHP prototype. This follows the strategy in other technologies (such as gas turbines) where aero engines and electrical turbines share similar components and designs. The general level of participation from utilities could be increased. Several of the European m-CHP manufacturers are relatively small and tend to have short-term financing. The involvement of larger companies would bring more confidence concerning financial stability.

At the mid-size of CHP systems, DEMOSOFC, with an output of 174 kW electrical and 89 kW thermal, aims to be the largest installation in Europe for co-generation of heat and power from biogas produced by a wastewater-treatment plant. Design studies have been completed and on-site work has begun near Turin, Italy.

At the larger size, DEMCOPEM-2MW has commissioned a PEMFC CHP system fuelled by by-product hydrogen from an industrial chlor-alkali plant in China. The system has demonstrated an electrical efficiency of 50 %, which is greater than the 2017 KPI of 45 % for this sector.

The reviewers noted that several projects were having difficulty reaching the targets specified in the MAIP and MAWP documents for this sector. As in the transport pillar, some targets might be too onerous and represent desirable values rather than those that are realistically achievable in the project timescales. This is particularly the case for costs and lifetimes. There is no generally accepted procedure to predict large-scale volume cost based on the present level of production. The provision of such a procedure would be very beneficial in future. Similarly, clearer and more detailed targets, broken down to component level, would be useful to assess progress on a finer scale.

Generally, in terms of technical performance, the European projects are close to the international state of the art. However, at deployment level, Europe is still lagging Japan in m-CHP and the USA for larger fuel cells (Fuel Cell Energy, Doosan and Bloom Energy).

Complementarity with other projects and programmes

Many projects build on previous results which increases the effectiveness of FCH-JU support. Many are also performed jointly with nationally funded initiatives, which is advantageous for increasing the scale of demonstration activities and wider promotion of the technologies. Projects are establishing links with others undertaking-related work, although in general the interactions and collaboration between the participating companies should be further improved.

International (extra-European) relationships are rather weak (except in the case of DEMCOPEM-2MW). Their enhancement would probably benefit the cross-fertilisation of knowledge in the field.

Horizontal and dissemination activities

The training aspects are good, particularly in the demonstration projects in which technical staff are trained to install and monitor the field units.

A general problem is that, in nearly all cases, the dissemination activities stay inside the FC community. There appears to be very little information being disseminated to the public or available at end-user conferences. More effort should be devoted to improving both wider (including the public) and international dissemination. Projects that are getting close to commercialisation could benefit from more dissemination to, and cooperation with, end-users or other companies, such as system integrators outside of the FC community. They could provide essential feedback regarding market needs and requirements for different applications.

Exploitation plans

Commercial activities, exploitation plans and strategies are strong in the large demonstration projects which integrate with other national initiatives, as seen with Callux, KFW, ene.field and PACE in the m-CHP technologies. In other cases, exploitation plans are rather weak, although DEMCOPEM-2MW and DEMOSOFC are positive exceptions. Often the plans do not consider how to compete with both existing and future technologies. This might be improved by engaging more end-users as project partners or in advisory groups. Projects should be encouraged to participate in the recent Horizon 2020 initiatives for the exploitation of results, such as the Common Exploitation Booster and the Support Service for the Exploitation of Research Results.

More effort on cost reduction and longer lifetimes is necessary, requiring feedback on results from demonstration and PoC activities into more basic research activities. It is not clear whether this feedback takes place or, if it does, where financial support would come from for this basic research.

The project reports confirm that the FCH JU programme is essential for the development of European FC technology. It has brought leading developers together and created strong alliances with the potential to further develop the technology towards commercialisation. FCH JU funding has also been essential to share the risks and succeed with the scaling-up activities.

3.4.2 RESEARCH ACTIVITIES FOR STATIONARY FUEL CELLS

Relevance to programme objectives

The 20 projects reviewed in panel 4 are given in Table 13.

In general, the reviewers judged the project portfolio to be generally well aligned with FCH JU objectives. Lifetime prediction capability has improved significantly, but there seems to be insufficient information to verify results relating to cost reduction and improved efficiency. The programme should concentrate on these core issues, perhaps with less-rigid targets but instead consider overall competitiveness and environmental benefit that would lead to market entry. This would also be helped by concentrating on the more common and currently available fuel types.

Effective collaboration between industry and research providers is evident and many very significant technical advances have been achieved. The effective participation of small and medium-sized enterprises (SMEs) is noteworthy, but more industrial involvement would be beneficial, particularly from larger industrial companies in the energy sector.

Compared to FCH research on stationary fuel cell applications in the USA and Japan, the EU programme appears to be both versatile and competitive. A generally recognised EU roadmap and an updated technology monitoring tool, owned and operated by an independent third party, would be a great help in assessing the relative competitiveness of EU technology in systems and components across the spectrum of applications.

Overlaps and duplication among projects is minimal and those working in the same area use different and complementary approaches.

Complementarity with other projects and programmes

Interaction between projects is mainly historical in that it consists of incorporating learning from previous projects undertaken by consortium participants in the past. This is highly relevant but not sufficient. Although some projects have organised joint workshops, there is still a general lack of effective exchange of current information and results that could speed up the attainment of project goals. This applies in particular to interaction between near-term development and long-term research (i.e. between higher and lower TRLs).

In general, the project portfolio in panel 4 shows a good level of complementarity and exploitation of synergies with past and present projects funded under EU programmes. Several projects (30 %) report co-funding at the national level. Denmark supports METSAPP and PROSOFC, Norway supports SAPPHIRE and SECOND ACT, Finland supports BEINENERGY and SCORED 2:0, and the Czech Republic supports CISTEM. In addition, DEMSTACK, HEALTH-CODE, NELLHI and T-CELL interact with national and international-level programmes. Formal interactions with organisations outside Europe is not evident, but would be beneficial given the pre-commercial state of the technology and the high costs of development.

Horizontal and dissemination activities

Dissemination in terms of publications and conference participation is very strong and workshop activity is growing. The programme performs well on these parameters. Public-awareness activities are modest (typically only a project website) and could become a problem in the longer term. The ENDURANCE project should be commended for introducing a game in an effort to engage public awareness.

Exploitation plans

The level of intellectual property activities and patent applications is rather low. For research-based projects such as these, this is a concern and more patenting activity should be encouraged.

Exploitation plans are more elaborate now, but do not always demonstrate a strong commitment. Clear guidance on what to include in an exploitation plan (how to evaluate a market, who to partner with, what risks to consider, etc.) may be helpful. None of the projects report the use of focus groups or advisory panels who could help in this respect.

The standard three-year consortium model for projects might not be the best way to address the lifetime issue. Longer-lasting projects devoted to experimentally determining the durability and lifetime of components and systems should be considered.

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

Relevance to programme objectives

Further details of the 21 projects reviewed in panel 5 are given in Table 16.

Overall, the projects under review appear highly relevant to the objectives of the FCH-JU MAIP and MAWP documents. Completed projects show both usable and valuable results.

However, not all the initial targets are met in all of the projects. This is evident mainly at the PoC level. Nevertheless, the results are in line with the international state of the art. In most cases, the advances in the state of the art are realistic and achievable and align quite well with international progress. This may indicate that some of the MAIP/MAWP targets are excessively ambitious and are reproduced in proposals simply to satisfy selection criteria. As in other parts of the programme, progress towards cost targets is difficult to assess as different projects use different models and assumptions for estimating costs at different levels of deployment. Whether the capital cost of equipment or the cost of delivered energy are reported, it is generally left to individual consortia to determine the basis for the cost analysis. This sometimes leads to unreliable conclusions and comparisons. For reporting on cost, endurance and transient operation, a standardised and well-defined methodology should be adopted and values should be treated with appropriate care regarding confidentiality.

For example, one gap identified in the programme is in the transient operation of electrolysers, particularly for renewable energy storage, and their reliability at PoC stage. Here, it is recommended to consider the need for standardised methodologies for reporting on related key parameters to enable a common understanding of progress, targets and needs.

There is evidence of some duplication in the projects, but this may be justified because the projects are high risk and therefore failure of some of them is highly likely. If there is any overlap then there is more chance that at least one of them will, in part, succeed.

Complementarity with other projects and programmes

There is reasonable general complementarity with, and further elaboration of results from, previous and parallel projects. Many projects build on results achieved in previous projects (sometimes going back to FP5) transferred by common project partners. There is some potential overlap with earlier projects in the areas of biomass gasification, reforming, water electrolysis and hydrogen storage, and it is not always clear how results from earlier projects have created a starting point for new projects

With the exception of projects addressing metal hydride hydrogen storage, few projects follow an agenda of cooperation with fellow projects where several exist in that field. Referring to non-FCH JU projects is the exception, but some projects do report complementarity with national programmes. It is striking that international connections and cooperation are relatively low, as the interests of individual organisations tend to mitigate against this. Perhaps a high-level workshop about the FCH activities of the USA, Japan, China and others would help to raise awareness of the international state of the art.

Horizontal and dissemination activities

Most projects provide on-the-job training for research and technical staff and PhD students, but large-scale training is not the projects' principal goal. Similarly, the projects take note of appropriate RCS developments where relevant.

All projects engage in public-awareness activities at some level. For most, this means providing a project website, as in other parts of the programme. Since it is probably unrealistic to expect research and innovation projects to conduct effective public awareness, it might be preferable for this to be undertaken by the FCH JU.

On the other hand, there is a strong output of conference presentations and journal papers, as expected from the high content of research activities. More could probably be done in producing articles for the technically interested layperson. In addition, as they move to higher TRLs, projects should concentrate more on presentations at conferences attended by end-users and other potential stakeholders.

Exploitation plans

Patenting activity in this area is judged to be rather low, in common with the findings in other panels.

Exploitation plans vary significantly in quality and focus. An exceptional few (e.g. BIOROBUR) have a clear picture and a reasonable plan – these tend to be projects with a high proportion of industry partners. It appears that in many projects exploitation is not considered seriously until the final stages of the project.

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 by:

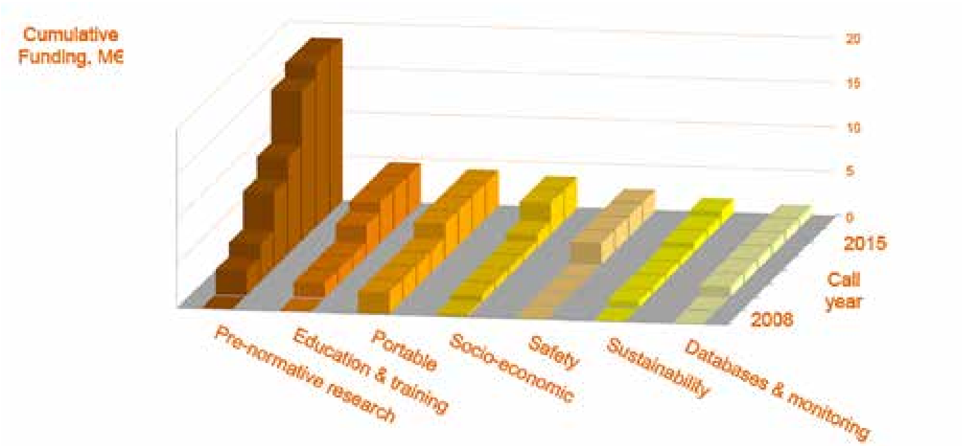
- Providing new knowledge to develop and improve regulations, codes and standards;
- Safety-related issues;
- Preparing the European workforce;
- Increasing public awareness and social acceptance;
- Ensuring FCH technologies are environmentally sustainable.

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

4.2 BUDGET

Since 2008, 31 projects have been undertaken in this area at a total cost of EUR 61 million, of which EUR 35 million is from FCH JU and EUR 26 million is from partners. The distribution of cumulative FCH JU financial contribution to the different project categories is shown in Figure 14.

FIGURE 14 I CUMULATIVE FCH JU FINANCIAL SUPPORT FOR CROSS-CUTTING PROJECTS IN DIFFERENT CATEGORIES



4.3 FOCUS AREAS AND ACHIEVEMENTS

Focus areas

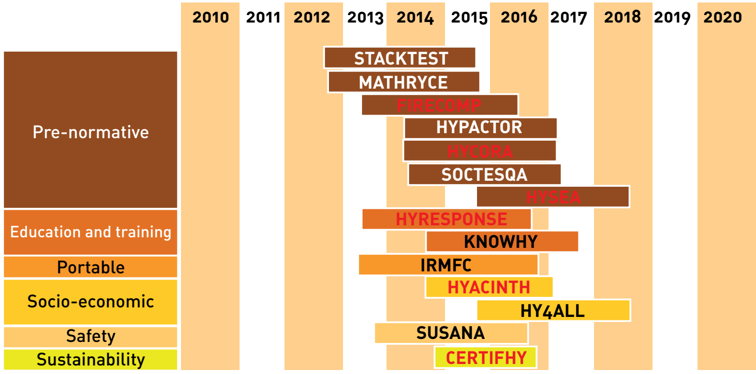
Both the existing and previous cross-cutting project portfolios support a number of distinct fields (with the emphasis on the first two):

- Pre-normative research (PNR): 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 fuel cell 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'; 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 assessment (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, and identification and development of financial mechanisms to support market introduction.

Achievements

The 2016 review covered 14 projects in panel 6 with a total FCH JU contribution of EUR 22 million; their distribution is shown in Figure 15. The projects indicated in red gave presentations at the PRDs and the project titles are given in Table 17.

FIGURE 15 I DISTRIBUTION OF CROSS-CUTTING PROJECTS INCLUDED IN THE 2016 REVIEW. PROJECTS THAT GAVE PRESENTATIONS AT THE PRDs ARE SHOWN IN RED



The PNR projects are providing solid information to improve and develop standards at international level, thereby contributing to develop an appropriate regulatory framework for FCH technologies. A Regulations, Codes and Standards Strategy Coordination Group (RCS SCG) has been created to establish, among others, a set of priority areas for the FCH industry.

HYRESPONSE has developed an operational training platform and a virtual reality platform to train first responders called to deal with incidents involving hydrogen. It has trained 71 firefighters from 15 countries. This system is being exported to train first responders outside of Europe using both training materials in the form of a web-based course and training sessions.

In project HYACINTH, the largest-ever exercise has been carried out to gain a deeper understanding of the social acceptance of hydrogen technologies across Europe. Covering both the transport and energy sectors, it has conducted around 7000 surveys and 200 interviews with interested stakeholders and the general public. These showed that awareness of μ-CHP technologies is generally low and the technology is mainly perceived as both costly and immature. Awareness of hydrogen FC vehicles in the transport sector is much higher, with cost and lack of refuelling infrastructure being seen as the main barriers to potential take-up.

An internationally pioneering scheme has been developed by the CERTIFHY project for specifying and guaranteeing the quality of 'green' hydrogen in order to inform end-users about the 'renewable content' of the hydrogen.

4.4 REVIEW FINDINGS

Relevance to programme objectives

The panel of cross-cutting activities is probably the most complex in its diversity, with projects that are addressing topics including: testing protocols; guarantee certification for renewable hydrogen; training for emergency response; building wider society awareness; and niche 'early market' applications. Further details of the projects reviewed in panel 6 are given in Table 17.

The projects are well aligned with FCH JU requirements and priorities and the reviewers considered the portfolio in this panel to be highly effective in addressing important issues. Hydrogen safety is a major thread in the portfolio (although currently only SUSANA is formally classified as such) and includes pressure vessel integrity, fire safety assessments, and training emergency services to deal with the unusual features of fires involving hydrogen leakage (as there is no visible flame or heat radiation). Another pre-normative issue addressed by the portfolio is the standardisation of tests for evaluating the performance of FC stacks. This has been done by STACKTEST for PEMFC stacks. The rationale has been to involve representative stakeholders in devising an agreed testing protocol for measuring the performance of stacks and reporting results, which will enable comparisons to be made and progress to be assessed under common conditions. SOCTESQA will perform a similar role for SOFC and SOEC stacks.

In general, the projects are in line with the international state of the art and, wherever possible, they seek to produce or improve standards at the international level. They also interact with appropriate national initiatives on standardisation. However, the effectiveness of efforts targeting international standards could be further improved.

No overlaps or duplications were identified in this panel, but the reviewers pointed out the current absence of projects addressing material recycling. This should be addressed by project HYTECHCYCLING which started its activities in May 2016.

Complementarity with other projects and programmes

The individual reports mention some general considerations regarding other relevant projects both from Europe and beyond, but the nature of these interactions is unclear.

Project SUSANA builds on expertise from other projects to produce protocols for the use of computational fluid dynamics in conducting safety assessments involving hydrogen.

There still does not appear to be a clear mechanism for feedback on experience from demonstration projects into requirements for cross-cutting activities in training and standardisation. As regards the latter, the FCH JU RCS Strategy Coordination Group[4] is committed to tackling this aspect.

Horizontal and dissemination activities

Horizontal and dissemination activities are at the forefront of the projects from the cross-cutting panel, which is clearly evidenced in the project documents submitted for the programme review. The main goals of the KNOWHY and HYRESPONSE projects concern education and training. For PNR projects, the outcomes are often intended to be used as input for international standardisation activities, but evidence of any clear impact would appear to be lacking. The assessment and improvement of public awareness of FCH technologies are also addressed in FCH JU projects, e.g. HYACINTH.

In general, the projects do a good job in publicising their activities to the FCH community in terms of workshops and conference presentations.

Exploitation plans

Due to the diversity of the projects in this panel, it is difficult to make a general remark regarding exploitation. Only IRMFC, which was part of the 'early markets' activities in FCH1 JU, is developing a technology product although this has not yet reached the status of commercial viability. For many projects, exploitation took the form of incorporating findings into relevant formal codes and standards. As mentioned earlier, the routes for achieving this need clarification.

Projects in the cross-cutting portfolio can definitely benefit from input from, and exploitation of, results from other FCH JU-funded projects, not only from previous cross-cutting ones but also from the demonstration projects. It would be beneficial to facilitate this by finding ways to remove intellectual property obstacles to the sharing of data from demonstration projects. In addition, consideration should be given to activities supporting the development of appropriate business models to enable market viability.

4 The FCH2 JU's 'Regulations, Codes and Standards Strategy Coordination Group', as foreseen in the FCH 2 JU MAWP 2014-2020, is intended to tackle all issues related to RCS and is made up of participants from the FCH2 JU, the Industry and Research Grouping and the European Commission's Joint Research Centre.

05
FCH 2 JU-FUNDED STUDIES

The FCH JU procured two studies which were delivered in 2016:

- Strategies for joint procurement of fuel cell buses

This study, performed by Element Energy, analyses the possibility to organise joint procurement procedures among transport operators. The idea is to enable better pricing through bigger procurement size, in turn improving the actual bus demand, the offer and competition between manufacturers. The study focused on five geographical regions (Benelux, France, Germany, Northern Europe and UK) and delivered concrete strategies for joint procurements in the five reference regions. It also estimated that the price threshold at which demand is likely to significantly pick up is EUR 450 k (for a 12-metre bus).

- The FCH JU Satisfaction Survey

A survey was carried out among FCH JU stakeholders to assess the level of satisfaction provided by the FCH JU PO. The 242 answers received showed a generally positive response. Details on the methodology, respondent statistics and answers can be found in the survey report.

06 CONCLUSIONS

6.1 OVERVIEW

The FCH JU portfolio has a balance between demonstration and PoC projects focused on proving technology readiness and research projects focused on improving performance and reducing cost.

The 2016 review of the FCH JU project portfolio re-emphasises the findings of previous reviews and provides evidence of implementing lessons learned from earlier reviews. The projects considered in the current review represent a strong portfolio that is well aligned with the FCH JU's strategic objectives and is pursuing the detailed targets set out in the MAIP and MAWP planning documents. The shift towards commercial readiness specified by the higher TRLs in the MAWP is already apparent in the portfolio. More projects are aligned to industrial needs and demonstration activities are increasing.

Demonstration activities now account for the majority of funding in the transport pillar and their success is impressive. Over 250 FC cars, which have accumulated a driven total of over 1 million kilometres, have been deployed in the demonstrations and have met performance metrics other than those of cost and durability. Networks of hydrogen refuelling stations have been expanded and now cover eight European countries and meet all performance targets. Bus demonstrations are particularly impressive and already involve 41 vehicles in seven cities, with excellent support and commitment from the host-city municipalities. The reviewers considered the bus demonstrations to be world leading. The demonstrations with MHVs have advanced the technology to the point of commercial readiness. However, the take-up by end-users in Europe is significantly lower than in the USA and reflects less-favourable market conditions and warehousing practice in Europe.

Research and Innovation in the Transport pillar has increased focus on cost reduction and improved durability through improved components and lower concentrations of platinum group metals. Significant progress has been achieved in building a European capability for manufacturing PEMFC stacks and these also incorporate improved components from other projects.

In the energy pillar, demonstration activities have also been expanded and cover micro CHP (more than 700 units installed in 11 countries), a 170 kW CHP SOFC system fuelled by bio-gas, and tens of off-grid and back-up power supplies. Europe is maintaining its leading position in hydrogen production by electrolysis for both fuel for transport and storage for renewable energy. Eight demonstration units have been installed, including on fuel-station forecourts.

Research and innovation within the energy pillar supports technology development for stationary fuel cell power (CHP) and hydrogen production, distribution and storage. The approach is similar to that in the transport pillar with a similar focus on reducing cost and improving lifetime, both of which have seen significant improvement. It is notable that projects involving manufacturing methods have an increasing role in reducing costs, and in diagnostics for improving lifetime and maximising durability.

The two technology pillars are complemented by the cross-cutting activities within the programme that contribute to its horizontal objectives. Hydrogen safety continues to be the main focus of both the pre-normative and training projects. In addition, standard test protocols have been developed for characterising the performance of PEMFC stacks, and are being extended to SOFC stacks, and significant initiatives are being taken to assess and improve public awareness and acceptance of FCH technologies.

The reviewers were also pleased to note a marked improvement in the quality of project reporting for the review.

6.2 PARTICIPATION IN THE FCH JU PROGRAMME

Since its inception, one continuing critical success of the FCH JU 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 49 have been selected for support as part of Horizon 2020, 30 of which had already started at the time of the PRDs. At that date, there were 1640 participations, representing 707[5] unique beneficiaries (a few of which are not receiving a financial contribution from the FCH JU).

Under FP7 and the first two calls of Horizon 2020, the programme has funded participants from 24 of the 28 EU Member States, 11 of which are 'new' Member States, and approximately 25 % of the funds have been allocated to SMEs.

The relevance of FCH technologies to Europe's future energy challenges is highlighted by the increasing numbers of municipalities and regions which have either confirmed their active interest in the technologies (20 regions and cities signed a memorandum of understanding in this direction on the day after the PRDs, during the FCH JU stakeholders' forum), or are actually involved in demonstration projects. Public bus operators seeking zero-emission solutions for public transport are increasingly turning towards the potential of FC buses, making use of the bus coalition, coordinated by the FCH JU, which is gathering momentum and will gain further prominence with the launch of project JIVE in 2017. Furthermore, the FCH JU is actively coordinating its projects with more and more hydrogen mobility initiatives in the Member States. These activities are effectively leveraging the FCH JU's resources, multiplying funds and efforts towards the commercialisation challenge.

A good example of this lies in Germany's KfW incentive programme for μ-CHP, which follows the good progress and publicity of FCH JU projects and studies.

The recruitment of a 'financial engineering officer', who started work at the FCH JU in November 2016, should also facilitate the pooling of funding opportunities for even more public support during the difficult phase of technology pre-marketing.

6.3 GENERAL OBSERVATIONS FROM THE REVIEWERS

Detailed observations are presented in the appropriate sections of the report, but some common observations are reiterated here.

The reviewers noted the impressive progress that has been made by the programme in both demonstration and research activities. Most of the more speculative or peripheral projects have now been concluded and the portfolio is better focused. Many of the interim (2017) performance indicators have been met and gaps in the portfolio coverage are rare. However, it has still not proved possible to achieve all the relevant performance indicators simultaneously for a given application. Despite greater emphasis on reducing cost and increasing durability, these remain the principal challenges.

5 Based on the 2008-2015 list of beneficiaries and participant organisations' legal names.

There is clear evidence of new projects building on the results of earlier ones while interactions between related projects are improving. Nevertheless, these interactions could be improved to extract greater benefits from the pooled results. Greater alignment and partnership with other publicly funded initiatives is notable within the transport demonstration projects.

The general shift towards exploitation and the associated increase in industry involvement are welcome, but should not occur at the expense of the more basic research underpinning the improvements required in the current technology.

Dissemination of results within the community in the form of journal publications and conference presentations is excellent, particularly from the research activities. However, in general, patenting activity remains stubbornly low. Similarly, exploitation plans tend to be rather vague.

6.4 LEARNING AND RECOMMENDATIONS

The review experts identified a number of areas for improvement in the current portfolio and in the project activities within the portfolio. These improvements and lessons learned echo those of previous reviews, emphasising their importance in ensuring the maximum effectiveness of the portfolio and the resources deployed.

The state-of-the-art assessments, as described in the project reports, are generally not sufficient for an effective monitoring of programme achievements or for enabling project participants to gauge where their project stands in the international context. Furthermore, different projects interpret 'state of the art' in different ways. Consideration should be given to organising workshops specifically to discuss the international state of the art in selected areas. This could also include consideration of the current and future potential of competing technologies. The rolling out of the FCH JU systematic data-collection exercise could certainly be helpful in determining the state-of-art of FCH JU projects, assuming that the projects contribute the required data. For 2016, this does not appear to have been the case and only sparse and qualitative conclusions could be drawn and disclosed. The need for projects to share their results more openly is fundamental here.

Exploitation plans in the project reports give the impression of being too cursory and vague. The reviewers suggest that it might be possible to give some additional instruction and guidance to projects regarding exploitation.

Cost reduction is one of the two critical issues in the FCH field. Unfortunately, in many projects, progress towards cost reduction is difficult to judge because each project uses its own approach to cost estimation. It is recommended that the FCH JU introduces some standard guidelines and methods for calculating current costs and estimating future costs with standard assumptions regarding input energy costs when estimating total cost of ownership.

Increased durability is the other critical issue. It is recommended that more effort should be devoted to diagnostics for lifetime assessment and identification of accelerated test regimes to shorten the development cycle when new components are introduced. In addition, it appears that the standard model of a three-year consortium project is not appropriate for durability testing and alternative actions should be considered.

Although some of the interim (2017) targets have been met, many others have not. Where there is a shortfall it is probably worth re-examining the targets for 2020 in the next revision of the MAWP to establish whether or not they are realistic.

The standard test protocols and hardware designs for FC stacks are potentially very useful for monitoring progress on a common basis and their mandatory use in future projects to which they are relevant would be desirable.

The increase in demonstration activities is a welcome and necessary step on the road to commercialisation. However, the reviewers reiterated the same concern as in 2015 that greater emphasis on demonstration activities should not lead to the 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.

Although there is a welcome increase in industrial participation, the lack of large industry involvement in the energy pillar remains a concern, in particular the apparently low level of interest from utilities. Any steps that can be taken to increase their engagement would be beneficial.

6.5 OUTLOOK

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. It has brought together European industrial companies and research providers in a collaborative enterprise focusing on the eventual commercialisation of these important technologies which have the potential to make a major contribution to combating climate change. As the programme has matured, the emphasis has gradually shifted towards higher levels of technological readiness and commercial viability. Nevertheless, further work is required to realise the ultimate goal of large-scale deployment in the market place.

In most technology applications addressed by the FCH-JU, the main performance indicators of efficiency, durability/reliability and total cost of ownership have been shown to be individually achievable, but so far not all at the same time. This is the main technical challenge for the future.

Demonstration activities have expanded considerably in recent years and should continue to do so as they yield valuable real-world data that cannot be obtained by other means, on statistically meaningful numbers of units. They also help validate projections of cost reduction, as manufacturing volumes increase, and provide valuable exposure for improving public awareness and customer acceptance. It is important that the demonstration activities continue to be aligned with related Member State initiatives to take full advantage of available resources. This effort must be supported by continuing activities in safety, standards, education and training and a robust programme of underlying science to ensure future improvements in device performance.

As the technologies become closer to commercialisation, it will become necessary to help consolidate partnerships that have formed during the FCH-JU activities so that they can become viable European supply chains for components, systems and access to markets.

SECTION 02

PROJECT POSTERS

INDEX OF POSTERS

3EMOTION

Environmentally Friendly, Efficient Electric Motion

PANEL 1

Technology validation in transport applications

ACRONYM	3EMOTION
CALL TOPIC	SP1-JTI-FCH.2013.1.1 (2): Large-scale demonstration of road vehicles and refuelling infrastructure VI
START DATE	1/01/2015
END DATE	31/12/2019
PROJECT TOTAL COST	€41,8 million
FCH JU MAXIMUM CONTRIBUTION	€14,9 million
WEBSITE	http://www.3emotion.eu/

PARTNERSHIP/CONSORTIUM LIST

VAN HOOL N.V., DANTHERM POWER A.S, AIR LIQUIDE ADVANCED TECHNOLOGIES SA, COMPAGNIA TRASPORTI LAZIALI, COMMUNE DE CHERBOURG-EN-COTENTIN, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, REGIONE LAZIO, Vlaamse Vervoersmaatschappij De Lijn, Provincie Zuid-Holland, LONDON BUS SERVICES LIMITED, ROTTERDAMSE ELEKTRISCHE TRAM NV, WaterstofNet vzw, FIT CONSULTING SRL, UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA

MAIN OBJECTIVES OF THE PROJECT

By achieving significant reductions of Fuel Cell buses, 3Emotion seeks to bridge the gap between current small scale demonstration projects towards larger scale deployment as foreseen by the Bus Commercialisation study. The demonstration activities in five key EU bus markets: London, Rotterdam, Antwerp, Rome and Cherbourg, the project demonstrates across Europe the potential value of this technology for different types of bus fleets. In addition, key information and opportunities to experience daily FCB operations in several locations in Europe will be generated.

PROGRESS/RESULTS TO-DATE

- The project is installed and functional: first administrative deliverables are defined, future way of working is defined.
- Two sites has ordered the equipment to be demonstrated (FC buses).
- The other sites are in negotiation about the purchase of the equipment. The site of Antwerp has to be redefined.

FUTURE STEPS

Accomplishment of the tender processes for FC Buses in Cherbourg and Rome.
A redefinition of the Antwerp demonstration site.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

Tendering for new technology as FC Buses in a strict defined legal framework has been shown a difficult process.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Reduce FC Bus cost	Not specified for time interval between 2012 and 2017	€850,000	85 %	850,000-900,000 €/bus (tender results 3E)	
Reduce FC Bus fuel consumption	2017: 8.51 kg/100km	Buses not in operation yet	unknown	8-11 kg H_2/100 km, very variable depending on the type of use	
Increase FC bus system lifetime	2017: 15,000 hours	Guaranteed by FC Supplier	100 %	15,000 h (High V.LO City data)	
Increase vehicle availability	2017: 90 %	Preceding project High V.LO City supports the achievability of this target	50 %	85-92 % (CHIC, High V.LO City and HyTransit results)	
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-2
Deployment of FC Bus fleets in 2 existing and 3 new sites in Europe: 22 new buses.	(2015) The large scale demonstration of FCEV's including HRI build-up.	4 buses are in production, purchase for 13 in negotiation.		56 FC Buses are in service (CHIC dissemination package)	
The refuelling stations in 3E will be used to refuel fleets of more than 5 buses.	(2015) Focus on hydrogen refuelling stations with higher capacity.	Start of production of HRI's in negotiation.	50 %	Largest amount of buses for one station: 10 (Aberdeen)	

ALKAMMONIA

Ammonia-fuelled alkaline fuel cells for remote power applications.

PANEL 3

Technology validation in stationary applications

ACRONYM	ALKAMMONIA
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 DATE	1/05/2013
END DATE	30/04/2017
PROJECT TOTAL COST	€2,8 million
FCH JU MAXIMUM CONTRIBUTION	€1,9 million
WEBSITE	http://alkammonia.eu/

PARTNERSHIP/CONSORTIUM LIST

AFC ENERGY PLC, ACTA SPA, UNIVERSITAET DUISBURG-ESSEN, ZENTRUM FÜR BRENNSTOFFZELLEN-TECHNIK GMBH, UPS SYSTEMS PLC, PAUL SCHERRER INSTITUT, FAST – FEDERAZIONE DELLE ASSOCIAZIONI SCIENTIFICHE E TECNICHE

MAIN OBJECTIVES OF THE PROJECT

In project ALKAMMONIA a proof-of-concept system designed to provide power for telecommunication mast applications is being developed and tested. The project integrates innovative and proven technologies: an efficient alkaline fuel cell system, a novel ammonia fuel system which consists of a fuel delivery system and a cracker system for generation of high purity hydrogen. These components are being developed to produce a prototype and integrated system showing the benefits of the concept. Once integrated, the system will be tested and results shared with end-users.

PROGRESS/RESULTS TO-DATE

- A two-dimensional, non-isothermal and stationary simulation model of a complete alkaline single cell has been developed.
- A pre-prototype fuel cell system has been built.
- Development of an effective catalyst for ammonia cracking is on schedule.
- A high-level integrated system design has been completed.
- Project presented at various conferences; scientific paper published.

FUTURE STEPS

- Develop and complete fuel cell prototype.
- Develop and complete ammonia cracker prototype.
- Refine power conditioning.
- Develop next generation cartridge.
- Further work on life-cycle and economic analyses to include new data acquired from cell and cracker development.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Alkaline fuel cell modelling highly dependent on actual data from fuel cell and cracker.
- Fuel cell and cracker must be developed hand-in-hand.
- Life Cycle Analysis revealing valuable insight into all environmental factors to be considered.
- Fuel cell efficiency can / will be further improved with more systematic development.
- System integration into relatively small container requires smart design and arrangement of components.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES /TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Integration of the cracker and the alkaline fuel cell technologies into a proof-of-concept system	Multi-MW installed electrical capacity in the EU for precommercial demonstration	System designed, built and currently being tested; updated system and stack are in preparation	90 %	Project is setting state-of-the-art	
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2012
Ammonia cracker that uses a combustion process to provide the heat for the dissociation process	Novel system architectures, including new fuel processing and storage materials	Burning of "off-gas" will improve the efficiency of cracking	98 %	Project is setting state-of-the-art	
Detailed analysis of the environmental and socio-economic impacts of the proof of concept system	Assessment of the fuel cell system's ability to successfully compete with existing technologies	Additional data gathered for multi-criteria decision analysis and further cost analysis	99 %	Project is setting state-of-the-art	

ARTEMIS

Automotive PEMFC range extender with high temperature improved MEAs and stacks

PANEL 2

Research activities for transport applications

ACRONYM	ARTEMIS
CALL TOPIC	SP1-JTI-FCH.2011.1.5: Next generation European MEAs for transportation applications
START DATE	1/10/2012
END DATE	31/12/2015
PROJECT TOTAL COST	€2,8 million
FCH JU MAXIMUM CONTRIBUTION	€2,8 million
WEBSITE	http://www.artemis-htpem.eu/

PARTNERSHIP/CONSORTIUM LIST

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, NEDSTACK FUEL CELL TECHNOLOGY BV, FUNDACION CIDETEC, CENTRO RICERCHE FIAT SCPA, POLITECNICO DI TORINO

MAIN OBJECTIVES OF THE PROJECT

ARTEMIS aimed at the development of new materials having higher performance and greater stability than current commercial materials for High Temperature PEMFC (130-180 °C) including a membrane, anode and cathode catalysts, and their implementation in MEAs and the MEAs in stacks, for application in an automotive range extender. The project plan included scale-up up to a 0.3 kW stack and consideration of scale-up to a 3 kW_e stack.

PROGRESS/RESULTS TO-DATE

- Cross-linked polybenzimidazole membrane with electrospun cross-linked reinforcement has conductivity >130 mS/cm at 130 °C, scaled-up to 400 cm^2.
- Electrodes fabricated after ink optimisation. Full size (200 cm^2) ARTEMIS MEAs produced by optimising the assembly parameters and sub-gaskets.
- ARTEMIS MEAs exceed 0.5 W/cm^2 at 1 A/cm^2 in 25 cm^2 single cells, and can be operated to 2 A/cm^2 (0.4 V) at ambient pressure, no humidification, 160 °C.
- ARTEMIS MEAs comprising ARTEMIS membrane and GDEs operated with range extender protocol >2200 hours without failure.
- Four-cell HT PEMFC stack produces >0.3 kW_e at 160 °C at ambient pressure and without humidification for currents over 165 A (825 mA/cm^2).

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:		MAWP 2008-2013	
New materials for high temperature MEAs and stacks	Membrane, catalyst, GDE, plate materials development	Membrane, electrode and plate materials with target specifications.	100 %
Automotive range extender application, 130-180 °C	Transport application, high temperature operation	MEAs operating 130-180 °C on RE protocol >2200 h to EoT	100 %
0.3 kW stack	MAIP 1- 10 kW built stack	0.3 kW_e stack built with ARTEMIS MEAs and tested	100 %
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:		AWP 2012	
MEA power density of 0.5 W/cm^2 @ 1 A/cm^2	Quantitative MEA target	MEA power density of 0.55 W/cm^2 @ 1 A/cm^2. Operation possible to 2 A/cm^2.	100 %
Acid loss and degradation understanding	Development of modelling tools	Models developed and used to assess FC performance and GDL degradation	100 %
(c) Other project objectives			
Dissemination of project results	Not applicable	Organisation of an ARTEMIS dissemination workshop	

ARTIPHYCTION

Fully artificial photo-electrochemical device for low temperature hydrogen production

PANEL 5	Hydrogen production, distribution and storage: research and validation
ACRONYM	ARTIPHYCTION
CALL TOPIC	SP1-JTI-FCH.2011.2.6: Low-temperature H_2 production processes
START DATE	1/05/2012
END DATE	31/10/2015
PROJECT TOTAL COST	€3,5 million
FCH JU MAXIMUM CONTRIBUTION	€2,1 million
WEBSITE	http://www.artiphyction.org/

PARTNERSHIP/CONSORTIUM LIST

POLITECNICO DI TORINO, HYSYTECH S.R.L., COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS, SOLARONIX SA, L'UREDERRA, FUNDACION PARA EL DESARROLLO TECNOLOGICO Y SOCIAL, TECNOLOGIA NAVARRA DE NANOPRODUCTOS SL, PYROGENESIS SA

MAIN OBJECTIVES OF THE PROJECT

The main project targets are:

1) 5 % Solar to Hydrogen (STH) efficiency (LHV basis) by exploiting improved and novel nano-structured materials for photo-activated processes.
2) Chemical systems for highly efficient low temperature water splitting using solar radiation with no noble metals employed.
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

- Best results achieved with a CoPi-catalysed Mo-doped BiVO4 photo-anode and a Co NPs-based cathodic electro-catalyst.
- 3 % STH efficiency achieved in the final 1,6 m^2 Artiphyction prototype with a bias generated via PV tiles covering the reactor frame.
- <10 % performance degradation over 1,000 h operation could be achieved only when operting at about 2 % STH efficiencies.
- A modular PEC concept was conceived and developed to fit the entire span of production ranges targeted.
- No noble metals were employed.

FUTURE STEPS

- Re-design of the reactor to achieve 5 % STH efficiency. Model calculaitons show this can be achieved.
- Development of more resistant anode photocatalysts with less sensitivity to (photo)corrosion to achieve durability targets.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The partnership believes that the above future steps should allow the fulfilment of the efficiency target with confidence.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET (%)	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					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 is 100 % reached.	Test the smallest scale of the range aside is 100 % reached.	The project has been a worldwide reference for the scale reached (1,6 m^2 PEC area).
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
Sun-to-hydrogen conversion efficiency	5 %	3 % efficiency achieved	No chance within Artiphyction, high chance in a future project.		Higher efficiencies were obtained but at mush smaller scales and with higher cost materials (e.g. multijunction semiconductors)
Durability	10,000 h	10 % performance loss over 1,000 h operation.	This is very critical. Chances are moderate within a future project.		

AutoRE

AUTomotive deRivative Energy system

PANEL 3
Technology validation in stationary applications

ACRONYM	AutoRE
CALL TOPIC	FCH-02.5-2014: Innovative fuel cell systems at intermediate power range for distributed combined heat and power generation
START DATE	1/08/2015
END DATE	31/07/2018
PROJECT TOTAL COST	€4,4 million
FCH JU MAXIMUM CONTRIBUTION	€3,4 million
WEBSITE	http://www.autore-fch.com/

PARTNERSHIP/CONSORTIUM LIST

ALSTOM POWER LTD, GENERAL ELECTRIC (SWITZERLAND) GMBH, DAIMLER AG, ELVIO ANONYMI ETAIREIA SYSTIMATON PARAGOGIS YDROGONOU KAI ENERGEIAS, SVEUCILISTE U SPLITU, FAKULTET ELEKTROTEHNIKE, STROJARSTVA I BRODOGRADNJE, UNIVERSITA DEGLI STUDI DELLA TUSCIA, STIFTELSEN SINTEF

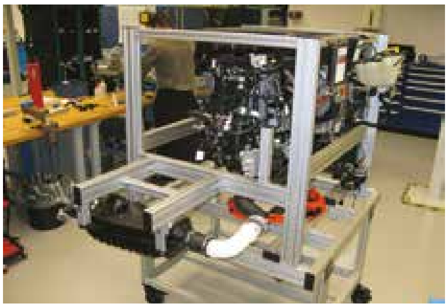
MAIN OBJECTIVES OF THE PROJECT

The main project objective is to create the foundations for commercialising an automotive derivative fuel cell system in the 50 to 100 kW_e range, for combined heat and power in commercial and industrial buildings.

1. To develop system components allowing reduced costs, increased durability and efficiency and, ultimately, allowing the levelised cost of electricity (LCOE) to reach grid parity
2. To build and validate a first 50 kW_e PEM prototype CHP system. To create the required value chain from automotive manufacturers to stationary energy end-users.

PROGRESS/RESULTS TO-DATE

- Full consortium meeting for project kick-off, first deliverable: management manual submitted and distributed to partners.
- First general assembly meeting held, website and logo created.
- System requirements determined and testing plan completed.
- Numerical performance modelling of the system completed; The PEM fuel cell stack (electrochemical), the fuel processor (thermo-chemical) & the BoP.
- Short stacks ordered and to be delivered this month.



FUTURE STEPS

- The system design will be finalised and the procurement plan made.
- Short' stacks will be adapted to operate on reformate gas and a report will document the results of these tests.
- Design and construction of the hydrogen production system including reactors, heat exchangers and steam generators.
- Validation and updating of performance model with single component and whole system test results.
- Delivery of fuel cell for integration into energy system.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Project at early stage of development, no major findings or conclusions yet.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAWP 2014-2020
System CAPEX <€3,000/kW	2017: CAPEX of €5-8.5k/kW	Testing stage not reached yet.	90 %	€6-10k/kW (2012)
Stack life-time >30,000 h, 15y operation	2017: 6-20 years of plant operation	Testing stage not reached yet.	90 %	2-20y (2012)
Scheduled and preventive maintenance for reaching >98 % availability	2017: 97 % plant availability	Testing stage not reached yet.	90 %	97 % (2012)
Electrical efficiency: End of project: 40 % Long term: 47 %	2017: 41-50 % electrical efficiency (LHV)	Projected up to 40 % (from modelling).	90 %	"39 %-43 % http://panasonic.co.jp/ap/FC/en_about_01.html http://www.nrel.gov/hydrogen/highlight-stationary-fc.html
Thermal Efficiency: >43 %	2017: 24-41 % thermal efficiency (LHV)	Testing stage not reached yet.	90 %	56 % http://panasonic.co.jp/ap/FC/en_about_01.html
Grid parity at mass production	2017: LCOE of 2.5*grid parity € ct/kWh	Testing stage not reached yet.	90 %	3*grid parity
NOx<40mg/kWh	2017: NOx emissions <40 mg/kWh	Testing stage not reached yet.	90 %	NOx<40

AUTO-STACK CORE

Automotive Fuel Cell Stack Cluster Initiative for Europe II

PANEL 2
Research activities for transport applications

ACRONYM	AUTO-STACK CORE
CALL TOPIC	SP1-JTI-FCH.2012.1.2: Next Generation European Automotive Stack
START DATE	1/05/2013
END DATE	28/02/2017
PROJECT TOTAL COST	€14,6 million
FCH JU MAXIMUM CONTRIBUTION	€7,7 million
WEBSITE	http://autostack.zsw-bw.de/index.php?id=1&L=1

PARTNERSHIP/CONSORTIUM LIST

ZENTRUM FUER SONNENENERGIE- UND WASSERSTOFF-FORSCHUNG, BADEN-WUERTEMBERG, BELENOS CLEAN POWER HOLDING AG, BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, REINZ-DICHTUNGS GMBH, FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V, JRC -JOINT RESEARCH CENTRE-EUROPEAN COMMISSION, FREUDENBERG FCCT SE & CO. KG, PAUL SCHERRER INSTITUT, Powercell Sweden AB, SOLVICORE GMBH & CO KG, SYMBIOFCELL SA, VOLKSWAGEN AG, VOLVO TECHNOLOGY AB, FREUDENBERG VLIESSTOFFE KG, SWISS HYDROGEN SA

MAIN OBJECTIVES OF THE PROJECT

Development of an automotive PEM fuel cell stack developed to automotive standards. Two stack evolutions will be built and tested in hardware, a third evolution will be designed. Component development is carried out based on industrial manufacturing concepts. Cost engineering is carried out to ensure the design meets automotive cost targets.

PROGRESS/RESULTS TO-DATE

- Stack evolution 1 designed, built and tested in more than 20 short stacks and one full sized stack.
- Design of evolution 2 stack completed. Significant reduction in weight and volume achieved.
- Evolution 2 component manufacturing and stack roll-out started. Evolution 2 test program started.
- Evolution 2 cost engineering study completed. Specific cost of <€38.31/kW.
- Evolution 3 design phase started.

FUTURE STEPS

- Completion of evolution 2 roll-out and test program.
- Improve CCM and GDL-selection.
- Completion of evolution 3 design.
- Continuation of benchmark studies.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Evolution 1 hardware successfully designed, built and tested as short and full sized stacks.
- Evolution 2 hardware successfully designed and built.
- Evolution 2 testing campaign started, initial results indicate high power density at low PGM-loading: (>2.75 kW/kg; >3.1 kW/kg @ 0.32 g/kW PGM).

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
	Integrate the fragmented PEM stack research and development activities in Europe	Consortium formed from OEMs, supply industry, system integrators and research	100 %		Objective achieved
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2012
Gross power 95 kW	Gross power 95 kW	Evo 2: 98 kW (extrapolated)	100 %	114 kW (TOYOTA)	Evo 3 design will consider increased power demand
Specific power 2.15 kW/kg	Specific power >2 kW/kg	Evo 2 (extrapolated) >2,75 kW/kg	100 %	2.0 kW/kg (TOYOTA)	Objective achieved
(c) Other project objectives:					
PGM-loading Evo 2 0.4 g/kW	Not applicable	Eva 2: 0,32 g/kW	100 %	~ 0.3 g/kW (TOYOTA)	Improve power density by use of thinner membrane and improved GDL
<€30/kW @ 500,000 units p.a.	Not applicable	Eva 2: <€38,31/kW @ 30,000 units p.a.	100 %	36.05 US$ x kW-1 @ 30,000 units p.a. (US DoE)	Achievement of cost target expected from learning curves

BEINGENERGY

Integrated low temperature methanol steam reforming and high temperature polymer electrolyte membrane fuel cell

PANEL 4
Research activities for stationary applications

ACRONYM	BEINGENERGY
CALL TOPIC	SP1-JTI-FCH.2011.4.4: Research, development and demonstration of new portable Fuel Cell systems
START DATE	1/09/2012
END DATE	29/02/2016
PROJECT TOTAL COST	€4,2 million
FCH JU MAXIMUM CONTRIBUTION	€2,2 million
WEBSITE	http://www.beingenergy.eu/

PARTNERSHIP/CONSORTIUM LIST

UNIVERSIDADE DO PORTO, DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, Teknologian tutkimuskeskus VTT Oy, SerEnergy A/S, CONSIGLIO NAZIONALE DELLE RICERCHE, UNIVERSITAT POLITECNICA DE VALENCIA, INOVAMAIS – SERVICOS DE CONSULTADORIA EM INOVACAO TECNOLOGICA S.A., Rhodia Operations

MAIN OBJECTIVES OF THE PROJECT

- Synthesizing, characterizing, and optimizing catalysts for low temp. methanol steam reforming (LT-MSR, 180 °C) & developing strategies for industrial prep. of selected catalysts.
- Development, characterization & optimization of cell-reactor for LT-MSR.
- Integration, characterization & optimization of LT-MSR reactors with high temp. PEMFC (HT-PEMFC).
- Development, characterization and optimization of a LT-MSR/HT-PEMFC 500 W_e prototype.

PROGRESS/RESULTS TO-DATE

- The BeingEnergy catalyst (CuZnZrGa) is more efficient ca. 2 times higher activity) than G66-MR, from Süd Chemie, at 180 °C.
- Thermal coupling & operation of a HT-PEMFC with a LT-MSR was demonstrated experimentally, with efficiencies >35 %.
- A new bipolar plate material was tested & FC stack lifetime increased to >16000 h.
- 500 W_e cooled FC system with liquid heated reformer was built and operated for 852 h, with avg. electric efficiency of 38 %.

FUTURE STEPS

- Use of Beingenergy catalyst in the 500 We prototype.
- Optimization of startup procedure of the power supply to reach 15-20 minutes.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- New catalyst, 2x more active and more selective.
- New bipolar plates / HT-PEMFC stack: much higher lifetime, better thermal energy integration & faster start up
- New reformer much smaller, with a far more efficient heat-exchange design.
- New and disruptive design associating reformer with fuel cells in a combined stack with a thin Pd-membrane divided the two reactors.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Electrical efficiencies >45 % for power only units	Program targets electrical efficiency for the combined power supply>30 % and the project aims>35 %	>35 %	100 %	Electrical efficiency for related power supplies: 27 % [Ballard, 5 kW system (1.1 LMeOH/kW)]	A new and far more active catalyst is now being up-scaled and will be soon tested
Lower emissions and use of multiple fuels	The project targets the use methanol as fuel. No objectives were defined concerning emissions.				
Cost of €1,500 – 2,500/kW for industrial/commercial units	€5,000/kW for the combined power supply unit at mass production	Mass production price of €5,656/kW	N/A		Research to continue after project for better/cheaper power supplies
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
Proof of concept systems containing stacks	Project expects an integrated unit between methanol reformer FC stack	Prototype w/methanol reformer & FC stack working @ 180 °C built and tested.	100 %	Many labs working on synergetic integration of HT-PEMFC & LT-MSR, but still no commercial units	
Demonstrate electrical efficiency >30 %	Nominal electrical efficiency: >35 %	>35 %	100 %		
1,000 h lifetime incl. 100 start-stop cycles @ <35 kg/kW and 50 L/kW	Operation lifetime >1000 h; specific size/weight <35 kg/kW and 50 L/kW	Operation lifetime >1500 h; 82 kg/kW & 215 L/kW	N/A		For larger systems, the power and volume per power should decrease substantially
(c) Other project objectives					
Development of a highly performing and stable LT-MSR catalyst	N/A	Catalyst (CuZnZrGa) proved more efficient (activity x2) vs G66-MR (Süd Chemie)		Commercial SoA catalyst: BASF (RP 60). Best lab catalyst: Tsang [doi:10.1038/ncomms2242]	
Modeling of Membrane Reactors for LT-MSR reaction	Modeling+exp. demo that MSR reaction works in Pd-based MRs at >280 °C	Pure H_2 produced by self-supported Pd-based MR @ 280 °C	N/A		Silica & composite Pd-based MRs could be a serious alternative to expensive self-supported MRs for high grade H_2 by MSR

BIONICO

BIOgas membrane reformer for decentralized hydrogen production

PANEL 5

Hydrogen production, distribution and storage: research and validation

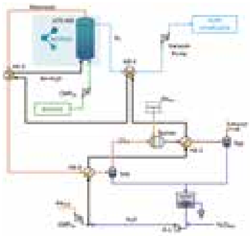
ACRONYM	BIONICO
CALL TOPIC	FCH-02.2-2014: Decentralized hydrogen production from clean CO_2-containing biogas
START DATE	1/09/2015
END DATE	31/08/2018
PROJECT TOTAL COST	€3,3 million
FCH JU MAXIMUM CONTRIBUTION	€3,1 million
WEBSITE	http://www.bionicoproject.eu/

PARTNERSHIP/CONSORTIUM LIST

POLITECNICO DI MILANO, FUNDACION TECNALIA RESEARCH & INNOVATION, TECHNISCHE UNIVERSITEIT EINDHOVEN, JOHNSON MATTHEY PLC, ABENGOA HIDROGENO SA, QUANTIS SARL, RAUSCHERT KLOSTER VEILSDORF GMBH, ENC POWER LDA

MAIN OBJECTIVES OF THE PROJECT

BIONICO will develop, build and demonstrate at a real biogas plant (TRL6) a catalytic membrane reactor integrating in a single vessel production and separation of 100 kg/day of H_2. Direct conversion of biogas to pure hydrogen is achieved in a single step, with increase of the overall efficiency (up to 72 %), strong decrease of volumes and auxiliary heat management units and reduction of operating temperature. Fluidization of the catalyst allows overcoming problems with temperature and concentration control and operating with smaller particles maintaining very low pressure drops.



PROGRESS/RESULTS TO-DATE

- Indetification of the preliminary BIONICO system design
- Identification and evaluation of the cost and performance of the reference technology for H_2 production from biogas to benchmarck BIONICO.
- Long term testing of the catalyst based on projecr FERRET under simulated biogas feed.
- Evaluation of two sealing methods – thin Pd-Ag dense membranes supported on Al2O3 and on ZrO_2 supports and selection of the best one.
- Test at lab scale of the first batches of catalysts and membranes.

FUTURE STEPS

- Final selection and manufacturing of the catalyst for the prototype.
- Final selection and manufacturing of the membrane for the prototype.
- Definition of the process flow diagrams of the pilot plant.
- Design of the membrane reactor.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET (%)	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2014-2020
Hydrogen production efficiency of 72 %	Innovation pillar 2, 1.b /Distributed H_2 production from biogas, efficiency (HHV) /70 % 2017	On-going	90 %	64 %	On-going. Tests at lab-scale will be used to assess the reactor performances and integrate them in the overall process flowsheet
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2014
Hydrogen production efficiency of 72 %	Increasing High Heating Value (HHV) efficiency up to 72 %	On-going	90 %	64 %	On-going. Tests at lab-scale will be used to assess the reactor performances and integrate them in the overall process flowsheet
Perform hydrogen production in one single step	Eliminate feedstock upgrading steps by developing more stable in time catalytic reactor systems	On-going	100 %	4 steps	
Demonstrate BIONICO concept at a landfill plant delivering 100 kg/day of hydrogen	Design, build, operate a reactor for continuous H_2 production at pre-commercial scale(50-250 kg/day)	On-going	90 %		

BIOROBUR

Biogas robust processing with combined catalytic reformer and trap

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	BIOROBUR
CALL TOPIC	SP1-JTI-FCH.2012.2.3: Biogas reforming
START DATE	1/05/2013
END DATE	31/08/2016
PROJECT TOTAL COST	€3,8 million
FCH JU MAXIMUM CONTRIBUTION	€2,4 million
WEBSITE	http://www.biorobur.org/

PARTNERSHIP/CONSORTIUM LIST

POLITECNICO DI TORINO, TECHNISCHE UNIVERSITAET BERGAKADEMIE FREIBERG, SCUOLA UNIVERSITARIA PROFESSIONALE DELLA SVIZZERA ITALIANA (SUPSI), CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS, Erbicol SA, HYSYTECH S.R.L., UAB MODERNIOS E-TECHNOLOGIJOS, PIRELLI & C. ECO TECHNOLOGY RO SRL

MAIN OBJECTIVES OF THE PROJECT

The project objective is 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. The nominal production rate of pure hydrogen of the BioRobur fuel processor is 50 Nm^3/h with an overall efficiency of the conversion of biogas to green hydrogen of 65 %.

PROGRESS/RESULTS TO-DATE

- 15-0,05 wt.% Ni-Rh/MgAl2O4 formulation was identified as a robust catalyst for autothermal reforming of biogas.
- LiFeO2 catalyst was selected as the most prominent candidate towards to carbon gasification in a reducing atmosphere.
- Homogenous SiSiC lattice structures composed of Cubic, Octet and Kelvin cells and the conventional foam structure supports were designed and tested.
- The Life-cycle analysis (LCA) has demonstrated that BioRobur is the most promising process to hydrogen production compared to other technologies.
- Preliminary tests in the demonstration BioRobur plant were performed.

FUTURE STEPS

- Final optimization of the biogas reformer.
- Tests with the integration of the catalytic trap downstream of the reforming reactor with the catalyzed foam and rotated cubic cell structures.
- Long duration test.

- Scale-up/marketing analysis and technology implementation plan.
- Dissemination and training activities.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Obtained results from the test-rig showed the rotated cube cell as the most suitable support structure for the BioRobur process.
- 15-0,05 wt.% Ni-Rh/MgAl2O4 and LiFeO2 catalysts were deposited over the auto-thermal reforming support and over the wall-flow filter, respectively.
- The Biorobur plant was able to reach the target with a nominal production rate corresponding to 50 Nm^3/h of hydrogen.
- Aspen results and LCA analysis showed that Biorobur concept is more efficient compared to other types of reforming process.
- Hazop and Safety Integrity Levels (SIL) analysis were performed.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2012
Nominal production rate of pure hydrogen (kg/day)	100 %	Target reached in the preliminary test using a noble metal based coated monolith.	During the preliminary test, the BioRobur plant was able to reach the nominal capacities corresponding to 50 Nm^3/h of hydrogen using as a noble metal based coated monolith.	Tests with Biorobur catalysts and supports are in progress.
CO concentration at the reformer exit (vol%) (dry basis)	<10 %	Target reached in the preliminary test using a noble metal based coated monolith.		
Biogas to hydrogen conversion efficiency (%)	>65 %	Target reached in the preliminary test using a noble metal based coated monolith.		
Materials costs for a 50 Nm^3/h hydrogen production rate (€)	<250,000 %			

BOR4STORE

Fast, reliable and cost effective boron hydride based high capacity solid state hydrogen storage materials

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	BOR4STORE
CALL TOPIC	SP1-JTI-FCH.2011.2.4: Novel H_2 storage materials for stationary and portable applications
START DATE	1/04/2012
END DATE	30/09/2015
PROJECT TOTAL COST	€4 million
FCH JU MAXIMUM CONTRIBUTION	€2,2 million
WEBSITE	http://bor4store.hzg.de/

PARTNERSHIP/CONSORTIUM LIST

HELMHOLTZ-ZENTRUM GEESTHACHT ZENTRUM FUR MATERIAL- UND KUSTENFORSCHUNG GMBH, ABENGOA HIDROGENO SA, ZOZ GMBH, KATCHEM SPOL SRO, AARHUS UNIVERSITET, INSTITUTT FOR ENERGITEKNIKK, UNIVERSITA DEGLI STUDI DI TORINO, EIDGENOESSISCHE MATERIALPRUEFUNGS- UND FORSCHUNGSANSTALT, NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS"

MAIN OBJECTIVES OF THE PROJECT

- Development of high capacity boron hydride-based compounds for H_2 storage.
- Fundamental investigations for understanding microstructures & hydrogenation properties.
- Selection of the most suitable material for use in H_2 storage tank
- Development of heat management system for heat transfer from an SOFC to the metal hydride store.
- Development of boron hydride-based solid state H_2 storage tank, thermally integrated with a SOFC, to demonstrate energy-efficient operation using SOFC off-heat only for H_2 release.

PROGRESS/RESULTS TO-DATE

- Fundamental understanding of reactions in a range of different high capacity boron hydride-based H_2 storage materials.
- Best storage material: LiBH4/MgH_2 RHC.: ca. 10 wt.%, 100 kg H_2/m^3. Loading time <1 h @ 50 bar, operating temp. 350-600 °C.
- Storage material mech.-chem. processing @<€1/kg. Prelim. succesful evaluation of various waste as cheap raw materials.
- Integrated SOFC/metal hydride tank systems simulation model, analysis of different heat transfer options between SOFC.
- Single tank modules constructed & certified. Optimised integrated system heat exchange established, under construct.

FUTURE STEPS

- Finalisation of heat transfer system. Establishment of fully integrated system.
- Testing of fully integrated system planned for 2016/2017.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Certain boron hydride-based storage materials offer suitable properties for hydrogen storage in SOEC/SOFC systems.
- Critical points with these materials: supply safety (boron) and cost. Novel approach: use of metal waste as raw materials.
- Thermal integration @ 650 °C for safe system technically feasible, but costly. More cost effective solutions have to operate @ <= 450 °C.
- Promising: exploiting reaction heats of metal hydrides for heat management of reversible power-to-power systems (e.g. reversible solid oxide cells, rSOCs) for increased energy efficiency.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET (%)	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Capacity 1 kg of H_2, potential cost <€500/kg	Storage of H_2 in solid materials - 2015: 5 t capa., €1.5 M/t	Modular storage system. Current cost ca. €5 k/kg H_2 stored	N/A - project finished	Project results	Future cost prospects for boron hydride prod. unclear (unclear market situation)
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					project results
capacities of >80 kg H_2/m^3 and >8 wt.%	Storage materials with capacities >6 wt.%, >60 kg H_2/m^3	Ca. 100 kg H_2/m^3, 9 – 10 wt.% on materials basis	100 %	Project results	
Release temperature 450 °C (compatible with SOFC)	Reversible H_2 release at operating temp. compatible with PEM FC, HT PEM FC or SOFC / MCFC	Release temperature 350-450 °C	100 %	Solid state H_2 storage systems, operating at <=50 bar: max.ca. 1-2 wt.%, ca. 35-50 kg H_2/m^3	
Loading time <1 h	Appropriate H_2 loading/unloading kinetics for the application	Loading time < 1 h in materials testing	100 %	C.f. above	
Prototype storage system with capacity >4 wt. %, >40 kg H_2/m^3	Small prototype syst. w/improved storage capa. vs compressed gas (>4 wt.%, >40 kg H_2/m^3)	Storage tank module construction, building & certification finished	N/A – project finished	Solid state based hydrogen storage systems, operating at <= 50 bar: max.ca. 1-2 wt.%, ca. 35-50 kg H_2/m^3, e.g. J.M. Bellosta von Colbe et al., Int. J. Hydrogen Energy 37 (2012) 2807-2811.	Exact storage weight & vol only known when system construction is finalised
Potential for reaching long-term target: system cost €500/kg H_2	Demonstrate potential for reaching long-term target: system cost €500/kg H_2	Prototype system under construction	N/A – project finished		Future cost prospects for boron hydride prod. unclear (unclear market situation)

CATAPULT

Novel catalyst structures employing Pt at Ultra Low and zero loadings for automotive MEAs

PANEL 2
Research activities for transport applications

ACRONYM	CATAPULT
CALL TOPIC	SP1-JTI-FCH.2012.1.5: New catalyst structures and concepts for automotive PEMFCs
START DATE	1/06/2013
END DATE	31/05/2016
PROJECT TOTAL COST	€4,6 million
FCH JU MAXIMUM CONTRIBUTION	€2,2 million
WEBSITE	http://www.catapult-fuelcells.eu/

PARTNERSHIP/CONSORTIUM LIST

UNIVERSITE DE MONTPELLIER, JOHNSON MATTHEY FUEL CELLS LIMITED, VOLKSWAGEN AG, BENEQ OY, TECHNISCHE UNIVERSITAET MUENCHEN, Teknologian tutkimuskeskus VTT Oy, UNIVERSITAET ULM, PRETEXO

MAIN OBJECTIVES OF THE PROJECT

The objective of CATAPULT is to develop ultra-low Pt loading cathode catalysts with mass activity exceeding that obtained with reference Pt/C using ultra-thin extended film coatings on novel nanostructured (fibrous) corrosion-resistant supports, and non-PGM catalysts and integrate the novel catalysts into MEAs. Modelling efforts support the materials development and provide fundamental insights into catalyst surface and crystallographic properties and the oxygen reduction reaction. The final aim is to achieve a platinum specific power density of 0.1 g/kW Pt.

PROGRESS/RESULTS TO-DATE

- Nanofiber supports and tie-layers using electrospinning and atomic layer deposition are corrosion-resistant, electronically conducting, scalable.
- Pt films deposited by atomic layer deposition on corrosion resistant fibrous supports exceed target mass activity, >0.5 A/mg Pt.
- Novel non-PGM catalysts with ultra-low Pt content demonstrate high stability in MEAs.
- Most mature catalyst has been scaled-up and integrated into novel electrode designs, and MEAs of size 50 cm^2 active area.
- DFT-validated force-field model of the oxidative disruption of Pt (111) crystal facets shows they are unlikely to persist in fuel cell operation.

FUTURE STEPS

- Complete technical assessment against incumbent conventional Pt/C catalysts.
- Complete final MEA performance, in situ accelerated stress test and catalyst durability testing.
- Finalise reports.
- CATAPULT ends 31/05/2016 – most promising technologies will be pursued in FCH 2 JU INSPIRE.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Pt thin films or nano-islands deposited on fibrous supports show high mass activity in ring disk electrode (RDE).
- Catalyst layer development with fibrous architecture electrocatalysts requires better understanding of the limiting factors.
- Future focus is needed also on use of alternative tie-layer compositions favouring Pt deposition as ultra-thin films.
- Current catalyst layer designs comprising novel extended thin layer catalysts show much higher stability to voltage cycling than conventional Pt/C.
- 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

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAWP 2008-2013
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AWP 2012
Nanometric supports with σ >10-2 S/cm	Development of robust and corrosion resistant supports	Nanofibrous supports with σ >10^{-2} S/cm and 10 times lower corrosion current than carbon black	100 %	
Development of ultra-low Pt loading catalysts by atomic layer deposition and electrochemical methods	Development of catalysts and electrode layers for significant reduction in precious metal loadings	Development of thin extended platinum surfaces having RDE mass activity >0.5 A/mg Pt.	100 % mass activity target reached in RDE.	Current status for MEA: 0.25 g Pt / kW at 70 % and 30 % RH
Development of iron-based and hybrid non-PGM-ultra-low Pt loading catalysts	Development of non-platinum based catalysts	Fe-based catalysts with high BoL performance, and stable hybrid non-PGM-ultra-low Pt catalysts.	100 % for development of new catalysts	MEA performance under automotive relevant conditions is 50 % of the target, however it exceeds the international SoA.
Supporting theoretical modelling to understand catalytic processes & catalyst-support interactions	Supporting theoretical modelling to understand catalytic processes & catalyst-support interactions	Pt-support tie-layers for Pt wettability and catalytic activity predicted by modelling.	100 %	
Catalysts integrated into novel electrode designs and MEAs	Demonstration of long-term stability under automotive fuel cell conditions	MEA performance 60 % of target with current catalyst layer design. High stability to voltage cycling	60 %	MEA performance is 60 % of the target with the current catalyst layer designs comprising the novel extended thin layer catalysts. Much higher stability to voltage cycling than with conventional Pt/C.
Techno-economic assessment	Techno-economic assessment	Techno-economic status report made of five CATAPULT catalyst developments	100 %	The technologies are all significantly less mature than conventional Pt/C meaning that this assessment is a status report and not a final assessment.
(c) Other project objectives:				
International workshop	Not applicable	Intern'l conference "Challenges for Zero Pt for Oxygen Reduction", 13-16/09/2016, 170 participants.	100 %	La Grande Motte, France. Joint session CATAPULT – CATHCAT – NanoCat – SMARTCAT

CATHCAT

Novel catalyst materials for the cathode side of MEAs suitable for transportation applications

PANEL 2
Research activities for transport applications

ACRONYM	CATHCAT
CALL TOPIC	SP1-JTI-FCH.2011.1.5: Next generation European MEAs for transportation applications & SP1-JTI-FCH.2011.1.6: Investigation of degradation phenomena
START DATE	1/01/2013
END DATE	31/12/2015
PROJECT TOTAL COST	€3 million
FCH JU MAXIMUM CONTRIBUTION	€1,8 million
WEBSITE	http://www.cathcat.eu/

PARTNERSHIP/CONSORTIUM LIST

TECHNISCHE UNIVERSITAET MUENCHEN, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, UNIVERSITE DE POITIERS, DANMARKS TEKNISKE UNIVERSITET, CHALMERS TEKNISKA HOEGSKOLA AB, UNIVERSITA DEGLI STUDI DI PADOVA, ION POWER INC CORP, FOUNDATION FOR RESEARCH AND TECHNOLOGY HELLAS, TOYOTA MOTOR EUROPE

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 support materials. Based on density functional theory (DFT) calculations and experimental studies of bulk analogues of Pt and Pd – Rare Earth Element alloys full understanding of these materials should be achieved. Synthesis of promising catalysts was to be up-scaled and integrated with advanced supports into MEAs for single cell testing. MEAs based on Nafion and on high temperature polymer electrolytes were applied.

PROGRESS/RESULTS TO-DATE

- Theoretical studies for all Pt-RE alloys of interest were carried out and validated with experimental studies. Pt5Gd best catalyst.
- Pt-Gd nanoparticles are 3.6 x more active than Pt nanoparticles, from RDE tests a current density of 0.8 – 1.4 A cm^2 at 0.9 V extrapolated.
- Several techniques explored for fabrication of Pt-RE nanoparticles. Pt-Y catalyst upscaled for MEA manufacture.
- Modified supported materials have been developed and upscaled for MEA testing.
- Several catalysts have been tested in MEAs, but not yet with Pt-RE alloys. MEAs tested so far not better than benchmark MEA.

FUTURE STEPS

- Testing of MEA with Pt-Y- alloy catalyst
- Continuation of catalyst synthesis efforts in the framework of other projects.

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 further work required for upscaling.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
New improved MEAs based on stable catalysts for the ORR in PEMFCs	Electrochemically stable and low-cost catalysts for MEAs	Benchmarks MEAs and first CathCat MEA with modified Catalyst and Support tested	0 %	n/a	With a reduced Pt loading, advanced C-based and oxide-based support materials
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
Development of catalysts based on Pt or Pd – RE element alloys, based on DFT calculations	Development of catalysts for reduction in precious metal loading	Successful materials development and physical understanding. Not tested in normal MEA	100 %	n/a	PtxY & PtxGd nanoparticles improved mass activity (x3.6) and activity at larger particle size, synthesis of large amounts difficult
Development of advanced C and oxide based supports	Development of catalysts for reduction in precious metal loading	Successful RTD and half cell testing	100 %	n/a	Good performance of ring disk electrodes, contrary of MEA tests where amount of material didn´t suffice to optimize catalyst layer composition
Use of HT membranes and testing of catalysts under these conditions	Demonstration of HT properties	HT MEAs fabricated and tested	100 %	n/a	Pt-Co alloys on MWCNT synthesized, MEAs with Pt/C and Pt/MWCNT fabricated and tested up to 180 °C. No Pt-Y alloy tested.
Durability studies carried out using Surface Science and microscopic techniques	Demonstration of long-term stability under automotive FC conditions	Half cell testing demonstrated stability of the catalyst materials under relevant conditions	0 %	2500 h / DOE Annual Merit Review 2015	Durability of new catalysts in MEA poor (Pt-Y2O3) or not tested (Pt-Y) due to lack of material
<0.1 g/kW Pt, activity increase by factor 10	Pt loadings <0.15 g/kW, BoL>55% efficiency, >1 W/cm^2 @ 1.5 A/cm^2	0.4 g/kW; efficiency: 56% @1 A cm-2; 50% @ 1.5 A cm-2, power density: >0.9 W cm-2 @ 1.5 A cm-2	0 %	0.9 W cm-2 @ 1.5A cm-2 (2010, Wagner), 0.17 g/kW Pt US (NSTF) DOE Fiscal year 2014 Budget at a glance, (2012)	Benchmark MEA with 20 µm Nafion gave best results
(c) Other project objectives					
Development of Synthetic Procedures for Pt-rare earth nanoparticles fabrication	Not applicable	Methods developed, up-scaling challenging	0	n/a	Sputter-deposition techniques successfull, electrochemical methods promising, but further research required, solid state method successful.

CERTIFHY

Developing a European Framework for the generation of guarantees of origin for green hydrogen

PANEL 6 Cross-cutting	
ACRONYM	CERTIFHY
CALL TOPIC	SP1-JTI-FCH.2013.5.5 (2): Development of a European framework for the generation of guarantees of origin for green H_2
START DATE	1/11/2014
END DATE	31/10/2016
PROJECT TOTAL COST	€0,5 million
FCH JU MAXIMUM CONTRIBUTION	€0,43 million
WEBSITE	http://www.certifhy.eu/

PARTNERSHIP/CONSORTIUM LIST

HINICIO SA, STICHTING ENERGIEONDERZOEK CENTRUM NEDERLAND, TUV SUD INDUSTRIE SERVICE GmbH, Ludwig-Boelkow-Systemtechnik GmbH

MAIN OBJECTIVES OF THE PROJECT

The CertifHy project, supported by a wide range of key European industry leaders (gas companies, energy utilities, green hydrogen technology developers, automobile manufacturers and other leading industrial players) therefore aims to:

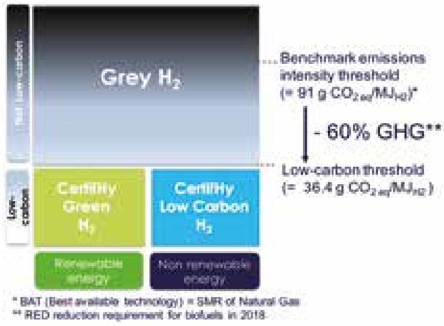
1. Define a widely acceptable definition of green hydrogen.
2. Determine how a robust Guarantee of Origin (GoO) scheme for green hydrogen should be designed and implemented throughout the EU.

PROGRESS/RESULTS TO-DATE

- Generic market outlook for hydrogen: overview of future trends, application areas and segmentation.
- Definition of "green" hydrogen: step-by-step consultation approach leading to a consensus common on the definition of green hydrogen in the EU (WP2).
- Review of existing platforms and interactions between existing GoO and green hydrogen; lessons learnt and mapping of interactions (WP3).

FUTURE STEPS

- Definition of a new framework of guarantees of origin for "green" hydrogen: technical specifications, rules and obligations for the GoO (WP4).
- Roadmap for the implementation of an EU-wide GoO scheme for green hydrogen: project implementation plan.



CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Under a policy-driven scenario, green hydrogen could represent about 15 % of all hydrogen demand in Europe by 2030, amounting up to 1.4 Mtons of H_2.
- CertifHy Green H_2 is from Renewable feedstock & has low GHG intensity. CertifHy Low Carbon H_2 is from non-renewable feedstock & low GHG intensity.
- When discussing a GoO scheme, it is important to distinguish the guarantee of origin from the actual product label.

CHIC

Clean Hydrogen in European Cities

PANEL 1

Technology validation in transport applications

ACRONYM	CHIC
CALL TOPIC	SP1-JTI-FCH.2009.1.1: Large-scale demonstration of road vehicles and refuelling infrastructure II
START DATE	1/04/2010
END DATE	31/12/2016
PROJECT TOTAL COST	€81,9 million
FCH JU MAXIMUM CONTRIBUTION	€25,8 million
WEBSITE	http://chic-project.eu/

PARTNERSHIP/CONSORTIUM LIST

EVOBUS and 25 partners

MAIN OBJECTIVES OF THE PROJECT

CHIC aimed to further enhance FC urban bus technology and offer a functional solution for cities to decarbonise their public bus fleets. For the H_2 Infrastructure targets were set for station refuelling capacity, availability, production efficiency, operating costs, H_2 purity, refuelling times and diesel replacement.
For the H_2FC buses targets were set for FC lifetime, fuel consumption, availability, running distance and hours of operation.

PROGRESS/RESULTS TO-DATE

- Buses have driven >9 million km satisfying daily demands of urban bus routes.
- Avg. 9 kg H_2/100km fuel efficiency for 12m buses -->25-30% more energy efficient vs diesel counterparts.
- High throughput; 350 bar stations are consistently achieving availability (98 %) and capacity (200 kg/day) targets.
- H_2FC buses achieve 10-100 % lower CO_2 emissions than diesel buses, depending on the primary energy source for H_2 generation.
- Bus availability and OPEX for the infrastructure remains a challenge (expected to be overcome with ramping up of bus numbers).

FUTURE STEPS

- CHIC cities are assessing the opportunity to continue operations after project end in Dec. 2016.
- H_2FC Bus Commercialisation Study proposes deploying a pan-European fleet of 500 buses by 2020, targeting cost reduction.
- CHIC project partners are sharing technical info and 'how to' guidelines with cities interested in procuring FC buses.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- CHIC has proved that FC buses can be operated with same flexibility and safety as diesel buses, with 0 tailpipe emissions and <noise.
- Purchase cost of a FC bus is <50 % vs 2011. Further reductions are needed to encourage widespread deployment.
- Many technological issues have been resolved within CHIC to increase bus availability; more buses will increase needed scale in the supply chain.
- Work is proceeding on standardising/simplifying designs for large HRS – to be harmonised at EU and international level.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) - indicate relevant multi-annual plan:					MAIP 2008-2013
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2009
AIP Objectives of the H_2 Infrastructure (Call 2009)					
Capacity of 200kg/day, upgradable to 100 vehicles per day	Capacity of 200kg/day, upgradable to 100 vehicles per day	All Phase 1 cities reached the required refuelling capacity	100 %	N/A	
Availability of station 98 %	Availability of station 98 %	>98 % at most sites	100 %	99,9 %	Project HyTransit achieved target availability. Bolzano and London performed similarly. 2 sites unlikely to reach target (downtime due to compressor)
OPEX <10EUR/kg (excl. tax)	OPEX <10EUR/kg (excl. tax)	>93 % at all sites (average ca. 96 %)	<5 %	No cost data	Electricity appears to be the dominant factor affecting hydrogen cost
H_2 quality will be according to SAE J2719	Hydrogen purity (according to SAE or analogous specification)	OPEX >€10/kg for all phase 1 sites	95 %	N/A	H_2 quality not readily measureable (difficult sampling, few labs, cost). Online quality ex SAE J2719 not feasible
Production efficiency target 50-70 %	Production efficiency target 50-70 %	Not all contaminants can be measured within SAE J2719 accuracy	100 %	50-70 %	Standard commercial performance
AIP Objectives of the Fuel Cell Buses (Call 2009)					
>4,000 h lifetime initially, min. 6,000 h lifetime as program target	Fuel cell lifetime >6,000 h	6,554 h/stack (@03/2016) excl. Berlin ICE buses	100 %	10102 h	>40 stacks in CHIC have exceeded 6,000 hours, 1 has operated in >21,000 h.
Availability >85 % with maintenance as for conventional buses	Average availability of fuel cell buses >85 %	69% based on operation time (@03/2016)		73 %	Availability of all Eur. FC buses excl. Oslo: 74% to 03/2015. Oslo had refueller contamination causing 6 mnoths unavailability
Fuel consumpt. <11-13 kg/100km	Average fuel consumption <13kg depending on drive cycle	12 kg/100km (only FC buses) (@03/2016)	100 %	9.94 kg/ 100 km in average	This calculation includes older Whistler buses. Fuel economy of the Eur. non-articulated FC buses was 10 kg/ 100 km.
(c) Other project objectives					
Additional project target	Replacement of 500,000 l diesel fuel, Running distance (fleet) >2,75 Mio km & >160,000 h of operation (fleet)	@03/2016: Diesel replacement: Phase 0 /1 cities: 2,833,036 / 1,427,883, 9.02 Million km, 475,455 h	100%	N/A	As comparison, the 12 AC Transit buses in California reported 1,423,655 km and 102,615 h in 4 yrs (2011 to 2015).

CISTEM

Construction of Improved HT-PEM MEAs and Stacks for long term stable modular CHP units

PANEL 4
Research activities for stationary applications

ACRONYM	CISTEM
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 DATE	1/06/2013
END DATE	30/09/2016
PROJECT TOTAL COST	€6,0 million
FCH JU MAXIMUM CONTRIBUTION	€3,9 million
WEBSITE	http://www.project-cistem.eu/

PARTNERSHIP/CONSORTIUM LIST

EWE-Forschungszentrum für Energietechnologie e. V., DANISH POWER SYSTEM APS, INHOUSE ENGINEERING GMBH, Eisenhuth GmbH & Co. KG, UNIVERSIDAD DE CASTILLA – LA MANCHA, VYSOKA SKOLA CHEMICKO-TECHNOLOGICKA V PRAZE, ICI CALDAIE SPA, OWI Oel-Waerme Institut GmbH

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 kW_e. The modular concept will be investigated in a Hardware-in-the-Loop (H-i-L) test bench with one module physically installed and 12 emulated by software. The development strategy starts on the single component level and rises up to the complete CHP system. Research and development includes the most important components like MEAs, bipolar plates (BPP), reformer system and the final CHP unit design with all necessary Balance-of-Plant (BoP) components.

PROGRESS/RESULTS TO-DATE

- 12,000 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 behaviour and the lowest electrochemical surface area (ECSA) decrease and agglomeration (40 % Pt/SiCTiC).
- Bipolar plate material PPS (polyphenylene sulfide) 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

- Testing of BoP components in H-i-L enviroment.
- Finalization of CHP system operational evaluation.
- Conversion of stationary to dynamic model and implementation of catalyst degradation.
- Finalization of Final Report.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- FC electrical efficiency has been improved to more than 40 % by different measures.
- Significant improvement in reduction of degradation rates while using MEAs with thermally cured membranes.
- Short stack long term testing support improved durability of the FC stack.
- Final optimization made on the stamping tools and backing materials during hot-pressing procedure for manufacturing of commercial MEAs.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Application range: Up to 100 kW	Small scale commercial application range 5-50 kW and midscale industrial range	Modular set-up with 1 module (8 kWel) installed as hardware and 12 emulated modules (H-i-L)	100 %		
Electrical efficiency: Up to 45 %	Electrical efficiency: >40 %	42 % gross efficiency calculated (gain by oxygen enrichment not included)	95 %	Electrical efficiency of 40 %: Yuka Oona, PhD Thesis, 2013, Daido University, p. 16	100 % for targeting above 40 %, 75 % for targeting 45 % efficiency
Lifetime: Extended lifetime up to 40,000 hours	Lifetime: >20,000 hours	MEA degradation rate: <4 µV/h	100 %	Best degradation rate for HT-PEM MEA so far: -4.9 µV/h, S. Yu, *Fuel Cells*, 08, 3-4. 165-174 (2008)	
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2012
MEA and bipolar plate (BPP) degradation, accelerated stress testing on MEAs to access lifetime predictions	Increased knowledge on degradation and failure mechanisms	ASTs predict improvement in lifetime. 10,000 h BPP material test. Degradation rate MEA <4µV/h	100 %	Best degradation rate for HT-PEM MEA so far: -4.9 µV/h, S. Yu, *Fuel Cells*, 08, 3-4. 165-174 (2008)	
One module, consisting of two 4 kW HT-PEM stacks and one reformer, in a H-i-L- environment	PoC prototype modular CHP system based on HT-PEM technology	Short stacks have been tested. Full stacks are currently under operation. BoP component finished	95 %		

CLEARGEN DEMO

The Integration and demonstration of Large Stationary Fuel Cell Systems for Distributed Generation

PANEL 3
Technology validation in stationary applications

ACRONYM	CLEARGEN DEMO
CALL TOPIC	SP1-JTI-FCH.2011.3.6: Field demonstration of large stationary fuel cell systems for distributed generation and other relevant commercial or industrial applications
START DATE	1/05/2012
END DATE	31/12/2019
PROJECT TOTAL COST	€8,5 million
FCH JU MAXIMUM CONTRIBUTION	€4,5 million
WEBSITE	

PARTNERSHIP/CONSORTIUM LIST

DANTHERM POWER A.S, HYDROGENE DE FRANCE, AQUIPAC SAS, JEMA ENERGY SA, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, LOGAN ENERGY LIMITED, LINDE GAS MAGYARORSZAG ZARTKORUEN MUKODO RESZVENYTARSASAG, BUDAPESTI MUSZAKI ES GAZDASAGTUDOMANYI EGYETEM

MAIN OBJECTIVES OF THE PROJECT

The objectives of the CLEARGen Demo project are: 1) The development and construction of a large scale fuel cell system, purpose-built for the European market; 2) The validation of the technical and economic readiness of the fuel cell system at the megawatt scale, and 3) The field demonstration and development of megawatt scale system at a European chemical production plant.

PROGRESS/RESULTS TO-DATE

- The project details are defined.
- The agreement between beneficiaries is negotiated and signed.
- The contract with Ballard Power System on supply of equipment is signed.
- Agreement with AkzoNobel on providing hydrogen and area for locating the equipment is made.
- The dialog for getting political support for a feed-in tariff for the produced electricity is initiated.

FUTURE STEPS

- Procurement of components and manufacture of a European compliant ClearGen fuel cell system.
- Prepare the host site and get the building and operation permissions.
- Design the fuel purification system.

- Installation and commissioning of the ClearGen unit with all associated components and support services.
- System operation and maintenance; system monitoring assessment.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Getting a feed in tariff for the produced electricity is taking a long time, so alternative options are being investigated.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Cost target	€3,000/kW	€3,000/kW	90 %	To be done	Market price is very sensitive to the volume produced. Hence, the market development will be important to the price reduction
Stack lifetime	20,000 h	To be done	98 %	To be done	Expected to be exceeded after the project end
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
Electrical efficiency (LHV)	>50 %	43 %	70 %	48 % in lab test	Reduction of parasitic losses is an important exercise in achieving the high system efficiency
System lifetime	20,000 h	To be done	98 %	To be done	Expected to be exceeded after the project end
(c) Other project objectives:					
Availability	95 %	80 %	95 %	To be done	Not part of MAIP and AIP

COBRA

Coatings for bipolar plates

PANEL 2

Research activities for transport applications

ACRONYM	COBRA
CALL TOPIC	SP1-JTI-FCH.2013.1.2: Research & Development on Bipolar Plates for PEM fuel cells
START DATE	1/04/2014
END DATE	31/03/2017
PROJECT TOTAL COST	€3,8 million
FCH JU MAXIMUM CONTRIBUTION	€2,3 million
WEBSITE	http://www.cobra-fuelcell.eu/

PARTNERSHIP/CONSORTIUM LIST

COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, BORIT NV, IMPACT COATINGS AB, SYMBIOFCELL SA, FUNDACION CIDETEC, INSTITUT NATIONAL DES SCIENCES APPLIQUEES DE LYON

MAIN OBJECTIVES OF THE PROJECT

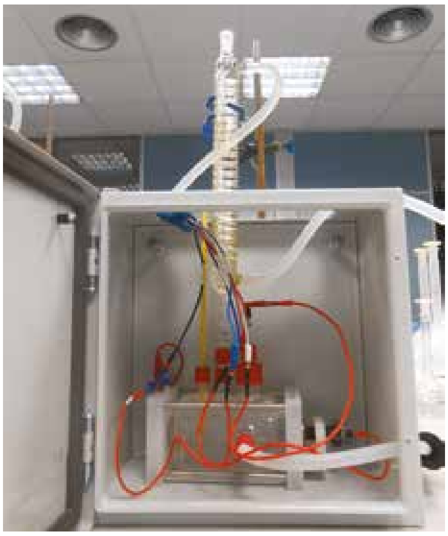
With a consortium integrating expertise in bipolar plate (BP) design and manufacturing, COBRA project aims to develop and prepare the industrialization of new metallic bipolar plates coatings, demonstrating a higher corrosion resistance (corrosion <1µA/cm²), lower electrical resistance (<25mOhm.cm²) and lower price (<2.5€/kW). The project organization emphasis the importance of field tests, using post-mortem and adapted tests procedures to understand ageing mechanisms in system conditions. This approach will help develop corrosion resistant and conductive new coatings suitable for FC applications.

PROGRESS/RESULTS TO-DATE

- Reference plates have been manufactured and tested on field in automotive and marine conditions.
- A complete post-mortem analysis have 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.
- Innovative manufacturing process and coatings were developed.
- Best coatings are defined and new COBRA plates are being manufactured.

FUTURE STEPS

- New stacks, including innovative coatings, will be tested on-field in same conditions has references plates.
- A complete Life Cycle Analysis (LCA) will be provided.
- A technico-economical study will be realized.
- Following STAMPEM-COBRA joint workshop, a new workshop in Grenoble will be organized to strengthen BP stakeholder community.



CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

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

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Durability (h)	>5,000	N/A (test not yet finalized)	N/A	3,000	To be done during the last year of the project
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
Corrosion, anode (µA/cm²)	<10	0.119	100 %	state of the art	Part of COBRA coating selection matrix
Corrosion, cathode (µA/cm²)	<10	0.77	100 %	state of the art	Part of COBRA coating selection matrix
Areal specific resistance (m.cm²)	<25	11	100 %	state of the art	Part of COBRA coating selection matrix
Cost (production of 500,000 units)	<2,5€/kW	N/A (test not yet finalized)	N/A	20	To be done during the last year of the project

COMETHY

Compact multifuel-energy to hydrogen converter

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	COMETHY
CALL TOPIC	SP1-JTI-FCH.2010.2.2: Development of fuel processing catalyst, modules and systems
START DATE	1/12/2011
END DATE	31/12/2015
PROJECT TOTAL COST	€4,9 million
FCH JU MAXIMUM CONTRIBUTION	€2,4 million
WEBSITE	http://www.comethy.enea.it/

PARTNERSHIP/CONSORTIUM LIST

AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE,L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE, Processi Innovativi SRL, ACKTAR LTD., TECHNION – ISRAEL INSTITUTE OF TECHNOLOGY., FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V, UNIVERSITA DEGLI STUDI DI SALERNO, CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS, ARISTOTELIO PANEPISTIMIO THESSALONIKIS, UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA, STICHTING ENERGIEONDERZOEK CENTRUM NEDERLAND, GKN SINTER METALS ENGINEERING GMBH, UNIVERSITA CAMPUS BIO MEDICO DI ROMA

MAIN OBJECTIVES OF THE PROJECT

CoMETHy aimed at developing a new hydrogen production technology combining different energy sources (solar, biomass and fossil fuels). The steam reforming process has been revised to exploit renewable energy: the aim was to power the process with a mixture of molten salts widely used in Concentrating Solar plants. Hence, a steam reforming reactor operating at temperatures up to 550 °C had to be developed. This result was achieved after extensive research, from the development of specific catalysts and membranes, to their integration in an innovative membrane reformer heated with molten salts.

PROGRESS/RESULTS TO-DATE

- Catalysts for methane & bioethanol steam reforming of up to 550 °C developed exhibiting low pressure drops, enhanced heat transfer & shift activity.
- Pd-based composite membranes tested for the membrane reformer with permeability/stability within project targets.
- Catalysts and membranes identified coupled in integrated membrane reformers proved up to pilot scale (3,5 Nm³/h H_2).
- The fuel-flexible approach successfully proved with feed methane/ethanol changeover over the same catalyst.
- Strategies to couple the reformer with a concentrating solar plant were positively evaluated from a techno-economic perspective.

FUTURE STEPS

- The project has been positively concluded.
- Next steps will consist of technology validation in demonstration follow-up projects.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Possibility to power a steam reforming process with solar energy has been proved.
- Besides environmental benefits (CO_2 emission red.) CoMETHy technol. proved attractive from techno-economic perspective.
- Developed technology can be interestingly applied for centralized and decentralized hydrogen production for different uses.
- Thermochem. fuel conversion (methane, biogas, bioethanol, etc.) represents a sustainable route alternative to water electrolysis.
- Demonstration of the technology in real industrial environment will boost market penetration.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET (%)	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
38-100 % CO_2 emissions & fossil fuel use red. in steam reforming using renewable energy sources (RES)	Up to 50 % of the hydrogen energy supplied from renewables	>40 % CO_2 emissions reduction proved; reforming of biofuels proved too (100 % renewable H_2)	100 %	Solar reforming developed by EU project SOLREF with a solar receiver reactor, same CO_2 emissions, CoMETHy technol. eases process mgmt	
Methane reforming efficiency >70 %	Methane reforming processes efficiencies >67 % for decentralized production	68-80 % steam reforming efficiency for a 1,500 Nm³/h methane steam reforming plant incl. CO_2 capture	100 %	Solar reforming developed by EU project SOLREF with a solar receiver reactor, same CO_2 emissions, CoMETHy technol. eases process mgmt	Efficiency of solar reforming defined as produced H_2 thermal power (LHV) / (feed + fuel + thermal power input)
Lowering the hydrogen production costs	Lowering the hydrogen production costs	H_2 prod. cost approach traditional process @ plant scale >1500 Nm³/h	100 %	Ref. cost for traditional process (€1,7/kg) determined in the process	
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2010
Reforming catalysts w/shift activity to get CO <10 vol%	Reforming catalysts w/shift activity to get CO <10 vol%	2-5 vol%	100 %	Not available	
Catalyst replacement time <4 hours	Catalyst replacement time <4 hours	Reactor catalysts & membranes replaced in <4 hours	100 %	Not available	
Plant compactness: hydrogen production and separation in n.1 unit	Reactor compactness & design simplification	>99,8 % hydrogen produced in n.1 unit (membrane reactor)	100 %	3 units (main reformer, water gas shift reactor, PSA, etc.)	
Scalability 2-750 Nm³/h (hydrogen production rate)	Scalability from 2 to 750 Nm³/h (hydrogen production rate)	Shell-and-tube heat exchanger eases scalability from 1,5 Nm³/h (CoMETHy pilot unit) to >1,500 Nm³/h	100 %	Not available	
(c) Other project objectives					
Reforming temperatures <550 °C	Not applicable	400-550 °C	100 %	>850 °C (current technology)	

COPERNIC

Cost & performances improvement for CGH2 composite tanks

PANEL 2

Research activities for transport applications

ACRONYM	COPERNIC
CALL TOPIC	SP1-JTI-FCH.2012.1.3: Compressed hydrogen on board storage (CGH2)
START DATE	1/06/2013
END DATE	30/11/2016
PROJECT TOTAL COST	€3,5 million
FCH JU MAXIMUM CONTRIBUTION	€1,9 million
WEBSITE	http://www.project-copernic.com/

PARTNERSHIP/CONSORTIUM LIST

COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, RAIGI SAS, SYMBIOFCELL SA, HOCHDRUCK REDUZIERTECHNIK GMBH, POLITECHNIKA WROCLAWSKA, OPTIMUM CPV, H2 Logic A/S, ANLEG GMBH

MAIN OBJECTIVES OF THE PROJECT

To improve the CGH2 storage system cost, COPERNIC will provide real scale demonstration on a pilot manufacturing line and quantitative assessment of strategies including evolution of materials, components, processes and designs:

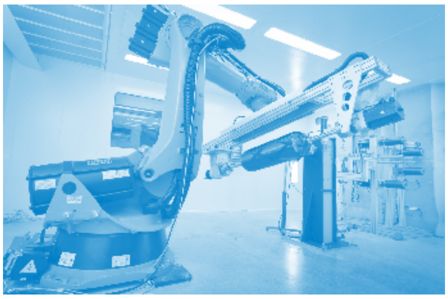
- Enhanced materials (resins, carbon fibre, inserts).
- Innovative components (all-in-one on-tank valve, on/off board structural health monitoring).
- Enhanced composite design (improved geometries).
- Improved composite quality (tank performance repeatability).
- Higher manufacturing process control and productivity (automation, winding numerical control).

PROGRESS/RESULTS TO-DATE

- Reduction costs: Optimisation of composite (-13 %), + Higher volume (37L to 61L: -40 %)+ Higher annual production (for 8,000 unit -70 %). Target achieved.
- Improvement vessel performance: Copernic Gravimetric capacity: 4.99 %; Volumetric capacity: 0.0221kg/L.
- Significant breakthroughs implemented in the on-tank valve (OTV) (reduction of mass, number of parts, power consumption). Certification process on-going.
- Productivity improvement (27kg of composite) from a 120 minutes winding time (wet winding) to 70 minutes (with 8 axes robot and prepreg).

FUTURE STEPS

- Structural health monitoring (SHM) tests activities remain on-going for manufacturing quality process.
- New target for winding time with prepreg: 54 min (-55 %).
- ComposicaD batchmode.
- Work on alternative geometries (tubes and sphere design).
- Pass the certification process – October 2016.



CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The FCH JU 2020 target on cost= 600€/H2Kg is realistic and feasible according to actual Copernic result which is at 608€/H2Kg.
- Copernic Gravimetric capacity is in line with FCH JU 2020 target (5 %).
- Copernic Volumetric capacity is in line with FCH JU target 2017 (0.022Kg/L).
- SHM allows the identification of abnormal behaviour of the vessel before leak, and the upgrade of the SAE J2601 protocol to improve safety.
- The Copernic OTV is ready to be commercially launched

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Design/ test criteria for CGH2 storage system	Contribute to advancement of relevant test methods	Tanks and pressure components have been defined, tested and validated	100 %	(37L) System cost: 1841€/H2Kg Gravimetric capacity = 3.57 % Volumetric capacity: 0.0217kg/L	Copernic result on cost: 608€/H2Kg Gravimetric capacity: 4.99 % Volumetric capacity: 0.0221kg/L
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2012
Development activities on materials	Assess alternative materials to improve performance/ cost ratio	Alternative materials selected	100 %	– Resin SoA: 16€kg – Machining Boss SoA: 150€/ unit boss – Composite Design SoA: 27kg (37L)	– Resin: 7€ kg (-56 %) – Boss (price for 8,000 forged units): €15-20 (reduced by factor 8) – No low cost fiber Carbon for automotive application
Lower cost production processes	Assess manufacturing technology improvement strategies	Comparison of winding technologies Equipment improvement under implementation on pilot line	100 %	– Initial winding time for 37L with wet winding and 27 Kg of composite: 120 min	– Winding time reduced to 70 min with prepreg (-41 %) – Improvement of programming tool Robot interface
Improved complete tank systems and components	Reduced weight and volume. Fully integrated OTV	Innovative vessel design and all-in-one compact pressure device: defined, produced	100 %	Vessel 37L: 27kg composite OTV: – Reduction of weight: 6 kg down to 3.5 kg. – number of parts from 146 down to 80 – power consumption: /10	– Optimised design vessel: 27 to 21kg composite. – OTV: mass 1,2kg number of parts: 96 Power consumption: 10 Watt
On or off/board diagnosis systems for containers	Develop and assess non destructive examination method methods for SHM of composite overwrapped pressure vessel	Identification of abnormal behaviour of vessel before leak. Update on protocol SAE J2601	100 %		SHM allows the identification of abnormal behaviour of the vessel before leak, and the upgrade of the SAE J2601 protocol to improve safety.

D2Service

Design of 2 technologies and applications to service

PANEL 3

Technology validation in stationary applications

ACRONYM	D2Service
CALL TOPIC	FCH-02.9-2014: Significant improvement of installation and service for fuel cell systems by Design-to-Service
START DATE	1/09/2015
END DATE	31/08/2018
PROJECT TOTAL COST	€3,6 million
FCH JU MAXIMUM CONTRIBUTION	€2,9 million
WEBSITE	www.project-D2Service.eu

PARTNERSHIP/CONSORTIUM LIST

EWE-Forschungszentrum für Energietechnologie e. V., SOLIDPOWER SPA, DANTHERM POWER A/S, ZENTRUM FUR BRENNSTOFFZELLEN-TECHNIK GMBH, BOSAL EMISSION CONTROL SYSTEMS NV, BRITISH GAS TRADING LIMITED, ENERGY PARTNERS SRL

MAIN OBJECTIVES OF THE PROJECT

The main objective of the project D2Service is to noticeably reduce costs and labour for repair work (maintenance), thereby increasing the distribution of energy-efficient fuel-cell-based technology

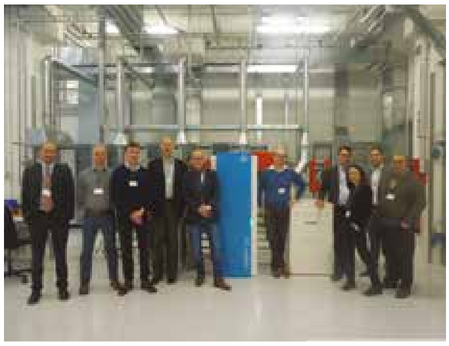
The main objective of the project D2Service is to noticeably reduce costs and labour for maintenance and repair for energy-efficient fuel-cell-based CHP units in Europe. This will be achieved be simplifying & standardising the construction of 2 CHP systems (PEM and SOFC) available on the market, so that important components are easy to exchange. In addition the project will develop graphical service manuals that explain the maintenance process to non-specialist installers.

PROGRESS/RESULTS TO-DATE

- Installation of SOFC & PEMFC units @NEXT ENERGY for analysing & evaluating failure modes, efficiencies & installation requirements.
- Prep. of lessons learned questionnaire on service issues e.g. shutdowns, downtime, failure modes & service characteristics.
- Develop a system model of the Dantherm Power µCHP to predict the amt of reactant consumed & define service intervals.
- Developing a model of the Dantherm unit, incl. mounting methods & risk assessments for service through the front.
- Set up of the D2Service website including description of the objectives, companies and related projects.

FUTURE STEPS

- Evaluation of both CHP system with regard to performance testing and annual efficiency.
- Identification of HydroDeSulphurization-material and operation parameter for life time desulphurization.



- Improving the design of hot components of the SOFC unit for critical component on-site replacement.
- Condensing the lessons learned information to a public report.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Lessons learned related to service issues e.g. downtime, shutdowns, failure modes & service characteristics.
- Solving of installation issues & experiences of both units related to grid gas composition, installation requirements on Eur. sites.
- Agreement of operation mode of the CHP systems based on specific state regulations/requirements.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAWP 2014-2020
Extend components lifetime (stack, reformer, water clean-up, desulphurization, filter)	Durability of components in fuel cell units	Still ongoing	100 %	Raw materials available on the market. Tech. design for novel 2,5 Kwel system is based on performance data. No commercial systems available.	Process ongoing: analysis of desulphurization material incl. gas composition of various sites +design adaptation to requirements (increase of surface area, lower flow velocity).
Identification of ion exchange resins + design of optimised water cartridge					AWP 2014
Ease and clear construction for fault-free exchange of components without dismantling	Reduce on-site tech. intervention time & equipment total down-time for servicing	Risk assessment finalised & submitted to FCH-JU Construction changes still ongoing	100 %	Quick connectors for tubes available; for key components like reformer, stack etc.: to be developed	Optimization of the construction still ongoing. Quick connectors to be included in the new Dantherm unit. Risk assessment performed.
Adaptation/harmonization of overall setup and components with same service lifetime for increasing the service interval time.	Increase the service interval time	Implementation of FIX and/or FLEXIBLE interval times - still ongoing	100 %	Fix & FLEXIBLE service interval time is SoA in many industries e.g. cars or household heating systems Product-specific service strategies to be developed.	Still analysing different components and materials including gas compositions in Europe. Components harmonization to same/longer interval time leads to cost reduction, but designs have to be adjusted.
Development of a graphical service manual for easy and cheap service & maintenance, foolproof installation	Simplify service operation so that normally trained installers/ technicians can accomplish task using "service manual"	To be started shortly	100 %	Manuals available for many commercial CHP systems.	The process will start in few weeks/month
Reduce service costs by reducing service downtime and enhance lifetime of components	Reduce the service cost	All mentioned objectives 1-4 results	100 %		Development of useful intervals incl. specific procedures during the service, easy maintenance and reduction of time by unification of service aspects and components, remote diagnosis

DEMCOPEM-2MW

Demonstration of a combined heat and power 2 MW_e PEM fuel cell generator and integration into an existing chlorine production plant

PANEL 3
Technology validation in stationary applications

ACRONYM	DEMCOPEM-2MW
CALL TOPIC	SP1-JTI-FCH.2013.3.5: Field demonstration of large scale stationary power and CHP fuel cell systems
START DATE	1/01/2015
END DATE	31/12/2018
PROJECT TOTAL COST	€10,5 million
FCH JU MAXIMUM CONTRIBUTION	€5,4 million
WEBSITE	http://www.demcopem-2mw.eu

PARTNERSHIP/CONSORTIUM LIST

Akzo Nobel Industrial Chemicals B.V., NEDSTACK FUEL CELL TECHNOLOGY BV, MTSA TECHNOPOWER BV, JOHNSON MATTHEY FUEL CELLS LIMITED, POLITECNICO DI MILANO

MAIN OBJECTIVES OF THE PROJECT

The main objective of the four years DEMCOPEM-2MW project is to design, build and operate a 2 MW power generator, with the following attributes: Full integration of heat and power – High net conversion efficiency – Long lifetime of system and fuel cells – Fully automated way of operation and remote control – Economical design to reach a competitive price – Contribute to the general goals of the Joint Technology Initiative (JTI) FCH, as stated in the revised Multi Annual Implementation Plan.

PROGRESS/RESULTS TO-DATE

- Complete design of the 2 MW plant according to the project targets of high conversion efficiency and CHP integration.
- Successful design and manufacturing of PEM fuel cell MEA and stacks for the 2 MW plant.
- Building of the plant with all electric, hydraulic and gas circuits, auxiliaries and control system.
- Successful factory acceptance test of the 2 MW plant at MTSA, plant disassembly and shipping to China.
- Complete modelling and preliminary simulations of the 2 MW plant confirming the project efficiency targets.

FUTURE STEPS

- Plant installation at final site (Ynnovate Chlor-Alkali plant – China).
- Plant startup and testing.
- Plant operation and remote monitoring, data acquisition, long-term performance analysis.
- Measurements collection and calibration of plant simulations.
- Supply of improved MEA's and stacks for field testing.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Demonstration of a multi-MW PEM plant in a fully industrial environment.
- Demonstration of enhanced fuel cell lifetime (>16,000 h) and durability according to FCH-JU targets.
- Demonstration of 2 MW PEM plant high conversion efficiency and CHP potential, waste hydrogen use and energy integration with the production process.
- Demonstration of improvements in plant design to achieve perspective economic targets.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
2 MW and potential for 20 more similar sized PEM power plants	2015 target: >5 MW / €3,000/kW	1 MW	100 %	1 MW	Proceeding according to plan
<€2,500/kW	2015 target: €3,000/kW		100 %		
Commercial Introduction in 2017 and stepwise cost reductions to reach <€1,500/kW	2020 target: >50 MW / €1,500/kW	System not yet operative	100 %		
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AWP 2014
100 kW with on-stream	100 kW with on-stream	System not yet operative			Proceeding according to plan
On stream availability >95 %	Availability of 95 % or higher	System not yet operative			Proceeding according to plan
16,000 h up to 40,000 h (for fuel cell stacks) on the long term	Minimum of 16,000 h	System not yet operative			Proceeding according to plan
(c) Other project objectives:					
Full integration of heat and power with existing chlorine production plant	Not applicable	On track for power (heat recovery possibility is ready)	50 %	On track for power (heat recovery possibility is ready)	
High net conversion efficiency (>50 % electric energy on system level)	Not applicable				
Fully automated way of operation and remote control	Not applicable	On track	100 %	On track	Proceeding according to plan

DEMOSOFC

Demonstration of large SOFC system fed with biogas from WWTP

PANEL 3

Technology validation in stationary applications

ACRONYM	DEMOSOFC
CALL TOPIC	FCH-02.11-2014: Large scale fuel cell power plant demonstration in industrial/commercial market segments
START DATE	1/09/2015
END DATE	31/08/2020
PROJECT TOTAL COST	€5,9 million
FCH JU MAXIMUM CONTRIBUTION	€4,4 million
WEBSITE	www.demosofc.eu

PARTNERSHIP/CONSORTIUM LIST

POLITECNICO DI TORINO, CONVION OY, Società Metropolitana Acque Torino S.p.A., Teknologian tutkimuskeskus VTT Oy, IMPERIAL COLLEGE OF SCIENCE TECHNOLOGY AND MEDICINE

MAIN OBJECTIVES OF THE PROJECT

DEMO and analysis of a solution of distributed CHP based on SOFC, in the industrial/commercial application, the best solution in the sub-MW distributed CHP in terms of efficiency and emissions.
DEMO of a distributed CHP system fed by a biogenous CO_2 neutral fuel: biogas.
DEMO in a real industrial installation.
DEMO of the achievements: electrical efficiency, thermal recovery, low emissions, plant integration, economic interest.
EXPLOITATION and BUSINESS analysis of replication of this type of innovative energy systems.
DISSEMINATION of the interest (energy and economic) of such systems.

PROGRESS/RESULTS TO-DATE

- Energy planning and Optimization of the DEMO.
- Detailed engineering of the DEMO.
- Site preparation for the installation of the DEMO: under development, conclusion foreseen at M13 (September 2016).
- Cost/benefit analysis of the system.
- Dissemination of the results;§: workshops, conferences, social media, press releases.

FUTURE STEPS

- Installation of the SOFC system in the DEMO: foreseen in M14 (October 2016) and M15 (November 2016); last SOFC module foreseen in M19 (March 2017).
- Connection of the SOFC system to the DEMO (fuel supply, electrical connection, thermal recovery): foreseen in M14-M15 (October – November 2016).
- Development of the control system of the complete DEMO (electrical and thermal sections): completion in M14 (October 2016).
- Start-up of the complete DEMO (October-November 2016).
- Update of the cost/benefit analysis of this kind of systems (SOFC CHP distributed systems fed by biogas from different biological sources).

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Main finding so far: detailed engineering of the complete DEMO (structure, electrical, thermal, clean-up section).
- Demonstrate the high efficiency of SOFC-based CHP systems fed by biogas.
- DEMO of an industrial size FC system fed by biogas, completely integrated in a real industrial process.
- Reduction of the CAPEX of SOFC systems to less than €7,000/kW thanks to higher volume of production.
- Strong dissemination for public awareness.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAWP 2014-2020
DEMO of a SOFC-based distributed CHP system fed by a biogenous CO_2-neutral fuel	Boost the share of FCH technologies in a sustainable, low-carbon energy system	Under construction	100 %	No industrial size SOFC-based systems in EU	The installation is evolving according to the expressed schedule
Build technical knowledge, customer confidence, about the introduction of SOFC technology	To ensure a world leading, competitive European FCH industry	Under construction	80 %	CAPEX €6,000-1,000/kW	Foresaw the installation of 1 module (out of 3) based on a new generation stack
Demonstrate the high efficiency of SOFC-based CHP systems fed by biogas	Increase electrical efficiency and durability of FC systems	Under construction	100 %	50 %	We foresee an electrical efficiency ~53%, and an overall efficiency ~80-90%
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AWP 2014
Reduce CO_2 emission and other contaminants compared to competing technologies	Meaningfully reduce harmful emissions.	Under construction	100 %	422 gCO_2/kWhe in case of NG fuel	The CO_2 emissions will be neutral (biogas fuel) but also significantly lower compared to an ICE (reduction of 27%).
DEMO of an industrial size FC system fed by biogas, integrated in a industrial process	(a) 50 kW up to several MW capacity; (b)Integration of a FC power plant in industrial processes	Under construction a plant of 174 kW_e (+ 89 kWth) fed by biogas from WWTP	100 %	No industrial size SOFC-based systems in EU	Installation on-going, to be completed by November 2016 (last SOFC module in March 2017).
Reduction of CAPEX <€7,000/kW thanks to higher volume of production	CAPEX <€7,000/kW (systems <1 MW)	Under construction	80 %	CAPEX €6,000-1,000/k	Foresaw the installation of 1 module (out of 3) based on a new generation stack
(c) Other project objectives:					
Strong dissemination for public awareness	Not applicable	Dissemination plan already produced	100 %	Not applicable	Press release, social media and website. Next actions on workshops and seminars.

DEMSTACK

Understanding the degradation mechanisms of a High Temperature PEMFCs Stack and optimization of the individual components

PANEL 4

Research activities for stationary applications

ACRONYM	DEMSTACK
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 DATE	1/05/2013
END DATE	31/10/2016
PROJECT TOTAL COST	€2,5 million
FCH JU MAXIMUM CONTRIBUTION	€1,4 million
WEBSITE	http://demstack.iceht.forth.gr/

PARTNERSHIP/CONSORTIUM LIST

FOUNDATION FOR RESEARCH AND TECHNOLOGY HELLAS, FUNDACION CIDETEC, VYSOKA SKOLA CHEMICKO-TECHNOLOGICKA V PRAZE, ADVANCED ENERGY TECHNOLOGIES AE EREUNAS & ANAPTYXIS YLIKON & PROIONTONANANEOSIMON PIGON ENERGEIAS & SYNAFON SYMVOULEFTIKON Y PIRESION*ADVEN, JRC -JOINT RESEARCH CENTRE-EUROPEAN COMMISSION, ELVIO ANONYMI ETAIREIA SYSTIMATON PARAGOGIS YDROGONOU KAI ENERGEIAS, Prototech AS

MAIN OBJECTIVES OF THE PROJECT

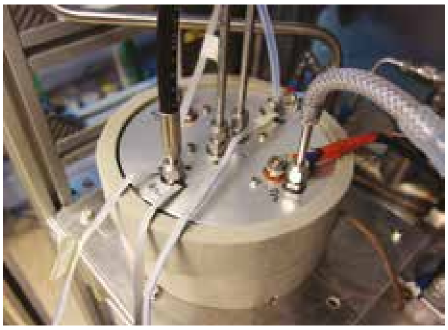
The activities of DeMStack are on the stack optimization and construction based on the high temperature MEA technology of Advent S.A.. The aim is to enhance the lifetime and reduce the cost of the HT PEMFC technology. The strategy involves improvements based on degradation studies and materials development. A fuel processor operating on natural gas will be 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.
- The designs for the bipolar plates, fuel cell stack and fuel processor have been completed.
- Two 1 kW stacks have been constructed employing: (i) graphitic bipolar plates and external cooling (ii) metallic bipolar plates and internal cooling.
- The fuel processor has been constructed and integration with the stack is currently underway.

FUTURE STEPS

- Demonstration of the effective operation of the integrated system (reformer with graphitic stack).
- Testing of the 1kW metallic stack using synthetic reformate gas.



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

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:			MAIP 2008-2013
Small Scale – Domestic 1 – 5 kW	1 kW HT PEMFC operating on reformates (operating at a current density of 0.2 A/cm^2 at 180oC)	Stacks from optimized components and fuel processor are constructed.	100 %
2015 target: Cost of €4,000/kW for industrial/ commercial units	<€3,000/kW	Cost analysis for mass production give close to €2500/kW	100 %
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:			AIP 2012
Electrical efficiencies of 35-45 % for power units and 75-85 % for CHP units	Electrical efficiency of 45 % at 180oC	Already validated efficiency	100 %
Operational lifetime >20,000 h	5-6 month testing under reformate feed including measurements in an accelerated basis	Testing has not been completed	80 %
...improving stack & cell designs... components with improved performance, durability & cost...	Optimization of key MEA and stack components (lower cost, higher performance or stability)	This target has been achieved	100 %

DIAMOND

Diagnosis-aided control for SOFC power systems

PANEL 4
Research activities for stationary applications

ACRONYM	DIAMOND
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 DATE	1/04/2014
END DATE	31/03/2017
PROJECT TOTAL COST	€3,6 million
FCH JU MAXIMUM CONTRIBUTION	€2,1 million
WEBSITE	http://www.diamond-sofc-project.eu/about/

PARTNERSHIP/CONSORTIUM LIST

HyGear B.V., COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, Teknologian tutkimuskeskus VTT Oy, UNIVERSITA DEGLI STUDI DI SALERNO, HTceramix SA, INEA INFORMATIZACIJA ENERGETIKA AVTOMATIZACIJA DOO, INSTITUT JOZEF STEFAN

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.
- Fault signature matrices for FDI (fauld detection and isolation) developed; low level control schemes for both systems developed and analysed and soft sensors developed.
- System models for both systems developed.
- First sets of experimental data for both systems sent to partners for use of control, model, and diagnosis development.
- Applicability of THDA (total harmonic distrotion analysis) for SOFC systems shown.

FUTURE STEPS

- Implement improved low level conrol in both DIAMOND A and C system.
- Implement supervisory control.
- Implementation of signal- and model-based diagnosis schemes in the advanced system control.
- Experimentally validate control and diagnosis schemes.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Applicability of THDA for SOFC systems shown.
- Low-level control was designed and verified on a stack model. It provides better temperature control and system efficiency.
- A supervisory controller has been developed able to monitor and control the overall SOFC system performance.
- The system models have been verified using experimental data. The modelling appraoch is validated.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
Electric efficiency 50 %	2013	The systems are being tested using standard control. In the final stage of the project advanced control and diagnostic tools will be implemented. These will aid in achieving the target.	100 %	Developments are delayed due to experimental problems
Durability, 10 years, >85,000 hrs.	2013	The systems are being tested using standard control. In the final stage of the project advanced control and diagnostic tools will be implemented. These will aid in achieving the target.	100 %	Developments are delayed due to experimental problems
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2013-1
To develop advanced diagnostic and innovative control strategies	SP!-JTI-FCH.2013.3.3; 2013	Dynamic models of both power systems have been developed and validated.		
To develop advanced diagnostic and innovative control strategies	SP!-JTI-FCH.2013.3.3; 2013	Control and diagnostic strategies are being designed using the models		
To develop advanced diagnostic and innovative control strategies	SP!-JTI-FCH.2013.3.3; 2013	Low-level controls were developed and tested using a stack model		
To develop advanced diagnostic and innovative control strategies	SP!-JTI-FCH.2013.3.3; 2013	Soft sensors have been designed and validated with the real SOFC system data		
System life 10 years for smaller-scale applications	SP!-JTI-FCH.2013.3.3; 2013	In the final stage of the project advanced control and diagnostic tools will be implemented.		

DON QUICHOTE

Demonstration of new qualitative concept of hydrogen out of wind turbine electricity

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	DON QUICHOTE
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 DATE	1/10/2012
END DATE	31/03/2018
PROJECT TOTAL COST	€4,8 million
FCH JU MAXIMUM CONTRIBUTION	€2,9 million
WEBSITE	http://www.don-quichote.eu/

PARTNERSHIP/CONSORTIUM LIST

HYDROGENICS EUROPE NV, HYDROGEN EFFICIENCY TECHNOLOGIES (HYET) BV, WaterstofNet vzw, ETABLISSEMENTEN FRANZ COLRUYT NV, TUV Rheinland Industrie Service GmbH, JRC -JOINT RESEARCH CENTRE-EUROPEAN COMMISSION, THINKSTEP AG, ICELANDIC NEW ENERGY LTD, FAST – FEDERAZIONE DELLE ASSOCIAZIONI SCIENTIFICHE E TECNICHE

MAIN OBJECTIVES OF THE PROJECT

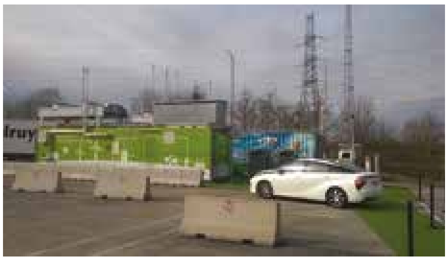
The Don Quichote (DQ) project complements and expands existing hydrogen refuelling system in Halle, Belgium, with innovative, components: a PEM electrolyser and a fuel cell re-electrification unit. Integration with a windmill realizes hydrogen-based energy storage. The hydrogen fuels forklifts at 350bar 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 Nm³/h, 10 bar).
- Development, construction and operation 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 a new compressor.
- Continuous performance monitoring of the system with a new compressor (final phase).
- Detailed yearly datasets on the performance of the plant.
- Complete upscaling scenario's deliverable 6.2.

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

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET (%)	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Wind as well as solar electricity	...develop a portfolio of sustainable H_2 production...	Power based (energy supply side) steering of electrolyser implemented	100 %		Installed and tested
Alkaline as well as PEME	R&D in innovative H_2 production and supply chains	PEM units constructed, ready for upscaling to MW's	100 %		Operational since Q3;2015
Modular systems for H_2 storage	Storage, distribution processes which can meet incr. share H_2 demand for applications	Installed and tested carbon fibre storage solution	100 %		Operational since Q3, 2015
H_2 for transport, controllable load		Forklift base extension, infrastructure adaptions in permitting process.	100 %		Ca. 80-100 fuelings every month since start of operation.
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
Efficiency (WtT; well to tank)	>55 %	Electrolyser 69 % Compressor 85 %	90 %	70 % (60kWh/kg compressed hydrogen)	Stack at 77% efficiency. Intermittent operation optimization ongoing.
Cost of H_2 delivered	<€15/kg	<€13/kg	10 %		Relatively low H_2 use and occupation makes bad OPEX case. Phase 2 TCO analysis in progress, Phase 3 demo cost unclear
H_2 production facility turn-key CAPEX	€3,5 M/(t/d) (i.e. €1,7 M/MWel)	€3,5 M/(t/d) (i.e. €1,7 M/MWel)	80 %	NA	To be assessed during economical evaluation
H_2 quality	ISO/DIS 14786-2 compliant	ISO/DIS 14786-2 compliant	100 %		PEM unit qualified. Compressor to be done
Availability	>95 %	>95 %	100 %		Succesfull site acceptance test. Measurements phase II started Q3, 2015

EDEN

High energy density Mg-based metal hydrides storage system

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	EDEN
CALL TOPIC	SP1-JTI-FCH.2011.2.4: Novel H_2 storage materials for stationary and portable applications
START DATE	1/10/2012
END DATE	30/06/2016
PROJECT TOTAL COST	€2,6 million
FCH JU MAXIMUM CONTRIBUTION	€1,5 million
WEBSITE	http://www.h2eden.eu/

PARTNERSHIP/CONSORTIUM LIST

FONDAZIONE BRUNO KESSLER, MBN NANOMATERIALIA SPA, CIDETE INGENIEROS SL, MATRES SCRL, PANCO – PHYSIKALISCHE TECHNIK ANLAGENENTWICKLUNG & CONSULTING GMBH, UNIVERSIDAD DE LA LAGUNA, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION

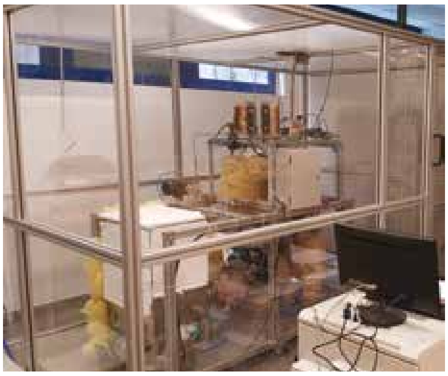
MAIN OBJECTIVES OF THE PROJECT

Develop a new storage material with high hydrogen storage capacity, manageable in real-time, for distributed applications. It will be interlinked to an energy provision system able to match intermittent sources with local energy demand. 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

- Mg-based powder produced by High Energy Ball Milling, with 7,1 wt.% H_2/MH storage capacity and desorption rate >1 gH_2/min/kg at 320 °C and 1,2 bar.
- Consolidation method of Mg-based powder, suitable for enhancing thermal and mechanical properties, to full exploit its storage properties in a tank.
- Intermediate and full Storage Tanks realized, integrated of thermal and hydrogen management 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 high temperature electrolyzer / fuel cell and solid state integrated storage.



FUTURE STEPS

- Conclude demo tests in Barcelona, in a site managed by the local Energy Agency. It is controlled both at local level and from remote.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Storage properties of Mg-based material validated with a tank prototype in urban environment: capacity 815 g H_2, 37 g H_2/l storage density.
- Realization of prototype coupling reversible solide oxide cell (rSOC) with hydrogen storage tank Mg-based. System Efficiency 25 %. Power production: 1,5 kW.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
€500/kg of stored hydrogen, a capacity of 0,6 kg H_2 and 100 cycles in system lifetime	Cost of hydrogen delivered to retail station €5/kg	Storage capacity 0,8 kg H_2, €500/kg (estimated in the long run), 20 cycles performed (including preliminary tests) = €25/kg of H_2 delivered to SOFC	80 %		Proceed with demonstration activities in urban environment, validating a longer lifetime of EDen system. Cost of delivered H_2 based on system lifetime: number of performed cycles will increase during last period of demonstration
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
A material having: H_2 storage capacity >6,0 wt.%, H_2 sorption density >80 kgH_2/m^2, desorption rate >3g/min	Storage material with capacities >6 wt.% and >60 kg H_2/m^3, reversibly releasing hydrogen at operating temperatures compatible with PEM FC, HT-PEM FC or SOFC / MCFC or other applications and appropriate hydrogen loading and unloading kinetics for the envisaged application	ED011 material: 7,1 wt.% storage capacity, 130 kgH_2/m^3 sorption density, desorption rate 1 g/min (per kg material at 320 °C and 1 bar = operating conditions). Storage material consolidated in pallet and loaded in storage tank shown appropriate kinetics for coupling with reversible SOFC	100 %		Achieved desorption rate is referred to operative condition and not to characterization conditions (pressure <1 bar) as indicated in project objectives
A material having cost <€30/kg	Cost effective production routes of the materials, giving opportunities to SMEs in the field of materials production	Projected material cost at industrial scale (1 ton/year) = €42/kg. Manufacturing route validated at pilot scale (100 kg/year) by the SME MBN.			Scale up of production will be driven by market demand
A tank having: H_2 storage capacity > 4,0 wt.%, H_2 sorption density >40 kg/m^3, absorption heat recovery 25 %, H_2 stored 600g, desorption rate 1,5 g/min	Small scale prototype storage systems with significantly improved storage capacity compared to compressed gas storage (>4 wt.%, >40 kg H_2/m^3), taking into account the reversible charge/discharge cyclability	Tank sorption density 37 kg/m^3, H_2 stored 815g, desorption rate 1,7 g/min		Gravimetric target not relevant for addressed application.	Validate the cyclability of storage system during latest demonstration period

ELECTRA

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	ELECTRA
CALL TOPIC	SP1-JTI-FCH.2013.2.4: New generation of high temperature electrolysers
START DATE	3/03/2014
END DATE	2/03/2017
PROJECT TOTAL COST	€4 million
FCH JU MAXIMUM CONTRIBUTION	€2,2 million
WEBSITE	http://www.mn.uio.no/smn/english/research/projects/chemistry/electra/index.html

PARTNERSHIP/CONSORTIUM LIST

UNIVERSITETET I OSLO, AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS, STIFTELSEN SINTEF, MARION TECHNOLOGIES S.A., PROTIA AS, ABENGOA HIDROGENO SA, CRI EHF

MAIN OBJECTIVES OF THE PROJECT

The main objective of ELECTRA is to develop scalable fabrication of tubular High Temperature Electrolyser (HTE) cells with proton conducting electrolytes. The robust tubular cells will be assembled in a flexible multi-tube module to produce pure dry pressurised H_2 more efficiently than competing technologies. The cells will reliably operate at temperatures of 600-800 °C in steam electrolysis mode to promote efficient integration of proton ceramic electrolyser (PCE) technology in geothermal and solar heat power plants. ELECTRA will also perform proof-of-concept test of CO_2 and steam co-electrolysis enabling novel concepts for economical production of dimethyl ether (DME).

PROGRESS/RESULTS TO-DATE

- Fabrication of fully assembled single-cell tubular proton ceramic electrolyser.
- Anode performance of <0,2 Ohm cm^2.
- Single cell with total resistance of 2,5 Ohm cm^2.
- Multi-tubular module with individually monitorable tubes designed, commisioned and built.
- proof-of-concept of segment-in-series design.

FUTURE STEPS

- Production of 3rd generation segmented-in-series PCE.
- Evaluation of different electrode materials and processing conditions.
- Electrolysis tests of segment-in-series tubes.
- Testing multi-tube reactor with single and segmented cells.
- DME production by PCEs.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Suitable anode materials have been developed.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET (%)	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Module capacity: 250 L/h	2015 target: Unit capacity ~1,5 t/day	Module designed, commissioned and built	80 %	No value for proton conducting electrolyser cells (PCECs) exist.	Production of tubes is challenging. Currently pursuing Generation 1, 2, and 3.
Total efficiency: 68 %	2015 target: 68 % efficiency	Module not scheduled for testing yet	80 %	No value for proton conducting electrolyser cells (PCECs) exist.	faradayic efficiency reduced by electronic conduction – mainly p-type at anode side – and this may lower overall H_2 production efficiency.
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
Fabrication of 25 cm length tubular cells with a total area specific resistance (ASR) of 1 Ωcm^2	Cells operating at >1 Acm-2	2,5 Ωcm^2 at 700C	80 %	No value for proton conducting electrolyser cells (PCECs) exist.	Currently limited by narrow set of production parameters and currrent collection. Both expectedly possible to optimise.
Co-ionic co-electrolysis of syngas and DME production. Overall efficiency >85 % incl. BoP	Proof-of-concept co-electrolysis, with efficiencies in the 85-90 % range	Tests not scheduled yet	100 %		
Degradation of <0,5 % per 1,000 hrs	<0,5 % per 1,000 hrs	Tests not scheduled yet	100 %		
(c) Other project objectives					
Anode performance <0,2 Ωcm^2 at 700 °C	Not applicable	<0,2 Ωcm^2 at 700 °C	100 %	This is state-of-the-art for PCECs	

ELYntegration

Grid Integrated Multi Megawatt High Pressure Alkaline Electrolysers for Energy Applications

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	ELYntegration
CALL TOPIC	FCH-02.8-2014: Improvement of electrolyser design for grid integration
START DATE	1/09/2015
END DATE	31/08/2018
PROJECT TOTAL COST	€3,2 million
FCH JU MAXIMUM CONTRIBUTION	€1,8 million
WEBSITE	http://www.elyntegration.eu

PARTNERSHIP/CONSORTIUM LIST

FUNDACION PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGIAS DEL HIDROGENO EN ARAGON, INDUSTRIE HAUTE TECHNOLOGIE SA, VLAAMSE INSTELLING VOOR TECHNOLOGISCH ONDERZOEK N.V., FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V., INSTRUMENTACION Y COMPONENTES SA, RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE AACHEN

MAIN OBJECTIVES OF THE PROJECT

The strategic goal of the ELYntegration project is the design and engineering of a robust, flexible, efficient and cost-competitive single stack multi-megawatt High Pressure Alkaline Water Electrolysis of 4,5 T H_2/day capable to provide cutting-edge operational capabilities under highly dynamic power supplies expected in the frame of generation/ transmission/ distribution scenarios integrating high renewable energies (RE) shares.

PROGRESS/RESULTS TO-DATE

- Dissemination and awareness plan in progress (web of the project published, public presentation, presentation of the project in conferences).
- Technical, regulatory framework and requirements for electrolysers providing additional services (ramps, dynamic, control) studied.
- Electrodes and membranes for alkaline water electrolysis: first batch of developed materials tested in lab, first selection to be tested in-situ.
- Business models and market assessment in progress.

FUTURE STEPS

- Selection of components/next candidates to be tested in next stack's scale.

- Identification of most attractive business models.
- Second batch of materials to be developed according to first assessment of results.
- Selection of materials to be tested in dynamic operation (medium scale).

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Non consistent regulations and grid services within Europe, different requirements and specifications.
- It is needed to mark a set of recommendations (response time, bids, communication with operator) at EU level.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET (%)	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2014-2020
Efficiency 52 kWh/kg at higher current densities	52 kWh/kg. MAWP [2020]	52 (kWh/kg)	100 %	52 (kWh/kg) [Study on development of water electrolysis in the EU (2014) for Alkaline, for 2015 at system level, including power supply, control, gas drying]; 57-60 range in MAWP (2014)	The KPI in MAWP is referred to nominal rate, for a production >1,000 kg/day. Current status has been measured for lower current densities than the ones to be reached within the project
CAPEX <€1,3 M at higher current densities, whilst providing higher system flexibility	€2 M/(t/d) MAWP [2020] at rated power including ancillary equipments and comissioning	<€1,6 M (extrapolated value for the same production as reference)	95 %	MAWP for CAPEX (2017) is ~€3,7M/(t/d); Value from "Study on development of water electrolysis in the EU (2014) for Alkaline", for 2015 at system level is €930/kW	Previous calculations indicated that considering the actual value of <€750/kW, the estimation for a ton/day production is possible to reach in the project framework
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2014
CAPEX <€1,3 M at higher current densities, whilst providing higher system flexibility	€630/kW 2020 central KPI as expressed in AWP 2014	<750	95 %	Value from "Study on development of water electrolysis in the EU (2014) for Alkaline", for 2015 at system level is €930/kW	Challenge: keep CAPEX inline with technological improvements, changes in current densities and flexibility
(c) Other project objectives					
Design of a stack capacity >9,5 MW	Not applicable	3,5MW	95 %	Manufacturer's stack size (state of art)	Current design up to 6,5 MW per stack (not tested at full power scale, but in pilot scale)
Stack lifetime >10 years	Not applicable		95 %	Literature (Electrolysis study, 2014) indicates an average demostrated lifetime of >60,000h. Increasing lifetime has an impact on cost (CAPEX) and efficiency	The project will study the impact on the materials developed to achieve the improved capabilities of working with high flexibility. It will be used to extrapolate the impact on expected lifetime

ENDURANCE

Enhanced durability materials for advanced stacks of new solid oxide fuel cells

PANEL 4

Research activities for stationary applications

ACRONYM	ENDURANCE
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 DATE	1/04/2014
END DATE	31/03/2017
PROJECT TOTAL COST	€4,4 million
FCH JU MAXIMUM CONTRIBUTION	€2,5 million
WEBSITE	http://www.durablepower.eu/index.php

PARTNERSHIP/CONSORTIUM LIST

UNIVERSITA DEGLI STUDI DI GENOVA, SOLIDPOWER SPA, MARION TECHNOLOGIES S.A., FUNDACIO INSTITUT DE RECERCA DE L'ENERGIA DE CATALUNYA, DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, INSTITUTE OF ELECTROCHEMISTRY AND ENERGY SYSTEMS, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, SCHOTT AG, HTceramix SA, ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE, UNIVERSITA DI PISA

MAIN OBJECTIVES OF THE PROJECT

Improved and reliable predictive models to estimate long-term (i.e. >20 kh) performance, and real enhanced durability of SOFC stacks are the main goals of this project. To increase the knowledge of electrochemical and physicochemical phenomena occurring inside the stack during operation is considered the main tool to achieve such goals. To do so the strategy on two main axes was refined: design of micro-samples representative of meaningful zones of a real stack; selection of real-time and post operation investigation protocols suitable to enhance the models.

PROGRESS/RESULTS TO-DATE

- Electrochemical and thermomechanical models achieved higher resolution and a more accurate predictability of phenomena occurring at the stack level.
- Improved sealant better resisting to chemical stress and polarization.
- Enhanced diffusion barrier layer for a more reliable and durable cell.
- Tuned red-ox cycles to be applied to the anode for triple phase boundary (TPB) life extension with minor effects on Ni network.
- Microsamples simulating stack zones at operating conditions.

FUTURE STEPS

- Application of improved sealant in short stacks for statistical validation.
- Monitoring of the performances of a stack made with enhanced cells.
- Cycles (Idle to Load) applied 50 times to and improved short stack and evaluation of the degradation rate.
- Models further refined thanks to the operation of a segmented cells where each segment corresponds to specific operating conditions.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Degradation rate, modes and effects analyses is assessed and implemented with gathered results allowing an increased knowledge on phenomena.
- Improved and enhanced material more resilient degradation factors increase the reliability of the stacks making them more intersting for the market.
- Successful refinement of predictive and descriptive models allow to start the step forward of a more reliable predictability of the stack behaviour.
- The R&D strategy of this project was further optimized, a follow up to a more close to the market project is a realistic perspective.
- Dissemination and cross-cutting activities to increase public awareness and acceptation were successful.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
Improvement of durability & reliability (cost is not a target here)	2015: Cost of €1,500-2,500/kW for industrial/commercial units	First improvement carried on operated stacks, analysis of electrochem Performance	N/A	Stack costs €6-8k/kW depending on application (fuel type, lifetime specs etc.) which can impact current density & Capex/kW
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2013-1
a) Failure modes and effects analysis (FMEA) b) Identification of sensitive zones and interfaces inside a stack C) Advanced predictive modelling	Identify, quantify and document relevant degradation and failure mechanisms over the long term	70% a) FMEA defined as Degradation Rate, Mode and Effect Analysis (DRMEA) b) Stack is divided in the min. nr of interfaces and materials interacting w/each other, leading to a list of "minima phenomena" needed to understand the origin and predict the consequences of materials/interfaces evolution c) Existing models refined using microstructural data & by testing specific microsamples. Sealant found to be critical	90 %	All results are from operated stacks (short and segmented type),& microsamples designed to represent the minima phenomena. They are analyzed in-experiment (electrochemical performances) & post- experiment (microstructural features). Technical risks & challenges are still ahead
Statistical validation loop on companies stacks (i.e. the core of the project)	Identify improvements, and verify these in existing cells and stack design	40 % Thermo-mechanical tests of materials are running. 50 thermal cycles succesfully achieved	90 %	Most planned targets achieved. Idle to load cycles (off-standard protocols) represent a minor issue
Statistically validated predictive modelling verified with segmented stacks and near-RealLife tests (@ fully operating & working conditions) on micro-samples replicating sensitive stack interfaces/interphases.	Development of accelerated testing strategies for specific failure modes, backed by modelling or specific experiments to verify the method(s) used and validate of claimed improvement(s)	80 % Improved cells checked in reversible mode to stress degradation without failure. New sealant composition tested under humid fuel & polarization without showing detrimental degradation after a few 100h. Improved cells stacked & tested using reformed fuel without visible degradation after a few 100 h	100 %	Results will be available only at end of the project

ENE.FIELD

European-wide field trials for residential fuel cell micro-CHP

PANEL 3

Technology validation in stationary applications

ACRONYM	ENE.FIELD
CALL TOPIC	SP1-JTI-FCH.2011.3.7: Field demonstration of small stationary fuel cell systems for residential and commercial applications
START DATE	1/09/2012
END DATE	31/08/2017
PROJECT TOTAL COST	€52,4 million
FCH JU MAXIMUM CONTRIBUTION	€25,9 million
WEBSITE	http://enefield.eu/

PARTNERSHIP/CONSORTIUM LIST

THE EUROPEAN ASSOCIATION FOR THE PROMOTION OF COGENERATION VZW, BAXI INNOTECH GMBH, BOSCH THERMOTECHNIK GMBH, DANTHERM POWER A.S, ELCORE GMBH, Riesaer Brennstoffzellentechnik GmbH, SOLIDPOWER SPA, VAILLANT GMBH, DOLOMITI ENERGIA SPA, BRITISH GAS TRADING LIMITED, ELEMENT ENERGY LIMITED, ENGIE, ITHO DAALDEROP GROUP BV, HYDROGEN, FUEL CELLS AND ELECTRO-MOBILITY IN EUROPEAN REGIONS, IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE, RAZVOJNI CENTER ZA VODIKOVE TEHNOLOGIJE, PARCO SCIENTIFICO E TECNOLOGICO PER L'AMBIENTE – ENVIRONMENT PARK SPA, POLITECNICO DI TORINO, DBI – GASTECHNOLOGISCHES INSTITUT GMBH FREIBERG, THE ENERGY SAVING TRUST LTD BY GUARANTEE, GASWARME-INSTITUT ESSEN EV, DANMARKS TEKNISKE UNIVERSITET, EIFER EUROPAISCHES INSTITUT FUR ENERGIEFORSCHUNG EDF-KIT EWIV, DONG ENERGY WIND POWER HOLDING AS, HEXIS AG, DONG ENERGY OIL & GAS AS, SENERTEC KRAFT-WARME ÉNERGIESYSTEME GMBH, VIESSMANN WERKE GMBH & CO KG, CERES POWER LIMITED

MAIN OBJECTIVES OF THE PROJECT

The ene.field project will deploy and monitor 867 new installations of residential fuel cell CHP across 11 key European countries. It represents a step change in the volume of fuel cell deployment for this sector in each country. By learning the practical implications of installing, operating and supporting a fleet of fuel cells with real world customers, ene.field will demonstrate the environmental and economic imperative of micro FC-CHP, and lay the foundations for market exploitation.

PROGRESS/RESULTS TO-DATE

- 507 out of 867 units have been installed/delivered, 670 contracts signed.
- 69 units with detailed monitoring.
- Non-economic barriers: preliminary report has been prepared and presented at the Hannover Fair 2016.
- 16 press releases and 7 newsflashes published.
- European Supply Chain Analysis Report completed.

FUTURE STEPS

- All 867 units to be installed by the end of 2016.
- Non-economic barriers: final report to be published by the end of 2016.

- Report on technical performance of all mCHP units in the trial.
- National dissemination workshops.
- Report on economics of micro-CHP to 2030 and uptake scenarios.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- FC micro-CHPs are capable of and ready for smart grid integration.
- Financial support for FC mCHP have a determining impact on the geographic localisation of systems in Europe.
- FC mCHP are already competitive with regards to OPEX and GHG emissions compared to other heating technologies, but CAPEX needs to be reduced.
- A lack of common standards across Europan countries poses a large barrier for market uptake.
- Development of recommendations for the way in which FC mCHP can play a role in Europe's energy mix.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:			MAIP 2008-2013
867 units by Q4 2016	Target 2015 – 1,000 units / €10,000 per system (1 kW_e + household heat)	507 units installed/delivered	98 %
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:			AIP 2011
39-174 identical units from each manufacturer will be installed across a number of different sites	Install sufficient numbers of systems to give confidence by redundancy	Between 6 and 150 identical units from each manufacturer will be installed.	100 %
9 FC CHP products trialed in up to 1,000 demo sites. Monitoring for up to 2 year period	Increase the operational experience (including installation and maintenance)	10 FC CHP products trialled in >500 demo sites. Installations and monitoring ongoing	100 %
Optimised series production techniques will be developed	Provide proof of a suitable supply chain and increase capability	Consolidation of the sector has strengthened the position of key suppliers	100 %
The systems will be installed in customer homes, as a permanent replacement	Show commitment to running the systems after the end of the support phase	All manufacturers continue to install with the intention of life for the product	100 %
A full life cycle cost (LCC) and life cycle environmental assessment (LCA) will be delivered	Estimate full life cycle costs, carry out an environmental sustainability assessment	A first draft of the LCA has been done. First draft of LCC expected 6th of June	100 %
A Utility Working group will provide position papers on micro-CHP in future grid systems	Understand the benefits and risks of smart grid integration	A position paper on smart grid capabilities of FC micro-CHPs has been delivered	100 %

EURECA

Efficient use of resources in energy converting applications

PANEL 4

Research activities for stationary applications

ACRONYM	EURECA
CALL TOPIC	SP1-JTI-FCH.2011.3.1: Next generation stack and cell design
START DATE	1/07/2012
END DATE	31/08/2015
PROJECT TOTAL COST	€6,2 million
FCH JU MAXIMUM CONTRIBUTION	€3,5 million
WEBSITE	www.project-eureca.com

PARTNERSHIP/CONSORTIUM LIST

EWE-Forschungszentrum für Energietechnologie e. V., Eisenhuth GmbH & Co. KG, UNIVERZITET U BEOGRADU, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, FOUNDATION FOR RESEARCH AND TECHNOLOGY HELLAS, INHOUSE ENGINEERING GMBH, CELAYA, EMPARANZA Y GALDOS INTERNACIONAL, S.A., FUNDACION CIDETEC, FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V, HYDROGENICS EUROPE NV, HYDROGEN EFFICIENCY TECHNOLOGIES (HYET) BV, WaterstofNet vzw, ETABLISSEMENTEN FRANZ COLRUYT NV, TUV Rheinland Industrie Service GmbH, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, THINKSTEP AG, ICELANDIC NEW ENERGY LTD, FAST – FEDERAZIONE DELLE ASSOCIAZIONI SCIENTIFICHE E TECNICHE, ITM POWER (TRADING) LIMITED, H2 Logic A/S, RAUFOSS FUEL SYSTEMS AS, DAIMLER AG, SHELL GLOBAL SOLUTIONS INTERNATIONAL B.V., BUNDESANSTALT FUER MATERIALFORSCHUNG UND -PRUEFUNG, ASSOCIATION POUR LA RECHERCHE ET LE DEVÉLOPPEMENT DES MÉTHODES ET PROCESSUS INDUSTRIELS – ARMINES, HOCHSCHULE ESSLINGEN, UNIRESEARCH BV, DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV

MAIN OBJECTIVES OF THE PROJECT

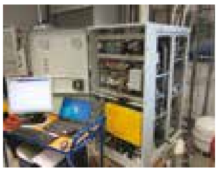
The project aims at the development of Stationary Power Generation and Combined Heat and Power (SPG&CHP) systems based on PEMFC operating at 90 °C-120 °C. The main objective is to give a clear demonstration of the SPG&CHP systems, based on recent knowledge on the degradation mechanisms and innovative synthetic approaches. Main research tasks: (1) Develop long-life membranes, catalytic electrodes and MEAs; (2) Perform accelerated ageing tests (3) Develop a prototype of a modular SPG&CHP system.

PROGRESS/RESULTS TO-DATE

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

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Efficient energy supply.
- Middle temperature fuel cells are a resonable bridge between high and low temperature fuel cells.
- Influence of components to system costs and properties is sharpening the development strategy.



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:			MAIP 2008-2013
Cost of <€3k/kW	Cost of €4-5k/kW	<€5k/kW	MAIP aim is fulfilled, Project objective not reached
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:			AIP 2011
Efficiency Improvement	35 % efficiency based on the the integrated reformer	Electrical effiency of 37 %	
Cost reduction	Lifetime improvement >10 kh (stack) and >12 kh (system)	stack >12 kh	

EVOLVE

Evolved materials and innovative design for high-performance, durable and reliable SOFC cell and stack

PANEL 4

Research activities for stationary applications

ACRONYM	EVOLVE
CALL TOPIC	SP1-JTI-FCH.2011.3.1: Next generation stack and cell design
START DATE	1/11/2012
END DATE	31/10/2016
PROJECT TOTAL COST	€5,7 million
FCH JU MAXIMUM CONTRIBUTION	€3,1 million
WEBSITE	http://www.evolve-fcell.eu/

PARTNERSHIP/CONSORTIUM LIST

DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, ALANTUM EUROPE GMBH, ASSOCIATION POUR LA RECHERCHE ET LE DEVÉLOPPEMENT DES MÉTHODES ET PROCESSUS INDUSTRIELS – ARMINES, Ceramic Powder Technology AS, CONSIGLIO NAZIONALE DELLE RICERCHE, INSTITUT POLYTECHNIQUE DE GRENOBLE, SAAN ENERGI AB, CERACO CERAMIC COATING GMBH

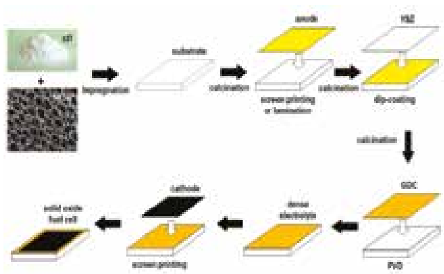
MAIN OBJECTIVES OF THE PROJECT

The project targets the demonstration at the stack level of a SOFC, implementing an innovative substrate resilient toward redox cycles with higher durability than mainstream Metal Supported Cells implementing porous ferritic stainless steel substrates and greater cyclability than mainstream anode-supported cells implementing the Ni-based cermet.

Focus: An innovative combination of advanced materials with reduced amount of nickel, showing improved tolerance against common fuel contaminants compared to mainstream nickel-based cermet Anode and higher resilience toward redox cycles.

PROGRESS/RESULTS TO-DATE

- A first prototype with La0,1Sr0,9TiO3-α (LST) based anode material and a thin film multi-layer electrolyte technology (less than 3µm).
- Power density above 350 mW.cm-2 at 750 °C and 0.7 V could be demonstrated with addition of nickel in the anode compartment.
- The EVOLVE cell can withstand at least 10 redox cycles without significant degradation.
- Cell architecture has been successfully up-scaled to a 90 mm x 100 mm footprint for stack integration.



FUTURE STEPS

- Performance shall be evaluated at stack level until the end of the project.
- Rationalization of the manufacturing route.
- Cost analysis.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Replacement of nickel based cermet anodes for high performance SOFC is still challenging.
- The architecture showed remarkable stability against redox cycles despite use of nickel.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
Cell survives at least 50 redox cycles	2020 target: must sustain repeated on/off cycling (CHP Unit)	Cell prototype has been demonstrated redox stable for at least 13 cycles without noticeable drop of Open Circuit Voltage	90 %	To be experimentally verified at cell level in October 2016
Degradation rate of cell voltage below 0.25 % per 1,000 hours with H_2 as fuel	2020 target: (CHP Unit) Life Time expected >20,000 hours	30 % of degradation of power density for 500 hours of operation in potentiostatic conditions. Origin of degradation is under investigation	<10 %	Unexpected high degradation rate measured on proof of concept cells. Degradation mechanisms not yet fully understood to propose adequate mitigation strategy
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2011
Degradation rate of cell voltage below 1.5 % per 1,000 hours in Syngas (with H_2S)	Improved Tolerance to contaminants with respect to state of art FCs	Nickel amount reduced to 5wt% of the active anode material. Ni free catalysts under investigations	<10 %	
Heating rate of 25K/min for thermal cycles	Improved start-up time from room temperature to 30 % of power rating below 1 hour	Not yet evaluated	50 %	
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	Decreased material consumption	Cell architecture up-scaled in size to industrially relevant dimensions	75 %	Reduction from 100µm to 3µm the thickness of the electrolyte required for comparable gas tightness at level 90 mm x 100mm. Manufacturing route still needs rationalization before being considered as competitive.

FCPOWEREDRBS

Demonstration project for power supply to telecom stations through FC technology

PANEL 3
Technology validation in stationary applications

ACRONYM	FCPOWEREDRBS
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	1/01/2012
END DATE	31/12/2015
PROJECT TOTAL COST	€10,5 million
FCH JU MAXIMUM CONTRIBUTION	€4,2 million
WEBSITE	www.fcpoweredrbs.eu

PARTNERSHIP/CONSORTIUM LIST

ERICSSON TELECOMUNICAZIONI, DANTHERM POWER A.S, GREENHYDROGEN DK APS, MES SA, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, UNIVERSITA DEGLI STUDI DI ROMA TOR VERGATA, FUNDACION TECNALIA RESEARCH & INNOVATION, TECHNISCHE UNIVERSITEIT EINDHOVEN, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, POLITECNICO DI MILANO, STIFTELSEN SINTEF, ICI CALDAIE SPA, HyGear B.V., SOPRANO INDUSTRY, HYBRID CATALYSIS BV, Quantis Sàrl, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE,L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE, Processi Innovativi SRL, ACKTAR LTD., TECHNION – ISRAEL INSTITUTE OF TECHNOLOGY., FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V, UNIVERSITA DEGLI STUDI DI SALERNO, CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS, ARISTOTELIO PANEPISTIMIO THESSALONIKIS, UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA, STICHTING ENERGIEONDERZOEK CENTRUM NEDERLAND, GKN SINTER METALS ENGINEERING GMBH, UNIVERSITA CAMPUS BIO MEDICO DI ROMA, CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS

MAIN OBJECTIVES OF THE PROJECT

Scope of the project is to demonstrate the advantages of a stationary application combining renewable energy and Fuel Cell in term of total cost of ownership (TCO), comparing to the solutions used today in Telecommunication off-grid Radio Base Station (Diesel Gen Set). Assess the market readiness of the Fuel Cell technology vs the TLC reliability demanding targets integrating the solution into real live operation.

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 successfully implemented.
- H_2 supply solution and safety procedures implemented.
- Real Radio sites powered successfully for months.

FUTURE STEPS

- The project is finished.
- Commercial proposition of other Fuel Cell based application for telecommunication (TLC) market.
- System scalability.
- Dissemination in TLC industry.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The project results gave an immediate picture with respect to the market readiness of the proposed solution.
- The TCO calculated is in line with expectations and of a proper market proposition may be already available for TLC off-grid sites.
- 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

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
Number of units 15 radio sites+ 2 Lab sites	Early Market application area 1-6 kW back-up power system Volume in the EU 2015: 8,000 units (1,000 electr)	Up & Running: 13 + 2 Lab sites		
Durability 10,000 h	AA4 Early Market – 1-6 kW back-up power system Durability 2015: 10,000 h	>12,000 h for the first deployed site		
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2010
Increasing the hours of unattended operation due to the higher efficiency	Demonstrate the advantages of hydrogen and fuel cells compared to the solutions used today	Av. # yearly refuelling at site: 21 with FC Methanol 28 with FC H_2 35 with today Diesel	100 %	
TCO analysis with real business case approach	Show the commercial operator value proposition	TCO analysis performed based on measurements from field trial	100 %	
(c) Other project objectives:				
Demonstrate a viable hydrogen supply solution for this application	Not applicable	The hydrogen logistic for refuelling of H_2 and Methanol is in place. The processes have been agreed and implemented with supplier.	98 %	Some improvements in viability could be done in order to guarantee a safe increasing of volumes in the future.

FERRET

A flexible natural gas membrane reformer for m-CHP applications

PANEL 4
Research activities for stationary applications

ACRONYM	FERRET
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 DATE	1/04/2014
END DATE	31/03/2017
PROJECT TOTAL COST	€3,2 million
FCH JU MAXIMUM CONTRIBUTION	€1,7 million
WEBSITE	http://www.ferret-h2.eu/

PARTNERSHIP/CONSORTIUM LIST

TECHNISCHE UNIVERSITEIT EINDHOVEN, FUNDACION TECNALIA RESEARCH & INNOVATION, POLITECNICO DI MILANO, ICI CALDAIE SPA, HyGear B.V., JOHNSON MATTHEY PLC

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 Hygear m-CHP unit.
FERRET project will:
- Design a flexible reformer: catalyst, membranes & control for different natural gas (NG) compositions.
- Use H_2 membranes to produce pure H_2.
- Scale-up the new H_2 selective membranes and catalyst production.
- Introduce ways to improve membrane recyclability.

PROGRESS/RESULTS TO-DATE

- NG reforming catalysts at 600 °C developed, stable with different NG compositions.
- Thin Pd-based membranes (<5 m) prepared & tested at lab scale + further scaled up.
- 1st experimental lab-scale tests concluded, phenomenological model validated.
- Pilot scale reformed assembled.
- BoP under construction for final testing.

FUTURE STEPS

- Prototype reactor testing and validation.
- Further validation at lab scale.
- Proof of concept of the novel micro-CHP system.
- Tech-economic assessment + optimization of reactors & complete system.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- New catalysts been produced - can be scaled up.
- Fluidized Bed Membrane Reactor concept validated @ lab-scale.
- Membranes produced at larger scales for prototype unit.
- Pilot scale prototype built.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Overall efficiency CHP units	>80 %	>90 %	80 %		70% achievement. Simulation shows it is possible
Emissions and fuels	< Emissions, use of multiple fuels	Flexibility to use different NG qualities, reduced CO_2 emissions	100 %		75% achievement
Cost per system (1kW$_e$ + household heat).	Cost: €10k/system (2015), €5k/system (2020)	€5,000 (1 kW$_e$ + house heat)	100 %		Cost could be achieved @ mass prod. or slightly bigger m-CHP. Cost analysis to be carried out
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
Cost: €10k/system (2015), €5k/system (2020)	Cost: €10k/system (2015), €5k/system (2020)	TRL 4 – technology validated in lab. Prototype built	100 %		The prototype is built and ready for FAT, afterwards proof-of-concept will start
Durability	Several 100h of continuous operating	1,000 h of operation	100 %		If factory acceptance testing is achieved, final durability test will be performed as planned
(c) Other project objectives					
Novel catalyst for NG reforming in fluidized beds	Not applicable	Novel catalyst for NG reforming in fluidized beds produced & upscaled	100 %	State of the art catalyst	
Development of >15 cm mechanicaly stronger H_2 selective membranes	Not applicable	40 membranes of >20 cm each have been produced for the prototype.	100 %	State-of art membranes	
Membrane reactor	Not applicable	Fluidized bed membrane reactor validated & scaled-up for prototype	100 %	State-of art reactors	

FIRECOMP

Modelling the thermo-mechanical behaviour of high pressure vessel in composite materials when exposed to fire conditions

PANEL 6
Cross-cutting

ACRONYM	FIRECOMP
CALL TOPIC	SP1-JTI-FCH.2012.5.4: Pre-normative research on fire safety of pressure vessels in composite materials
START DATE	1/06/2013
END DATE	31/05/2016
PROJECT TOTAL COST	€3,5 million
FCH JU MAXIMUM CONTRIBUTION	€1,8 million
WEBSITE	http://www.firecomp.info/

PARTNERSHIP/CONSORTIUM LIST

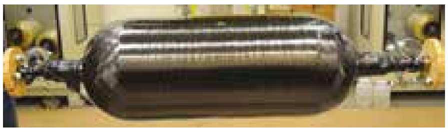
L'AIR LIQUIDE S.A, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, THE UNIVERSITY OF EDINBURGH, RAUFOSS FUEL SYSTEMS AS, INSTITUT NATIONAL DE L'ENVIRONNEMENT ET DES RISQUES INERIS, HEALTH AND SAFETY EXECUTIVE, SAMTECH SA, ALMA CONSULTING GROUP SAS

MAIN OBJECTIVES OF THE PROJECT

Better characterize the conditions that need to be achieved to avoid burst of composite vessels for CGH_2 storage. To this aim, experimental work has been done in order to improve the understanding of heat transfer mechanisms and the loss of strength of composite high-pressure vessels in fire conditions. We modelled the thermo-mechanical behaviour of these vessels. Different applications have been considered: automotive application, stationary application, transportable cylinders, bundles and tube trailers.

PROGRESS/RESULTS TO-DATE

- Bonfire test campaign on 19 and 36L composite cylinders performed.
- Parametric study model performed and comparison with experimental results satisfying.
- Proposed approach for comparison with metallic cylinder of risk evaluation.
- Definition of RCS recommendations.
- Dissemination at WHEC Zaragoza, Spain June 16, ECCM Munich, Germany June 16.



FUTURE STEPS

- Finalizing last deliverables and public RCS recommendations.
- Prepare the publications for scientific results.
- Dissemination at ISO TC58SC3 WG24 and ISO TC197.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- If a reliable pressure relief system is used, composite cylinders are able to provide satisfying safety levels comparable to metallic ones.
- Fire scenarios include both engulfing and localised fires, which should be taken into account in the risk analysis.
- Whatever other protections are used, the pressure relief system shall activate for all types of fires which can lead to a burst.
- The performance of the cylinder alone (without any protection) should be assessed in order to provide information to the integrator.
- Then, the integrator should design and test his safety devices using his own risk analysis.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
Deliverables 2.1 and D6.6 Current fire approach for cylinders, RCS mapping and project expected outcomes	Compare policy and technology options	ACHIEVED	100 %	
WP2: Define & characterize fire scenario, perform risk assessment, compare with metallic cylinders	Specify technology assessment, collect and compare data for alternative technologies	ACHIEVED	100 %	Risk mythology presented at IchemE, proposition of approach for comparison with metallic cylinder
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2012
WP3- develop and validate a model representing the thermal degradation of a composite cylinder	Understand the evolution of the composite material when exposed to fire conditions	ACHIEVED	100 %	Succeeded in extracting "general" thermal properties
WP4- develop a thermo-mechanical damage model	Develop a model for predicting loss of strength & Identify conditions to avoid burst	ACHIEVED	100 %	Characterization of the mechanical behaviour and the different damage modes at different temperatures in the range [20 °C-150 °C]
WP5: Test composite reservoir behaviour in referenced fires and thermo-mechanical model validation	Validation of the model by an experimental programme. Propose safety pressure relief curve	ACHIEVED	95 %	Simulated times to burst and times to leak in accordance with the experiment, without parameter recalibration

FLUIDCELL

Advanced m-CHP fuel cell system based on a novel bio-ethanol fluidized bed membrane reformer

PANEL 4

Research activities for stationary applications

ACRONYM	FLUIDCELL
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	1/04/2014
END DATE	30/11/2017
PROJECT TOTAL COST	€4,1 million
FCH JU MAXIMUM CONTRIBUTION	€2,4 million
WEBSITE	http://www.fluidcell.eu/

PARTNERSHIP/CONSORTIUM LIST

FUNDACION TECNALIA RESEARCH & INNOVATION, TECHNISCHE UNIVERSITEIT EINDHOVEN, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, POLITECNICO DI MILANO, UNIVERSITA DEGLI STUDI DI SALERNO, UNIVERSIDADE DO PORTO, ICI CALDAIE SPA, HyGear B.V., Quantis Sàrl

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:

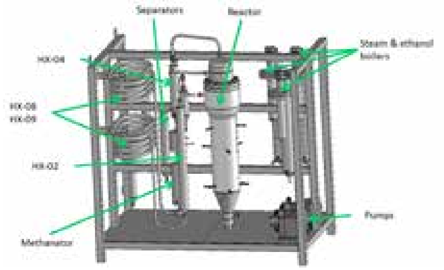
- Design, construction and testing of an advanced bio-ethanol reformer for pure H_2 production (3.5 Nm^3/h) based on Catalytic Membrane Reactor (CMR) &
- Design/ptimization of all subcomponents for the BoP with particular attention to the optimized thermal integration & connection of the membrane reformer to the FC stack.

PROGRESS/RESULTS TO-DATE

- Catalyst for bio-ethanol reforming under moderated (<500ºC) condition developed.
- New plating system for long (50 cm) Pd-based membranes developed. First batch prepared.
- First experimental lab-scale testing campaign of the CMR concluded. Phenomenological model validated.
- Pilot scale reformed designed. Assembling on going.
- Fuel Cell stack prototype layout defined.

FUTURE STEPS

- Development of the membranes for the prototype.
- Prototype reactor assembling, testing and validation.
- Proof of concept of the novel micro-CHP system, to 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

- Novel catalyst for bio-ethanol reforming under moderate conditions (<500ºC) and fluidization has been developed.
- The Fluidized Bed Membrane Reactor concept validated a lab-scale.
- Pilot scale prototype design concluded.
- Fuel Cell stack prototype defined.
- FluidCELL gives an answer to the many off-grid decentralized energy consumers dependant on expensive & polluting sources.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Overall efficiency CHP units	>80 %	>90 %	80 %		60% achievement, to be confirmed end of project.
Emissions and fuels	< emissions, use of multiple fuels	Bio-ethanol as fuel (instead of natural gas).	100 %		60 % achievement. To be confirmed end of the project. Reduced anthropogenic CO_2 emissions compared to conventional fossil fuels.
Cost per system (1 kW_e + household heat).	Cost: €10k/system (2015), €5k/system (2020)	€5,000 (1 kW_e + house heat)	70 %		Cost could be achieved @ mass prod. or slightly bigger m-CHP. Cost analysis to be carried out.
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
Lab Proof-of-Concept of CHP	Lab Proof-of-Concept of CHP	N/A	80 %		Project extension needed
Durability	Several 100h of continuous operating	1,000 h of operation	80 %		Project extension needed
(c) Other project objectives					
Novel catalyst for bio-ethanol reforming	Not applicable	Novel catalyst for bio-ethanol reforming (<500ºC) & fluidization	100 %	State of the art catalyst	
Development of >15 cm mechanicaly stronger H_2 selective membranes	Not applicable	New plating system for long (50 cm) Pd based membranes. 1st batch.	100 %	State-of art membranes	Further developments are needed to ensure improved selectivity.
Membrane Scale-up, processing issues	Not applicable	Suitable 45 cm long ceramic supported membranes have been developed.	100 %	State-of art membranes	Further developments are needed to ensure improved selectivity.
Membrane reactor	Not applicable	FBMR concept validated at lab-scale (TRL 4) for bio-ethanol reforming	100 %	State of the art	Phenomenological model validated.

H2ME

Hydrogen Mobility Europe

PANEL 1

Technology validation in transport applications

ACRONYM	H2ME
CALL TOPIC	FCH-01.7-2014: Large scale demonstration of refuelling infrastructure for road vehicles
START DATE	1/06/2015
END DATE	31/05/2020
PROJECT TOTAL COST	€62,6 million
FCH JU MAXIMUM CONTRIBUTION	€32 million
WEBSITE	www.h2me.eu

PARTNERSHIP/CONSORTIUM LIST

ELEMENT ENERGY LIMITED, H2 MOBILITY DEUTSCHLAND GMBH & CO KG, ICELANDIC NEW ENERGY LTD, SYMBIOFCELL SA, ITM POWER (TRADING) LIMITED, AIR LIQUIDE ADVANCED TECHNOLOGIES SA, LINDE AG, H2 Logic A/S, FALKENBERG ENERGI AB, HYOP AS, AIR LIQUIDE ADVANCED BUSINESS, EIFER EUROPAISCHES INSTITUT FUR ENERGIEFORSCHUNG EDF KIT EWIV, COMMUNAUTE D'AGGLOMERATION SARREGUEMINES CONFLUENCES, McPhy Energy SA, AREVA H2GEN, BOC LIMITED, DAIMLER AG, HYUNDAI MOTOR EUROPE GMBH, CENEX – CENTRE OF EXCELLENCE FOR LOW CARBON AND FUEL CELL TECHNOLOGIES, WATERSTOFNET VZW, OMV REFINING & MARKETING GMBH, HONDA R&D EUROPE (DEUTSCHLAND) GMBH, INTELLIGENT ENERGY LIMITED, Nissan Motor Manufacturing (UK) Limited, AGA AB, BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT, RENAULT SAS, DANISH HYDROGEN FUEL AS

MAIN OBJECTIVES OF THE PROJECT

H2ME is the most ambitious coordinated H_2 deployment project attempted in Europe to date. Key objectives are:

- Creation of a physical and strategical pan-European network.
- Real world testing of 4 national H_2 mobility strategies and share learnings to support other countries' strategy development.
- Trial fleets of FCEVs in diverse applications – 200 OEM FCEVs (Daimler and Hyundai) and 125 fuel cell range-extended vans (Symbio FCell).
- Deploy 29 state of the art HRS.
- Analyse the customer value proposition and assess performance to validate the readiness of the technology.

PROGRESS/RESULTS TO-DATE

- Fruitful 1st year with 1st HRS commissioned (in Kolding, DK) and vehicles in operation (40 B-CLASS F-CELL Daimlers and 27 SymbioFCell as of Jun 16).
- 1st technical data set delivered and analysed.
- Successful proposal evaluation and launch of follow-up project, H2ME-2, with an extra 1230 vehicles and 20 HRS planned for the next 6 years.

FUTURE STEPS

- Continue deployment activities for H2ME and H2ME 2 projects with an additional 48 HRS and another ~ 1,500 vehicles to be trialled by 2020.
- Commercialisation discussion forum to start with first analysis conducted and disseminated in 2016.
- Increase reachout activities to key audiences.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- FCEVs and fuel cell range-extended vans are operated with very similar patterns to petrol/diesel vehicles (trip distance, refuelling etc.).
- Financial incentives work best in combination with other benefits types for users to develop and support national markets e.g priority lanes access.
- Additional work is required on vehicle needs with regards to HRS deployment and understanding business cases from a customer point of view.
- Lead time for building permits and planning authorisations need to be reduced.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAWP 2014-2020
TRL of HRS and onsite H_2 production (if any) min. 6	TRL of HRS and onsite H_2 production (if any) min. 6	1 HRS deployed with TRL 6.	100 %	TLR 6	N/A
Hydrogen purity min. 99.999 %; refuelling process: SAE J2601; IR communication; SAE J2799. Exceptions allowed if justified	Hydrogen purity min. 99.999 %; refuelling process: SAE J2601; IR communication; SAE J2799. Exceptions allowed if justified	1 HRS deployed meeting standards	100 %	Vary depending on HRS	Exceptions for 350 bar HRS
HRS availability min. 97 % (measured in usable operation)	HRS availability min. 97 % (measured in usable operation)	1 HRS deployed with 99 % availability reached	100 %	95 %	N/A
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AWP 2014
All vehicles are designed to be operated for min. 6,000 h	Vehicle operation lifetime >5,000 h initially and min 6,000 h as program target	Vans are operating for around 500 h/year (start of day to end of day).	100 %	6,000 h	N/A
All vehicles will be operated for min. 1 year or 10,000 km	Minimum vehicle operation during the project 12 months or 10,000 km	9 months operation for 40 B Class F-Cell. Operation period ranging from 9 to 1 month for 27 Symbio FCell	100 %	N/A	N/A
Mean Time Between Failure (MTBF) >1,000 km	MTBF >1,000 km	Observed MTBF >1,000km as no failures reported	100 %	MTBF >1,000 km	N/A
Availability >95 %	Availability >95 % (To be measured in available operation time)	Availability >99 %	100 %	Availability 95 %	N/A
Tank-to-wheel (TTW) efficiency >40 %	TTW efficiency >40 %	Measured TTW efficiency of passenger cars = 46 %	100 %	TTW efficiency 40 %	

H2REF

Development of a cost effective and reliable hydrogen fuel cell vehicle refuelling system

PANEL 2
Research activities for transport applications

ACRONYM	H2REF
CALL TOPIC	FCH-01.5-2014: Development of cost effective and reliable hydrogen refuelling station components and systems for fuel cell vehicles
START DATE	1/09/2015
END DATE	31/08/2018
PROJECT TOTAL COST	€6,4 million
FCH JU MAXIMUM CONTRIBUTION	€5,9 million
WEBSITE	

PARTNERSHIP/CONSORTIUM LIST

CENTRE TECHNIQUE DES INDUSTRIES MECANIQUES, H2NOVA, HASKEL FRANCE, HEXAGON RAUFOSS AS, THE CCS GLOBAL GROUP LIMITED, Ludwig-Boelkow-Systemtechnik GmbH

MAIN OBJECTIVES OF THE PROJECT

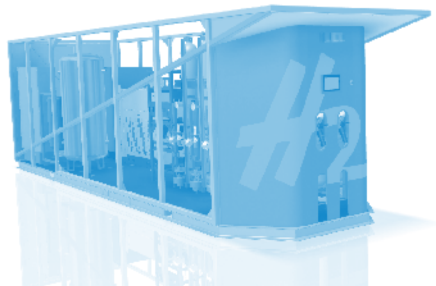
H2Ref addresses the compression and buffering function for the refuelling of 70 MPa passenger vehicles and encompasses all the necessary activities for advancing a novel hydraulics-based compression and buffering module (CBM) that is very cost effective and reliable from TRL 3 (experimentally proven concept) to TRL 6 (technology demonstrated in relevant environment), thereby proving highly improved performance and reliability.

PROGRESS/RESULTS TO-DATE

- Specification of the CBM prototype.
- Detailed specification of CBM component test bench.
- Multi physical (hydraulic, thermal, thermodynamic) model of the CBM prototype.

FUTURE STEPS

- Construction and implementation of the CBM component test bench.
- Qualification of CBM components.
- Construction of CBM prototype.



CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Not applicable, project started in September 2015.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAWP 2014-2020
Bring from TRL3 to TRL6 a technical solution providing a step change in cost and reliability	Compressors are both too expensive and not reliable enough for commercialisation purposes	70 % (research and innovation action)		Work in progress (1st year of the project)
Compression and buffering module manufacturing cost: €300k assuming a production of 50 / year	Hydrogen refuelling stations cost 0,8 M€ for a 200 kg per day in 2020	70 % (research and innovation action)	€750k (50 % of the current HRS cost)	Work in progress (1st year of the project)
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AWP 2014
Prepare RCS framework for commercialisation worldwide	Not applicable	90 %	Gaps need to be addressed for covering the new solution developed	Work in progress (1st year of the project)

HAWL

Large scale demonstration of substitution of battery electric forklifts by hydrogen fuel cell forklifts in logistics warehouses

PANEL 1

Technology validation in transport applications

ACRONYM	HAWL
CALL TOPIC	SP1-JTI-FCH.2012.4.1: Demonstration of fuel cell powered material handling equipment vehicles including infrastructure
START DATE	1/09/2013
END DATE	31/08/2017
PROJECT TOTAL COST	€8,5 million
FCH JU MAXIMUM CONTRIBUTION	€4,2 million
WEBSITE	https://hawlproject.eu/en

PARTNERSHIP/CONSORTIUM LIST

AIR LIQUIDE ADVANCED BUSINESS, HYPULSION SAS, CROWN GABELSTAPLER GMBH & CO KG, Toyota Material Handling Europe AB, FM POLSKA SP ZOO, AIR LIQUIDE ADVANCED TECHNOLOGIES SA, DIAGMA, BT PRODUCTS AB, CESAB CARRELLI ELEVATORI SPA, FM France SAS, FM LOGISTIC CORPORATE

MAIN OBJECTIVES OF THE PROJECT

The main objectives of this project are to develop and certify European ranges of fuel cell products and fuel cell ready vehicles, to deploy full fleets of FC powered forklifts in multiple warehouses, to assess and demonstrate the productivity given by the technology, to solve the relevant safety and acceptance issues, to pass required certification steps and to obtain necessary operating permits.

The overall objective is to help increase awareness of the fuel cell technology value proposition on customer sites throughout Europe.

PROGRESS/RESULTS TO-DATE

- 8 types of fuel cells developed by Hypulsion for the European market.
- 4 types of forklifts (reach trucks and pallet trucks from Toyota and Crown) qualified with Hypulsion fuel cell.
- 1 year test in real conditions in a FM Logistic site of a fleet of 10 fuel cell forklift trucks using Air Liquide hydrogen infrastructure.
- Over 5600 refuellings performed on site.
- Productivity business case demonstrated for class 3 trucks.

FUTURE STEPS

- Additional fleet deployment (36 additional forklifts).
- Installation of a second dispenser.
- Operation report and productivity business case demonstration for a large scale deployment.
- Identification of further sites for additional deployments.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Confirmation of the operational interest of the fuel cell solution in material handling applications.
- Solution acceptance by workers.
- French reference code published December 23rd will allow faster permitting and will facilitate deployment.
- Full range of products (fuel cells, hydrogen refuelling infrastructure, vehicles) available to the European market.
- Appropriate funding scheme needed for further developments.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Total cost of FC system (at early volume production) for FC >3kW:	<50 units / < €3,500/kW	< €3,000/kW	100 %	€2,000/kW for class 2 10 kW fuel cell	Achieved
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2012
System lifetime (with service/ stack refurbishment)	Not defined	>7 500 h			Not demonstrated in the project yet
FC system efficiency (%)	>40 %	>45 %	100 %	>45 %	Achieved
Refuelling time	3 min	3 min	100 %		Achieved

HEALTH-CODE

Real operation PEM fuel cells HEALTH-state monitoring and diagnosis based on dc-dc COnverter embeddeD Eis

PANEL 4

Research activities for stationary applications

ACRONYM	HEALTH-CODE
CALL TOPIC	FCH-02.3-2014: Stationary fuel cell system diagnostics: development of online monitoring and diagnostics systems for reliable and durable fuel cell system operation
START DATE	1/09/2015
END DATE	31/08/2018
PROJECT TOTAL COST	€2,3 million
FCH JU MAXIMUM CONTRIBUTION	€2,3 million
WEBSITE	http://pemfc.health-code.eu/

PARTNERSHIP/CONSORTIUM LIST

UNIVERSITA DEGLI STUDI DI SALERNO, AALBORG UNIVERSITET, DANTHERM POWER A/S, EIFER EUROPAISCHES INSTITUT FUR ENERGIEFORSCHUNG EDF KIT EWIV, ELECTRO POWER SYSTEMS MANUFACTURINGSRL, TORINO E-DISTRICT CONSORZIO, UNIVERSITE DE FRANCHE-COMTE, ABSISKEY CP

MAIN OBJECTIVES OF THE PROJECT

1) Implementation of monitoring & diagnostic tool based on Electrochemical Impedance Spectroscopy (EIS) for µ-CHP & O_2-fed backup PEMFC.
2) Development of a tool for state-of-health assessment, fault detection & isolation as well as degradation level analysis for lifetime extrapolation. Determine the current status for the detection of 5 faults: i) change in fuel composition; ii) air and iii) fuel starvation; iv) sulphur poisoning; v) flooding and dehydration. Infer on the residual useful lifetime.
3) Reduce experiments, time & costs through scaling-up methodology.

PROGRESS/RESULTS TO-DATE

- Thorough state-of-art study on the most relevant PEMFC faults & on relevant diagnostic strategies.
- Test protocols developed for both µ-CHP and backup stacks, with respect to normal & faulty operation testing.
- All stacks have been installed on test benches at three laboratories.
- EIS board and power electronics under design process to meet measurements targets for monitoring & diagnostic purposes.
- Several diagnostic algorithms under development; preliminary analysis performed based on data from previous projects.

FUTURE STEPS

- Expecting a 1st set of EIS measurements for stacks characterization to be released in June 2016.
- Release of the 1st scaling-up algorithm to model stack behaviour from single cell EIS data.
- 2nd generation of the EIS board, improved with respet to the one developed in D-CODE project, will be released for first tests.
- Interfacing the EIS board and the converters to perform EIS during FC system operations.
- Integration of both hardware and algorithms for testing on FC systems.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Main activities are still ongoing and conclusions can't be drawn yet.
- Transfer EIS measurements from lab. to on-board applications to improve diagnostics + support advanced lifetime analysis.
- It is expected the implementation of a low cost board driving the DC/DC converter to perform the EIS, while the system is running on field.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAWP 2014-2020
Monitoring and diagnostic algorithm for improved PEMFC system efficiency, reliability & availability.	Increase electrical efficiency and durability of the different FCs used for power production	Several diagnostic algorithms (i.e. model- and signal-based) under design	100 %	From D-CODE project results, diagnostic algorithms have been successfully applied on PEMFC systems.	Activities are on time; preliminary results based on available data. Algorithms will tested on data acquired during project experiments.
EIS board cost <3% of the overall system manufacturing cost.	Reduce total cost ownership (TCO in €/kWh)	EIS board design based on components improvement for cost reduction.	100 %	From D-CODE project: overall cost of EIS board (with the provided accuracy) within 3% of the tested PEMFC system	EIS board cost under analysis vs the considered components for the the 2 systems (µ-CHP and backup).
Backup system designed to be coupled with electrolyser for an independent power production system	Improve grid stability through applications of stationary FCs + energy storage	Investigation of pure O_2 feed instead of air considered for backup system	100 %	Negligible activity in literature on EIS applications & diagnostic analysis combined with O_2-fed systems.	Test bench organized to perform tests on this system under normal & faulty conditions.
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AWP 2014
Demo of fault diagnosis on 2 stacks for µ-CHP and Backup	Demo of detection of major stack/ system failure modes in lab tests with min. 2 different platforms	Stack installed on test benches and experimental activity at early stages	100 %	Not available for FC systems, few data available on stacks	Some delay due to change from air- to O_2-fed system. However, overall progress is still on time, no further problem
5 faults considered: i) change in fuel composition; ii) air starvation; iii) fuel starvation; iv) sulphur poisoning; v) flooding and dehydration	5 failure modes detectable	Testing protocol defined; diagnostic algorithms under design	100 %	From D-CODE project, only 3 faults (flooding, dehydration & air starvation) were considered	Preliminary results obtained. Refinement on diagnostic algorithms with data from experimental activity to be done
Lab tests & field operation emulated on 2 PEMFC systems (µ-CHP and backup) to validate monitoring & diagnostic algorithms	Lab or field- demo of the monitoring/ diagnostics approach integrated into2 FC systems	Lab tests at early stages	100 %	From D-CODE: only lab tests on backup system	Field operation planned after the 1st mid-term
EIS to estimate electrochemical info at cell level to monitor/follow time evolution of several metrics	A methodology for state-of-health monitoring incl. degradation measurement & remaining lifetime prediction	Methodologies under investigation for lifetime evaluation from EIS data	100 %	Only few works available on this topic, mostly for lab application	No preliminary results yet; most work performed on literature data.

HELMETH

Integrated High-Temperature electrolysis and methanation for effective power to gas conversion

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	HELMETH
CALL TOPIC	SP1-JTI-FCH.2013.2.4: New generation of high temperature electrolysers
START DATE	1/04/2014
END DATE	31/03/2017
PROJECT TOTAL COST	€3,8 million
FCH JU MAXIMUM CONTRIBUTION	€2,5 million
WEBSITE	http://www.helmeth.eu/

PARTNERSHIP/CONSORTIUM LIST

Karlsruher Institut fuer Technologie, POLITECNICO DI TORINO, SUNFIRE GMBH, European Research Institute of Catalysis A.I.S.B.L., ETHOSENERGY ITALIA SPA, NATIONAL TECHNICAL UNIVERSITY OF ATHENS – NTUA, DVGW DEUTSCHER VEREIN DES GAS- UND WASSERFACHES – TECHNISCH-WISSENSCHAFTLICHER VEREIN EV

MAIN OBJECTIVES OF THE PROJECT

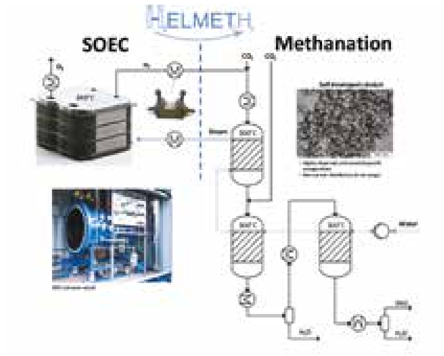
The objective of the HELMETH project is the proof of concept of a highly efficient Power-to-Gas (P2G) technology with methane as a chemical storage, and by thermally integrating high temperature electrolysis (SOEC technology) with CO_2 methanation. The aim is to prove and demonstrate that high temperature 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

- SOEC short stack tests show voltage degradation rates <0,5 %/1,000 h and feasibility of co-electrolysis.
- Multiple nickel-based catalysts for the methanation were developed, tested at up to 30 bar and optimized.
- A multistep methanation module has been designed with a boiling water cooling. The thermal coupling with the SOEC is realized by the generated steam.
- Lab tests confirm that Synthetic Natural Gas (SNG) quality requirements are met with the chosen methanation module concept.
- Process simulation of HELMETH concept confirm efficiencies >85 % for large scale plants based on realistic assumptions.

FUTURE STEPS

- Manufacturing of the methanation module will soon be completed.
- The methanation and SOEC modules are at first tested separately.
- Operation of complete PtG prototype at the beginning of 2017.



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.
- A boiling water cooling of the methanation at 300 °C is optimal considering the SNG quality requirements and the coupling with the SOEC by steam.
- Minimal heat losses can be reached by combining catalytic reactors in one pressure vessel.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
High-temperature (800-1,000 °C), high current density (>1 A/cm^2), pressurised conditions	High-temperature (800-1,000 °C), high current density (>1 A/cm^2), pressurised conditions	Electrodes and interconnector protection layers feasible for HTE under pressurized conditions	100 %	Pressurized operation only proven at cell and short stack level, sunfire is first institution to prove it on full-scale, thermally self-sustained stack	1 A/cm^2 achieved with cell tests, integration of high-performance cells in stack ongoing
HELMETH will deliver a proof of concept towards large scale systems	Manufacture of dedicated HTE cell and stacks for use in large systems	The durability has been proven by short stack tests and will be verified in the final prototype	95 %	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 also within HELMETH	The operation of final prototype is planned for the beginning of 2017
Degradation rates around 1 %/1,000 h (0,5 %/1,000 h for short stacks) for a 10-15 kW class system	Degradation rates around 1 %/1,000 h (0,5 %/1,000 h for short stacks) for an HTE system in kW size	First SOEC short stack tests confirm degradation rates <0,5 % / 1,000 h	100 %	Kerafol cells (sunfire supplier) achieved 20,000 h in electrolysis mode -->SOEC world record	
Conversion efficiencies >85 % from electricity to methane	Total efficiencies for co-electrolysis, syngas production or chemical product in the 85-95 % range	Detailed simulations including BoP predict a total conversion efficiency of 86 % (large scale plant)	95 %	The efficiency of a combination of low temperature electrolysis and a methanation would result in total conversion efficiencies around 60 % in the best case	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

PANEL 1

Technology validation in transport applications

ACRONYM	HIGH V.LO-CITY
CALL TOPIC	SP1-JTI-FCH.2010.1.1: Large-scale demonstration of road vehicles and refuelling infrastructure III
START DATE	1/01/2012
END DATE	31/12/2018
PROJECT TOTAL COST	€29,2 million
FCH JU MAXIMUM CONTRIBUTION	€13,4 million
WEBSITE	http://highvlocity.eu/

PARTNERSHIP/CONSORTIUM LIST

VAN HOOL N.V., RIVIERA TRASPORTI SPA, DANTHERM POWER A.S, SOLVAY SA, Vlaamse Vervoersmaatschappij De Lijn, WaterstofNet vzw, HYDROGEN, FUEL CELLS AND ELECTRO-MOBILITY IN EUROPEAN REGIONS, UNIVERSITA DEGLI STUDI DI GENOVA, REGIONE LIGURIA, FIT CONSULTING SRL, ABERDEEN CITY COUNCIL*, BALLAST NEDAM INTERNATIONAL PRODUCT MANAGEMENT B.V., CNG NET BV, DANMARKS TEKNISKE UNIVERSITET, SANDVIK MATERIALS TECHNOLOGY AB, TOPSOE FUEL CELL A/S, AVL LIST GMBH, CHALMERS TEKNISKA HOEGSKOLA AB, Karlsruher Institut fuer Technologie, THE UNIVERSITY COURT OF THE UNIVERSITY OF ST ANDREWS, ICE STROMUNGSFORSCHUNG GMBH, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, ELRINGKLINGER AG, HyGear Fuel Cell Systems B.V., ADELAN LTD, CATATOR AB, CONSIGLIO NAZIONALE DELLE RICERCHE, EADS DEUTSCHLAND GMBH, EADS UK Ltd., ERDLE ERICH KONRAD

MAIN OBJECTIVES OF THE PROJECT

The overall objective of High V.LO City is to facilitate rapid deployment of the last generation FC Buses in public transport operations, by addressing key environmental and operational concerns that transport authorities are facing today. This is realized with the demonstration of 14 Fuel Cell buses in 4 different sites: 5 in Antwerp (Belgium), 4 in Aberdeen (Scotland), 3 in Sanremo (Italy) and 2 in Groningen (The Netherlands). These buses are refuelled from sustainable hydrogen by local refuelling stations. The projects achievements are disseminated to new adopters to inform and engage.

PROGRESS/RESULTS TO-DATE

- 9 FC Buses are operational: 5 FC Buses operate in Antwerp (Belgium) and 4 in Aberdeen (Scotland).
- For the two sites acceptable technical availability is noted. The total amount of distance accumulates over 300,000 km.
- 2 HRI are put in place and refuel the 9 operational buses with a very high availability rate (>85 %).

FUTURE STEPS

- The sites of Sanremo (Italy) and Groningen (The Netherlands) will be made operational in 2016.
- Conclude about the operational issues met in the different sites that delay start of FC Bus operations.
- Further follow-up operations with detailed data recording and analysis.
- Major dissemination events to be organised.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Local technical assistance is a major requirement for a success story. Traditional mechanics have to be re-educated.
- Immature supply chains cause longer waiting times for parts – will be solved with larger scale fleets.
- FC Buses should be introduced smoothly in diesel fleets.
- Marginal costs for small FC Fleets are large – but will be acceptable for large fleets.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
14 buses operational in 4 sites	500 buses at 10 EU sites (at least 7 new ones)	All 14 buses put in place, 9 buses in services, the other 5 coming soon.	100 %	Not relevant	
15,000 h warranty on FC system	Durability of over 5,000 h	Demonstration is ongoing.	100 %	10,000 – 15,000 h, according to the FC Supplier	
Project target is €2,500/kW	System cost below €3,500/kW	€2,500/kW	100 %		
Operate 4 HRI's for FC Buses	Roadmap for the establishment of a commercial HRI	2 HRI's are installed and operational.	100 %	Not relevant	
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2010
Set up Centres of Excellence to communicate about local FC Bus demonstrations.	Place Europe at the forefront of FC technology worldwide to enable market breakthrough.	High V.LO City dissemination comes into highest gear.	100 %	Not relevant	
Demonstrate 14 buses in operations with the required Refuelling stations.	Speed up the development of hydrogen supply and FC Technology.	High V.LO Cities demands create market demands.	100 %	About 90 FC Buses are planned to be in Europe at the end of 2016, including CHIC and 3Emotion projects.	

HY4ALL

Hydrogen For All of Europe (HY4ALL)

PANEL 6
Cross-cutting

ACRONYM	HY4ALL
CALL TOPIC	FCH-04.2-2014: Develop strategies to raise public awareness of fuel cell and hydrogen technologies
START DATE	1/09/2015
END DATE	31/08/2018
PROJECT TOTAL COST	€1,9 million
FCH JU MAXIMUM CONTRIBUTION	€1,9 million
WEBSITE	

PARTNERSHIP/CONSORTIUM LIST

AIR LIQUIDE ADVANCED TECHNOLOGIES SA, DAIMLER AG, FUELCELL ENERGY SOLUTIONS GMBH, SIEMENS AKTIENGESELLSCHAFT, IMAGINATION FACTORY, CAMBRIDGE ECONOMETRICS LIMITED, ISTITUTO PER INNOVAZIONI TECNOLOGICHE BOLZANO SCARL, FUNDACION PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGIAS DEL HIDROGENO EN ARAGON, INTELLIGENT ENERGY LIMITED, PRAGMA INDUSTRIES, ELEMENT ENERGY LIMITED, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, NUCELLSYS GMBH

MAIN OBJECTIVES OF THE PROJECT

- Development of an overarching communication strategy.
- Robust assessment of macro-economic & societal benefits of FCH technologies.
- Creation of web portal for FCH technologies: 'one stop shop' for the general public.
- Pan-European cross-sectoral 'Hydrogen in Society' roadshow with a comprehensive media campaign in each country.
- Sector-specific dissemination events for mobility, stationary fuel cells, green H2 & energy storage, e.g. workshops & open days.

PROGRESS/RESULTS TO-DATE

- Validation of the communication strategy with the consortium with targets and tools.
- Collection of all inputs for the database and first assumptions on the scenarios and modelling.
- Workshop with external FCH stakeholders from industries and European Commission members for sharing first assumptions.
- First route for the roadshow with selection of stops and consultation of local organisations for supporting us into the dissemination.

FUTURE STEPS

- Share of the strategy with external Parties.
- Messages written & validated for the targeted audiences.
- Choice of the scenarios for the study and modelling to be initiated.
- Decision on website: subcontractort responsibility & choice.
- Validation of the presence of a local organisation or partners / affiliated entities to support the roadshow at each selected stop.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Need to define & disseminate one H2 sector voice, adapted to all target audiences.
- HY4ALL will target mainly the general public and local decision makers thanks to the planned tools and actions (website, roadshow…).
- Hydrogen Europe will be project sponsor, with an influence strategy at top levels.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2014-2020
Build political support & societal acceptance for FCH technol. in EU	Dissemination in Member States, targeted messages / key figures	Preparation phase only: nothing done at this stage	100 %	Project is the largest action targeted @ raising political support & social acceptance for FCH technol.	HY4ALL is part of an overall H2 strategy to tackle this objective.
Improve public acceptance & risk perception on FCH technologies	Extensive & varied set of awareness-raising activities	Preparation phase only: nothing done at this stage	100 %	as above	HY4ALL is part of an overall H_2 strategy to tackle this objective
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2014
Study on macro-economic & societal benefits of FCH technol.	Maximise use of existing research & inputs from consortium	Almost done.	100%		Initially planned by 2015, extended to mid-2016
Disseminate the results of the meta-study	Dissem. activities (study), lobbying strategy (policymakers, NGO, EC)	Workshop with external FCH stakeholders already organised.	100%		Dissemination will mainly begin when first results are available
Supply a 'one stop shop' web portal	One stop shop' web portal: accessible language & tools	Subcontractor choice/role to be clarified.	100%	No single place for public to learn on benefits of the technologies	WP delayed waiting for strategy styudy
Technical content suitable for general public	Website to include content adapted for the public (videos)	This tasks is part of the website WP which is going to begin.	100%	Hard to find non-corporate info on H_2 technologies adapted general public	WP delayed waiting for strategy styudy
Supply demonstrational items	Exhibition items for into roadshow from project & external partners	Exhibit items from partners listed External items to be organised	100%	Project will show items in all H_2 technology sectors	Part of roadshow organisation: ongoing
Organise public debates in different Member States	30 public debates in different EU States, min. 2 for politicians	This is part of the roadshow organisation and not yet planned	80%	Debates are usually organised in parallel to dedicated events or tour.	Nr of debates depends on nr of stops & local parties involvement
(c) Other project objectives					
Be active in 11 EU member states plus Norway	Not applicable	Route to be defined, including selection of the countries	80%	H2moves Scandinavia's European H_2 Road Tour 2012: 5 countries, 9 stops	Need to secure strong local involvement at each stop
Dissemination activities in green H_2 and stationary FC sector	Not applicable	Workshops & open days planned from end 2016	100%		Dedicated budget

HYACINTH

Hydrogen acceptance in the transition phase

PANEL 6 Cross-cutting	
ACRONYM	HYACINTH
CALL TOPIC	SP1-JTI-FCH.2013.5.3: Social acceptance of FCH technologies throughout Europe
START DATE	1/09/2014
END DATE	28/02/2017
PROJECT TOTAL COST	€0,9 million
FCH JU MAXIMUM CONTRIBUTION	€0,6 million
WEBSITE	http://hyacinthproject.eu/

PARTNERSHIP/CONSORTIUM LIST

CENTRO NACIONAL DE EXPERIMENTACION DE TECNOLOGIAS DE HIDRO- GENO Y PILASDE COMBUSTIBLE CONSORCIO, I PLUS F FRANCE SARL, FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV, ABERDEEN CITY COUNCIL*, CENTRO DE INVESTIGACIONES ENERGETICAS, MEDIOAMBIENTALES Y TECNOLOGICAS-CIEMAT, FUNDACION CIDAUT, RAZVOJNI CENTER ZA VODIKOVE TEHNOLOGIJE, NORSTAT DEUSTCHLAND GmbH, UNI-VERSITY OF LEEDS, UNIVERSITY OF SUNDERLAND, CONSULTORIA DE INNOVACION Y FINANCIACION SL

MAIN OBJECTIVES OF THE PROJECT

The objective of HYACINTH is to gain a deeper understanding of the social acceptance of hydrogen and fuel cell 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 in 7 European countries. The main aims are to:
identify and understand awareness and acceptance of HFC technologies, identify its main drivers and develop a support toolbox.

PROGRESS/RESULTS TO-DATE

- Context analysis done: policies, projects and stakeholders in the selected countries and information for the methodological design.
- Research concept for the data gathering realized.
- Questionnaires for the general public and the stakeholders (quantitative and qualitative) parts done.
- Information gathered from the general public surveys obtained and most of the stakeholders part (interviews and surveys) done.

FUTURE STEPS

- To finalize the analysis of the general public awareness and acceptance study.
- To finalize the analysis of the stakeholders awareness and acceptance study.
- To develop and implement the support toolbox.

- To disseminate the results of the project (social awareness and acceptance studies and the support toolbox).

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Different levels of response between countries for the stake-holders part of the project due to different state of HFC technologies in each country.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AWP 2013
Current state of public awareness and public acceptance of FCH technologies in Europe	Interviews of up to 7,000 European citizens and 455 stakeholders in 7 different countries	General public surveys done, finalizing stakeholder interviews	100 %	Information gathered for general public. Last interviews are been carried out now (1-2 month delay)
What kind of fears is associated with FCH technologies to date? How is hydrogen safety perceived?	To identify bottlenecks. To discern handicaps geographically linked or for a certain application	Analysis ongoing for general public and stakeholders	100 %	Analysis started for stakeholders and general public. Some delay (1-2 months) expected in the stakeholders part
How can a successful transition towards the use of hydrogen in the mobility sector be achieved?	Development of a specific toolbox. Dissemination	Design of toolbox completed. Performing Dissemination Plan	100 %	Development and trials for toolbox prepared for the last part of the project

HyBalance

PANEL 5
Hydrogen production, distribution and storage: research and validation

ACRONYM	HyBalance
CALL TOPIC	FCH-02.10-2014: Demonstrating the feasibility of central large scale electrolysers in providing grid services and hydrogen distribution and supply to multiple high value markets
START DATE	1/10/2015
END DATE	30/09/2020
PROJECT TOTAL COST	€15,1 million
FCH JU MAXIMUM CONTRIBUTION	€7,9 million
WEBSITE	hybalance.eu

PARTNERSHIP/CONSORTIUM LIST

AIR LIQUIDE ADVANCED BUSINESS, Ludwig-Boelkow-Systemtechnik GmbH, NEAS ENERGY AS, CEMTEC FONDEN, COPENHAGEN HYDROGEN NETWORK AS, AIR LIQUIDE GLOBAL E&C SOLUTIONS FRANCE, HYDROGENICS EUROPE NV

MAIN OBJECTIVES OF THE PROJECT

HyBalance is a project that demonstrates the use of hydrogen in energy systems. The hydrogen will be produced from water electrolyses, enabling the storage of cheap renewable electricity from wind turbines. It will thus help balance the grid, and the green hydrogen will be used for clean transportation and in the industrial sector.
HyBalance will be one of Europe's largest and most advanced facilities for production of green hydrogen and will contribute to accelerating the development of clean mobility in Denmark.

PROGRESS/RESULTS TO-DATE

- Danish minister of energy cut the first sod in April 2016.
- Piping and Instrumentation Diagram frozen – Electrical architecture validated – Plot plan finalised.
- Permiting in progress.
- Website launched.

FUTURE STEPS

- Electrolyser Factory Acceptance Test.
- Plant Acceptance Test.
- Optimisation test phase including grid balancing features.
- Continuous monitoring of the operations.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Grid balancing features bring technical constraints which need to be included in the design of the plant.
- The project will demonstrate the complete value chain from hydrogen renewable energy production to end users, including hydrogen charging stations.
- Expectations related to highly dynamic PEM electrolysis will be validated in a real-industrial environment.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET (%)	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2014-2020
Cost goal	€1,570/kWel	€1,810/kWel	85 %	No 2016 competitive/ public information available.	Slightly >than programme target because of: – first-built including non-recurrent engineering – two stack platform for reliability
Efficiency	57,5 kWhel/kgH_2	designed for target	97 %	Smaller installation 150 kW / 30Nm³/hr performs at 59 kWh/kg (Don Quichote FP7-project 303411)	Unit is designed for >20khrs performance within this target.

HYCARUS

Hydrogen cells for airborne usage

PANEL 1

Technology validation in transport applications

ACRONYM	HYCARUS
CALL TOPIC	SP1-JTI-FCH.2012.1.6: Fuel cell systems for airborne application
START DATE	1/05/2013
END DATE	30/04/2017
PROJECT TOTAL COST	€12 million
FCH JU MAXIMUM CONTRIBUTION	€5,2 million
WEBSITE	http://hycarus.eu/

PARTNERSHIP/CONSORTIUM LIST

ZODIAC AEROTECHNICS SAS, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, DASSAULT AVIATION SA, AIR LIQUIDE ADVANCED TECHNOLOGIES SA, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, INSTITUTO NACIONAL DE TECNICA AEROESPACIAL, ARTTIC, Zodiac ECE, DRIESSEN AEROSPACE CZ SRO, ZODIAC CABIN CONTROLS GMBH

MAIN OBJECTIVES OF THE PROJECT

HYCARUS develops a Generic FC 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) produced by the FC system to increase its global efficiency.

PROGRESS/RESULTS TO-DATE

- Completion of specifications and sizing of the GFCS.
- Completion of the design of the different sub-systems and components of the GFCS.
- Completion of the tests of the different sub-systems (except for the hydrogen high pressure sub-system (HHPS) on which only risk mitigation tests were performed) of the GFCS.
- Completion of the Functional Hazard Assessment & Preliminary System Safety Assessment, Achievement of the System Safety Assessment.
- Preparation for the "permit to Fly" including Qualification Program Plan and Test Flight conditions.

FUTURE STEPS

- Verification tests of the HHPS and of the whole GFCS.
- System Safety Assessment completion.
- Flight Readiness Process completion.
- Environmental tests of the GFCS for the flight test configuration.
- Flight tests on-board a Falcon Aircraft.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The Consortium will build on the results to provide and test the GFCS in a representative aircraft environment, in accordance with 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 FC system in a cabin environment.
- HYCARUS will accelerate market introduction of FC systems on board aircraft.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
TRL6 Demonstrator	TRL6 Demonstrator with flight tests on-board an aircraft	TRL4-5. Fuel cell system Demonstrator development in progress. Qualification Program Plan and Test Flight conditions defined	75%	TRL4-5	Fuel cell sub-systems are tested, Functional Fuel Cell system are on going
Demonstrator in the 20-100 kW power range	Fuel Cell System in the 20-25 kW power range to be representative and appropriate for target applications	Fuel Cell system demonstrator development in progress. Power range demonstrated by simulation.	80%	None	Fuel cell sub-systems are tested, Functional Fuel Cell system tests are on going for flight tests configuration (Galley configuration tests are planned later on)
Durability with cycling h: 2500 h under flight representative load profiles	Performing durability tests under flight representative load profiles (AIP 2011: SPI-JTI-FCH-2012.1.6)	Fuel Cell system durability test out of scope of the project. Only Fuel Cell stack (30 cells) durability test performed (2,000 h, under flight representative load profiles)	100%	10,000 h for stationary application 4,000 h for automotive sector	
Fuel Cell system efficiency (LHV) at 25% of rated power: 55%	Fuel Cell system efficiency at 25% of rated power: 55%	Current estimated Fuel Cell system efficiency: 45% (based on simulation results, test to be performed in 2016)	0%	55%	For target application (GFCS), maximum efficiency operating point is 55% of rated power. Corresponding target efficiency is 46% under airborne operating conditions. Due to specific system architecture and rated power (20-25 kW), achievement of this objective was very challenging.
FC system specific power (EOL): 0.65kW/kg					
Proof of concept of H_2 storage and supply on-board an aircraft	TRL6 H_2 storage system demonstration on-board aircraft	Gaseous 350 bars H_2 storage and supply system under development. H_2 leakage and safety management strategy approved. Implementation and demonstration planned for 2017.	75%	None	
Demonstrate operational capability at ranges of altitude and in-flight variations typical for such packaged systems in aircrafts	Demonstrate operation under typical Airbus A320 and Dassault Falcon business jets inflight operating conditions	Fuel cell System demonstrator specification include A320/Dassault and RTCA DO160 environmental requirements. Equipment development and Qualification Plan include either ground or inflight demonstration of performances. Tests to be performed in 2016.	75%	None	

HYCORA

Hydrogen contaminant risk assessment

PANEL 6
Cross-cutting

ACRONYM	HYCORA
CALL TOPIC	SP1-JTI-FCH.2013.1.5: Fuel Quality Assurance for Hydrogen Refuelling Stations
START DATE	1/04/2014
END DATE	31/03/2017
PROJECT TOTAL COST	€3,9 million
FCH JU MAXIMUM CONTRIBUTION	€2,1 million
WEBSITE	http://hycora.eu/

PARTNERSHIP/CONSORTIUM LIST

Teknologian tutkimuskeskus VTT Oy, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, PROTEA LIMITED, STIFTELSEN SINTEF, Powercell Sweden AB

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 cell and stack hardware has been developed, enabling anode gas humidification by recirculation and fuel utilisation of 99.5 %.
- The effect of formaldehyde and formic acid have been studied and it seems that the limits in ISO 14687-2:2012 standard are too low.
- The results show that the drive cycle and anode operation mode (open anode vs recirculation) has significant effects on the contamination dynamics.
- A first sampling campaign at hydrogen refuelling stations has been completed and results have been disseminated.
- A qualitative risk and quantitative risk models for hydrogen fuel contamination have been developed.

FUTURE STEPS

- The effect of formaldehyde and formic acid will be studied in more detail to enable the review of the limits in ISO 14687-2:2012 standard.
- The effect of internal air bleed on the CO poisoning dynamics will be measured with help of CO with carbon 13 isotope.

- Evaluation of analytical techniques with focus on challenging/cost driving analyses (i.e. total sulphur and halogenates).
- Conduct and analyse hydrogen samples from second measurement campaign from new hydrogen refuelling stations.
- Quantitative risk model for hydrogen fuel contamination will be developed further and implemented in Matlab.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Hydrogen fuel contamination studies require high fuel utilisation and right hardware 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 both formic acid and formaldehyde in ISO 14687-2:2012 standard seem to be too low.
- The use of CO canary species may be problematic when contaminant level of CO is very low.
- Risk model results indicate that current FCEVs with high anode platinum have very low risk for CO contamination incident.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
To reduce cost of hydrogen fuel quality assurance (QA) so that €5-10/kg is possible to reach	H_2 price dispensed at pump €5-10/kg (2020)	MAIP 2008-13	100 %	Hydrogen fuel quality assurance (QA) part of the hydrogen cost can be reduced to lower level
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2013-1
Understanding hydrogen contaminant research in PEMFC system level	Completing current knowledge by identifying the impurity limits of PEMFCs	Critical contaminants for the quality assurance have been identified and studied	80 %	Work is progressing mostly as planned
To find out quality variation for automotive grade hydrogen in production and HRS nozzle	Providing technical data on fuel composition and impurity concentrations at HRS	The first measurement campaign has been completed	95 %	Work is progressing as planned
Work is performed International co-operation	Build on existing knowledge, as well as international networking and exchange	Co-operation and contacts have been established with LANL, ANL, NREL and JARI	100 %	Work is progressing as planned
Constructing a probabilistic risk assessment model for determining quality assurance needs	Establish a simplified and diversified set of requirements for hydrogen fuel quality	Qualitative risk model has been completed as well as first version of quantitative model	100 %	Work is progressing as planned
Constructing a probabilistic risk assessment model for determining quality assurance needs	Simplifying fuel quality control by enhancing knowledge of gas impurity concentrations	The first measurement campaign has been completed and samples have been analysed	90 %	Work is progressing as planned
Simplify and reduce cost of analysis by reducing the number of analytical techniques required	Establishing new analytical methodology relevant for gas impurity quantification	Manufacturing and testing of the pre-concentration device and sub-components is ongoing	90 %	Work is progressing as planned
Simplify and reduce cost of analysis by reducing the number of analytical techniques required	Designing and verifying of gas sampling instrumentation applicable to HRS operation	Verifying of gas sampling instrumentation is complete. Particle sampling will be verified	100 %	Work is progressing as planned

HYDROSOL-PLANT

Thermochemical hydrogen production in a solar monolithic reactor: construction and operation of a 750 kWth plant

PANEL 5
Hydrogen production, distribution and storage: research and validation

ACRONYM	HYDROSOL-PLANT
CALL TOPIC	SP1-JTI-FCH.2012.2.5: Thermo-electrical-chemical processes with solar heat sources
START DATE	1/01/2014
END DATE	31/12/2016
PROJECT TOTAL COST	€3,4 million
FCH JU MAXIMUM CONTRIBUTION	€2,2 million
WEBSITE	http://www.hydrosol-plant.certh.gr/

PARTNERSHIP/CONSORTIUM LIST

CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS, DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, CENTRO DE INVESTIGACIONES ENERGETICAS, MEDIOAMBIENTALES Y TECNOLOGICAS-CIEMAT, HyGear B.V., ELLINIKA PETRELAIA AE

MAIN OBJECTIVES OF THE PROJECT

The HYDROSOL-PLANT project comes as the natural continuation of the successful HYDROSOL project.
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 water splitting.
- Operate the plant and demonstrate hydrogen production and storage on site.
- Techno-economic study for the commercial exploitation of the solar process.

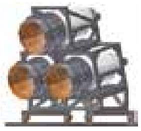
PROGRESS/RESULTS TO-DATE

- Definition of key components.
- Completion of process flowsheet layout and piping/instrumentation diagram.
- Procurement of redox porous structures-building blocks for the H_2 production reactor.
- Completion of H_2 purification unit.
- Completion of the adaptation of solar tower platform for the reactor, peripherals and components integration.

FUTURE STEPS

- Construction of the H_2 reactors.
- Placement of the reactors on the solar tower.
- Integration of the reactors with the other BoP and sub-BoP units.
- Thermal-only and solar hydrogen production campaigns of prototype plant.





CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- A piping & instrumentation diagram (P&ID) was elaborated in order to define the control strategy of the plant including the 3 parallel reactors.
- The design of the reactor was revisited to cover certain limitations (such as platform space and weight, reactor volume, budget).
- The final reactor design will include redox foam structures and involves a set-up of 3 reactors put in a triangular arrangement.
- Within this period a redox monolith was subjected to 740h of consecutive cycling in the laboratory with no significant degradation.
- Preparation of the solar tower platform for integration of the HYDROSOL-plant (structural changes at the 27m height platform, new heliostat facets).

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET (%)	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2012
Materials with performances suitable for economic operation, life timesmore than 1,000h operational	1,000 h	740 h	90 %	N/A	
Solar hydrogen generator in a demonstration range @ 0,5-2 MW scale	0,5-2 MW	0,75 MW	100 %	N/A	
Demonstration of hydrogen production and storage on site (>3kg/week)	3 kg H_2/week	3,3 kg H_2/week (average value based on lab-scale experiments)	90 %	N/A	

HYFIVE

Hydrogen for innovative vehicles

PANEL 1

Technology validation in transport applications

ACRONYM	HYFIVE
CALL TOPIC	SP1-JTI-FCH.2013.1.1: Large-scale demonstration of road vehicles and refuelling infrastructure VI
START DATE	1/04/2014
END DATE	30/09/2017
PROJECT TOTAL COST	€39 million
FCH JU MAXIMUM CONTRIBUTION	€17,9 million
WEBSITE	http://www.hyfive.eu/

PARTNERSHIP/CONSORTIUM LIST

GREATER LONDON AUTHORITY, BAYERISCHE MOTOREN WERKE AKTIEN- GESELLSCHAFT, DAIMLER AG, HONDA R&D EUROPE (DEUTSCHLAND) GMBH, HYUNDAI MOTOR EUROPE GMBH, TOYOTA MOTOR EUROPE, AIR PRODUCTS PLC, COPENHAGEN HYDROGEN NETWORK AS, ITM POWER (TRADING) LIMITED, LINDE AG, Foreningen Hydrogen Link Danmark, ISTITUTO PER INNOVAZIONI TECNOLOGICHE BOLZANO SCARL, ELEMENT ENERGY LIMITED, THINKSTEP AG, OMV REFINING & MARKETING GMBH, PARTNERSKAB FOR BRINT OG BRAENDSELS CELLER, DANISH HYDROGEN FUEL AS

MAIN OBJECTIVES OF THE PROJECT

To deploy and monitor 185 next generation FCEVs from leading global OEMs (BMW, Daimler, Honda, Hyundai and Toyota).
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.

PROGRESS/RESULTS TO-DATE

- Order placed for 110 vehicles in the three clusters.
- All refuelling stations installed in the southern and Danish cluster (Aarhus, Korsor and Innsbruck) and one of the three stations installed in London.
- Ongoing activities linking the HyFIVE project with other existing FCH JU projects as well as National Projects and Initiatives like the CEP.
- Sites identified and work underway to deploy the other two stations in London in summer 2016.

FUTURE STEPS

- Deploying the new generation Daimler vehicles and the Honda Clarity Fuel Cell.
- Deploying two more stations in London which will have two opening events involving UK politicians and decision makers.

- Using milestones in the project to disseminate information about it to local and national government, decision makers, etc.
- Planning a final event in a coordinated approach in order to maximise the impact.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- More work needs to be done to improve regulations around the use of the technology in vehicles and refuelling.
- More work needs to be done on dissemination of the technology in an interactive way that raises interest and clears myths.
- Learning came out of deploying the stations in the London cluster as these were the first of their kind.
- There is a lot of value coming out of the collaboration between regions.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET (%)	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
Cost of H_2 delivered at refuelling station <€5/kg (€0.15/kWh)	Cost of H_2 delivered at refuelling station <€5/kg (€0.15/kWh)	Hydrogen cost at station <€10/kg (ex. taxes)	This will be met in at least one of the clusters	Our target in the project is <€10/kg and this should be met by end of the project. We will be looking into pathways to lower this.
Durability in car propulsion systems 5,000 h	Durability in car propulsion systems 5,000 h	Vehicle Operation lifetime (>2,000 h initially, min. 3,000 h as programme target)	We expect to meet and exceed this	7,875 cumulative hours driven in the Southern cluster, 1,893 in the Copenhagen Cluster and 290 in the London Cluster
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2013-1
Vehicle availability >95 %	Vehicle availability >95 %	100 % in the London and Copenhagen clusters and 95.9 % in the Southern cluster	We expect to meet and exceed this	The vehicles are intensively in use in the Southern cluster which lead to the Hyundai vehicles issues (not related to fuel cell system)
Hydrogen purity and vehicle refuelling process	According to SAE J2601 and 2719 and ISO specifications. IR Communication according to SAE TIR J 2799	Implemented and on track	Target met	Included on all stations current average of refuelling time of 1.1 min.
Minimum vehicle operation during the project 12 months or 10,000 km	Minimum vehicle operation during the project 12 months or 10,000 km	On average per vehicle we are at an average of 3,000 km in each cluster	We expect to meet this target	In total there have been 20,581 km driven in the Copenhagen cluster, 3,049 in the London cluster and 69,787 in the Southern cluster.
(c) Other project objectives				
Roadmap for the establishment of a commercial European hydrogen refuelling infrastructure	N/A	Out of the 6 stations 4 have been deployed	We expect to meet this target	2 stations in London will be operational in august 2016 and opening events for them will take place in September/October 2016 to ensure better attendance

HYLIFT-EUROPE

Large scale demonstration of fuel cell powered material handling vehicles

PANEL 1

Technology validation in transport applications

ACRONYM	HYLIFT-EUROPE
CALL TOPIC	SP1-JTI-FCH.2011.4.1: Demonstration of fuel cell-powered Material Handling vehicles including infrastructure
START DATE	1/01/2013
END DATE	31/12/2017
PROJECT TOTAL COST	€22,3 million
FCH JU MAXIMUM CONTRIBUTION	€9,2 million
WEBSITE	http://www.hylift-europe.eu/

PARTNERSHIP/CONSORTIUM LIST

Ludwig-Boelkow-Systemtechnik GmbH, STILL GMBH, MULAG FAHRZEUGWERK HEINZ WÖSSNER GMBH U. CO. KG, AIR PRODUCTS GMBH, COPENHAGEN HYDROGEN NETWORK AS, ELEMENT ENERGY LIMITED, FAST – FEDERAZIONE DELLE ASSOCIAZIONI SCIENTIFICHE E TECNICHE, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, HEATHROW AIRPORT LIMITED, H2 Logic A/S, AIR LIQUIDE ADVANCED BUSINESS, DANTHERM POWER A.S, PRELOCENTRE

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

- The first hydrogen refuelling station in the framework of the HyLIFT-EUROPE project started operations in AUG 2015 (Prelocentre / France).
- 46 hydrogen powered fuel cell forklifts and warehouse trucks are in operation at a green field site in a logistics environment (Prelocentre / France).
- As the project has had to overcome some hiccups at the beginning of the project no vehicles from the participating OEMs are in demonstration yet.
- A significant contract for the deployment of forklifts and warehouse trucks has been signed with a retail group (Carrefour / France) in JUN 2016.
- HyLIFT-EUROPE will become one of the leading projects for materials handling vehicle deployments in Europe.

FUTURE STEPS

- Prelocentre fleet size will be enlarged to reach 60 units in 2017.
- Deployment at Carrefour will start operations on 1 JAN 2017 the latest.
- Carrefour fleet size is planned to reach a number of more than 150 units finally.
- 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 in operation is already beyond 10,000 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.
- Focus has to be on customers with large fleets, three-shift operations and cheap hydrogen available.
- Complete packages comprising vehicles, hydrogen refuelling station and hydrogen supply have to be offered to customers ideally from a single source.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Number of industrial and off-highway vehicles: >200	Number of industrial and off-highway vehicles (2015 target): 500 in total	46 %	90 %	>10,000 [Source: Plug Power]	A signed contract for the deployment of a large fleet (>35 units) as well as the plans and ongoing discussions to enlarge this fleet to more than 150 units might enable reaching the project's target
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
Number of FC-systems: >200 units	Number of FC systems: >50 units in project	46 %	90 %	>10,000 [Source: Plug Power]	A signed contract for the deployment of a large fleet (>35 units) as well as the plans and ongoing discussions to enlarge this fleet to more than 150 units might enable reaching the project's target
FC system efficiency (%): 45-50 %	FC system efficiency (%): >45 %	>45 %	100 %	>45 %	Programme objective achieved
Refuelling time: ~3 minutes	Refuelling time: 3 minutes	Class 1: 154 sec Class 3: 73 sec	100 %	<3 min (depending on MHV class)	Project target reached
HRS availability: 98 %	HRS availability: -	>99 %	100 %	>99 % (actual state-of-the-art)	Project target reached

HYPACTOR

Pre-normative research on resistance to mechanical impact of composite overwrapped pressure vessels

PANEL 6
Cross-cutting

ACRONYM	HYPACTOR
CALL TOPIC	SP1-JTI-FCH.2013.5.6: Pre-normative research on resistance to mechanical impact of pressure vessels in composite materials
START DATE	1/04/2014
END DATE	31/03/2017
PROJECT TOTAL COST	€4 million
FCH JU MAXIMUM CONTRIBUTION	€2,1 million
WEBSITE	http://www.hypactor.eu

PARTNERSHIP/CONSORTIUM LIST

COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, L'AIR LIQUIDE S.A, HEXAGON RAUFOSS AS, INSTITUT DE SOUDURE ASSOCIATION, POLITECHNIKA WROCLAWSKA, NORGES TEKNISK-NATURVITENSKAPELIGEUNIVERSITET NTNU, ALMA CONSULTING GROUP SAS

MAIN OBJECTIVES OF THE PROJECT

To provide recommendations for RCS regarding the qualification of new designs of Composite Overwrapped Pressure Vessel (COPV) and the procedures for periodic inspection in service of COPV subjected to mechanical impacts.
To this aim, experimental and numerical work will be combined with feedback from experience

PROGRESS/RESULTS TO-DATE

- Review of international impact related incidents on pressure composite cylinders.
- Investigation of industrial constraints for the use of non-destructive testing (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.

FUTURE STEPS

- Technical report on impact testing with characterization of induced tank damage.
- Choice of 2-3 relevant impact conditions to study residual performance.
- Definition of test matrix on the impact testing and residual performance assessment.

- Definition of NDT protocols.
- Modelling of residual performance of impacted COPV with given damage.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- First experimental database with impact parameters and characteristics of induced damage.
- First comparative assessment of NDT techniques and protocols to characterize impact damage.
- 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

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Assess NDT and define protocols to inspect composite damaged by impact	Recommendations to industry and for international standards development	On-going on WP2 impacted tanks	100 %	No literature reference	Impact testing in progress(XX impacts / XX impacted tanks). NDT development, damage characterization and short/long term residual performance assessment under progress
Revised methodology for qualification, inspection and testing to RCS committees	International cooperation strategy /safety	Not started	100 %	MAE methodology under investigation in USA	Critical damage definition under progress, dedicated workshop (intra consortium) is planned in sept 2016 to synthesize project results and draw first recommendations guidelines.
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
To determine damage characteristics induced by impacts	Identify types of alterations produced by mechanical impacts and develop an understanding of their consequences on short and long term structural integrity	On-going (WP2 and WP3)	100 %	No literature reference	Under progress (WP2 and WP3)
To identify impact conditions that produce short term failure; by testing, immediate failure	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	On-going	100 %	No literature reference	nearly completed (still waiting for repeatability testing and water load conditions)

HYPER

Integrated hydrogen power packs for portable and other autonomous applications

PANEL 1

Technology validation in transport applications

ACRONYM	HYPER
CALL TOPIC	SP1-JTI-FCH.2011.4.4: Research, development and demonstration of new portable Fuel Cell systems
START DATE	3/09/2012
END DATE	2/09/2015
PROJECT TOTAL COST	€3,9 million
FCH JU MAXIMUM CONTRIBUTION	€2,2 million
WEBSITE	

PARTNERSHIP/CONSORTIUM LIST

Orion Innovations (UK) Ltd, PAXITECH, UNIVERSITY OF GLASGOW, EADS DEUTSCHLAND GMBH, INSTYTUT ENERGETYKI, McPhy Energy SA, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION

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.
- Produced 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.
- Market analysis showed remote monitoring & control to be a particularly attractive applications for HYPER (requirements for reliable low power).
- Independent end users have expressed interest in trialling the complete system as soon as possible.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Field demonstration of HYPER System as 100 We portable power pack and 500 W_e UAV range extender	12,000 – 13,000 portable & micro FC's in the market by 2015	Two 100 W_e systems were tested under field conditions	50 %	Global shipments of portable units (1 W to 20 kW) estimated at 21,200 and 17,600 in 2014 and 2015 respectively, The Fuel Cell Industry Review 2015, E4Tech	Two 100 W_e systems for specific applications were tested, using interchangeable H_2 storage. Field testing of 500 We UAV range was not achieved during the lifetime of the project due to technical difficulties with scale up
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
Volume and weight: 100 W_e system: 65 kg/kW and 60 l/kW 500 W_e system: 20 kg/kW and 20 l/kW	Volume and weight: <35 kg/kW and 50 l/kW	100 W_e system, 85 kg/kW and 250 l/kW	50 %	35 – 50 kg/kW for similar 150-200 W H_2-based systems, e.g. BOC Hymera. 3 kg/kW for Horizon Energy Systems miniaturised fuel cells for UAVs (not commercially tested)	High wt and vol due to BoP and cooling requirements. However, call targets will readily be met at lower powers <40 W
<€5,000/kW final system cost	<€5,000/kW final system cost	Current high volume costs anticipated at >€5,000/kW	50 %	Commercial costs not widely available – current estimates at £2,500 to £5,000 for 150 W and 250 W systems respectively (BOC Hymera and EFOY Comfort series)	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)
System efficiency: >50 %	System efficiency: >30 %	Fuel cell efficiency of 50 % achieved	100 %	Most commercial portable products have a rated nominal power at a cell voltage of 0.6V/cell, corresponding to a FC efficiency of 48 % and system efficiency typically <40 %.	HYPER system efficiency will be very close to FC efficiency at low power (<40 W).
Lifetime: 1,000 h, 100 start stop cycles	Lifetime: 1,000 h, 100 start stop cycles	Targets for lifetime and start stop cycles were exceeded for the 20 W_e FC module	100 %	Project targets based on end user requirements (WP1)	Objectives achieved
Operating temperature: -20 °C to 60 °C	Operating temperature: -20 °C to 60 °C	FC demonstrated from -20 °C to 40 °C	100 %	Project targets based on end user requirements (WP1)	40 °C is a maximum operating temperature, but cooling triggered at 41 °C.

HYRESPONSE

European hydrogen emergency response training programme for first responders

PANEL 6
Cross-cutting

ACRONYM	HYRESPONSE
CALL TOPIC	SP1-JTI-FCH.2012.5.3: First responder educational and practical hydrogen safety training
START DATE	1/06/2013
END DATE	31/05/2016
PROJECT TOTAL COST	€2,6 million
FCH JU MAXIMUM CONTRIBUTION	€1,8 million
WEBSITE	http://www.hyresponse.eu/

PARTNERSHIP/CONSORTIUM LIST

ECOLE NATIONALE SUPERIEURE DES OFFICIERS DE SAPEURS-POMPIERS, AIR LIQUIDE HYDROGEN ENERGY, UNIVERSITY OF ULSTER, AREVA STOCKAGE D'ENERGIE SAS, FAST – FEDERAZIONE DELLE ASSOCIAZIONI SCIENTIFICHE E TECNICHE, THE CCS GLOBAL GROUP LIMITED, CRISIS SIMULATION ENGINEERING SARL

MAIN OBJECTIVES OF THE PROJECT

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

PROGRESS/RESULTS TO-DATE

- Definition of tactical manoeuvres to eliminate the hazard or due incidents to the use of responders (firemen or industrial sites security guards).
- Definition of educational training scenarios using the above defined tactical manoeuvres.
- Construction of the physical platform with 5 modules (clarinets, explosion area, simulating hydrogen vehicles, mikados, refuelling station).
- Elaboration of theoretical courses and construction of a virtual reality platform.
- Animation of three pilot training sessions (71 trainees, more than 15 observers).

FUTURE STEPS

- Second and final international workshop in September 2016 (15-16).
- Creating of an educational training material and recommendations guide.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- This project is becoming the first European training centre at the discretion of the hydrogen risk.
- It is regularly offer to all European stakeholders training sessions mixing theoretical courses, practical exercises and virtual reality approaches.
- This program has also had the effect of creating and meeting together a community of experts in this domain.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
3 training levels developed: discovery, advanced (as regulators), and expert	Developing training programmes at all levels	Lectures, practical training scenarios and 2 exercises in virtual reality for each level have been developed	100 %	
2 international workshops for European firefighters and 3 advisory consultation panel (ACP) meetings	Dissemination of the programme results through public awareness events and initiatives	1 international workshop for European firefighters and 3 advisory consultation panel (ACP) meetings	85 %	The last international workshop will be done on September 15-16 at ENSOSP school (Aix-en-Provence, France)
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2012
Construction of a physical platform and also a virtual reality platform	Install an European Hydrogen Training Platform on which will be realised full scale exercises	5 physical modules and several virtual reality exercises have been developed	100 %	

HySEA

Improving Hydrogen Safety for Energy Applications (HySEA) through pre-normative research on vented deflagrations

PANEL 6 Cross-cutting	
ACRONYM	HySEA
CALL TOPIC	FCH-04.3-2014: Pre-normative research on vented deflagrations in containers and enclosures for hydrogen energy applications
START DATE	1/09/2015
END DATE	31/08/2018
PROJECT TOTAL COST	€1,5 million
FCH JU MAXIMUM CONTRIBUTION	€1,4 million
WEBSITE	www.hysea.eu

PARTNERSHIP/CONSORTIUM LIST

GEXCON AS, THE UNIVERSITY OF WARWICK, UNIVERSITA DI PISA, FIKE EUROPE BVBA, IMPETUS ADVANCED FINITE ELEMENT ANALYSES AS, University of Science and Technology of China

MAIN OBJECTIVES OF THE PROJECT

The main objective of the HySEA project is to conduct pre-normative research on vented deflagrations in containers and smaller enclosures for hydrogen energy applications. The aim is to facilitate the safe and successful introduction of hydrogen energy systems by introducing harmonized vent sizing requirements in international standards. The project entails the development of predictive models and validation against experimental results.

PROGRESS/RESULTS TO-DATE

- Completed kick-off meeting and first progress meeting.
- Established logo, website, advisory board, etc.
- Designed experimental rigs.
- Initiated modelling activities.
- Scheduled first HySEA workshop.

FUTURE STEPS

- Complete construction of experimental rigs.
- Initiate experiments in small-scale enclosure.
- Initiate full-scale experiments in ISO containers.
- Complete first blind-prediction study with publication.
- Progress on modelling and dissemination activities.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The work progresses according to schedule.
- The first experimental results are expected in Q3 2016.
- The modelling will progress in parallel with the experiments.
- On-going dialogue with standardizing committees.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAWP 2014-2020
Safety	Overarching projects / cross-cutting activities	Planning and implementation	90 % (good control of experiments and modelling)	The HySEA project will define the international state-of-the-art in vented hydrogen deflagrations for actual industrial enclosures up to the size of 20-ft. ISO containers	MAWP 2014 – 2020
Pre-normative research	Overarching projects / cross-cutting activities	Initial networking	75 % (depends on standardizing committees)	The HySEA project will define the international state-of-the-art in vented hydrogen deflagrations for actual industrial enclosures up to the size of 20-ft. ISO containers	MAWP 2014 – 2020
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AWP 2014

HYTEC

Hydrogen Transport in European Cities

PANEL 1

Technology validation in transport applications

ACRONYM	HYTEC
CALL TOPIC	SP1-JTI-FCH.2010.1.1: Large-scale demonstration of road vehicles and refuelling infrastructure III
START DATE	1/09/2011
END DATE	31/08/2015
PROJECT TOTAL COST	€29,2 million
FCH JU MAXIMUM CONTRIBUTION	€11,9 million
WEBSITE	http://hy-tec.eu/

PARTNERSHIP/CONSORTIUM LIST

AIR PRODUCTS PLC, Element Energy Limited, EUROPEAN REGIONS AND MUNICIPALITIES PARTNERSHIP ON HYDROGEN AND FUEL CELLS, LTI LIMITED, CENEX – CENTRE OF EXCELLENCE FOR LOW CARBON AND FUEL CELL TECHNOLOGIES, GREATER LONDON AUTHORITY, hySOLUTIONS GmbH, MATGAS 2000 A.I.E., Ludwig-Boelkow-Systemtechnik GmbH, COPENHAGEN HYDROGEN NETWORK AS, KOBENHAVNS KOMMUNE, Foreningen Hydrogen Link Danmark, INTELLIGENT ENERGY LIMITED, LHR AIRPORTS LIMITED, LONDON BUS SERVICES LIMITED, FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V, HYUNDAI MOTOR EUROPE GMBH

MAIN OBJECTIVES OF THE PROJECT

The HyTEC project was tasked with creating new H_2 vehicle deployment centres in London, Copenhagen and Oslo. Diverse concepts were adopted and trialled in these cities:

- Copenhagen: Passenger cars trialled alongside a refuelling station dispensing green H_2
- London: Passenger cars & taxis deployed + state-of-the-art refuelling station using innovative delivered H_2 technology.
- Oslo: Passenger cars deployed, utilising existing infrastructure

The experience is being shared with other cities and communities.

PROGRESS/RESULTS TO-DATE

- Installation and operation of the UK's first publicly accessible H_2 fuelling station, in London.
- Vehicle test and shakedown, driver training and certification of five fuel cell taxis and creation of their operations base in London.
- Deployment and operation of FC passenger cars in London and Oslo.
- Tendering process for FCEV in Copenhagen, resulting in delivery and operation of 15 FCEVs (of which 9 supported by HyTEC).
- Installation and operation of three hydrogen fuelling stations based on green hydrogen in Copenhagen.

FUTURE STEPS

- Continued operation and data collection from H_2 vehicles and the fuelling infrastructure in Copenhagen and London (HyFIVE project).
- Sharing results for vehicles and stations: well to wheels life cycle impacts, tech. performance, non-tech. barriers.
- Sharing analysis on future commercialisation of the vehicles.
- Disseminating an approach for the rollout of vehicles and infrastructure, building on the demonstration projects.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- HyTEC addressed the challenge of transitioning from exemplar hydrogen vehicles to fully certified, operational vehicles.
- HyTEC's work led to networks in each country for the ongoing process coordination, leading to H_2 vehicle rollout in UK and DK.
- These networks are still used after the project, supporting continued commercialisation efforts in the hydrogen transport sector.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET(SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
Light Duty Vehicles deployment	~500 units	30 units	100 %	5 FC hybrid taxis & 2 FC cars in London, 15 FC cars in Copenhagen, 8 in Oslo
Additional sites and stations	2 additional sites with 3 new stations	2 additional sites with 4 new stations.	100 %	UK's first public station, 3 new stations in Copenhagen
Vehicle lifetime	>5,000 h	Objectives achieved for passenger cars. For the taxis and scooter, it was demonstrated in test stands in the lab.	100 %	This has been achieved for the passenger cars. For the taxis and scooter, this has been demonstrated in test stands in the laboratory.
Establishment of commercial Eur. H_2 refuelling Infrastructure	Roadmap for establishment of commercial Eur. H_2 refuelling infrastructure	Rollout strategies reports for Copenhagen & London; partnerships w/key stakeholders.	100 %	Statement of collaboration' signed by HyTEC regional/city partners at final project event.
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2010
Vehicle reliability	Mean Time Between Failure (MTBF) >1,000 km	Achieved	100 %	Achieved
Vehicle availability	>95 %	95 %-99 % (average - depending on vehicle type and location)	100 %	95 %-99 % (average - depending on vehicle type and location)
Vehicle efficiency	Efficiency >40 % (NEDC)	Real-world (non-NEDC) consumption of 70-74 km/kg H_2 (avg, depending on vehicle type/location)	Variable	
Refuelling capacity	Stations refuelling @ 35 & 70 MPa with 50 kg capacity & potential for extension to 200 kg	London HRS 35 & 70 MPa – 50kg/d with potential to extend up to 200kg/d. Copenhagen 3 HRS with 70 Mpa, 200kg/d	100 % (excl. 35 MPa in Copenhagen)	35 and 70 MPa, with potential for extension to 200 kg
Station availability	98 %	95 % ->99 % (average - depending on site)	Variable	95% >99% (average - depending on site)
Station hydrogen production efficiency	Efficiency of 50-70 %	N/A (Not tested as yet)	N/A	N/A (Not tested as yet)
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	100 %	€10/kg or price that matches cost per driven km on gasoline

HYTRANSFER

Pre-normative research for thermodynamic optimization of fast hydrogen transfer

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	HYTRANSFER
CALL TOPIC	SP1-JTI-FCH.2012.2.6: Pre-normative research on gaseous hydrogen transfer
START DATE	1/06/2013
END DATE	31/12/2016
PROJECT TOTAL COST	€3 million
FCH JU MAXIMUM CONTRIBUTION	€1,6 million
WEBSITE	http://www.hytransfer.eu/

PARTNERSHIP/CONSORTIUM LIST

Ludwig-Boelkow-Systemtechnik GmbH, L'AIR LIQUIDE S.A, THE CCS GLOBAL GROUP LIMITED, RAUFOSS FUEL SYSTEMS AS, HONDA R&D EUROPE (DEUTSCHLAND) GMBH, JRC -JOINT RESEARCH CENTRE-EUROPEAN COMMISSION, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, TESTNET ENGINEERING GMBH

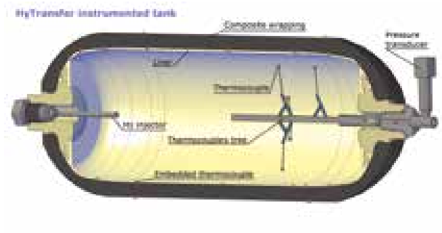
MAIN OBJECTIVES OF THE PROJECT

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 evaluated and its benefits quantified with regards to performance, costs, and safety. Recommendations for implementation into international standards will be proposed.

PROGRESS/RESULTS TO-DATE

- Tanks with temperature measuring devices 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 three different kinds of small tanks have been performed at three different labs in Europe.
- 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 June 2016.
- Finalizing new refuelling approach based on experimental results.
- Techno-economical evaluation of results.
- Prepare recommendations for RCS.
- Prepare final documents including public results.

CONCLUSIONS, MAJOR FINDINGS AND 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

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2014-2020
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2012
Identification of opportunities for optimization	Not specified	Optimization by focussing on heat transfer	100 %		
Identification of existing RCS and opportunities for improvement	Not specified	Work in progress	100 %		
Improved approaches for carrying out the transfer with less pre-cooling	Not specified	Work in progress	100 %	SAE J2601	
Recommendations for implementation in international standards	Not specified	This will be the final result of HyTransfer	100 %		
Evaluate the influence of tank construction on the maximum allowable filling speed	Not specified	A variety of tank sizes from two tank manufacturers were evaluated.	100 %		

HYTRANSIT

European Hydrogen Transit Buses in Scotland

PANEL 1

Technology validation in transport applications

ACRONYM	HYTRANSIT
CALL TOPIC	SP1-JTI-FCH.2011.1.1: Large-scale demonstration of road vehicles and refuelling infrastructure IV
START DATE	1/01/2013
END DATE	31/12/2018
PROJECT TOTAL COST	€17,7 million
FCH JU MAXIMUM CONTRIBUTION	€6,9 million
WEBSITE	http://aberdeeninvestlivevisit.co.uk/Invest/Aberdeens-Economy/City-Projects/H2-Aberdeen/Hydrogen-Bus/Hydrogen-Bus-Project.aspx

PARTNERSHIP/CONSORTIUM LIST

BOC LIMITED, VAN HOOL N.V., ABERDEEN CITY COUNCIL*, STAGECOACH BUS HOLDINGS LIMITED, HYDROGEN, FUEL CELLS AND ELECTRO-MOBILITY IN EUROPEAN REGIONS, PLANET PLANUNGSGRUPPE ENERGIE UND TECHNIK GBR, DANTHERM POWER A.S, ELEMENT ENERGY LIMITED

MAIN OBJECTIVES OF THE PROJECT

The project objective is to prove that the hybrid FC bus is capable of meeting the operational performance of an equivalent diesel bus in long route operation, whilst offering significant benefits in opex and environmental performance. The project will also address the main commercial barrier to the technology (bus capital cost) by deploying state of the art components to reduce bus unit cost to below €1.1 million (excluding non-recurring engineering costs).

PROGRESS/RESULTS TO-DATE

- 6 Van Hool A330 FC buses built/delivered to Aberdeen (12/2014).
- UK's largest HRS (300 kg/day) installed and commissioned by BOC (03/2015).
- Comprehensive awareness and training programme to inform drivers, technicians and local emergency services conducted (early 2015).
- Europe's largest FC l bus fleet has been operated for over a year in Aberdeen.
- HRS: >1,600 refuelling events, dispensed >35 t H_2.

FUTURE STEPS

- Evaluate the HRS and FC bus performance with life-cycle and technical assessments.

- Evaluate economic and environmental impact compared to operating regular diesel buses.
- Develop a concept design for a FC intercity coach.
- Develop a strategy for continuing FC bus and HRS operation beyond the project.
- Host an expert workshop, two new bus customer workshops and multiple public open days.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Emerging conclusions being prepared/agreed by consortium.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:			MAIP 2008-2013
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:			AIP 2011
FC life: >4,000h initially, >6,000h as program target	The system will have over 12,000h warranty	Not yet reached life time figures quoted	100 %
Availability >85%, with maintenance as for conventional buses	Availability >90%, maintenance based on conventional bus regime	Data is currently being analysed for year 1	100 %
Fuel consumption <11–13 kg of H_2/100km	Less than 10 kg of hydrogen /100 km	Data is currently being analysed for year 1	100 %
Bus platform – not specified	High-floor 13.15 m bus (3 axles),with partial high floor configuration	Buses designed and delivered to this configuration	100 %
Passenger capacity – not specified	Intercity and sub-urban buses need to carry a larger number of seated passengers (longer routes). HyTransit buses will will carrt >44 seated passengers. Through careful chassis design, buses will have same overall capacity as diesel equivalent.	Buses designed and delivered with 42 seated passengers, two wheel chairs spaces.	100 %
Top Speed – not specified	HyTransit buses will achieve a top speed of over 80km/h.	Data yet to be analysed	100 %
Range	Daily routes of 200 - 433 km (9 reservoirs of 205 l, tot. 45 kg H_2)	Daily route achieved on target (10 reservoirs, tot 50 kg H_2)	100 %
Pressure at filling station suitable for 350 and/or 700 bar refuelling	Aberdeen HRS based on 350 bar dispensed at max. continuous rate of 120g/s.	Criteria achieved in operation. Plans to upgrade to 700 bar	100 %
Ensure that 1–2 buses can be refuelled per hour	Station design concept incorporates ionic compressors in booster configuration, which allows continuous dispensing at 120g/s (>AIP targets).	Target achieved and up to 5 buses can be refuelled in an hour	100 %
The refuelling station concept must include a modular expansion to 100/vehicles per day	Station based on modular design to dispense up to 1,000 kg H_2/day to refuel >50 buse or 250 cars/day (with appropriate nozzles). (>the AIP targets).	Station based on modular design - subject to local conditions (space and electricity provision) can reach the target expansion levels	100 %
Station availability >98%	As per AIP target	Target achievable by the technology proposed. Core objective of the station operation.	100 %
H_2 purity/refuelling time according to SAE & ISO specs	SAE & ISO specs as contractual requirements for H_2 supplied by station	Standards in place & being achieved	100 %
H_2 Opex < €10/kg (excl. tax), strategy for €5/kg	H_2 delivered to buses (station opex + H_2 prod. costs) = €6/kg assuming 200kg/day. As this rises to 1,000kg/day, H_2 cost could fall to <€5/kg.	Data to be analysed	100 %

IMMEDIATE

Innovative automotive MEA development – implementation of IPHE-GENIE achievements targeted at excellence

PANEL 2

Research activities for transport applications

ACRONYM	IMMEDIATE
CALL TOPIC	SP1-JTI-FCH.2011.1.5: Next generation European MEAs for transportation applications
START DATE	1/01/2013
END DATE	31/03/2016
PROJECT TOTAL COST	€3,6 million
FCH JU MAXIMUM CONTRIBUTION	€2 million
WEBSITE	http://www.immediate.ird.dk/

PARTNERSHIP/CONSORTIUM LIST

IRD FUEL CELLS A/S (INDUSTRIAL RESEARCH & DEVELOPMENT A/S), USTAV CHEMICKYCH PROCESU AV CR, v. v. i., CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, FUMA-TECH GESELLSCHAFT FUER FUNKTIONELLE MEMBRANEN UND ANLAGENTECHNOLOGIE MBH, SHANGHAI JIAO TONG UNIVERSITY, VOLVO TECHNOLOGY AB, SGL CARBON GMBH, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, IMERYS GRAPHITE & CARBON SWITZERLAND LTD

MAIN OBJECTIVES OF THE PROJECT

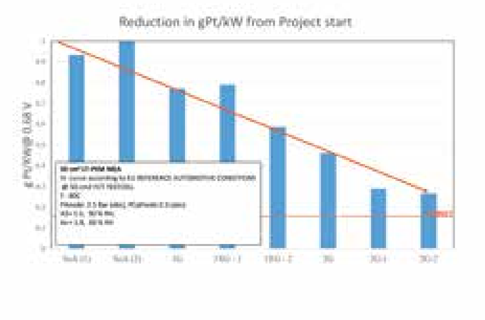
The overall objective of the IMMEDIATE project is to develop a medium temperature PEM MEA FC that will fulfil the OEM requirements with respect to cost, performance and durability. The prime focus of Immediate to develop MEAs aimed for transportation applications is through material R&D & process optimization and to screen and test precursor materials such as ionomers, membranes, catalyst, catalyst supports and gas diffusion layers aiming to demonstrate an optimized MEA and accomplish the target with performance >1.0 W/cm² @ automotive test conditions.

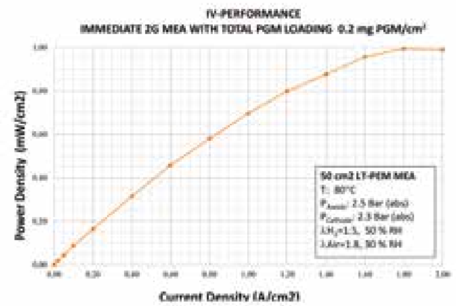
PROGRESS/RESULTS TO-DATE

- A range of carbon supports with a variety of surface properties and optimized mesoporosity have been developed
- A range of 60wt% PGM/C catalyst fabricated and evaluated (activity, accelerated stress test (AST), MEA performance)
- New short-side-chain (SSC) and cross-linkable ionomers based on perfluorosulfonic acid (PFSA) polymer have been developed
- Improved gas diffusion layer with enhanced conductivity and water retention
- MEA performance demonstrated with power density of 0.75 W/cm² @ 0.68 V

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- MEA performance: Power density 1.0 W/cm² @ 0.20 gPt/kW.
- New industrial production processes developed.
- Durability and stability of low PGM MEAs demonstrated.





CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan: MAIP 2008-2013			
The overall aim is to develop Membrane Electrode Assemblies with PGM-loading of <0.15 g PGM/kW	MAIP 2008-13: Busses Vehicle PEM-FC System: <3,500€/kW	0.22 g PGM/kW	Project ended April 31 2016
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan: AIP 2011			
Membrane with proton conductivity of at least 0.1S/cm at 95ºC & 25 % RH	2015: Membrane with proton conductivity [3] 100mS/cm at £ 25 % RH, 120ºC	90 mS/cm at 100 ºC and 50 % RH	Project ended April 31 2016
GDL with through plane conductivity >2 S/cm at nominal operating conditions	GDL with area conductivity (through plane) >2 S/cm at operating conditions	GDL with conductivity of 4.4 mOhm*cm²	Project ended April 31 2016
2015. MEA with PGM-loading of <0.15 g PGM/kW	2015. MEA with PGM-loading of <0.15 g PGM/kW	0.22 g PGM/kW	Project ended April 31 2016
MEA BOL of >1.0 W/cm² @ UCell=0.68 V	MEA BOL of >1.0 W/cm² @ UCell=0.68 V	MEA BOL of 0.8 W/cm² @ UCell=0.68 V	Project ended April 31 2016

IMPACT

Improved lifetime of automotive application fuel cells with ultra low Pt-loading

PANEL 2
Research activities for transport applications

ACRONYM	IMPACT
CALL TOPIC	SP1-JTI-FCH.2011.1.5: Next generation European MEAs for transportation applications & SP1-JTI-FCH.2011.1.6: Investigation of degradation phenomena
START DATE	1/11/2012
END DATE	31/10/2016
PROJECT TOTAL COST	€9,1 million
FCH JU MAXIMUM CONTRIBUTION	€3,9 million
WEBSITE	http://www.eu-project-impact.eu/

PARTNERSHIP/CONSORTIUM LIST

DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, CONSIGLIO NAZIONALE DELLE RICERCHE, ITM POWER (TRADING) LIMITED, JOHNSON MATTHEY FUEL CELLS LIMITED, ZENTRUM FUER SONNENENERGIE- UND WASSERSTOFF-FORSCHUNG, BADEN-WUERTEMBERG, HOCHSCHULE ESSLINGEN, TECHNISCHE UNIVERSITAT BERLIN, INSTITUT NATIONAL POLYTECHNIQUE DE TOULOUSE, GWANGJU INSTITUTE OF SCIENCE AND TECHNOLOGY, SOLVAY SPECIALTY POLYMERS ITALY S.P.A

MAIN OBJECTIVES OF THE PROJECT

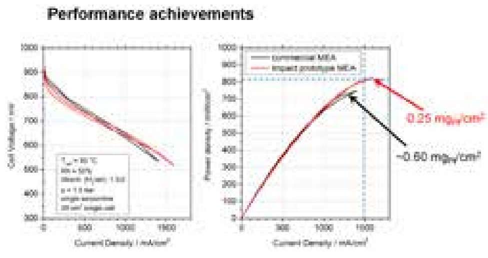
Main objectives are: to increase the life-time of ultra–low Pt-loaded MEAs (<0.2 mgcm-2) for automotive applications to 5,000 h in dynamic operation with degradation rates <10 µVh-1 and to obtain a power density of 1 Acm-2. To achieve these targets relevant degradation mechanisms are identified and mitigation strategies are implemented 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 PEMFC stack.

PROGRESS/RESULTS TO-DATE

- Seven iterations of MEA development accomplished allowing defining a final MEA to reach the durability objective.
- Development of i) improved thinner perfluorosulfonic acid (PFSA) membranes with stabilizing agents, ii) improved ink composition with novel ionomers.
- Reduction of irreversible degradation rate by factor >10 down to ~10 µVh-1 at 1 Acm-2 and 0.21 mgcm-2 overall Pt loading.
- Reduction of Pt loading from 0.6 to 0.25 mgcm-2 without performance losses.
- Detailed analysis of determination of reversible and irreversible degradation in dynamic conditions.

FUTURE STEPS

- Test of final project MEA in single cell and stack in dynamic conditions.
- Demonstration of durability targets in a 2,500 – 5,000 h stack test.



- Organization of a workshop on degradation issues of PEMFC for automotive applications.
- Publications of a study on comparability of single cell and stack measurements.
- Publication of a study on the effect of Pt loading on performance and durability.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Stability of ionomer in the catalyst layer is the limiting factor for MEA durability and irreversible degradation.
- Reversible degradation exhibits a linear-exponential behaviour and is dominated by water management issues.
- A shutdown recovery procedure leads to a temporary elimination of reversible performance losses.
- IMPACT recommends to establish a common way to determine and report degradation rates.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Lifetime of 5,000 h in dynamic operation, with a degradation rate below 10 µVh-1	Lifetime of 5,000 h in dynamic operation, with a degradation rate below 10 µVh-1	Demonstration of 10 µVh-1 in single cell; final 2,500 – 5,000 h stack test under preparation	80 %	~4,000 h (https://www.hydrogen.energy.gov/pdfs/review15/fc,000_papageorgopoulos_2015_o.pdf)	Reduction of irreversible degradation rate by factor >10 down to ~10 µVh-1 at 1 Acm-2 and 0.21 mgcm-2 overall Pt loading
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
Irreversible and reversible degradation mechanism categorization	Irreversible and reversible degradation mechanism categorization	Detailed study on irreversible degradation rates and performance recovery procedures	100 %	IMPACT outcomes are setting the state-of-the-art for degradation rate determination	
Pt loadings <0.2 mgPt/cm²	Development of catalysts and electrode layers allowing for significant reduction in precious metal catalyst loadings	Pt loading 0.21 – 0.25 mgPt/cm²	50 %	Pt loading around 0.3 – 0.5 mgPt/cm² (Autostack-CORE interim results, F-Cell 2015)	This target which goes beyond state-of-the-art can be considered as reached only if target 4 is reached in parallel
1 W/cm² at 670 mV (1.5 A/cm²) single cell performances	1 W/cm² at 670 mV (1.5 A/cm²) single cell performances	For 0.25 mgPt/cm² obtained: 0.93 W/cm² at 1.5 A/cm² and 2 bar, 0.81 W/cm² at 1.5 A/cm² and 1.5 bar	80 %	~ 1 W/cm² at 1.5 A/cm² and 2.2 bar (http://ecst.ecsdl.org/content/69/17/957.full.pdf)	Cell performance is highly affected by cell design and operation conditions; performance target will be achieved independent of durability target

IMPALA

Improve PEMFC with advanced water management and gas diffusion layers for automotive application

PANEL 2

Research activities for transport applications

ACRONYM	IMPALA
CALL TOPIC	SP1-JTI-FCH.2011.1.5: Next generation European MEAs for transportation applications
START DATE	1/12/2012
END DATE	30/11/2015
PROJECT TOTAL COST	€5 million
FCH JU MAXIMUM CONTRIBUTION	€2,6 million
WEBSITE	http://www.impala-project.eu/

PARTNERSHIP/CONSORTIUM LIST

COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, PAUL SCHERRER INSTITUT, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, INSTITUT NATIONAL POLYTECHNIQUE DE TOULOUSE, SGL CARBON GMBH, NEDSTACK FUEL CELL TECHNOLOGY BV

MAIN OBJECTIVES OF THE PROJECT

The aim of IMPALA is to produce improved GDL to increase performance (up to 1 W/cm²) of PEMFC for automotive application by a twofold approach: a) modification of homogeneous GDL (micro-porous layer (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.

PROGRESS/RESULTS TO-DATE

- An improved GDL (named IMPALA#30) has been developed and will be commercialized. It allows increasing performance (12 %) and reducing stack cost (7 %).
- Numerous modifications of GDL have been done and tested: MPL, hydrophobic treatment, structuration... Most are scalable and ready for future work.
- Pore Network Modelling (PNM) has been improved (use of real 3D images, condensation effect) and 3D X-Ray images of liquid patterns have been obtained.
- Intensive comparison has been done successfully between PNM and 3D X-Ray images on ex-situ and in-operando experiments.
- Condensation scenario is the most representative one, at least when operating around 80 °C. This is in full contrast with classical publications.

FUTURE STEPS

- Optimize the combination of different improvements (MPL, hydrophobic treatment...) and correlate them with modelling and characterisation results.
- Progress on the multiscale coupling of models especially in the case of two-phase flows.
- Measure key bulk properties of GDL (wettability, binder...) by non-destructive investigation tools.
- Analyse the MPL (structure, properties, penetration...) so as to analyse its role and propose more reliable "design" recommendations of GDL.
- Numerous publications have been done, some remaining ones are to be finalized.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Performance has been significantly increased by modifying properties of the backing and/or of the MPL of commercial reference GDL.
- Improvements of GDL are not always additive and the interaction with the electrodes is important, especially at high current densities.
- Other increase of performance could be obtained with a better matching combination of improved membrane, electrodes, and GDL.
- Major advances have been done (liquid visualisation, two-phase modelling...) and allows proposing more reliable water management scenario.
- Pore Network Modelling has been improved and validated. It can help analysing the influence of properties of GDL on performance.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)[1]	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET [2]	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Reach power density >1 W/cm² @ 1.5 A/cm² (BoL)	MEA Level 0: 0.75 W/cm² MEA Level 1: 0.9 W/cm² MEA Level 2: 1.0 W/cm²	MEA Level 0/1 reached, level 2 not reached Best MEA reaches 0.93 W/cm²	MEA Level 0 and 1: 100%, Level 2: 0%	Best performance with the commercial MEA used, as far as we know	Performance have been checked under the operating conditions for automotive: H2/air, gas hydration 50%, Stoe 1.2/2, 80 °C, 1.5 bara
Optimization of GDL and MPL for handling low RH levels	Improve performance at standard automotive conditions and check improvement at other conditions	Different hydrophobic treatments improve performance	100%		#IMPALA30 leads to an increase of performance for all operating conditions. Specific hydrophobic treatments improve performance at RH 20% or RH 100%
Demonstration of long term stability under automotive conditions.	Assess degradation rate of MEA Level 2	Durability of MEA Level 0 has been tested at stack level.	90%	N/A	The same durability tests should be done with the best GDL
Optimization and demonstration of MEA processing at pilot scale based on the innovative GDL	Analyze of the market and new investments	Pilot-scale production of best candidate material has been performed.	100%	New as SGL is the sole manufacturer of #IMPALA30	Target reached and the improved GDL (#IMPALA30) is now planned to be commercialized. This improvement leads to a stack cost reduction (~ - 7%)
Development and improvement of modelling tools for understanding of performance and phenomena.	PNM includes condensation	PNM: condensation is included	100%	This is the first time condensation is included in PNM	
Conductivity >2 S/cm (in-plane) and >100 S/cm (through-plane)	Reduce through-plane resistance by 10%	reached	100%		Electrical conductivity could still be improved
Contribute to the development of European Industry solutions	Improve materials of SGL	SGL materials have been improved.	100%		SGL has now a new improved GDL (#IMPALA30) to be commercialized
(b) Project objectives relevant to annual objectives (from AIP / AWP) if different than above- please specify AIP/AWP reference year: 2011					

INNO-SOFC

Development of innovative 50 kW SOFC system and related value chain

PANEL 3
Technology validation in stationary applications

ACRONYM	INNO-SOFC
CALL TOPIC	FCH-02.5-2014: Innovative fuel cell systems at intermediate power range for distributed combined heat and power generation
START DATE	1/09/2015
END DATE	28/02/2018
PROJECT TOTAL COST	€3,9 million
FCH JU MAXIMUM CONTRIBUTION	€3,9 million
WEBSITE	http://www.innosofc.eu/

PARTNERSHIP/CONSORTIUM LIST

Teknologian tutkimuskeskus VTT Oy, ELCOGEN OY, CONVION OY, ELRINGKLINGER AG, FORSCHUNGSZENTRUM JULICH GMBH, AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE, ENERGY MATTERS BV, AIR PRODUCTS GMBH, ELEMENT ENERGY LIMITED, ABENGOA HIDROGENO SA, ABERDEEN CITY COUNCIL*, AIR PRODUCTS PLC, AKERSHUS FYLKESKOMMUNE, BIRMINGHAM CITY COUNCIL, Vlaamse Vervoersmaatschappij De Lijn, EMPRESA MUNICIPAL DE TRANSPORTES DE MADRID SA, EVOBUS GMBH, H2 Logic A/S, HAMBURGER HOCHBAHN AG, HYDROGENICS GMBH, HYOP AS, INGENIEURTEAM BERGMEISTER SRL, ISTITUTO PER INNOVAZIONI TECNOLOGICHE BOLZANO SCARL, ITM POWER (TRADING) LIMITED, KUNNSKAPSBYEN LILLESTROM FORENING, LINDE AG, LONDON BUS SERVICES LIMITED, McPhy Energy Deutschland GmbH, THINKSTEP AG, RIGAS SATIKSME SIA

MAIN OBJECTIVES OF THE PROJECT

INNO-SOFC project aims to design and manufacture a State of the Art 50 kW solid oxide fuel cell (SOFC) system with 60 % electrical and 85 % total efficiency. The planned system and component lifetime is 3,0000 h with two-years of continuous operation without planned shut downs. System costs will be below €4,000/kW. Secondary objectives include the identification and analysis of most promising end-users and applications for stationary SOFC systems.

PROGRESS/RESULTS TO-DATE

- Interfaces with multi-stack and system manufacturers defined and optimized with computational fluid dynamic (CFD) and FEM calculations.
- System cost reduction by implementing advanced model based estimators to replace physical instrumentation.
- Analysis for most feasible end-user applications made.

FUTURE STEPS

- Manufacturing cost and quality optimization of interconnect plates.
- Stack conditioning process development, performance and lifetime tests.
- System control and diagnostics development.
- Full system demonstration an validation
- Techno-economic analysis of SOFC systems.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Open cathode by-pass leakage reduced by 60 % with new sealing structure around multi-stack system.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAWP 2014-2020
Total system cost of less than €4,000/kW	Techno-economic objective 2; increase electrical efficiency and the durability while reducing costs	Progressing as planned	75 %	€6,000 -10,000/kW in MAWP
(b) Other project objectives:				
Reduction of fuel cell stack cost to less than €2,000/kW	Not applicable	Progressing as planned	95 %	
System and components enabling life-time of 30,000 hours	Not applicable	Validation of stack lifetime in real system environment starting later	82 %	

INSIDE

In-situ Diagnostics in Water Electrolyzers

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	INSIDE
CALL TOPIC	SP1-JTI-FCH.2013.2.2: Diagnosis and monitoring of electrolyser performance
START DATE	1/11/2014
END DATE	31/10/2017
PROJECT TOTAL COST	€3,6 million
FCH JU MAXIMUM CONTRIBUTION	€2,1 million
WEBSITE	inside-project.eu

PARTNERSHIP/CONSORTIUM LIST

DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, NEW NEL HYDROGEN AS, ACTA SPA, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, HOCHSCHULE ESSLINGEN

MAIN OBJECTIVES OF THE PROJECT

In-situ online monitoring of current density distributions for three water electrolysis technologies: PEM, Alkaline and anion exchange membrane. A 2-dimension segmented printed circuit board (PCB) replaces a regular bipolar plate of the electrolyser system. The PCB is adapted to the specific requirements (physical, chemical, analytical) of each technology. Three stages of prototypes are planned. Implementation and evaluation of Advanced Stress Test (AST) protocols, and correlation with ex-situ analytics are planned to allow harvesting hidden potential and avoiding critical operation modes.

PROGRESS/RESULTS TO-DATE

- PEM water electrolyser: feasibility demonstrated in single test cell.
- PEM water electrolyser: hardware supplier on stack level coudl be identified.
- Alkaline water electrolyser: Design of first prototype fixed.
- Anion Exchange Memerane (AEM) water electrolyser: First prototype is under construction.
- Analytics: Ex-situ ambient pressure photoemission spectroscopy cell for electrochemical cycling was developed.

FUTURE STEPS

- PEM water electrolyser: Design and construction of first prototype.
- Alkaline water electrolyser: Construction and integration of first prototype into short stack.
- AEM water electrolyser: Integration of first prototype into stack and test operation.
- First feasibility studies of AST in AEM water electrolyser.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Segmented PCB technology is working in PEM water electrolyser.
- Perspective: Evaluation and adaptation of stressors over the length of the project.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET (%)	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Online diagnostics for PEMWE, AE, AEMWE	Distributed production of Hydrogen by water electrolysis	10 %	90 %		Project does not directly aim for MAIP targets, but provides the tools for targeted developments.
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
Online diagnostics for PEMWE, AE, AEMWE	2.2 Diagnosis and monitoring of electrolyser performance	10 %	90 %	Feasibility for 1D [Dedigama, JPS 2014] and 2D [García-Navarro, submitted] locally resolved current density measurement in PEMWE was shown.	PEMWE: feasibility of diagnostics tool proven, design pending; AE: design for diagnostics tool present, construction pending; AEMWE: construction of diagnostic tool under progress.
(c) Other project objectives					
Development, harmonisation, and evaluation of accelerated stress tests for water electrolysis	Not applicable	10 %	80 %	No published AST for water electrolysis as of 2016. JRC has started harmonisation inside EU.	The diagnostics tool will allow – in a later stage of this project – to monitor and evaluate proposed ASTs.

IRMFC

Development of a portable internal reforming methanol High Temperature PEM fuel cell system

PANEL 6
Cross-cutting

ACRONYM	IRMFC
CALL TOPIC	SP1-JTI-FCH.2012.4.2: Demonstration of portable generators, back-up power and Uninterruptible Power Systems & SP1-JTI-FCH.2012.4.4: Demonstration of portable fuel cell systems for various applications
START DATE	1/05/2013
END DATE	31/10/2016
PROJECT TOTAL COST	€3,4 million
FCH JU MAXIMUM CONTRIBUTION	€1,5 million
WEBSITE	http://irmfc.iceht.forth.gr/

PARTNERSHIP/CONSORTIUM LIST

FOUNDATION FOR RESEARCH AND TECHNOLOGY HELLAS, ADVANCED ENERGY TECHNOLOGIES AE EREUNAS & ANAPTYXIS YLIKON & PROIONTONANANEOSIMON PIGON ENERGEIAS & SYNAFON SYMVOULEFTIKON Y PIRESION*ADVEN, UNIWERSYTET MARII CURIE-SKLODOWSKIEJ, FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV, UNIVERSITY OF PATRAS, ZENTRUM FUR BRENNSTOFFZELLEN-TECHNIK GMBH, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, ENERFUEL INC, ARPEDON METRITIKES DIATAXEIS KAI ORGANA MICHANIMATA YPRESIES EPE

MAIN OBJECTIVES OF THE PROJECT

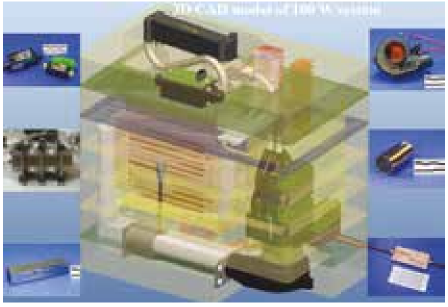
Development/demonstration of 100 W internal reforming methanol high temperature PEM fuel cell system for portable applications. It includes: Scale-up synthesis and optimization of the main components (HT-MEAs, methanol reforming catalysts, BoP) developed within the framework of previous FCH-JU IRAFC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

PROGRESS/RESULTS TO-DATE

- Scale-up synthesis and long term cycling stability of ultra thin Cu-based methanol reformer; highly active at 210 °C; easy embedding in the cell.
- Scale-up synthesis of MEAs operating at 210 °C; high stability (500 h) under simulated reformate gas; poor stability under on-off cycling tests.
- New graphite- and metal-based bipolar plates operating under IRMFC conditions.
- Integration/testing of short IRMFC modules (210 °C, 650 mV/MEA at 0.2 A/cm^2). Poor cycling tolerance (thicker MEAs will be employed in the final stack).
- BoP and main stack components already delivered, covering the size and weight restrictions. 100 W stacks tests will start in summer 2016.

FUTURE STEPS

- 100 W graphite- and metal-based stacks integrated and tested.
- Self-sustaining operation at 100 W net power output (no external power supply).



CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The first 36 months results clearly demonstrate the IRMFC functionality and open future perspectives in fuel cell market for portable applications.
- Crosslinking methodology adopted herein for the first time resulted in MEAs operating at 210 °C under reformate conditions.
- Poor cycling stability of MEAs will be confronted with thicker membranes in the final stacks; modified polymer electrolytes are under development.
- New-type methanol reformer (ultrathin and lightweight) and bipolar plates (operation at 200-230 °C) delivered and tested for >1,000 h.
- Promising results obtained from short modules testing gives high perspective to achieve the main objectives of the project.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Self-sustaining operation of 100 W Internal Reforming Methanol Fuel Cell (no external power supply)	Small-Micro Fuel Cells-logistic non-hydrogen fuel-Mini (50-500 W)	Main components (reformers, MEAs, BPPs, BoP) delivered and final stacks testing is under way	<70 % (due to limited cycling capability of MEA)	No direct comparison. Closest commercial systems: (i) Truma VeGa 250 W (LPG fuel, 140 kg/kW, 384 L/kW); (ii) SFC EFOY (105 W DMFC, 75 kg/kW, 20 % efficiency); (iii) UltraCell XX55 RMFC (50 W, 12V, 1.6 kg)	Poor cycling stability of MEAs due to expansion/shrinkage phenomena during cooling/heating runs which result in severe degradation of the membranes. Improved with thicker membranes
<€5,000/kW	2015 target: Cost of €24,000/kW for industrial/commercial units	A rough estimation of cost for mass production of the stack plus peripherals is below the target	100 % (for mass production)	N/A	The final cost is much higher because a single unit will be delivered
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2012
Electrical efficiency >30 % at 210-220 °C (MeOH/H_2O fuel)	Electrical efficiencies of 30 %+ (based on a logistic fuel input)	Efficiency >30 %	100 %	N/A	Design and evaluation report on the engineering issues of BoP completed. Integration/testing of the final system will start at the end of summer 2016
100 W IRMFC system fuelled with MeOH/H_2O will be tested at 210 °C (including 100 start-stop cycles)	1,000 h lifetime including 100 start-stop cycles	N/A	<70 % (limited on/off capability of membranes)	N/A	Integration/testing of the final system will start at the end of summer 2016

KNOWHY

Improving the knowledge in hydrogen and fuel cell technology for technicians and workers

PANEL 6
Cross-cutting

ACRONYM	KNOWHY
CALL TOPIC	SP1-JTI-FCH.2013.5.2: Training on H_2&FC technologies for Operation & Maintenance
START DATE	1/09/2014
END DATE	31/08/2017
PROJECT TOTAL COST	€1,4 million
FCH JU MAXIMUM CONTRIBUTION	€1 million
WEBSITE	http://knowhy.eu/

PARTNERSHIP/CONSORTIUM LIST

TECHNISCHE UNIVERSITEIT DELFT, FUNDACION PARA EL DESARROLLO DE LAS NUEVAS TECNOLOGIAS DEL HIDROGENO EN ARAGON, FUNDACION SAN VALERO, TECHNISCHE UNIVERSITAET MUENCHEN, PARCO SCIENTIFICO E TECNOLOGICO PER L'AMBIENTE – ENVIRONMENT PARK SPA, CAMPUS AUTOMOBILE SPA-FRANCORCHAMPSASBL, THE UNIVERSITY OF BIRMINGHAM, INSTITUTO SUPERIOR TECNICO, FAST – FEDERAZIONE DELLE ASSOCIAZIONI SCIENTIFICHE E TECNICHE, VERTIGO GAMES BV, PNO CONSULTANTS BV, KIWA TRAINING BV, McPhy Energy SA

MAIN OBJECTIVES OF THE PROJECT

The main objective of the project is to create blended learning program for technicians working with FC&H_2 applications and correspondingly train minimum of 1,000 technicians by the project end. To achieve this, several objectives are defined: identify training needs, identify the target group defining the profile of the technicians to be addressed, identify training modules based on survey with FC&H_2 organisations and companies, develop teaching methodology, set the online course platform, create course content in 7 languages along with serious games & practical sessions.

PROGRESS/RESULTS TO-DATE

- Stakeholders identified, market survey conducted & based on the results, training modules identified.
- Teaching methodology defined, course platform, the project website and LinkedIn page established.
- Target group of technicians to be addressed in the training identified & pilot course in progress in the Netherlands.
- Dissemination documents established & KnowHy disseminated at several events; publications also released.
- The course platform updated with the core module & one specialisation module in English and Dutch language.

FUTURE STEPS

- Four more specialisation modules to be created, validated & uploaded on the course platform.
- Translation of all modules in languages: English, Dutch, German, Spanish, Portuguese, French & Italian.

- Technician enrolment to begin soon and thereby courses will be provided in several countries in Europe.
- Establishment of KnowHy joint venture along with business case proposal.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- A special purpose vehicle will be set up to enable effective collaboration beyond the end of the EU-funded project.
- Based on interviews, survey & market analysis; five specialisation courses have been identified related to FC&H_2 applications.
- Interactions with participant industries of the pilot course gave positive results & highlighted the need for such courses.
- Some improvements are suggested by the pilot course participants to make the course more appealing to technicians.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
An offer of five courses based on applications of FC&H_2 technology along with a basic course	Ensure the human capital necessary in developing FC&H_2 technology in the mid-term is developed	40 %	90 %	No existing FC&H_2 training available online for technicians. OEMs normally train the technicians in-house	Target group & the training modules identified. The online course platform is set. Website and dissemination documents finalised. 2 courses uploaded on the platform & a pilot training is ongoing.

LIQUIDPOWER

Fuel cell systems and hydrogen supply for early markets

PANEL 4

Research activities for stationary applications

ACRONYM	LIQUIDPOWER
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 DATE	1/10/2012
END DATE	31/05/2016
PROJECT TOTAL COST	€3,8 million
FCH JU MAXIMUM CONTRIBUTION	€1,9 million
WEBSITE	Not provided PRD 2016

PARTNERSHIP/CONSORTIUM LIST

DANTHERM POWER A.S, CATATOR AB, H_2 Logic A/S, ZENTRUM FUR BRENNSTOFFZELLEN-TECHNIK GMBH

MAIN OBJECTIVES OF THE PROJECT

R&D giving improved reliability and cost reductions for Backup Power systems (BP). R&D giving improved reliability and cost reductions for Material Handling Vehicles (MHV) and R&D of a methanol reformer for onsite hydrogen supply giving the markets BP and MHV access to cheap hydrogen.

PROGRESS/RESULTS TO-DATE

- Scalability of the fuel cell system developed and new DC/DC converter configuration introduced (BP).
- Efficiency targets reached and Simple Network Management Protocol (SMNP) included in system (BP).
- Several new parts have been changed in the system in order to decrease cost (MHV).
- A compact and highly integrated reformer system has been developed (methanol reformer).

FUTURE STEPS

- The project is finalized however we will keep on working with several issues such as:
- A new cost reduction project is likely to be initiated (new stack) BP.
- DTP will continue working on a number of issues ie cost of controller, DC/DC converter (MHV).

- For both subsystems (reformer and Pressure-Swing Absorption, PSA) the lifetime needs to be further evaluated (methanol reforming).
- Continued search for better and cheaper components (all segments).

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The project is finalized however we will keep on working with several issues such as:
- BP several hot/humid and cold climate kits to our products in order for them to be able to operate in a larger temperature range.
- We will further test parts (and subsequently implement them) which can further decrease cost on the overall system (MHV).
- A cost reduction project will be initiated (mthanol reforming).

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
<€1.800/kW @ 5,000 unit production	Material handling fuel cell system cost of €1,500/kW in 2015	1700	100 %	On the material handling market we are competing with mainly North American (NA) based companies (Plug Power, Nuvera and Hydrogenics).They are state of the art 2016	DTP is working on a number of issues: Cost of controller, DC/DC converter, compressor etc. DTP will put an effort into finding better and cheaper components
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
€1.300/kW @ 5,000 unit production	Back-up power fuel cell system cost of €1,500/kW in 2015	<€1.300/kW	100 percent	DTP is generally considered to be the State of the art company in the BP segment	It is possible to meet this target if the sale is above >5,000 units. For now, the sale is below <300 units and the price is €2400.
Back-up power fuel cell system efficiency 45 %	Back-up power fuel cell system efficiency of 30 % in 2015	52 %	100 %	DTP	Reached through improved power electronics, Software and purge intervals.
Hydrogen cost at point of consumption of <€7/kg PSA: target 2,000 €/m³/h (1-10 units) Hydrogen cost at point of consumption of <€7/kg PSA: target 2,000 €/m³/h (1-10 units)	Hydrogen price ≈10 €/kg PSA: status 3500 €/m³/h (1 – 10 units) à + 75 %	0 %			For both subsystems (reformer and PSA) the lifetime needs to be further evaluated. Both subsystems also need a cost reduction project in order to reach the cost targets.

MATHRYCE

Material testing and recommendations for hydrogen components under fatigue

PANEL 6
Cross-cutting

ACRONYM	MATHRYCE
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 DATE	1/10/2012
END DATE	30/09/2015
PROJECT TOTAL COST	€2,4 million
FCH JU MAXIMUM CONTRIBUTION	€1,2 million
WEBSITE	http://www.mathryce.eu/

PARTNERSHIP/CONSORTIUM LIST

COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, L'AIR LIQUIDE S.A, Teknologian tutkimuskeskus VTT Oy, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, THE CCS GLOBAL GROUP LIMITED, CENTRO SVILUPPO MATERIALI SPA, DALMINE SPA

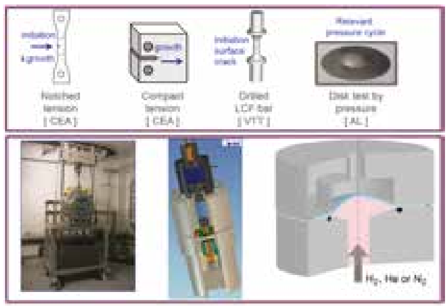
MAIN OBJECTIVES OF THE PROJECT

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

1. A reliable testing method to characterize materials exposed to hydrogen-enhanced fatigue.
2. Generating characterization data of metallic materials for hydrogen service.
3. Definition of a methodology for the design of metallic components exposed to hydrogen enhanced fatigue.
4. 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.
- Analysis of the results at lab-scale and full scale, helped by numerical simulations.
- Methodology proposal.



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.
- At low DK, it is necessary to use the fatigue crack growth rate law including the change of behaviour at such low values, not to be too conservative.
- A methodology and associated recommendations have been proposed and presented to ISO and CEN experts.
- A draft, including some of the Mathryce project recommendations, for an appendix to draft ISO/CD 19884 has been proposed to the ISO working group.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:			MAIP 2008-2013
To propose dedicated RCS for design of Hydrogen pressure vessels	RCS strategy – Development of RCS to avoid major barriers for the commercialisation of FCH products	Finished	Recommendations for RCS have been proposed and presented to the ISO and CEN experts of the field on the September 21 workshop.
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:			AIP 2011
Three types of tests are developed and applied to the metallic material AISI 4130	Metallic material characterization for hydrogen service	Finished	All the tests have been achieved. Only one material could be tested within the project.
Development of service life assessment methodology based on lab-scale tests under hydrogen gas.	Experimental implementation of design approach and design testing approach	Finished	Both lab-scale and full-scale tests have been used to identify an appropriate testing method under hydrogen gas.
Development of a design methodology taking into account hydrogen enhanced fatigue.	Design code for pressure equipment with metallic components in hydrogen service	Finished	Methodology as well as RCS recommendations have been presented to ISO and CEN experts.

MATISSE

Manufacturing improved stack with textured surface electrodes for stationary and CHP applications

PANEL 4

Research activities for stationary applications

ACRONYM	MATISSE
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 DATE	1/10/2014
END DATE	30/09/2017
PROJECT TOTAL COST	€3,1 million
FCH JU MAXIMUM CONTRIBUTION	€1,6 million
WEBSITE	http://matisse.zsw-bw.de/general-information.html

PARTNERSHIP/CONSORTIUM LIST

COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, ZENTRUM FUR SONNENENERGIE- UND WASSERSTOFF-FORSCHUNG BADEN-WURTTEMBERGSTIFTUNG, NEDSTACK FUEL CELL TECHNOLOGY BV, INHOUSE ENGINEERING GMBH, AREVA STOCKAGE D'ENERGIE SAS

MAIN OBJECTIVES OF THE PROJECT

Matisse aims at improving manufacturability thanks to the development of specific electrodes by screen printing; sealing solutions and automated assembly of MEAs and stacks for three stationary applications using: H_2/O2 (for Areva SE smart grid), H_2/Air (for Nedstack back-up or CHP in large power plant); or Reformate H_2/Air (for inhouse micro-CHP).

The final goal is to implement optimized MEAs improving performance and durability in the specific conditions of the partners' systems. Cost analysis is planned to check the impact of components and processes on the systems' cost.

PROGRESS/RESULTS TO-DATE

- Methodology and tools developed and set by all partners (manufacturing processes, in-situ tests including segmented cells and post-ageing).
- MEA components defined, manufactured and provided for the 3 stack designs considered (reference homogeneous electrodes and textured catalyst layers).
- Tests in specific conditions with Current Density Distribution Mapping; ageing in nominal or accelerated conditions. Post ageing analyses started.
- New gaskets, sub gasket, anti-wicking solutions identified, tested and proposed, with the aim to improve robustness for the different designs.
- Cost assessment done for the three stack designs and fuel cell technologies using the available reference data for each case.

FUTURE STEPS

- In-situ tests and post ageing characterizations to be analysed on first reference and textured electrodes for further improvements.
- Proposal of new designs and formulations for homogeneous or textured catalyst layers based on first results.
- Development, manufacturing and delivery of other reference MEAs for Areva SE design; of textured MEAs for Nedstack and Inhouse designs.
- Performance and durability testing with current density distribution mapping of new batches of MEAs and characterization of aged MEAs.
- Further developments for automated assembly of MEAs (including sealing solutions) and of stacks with adaptation of stacking machine to Areva SE design.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Validation of electrodes manufacturing process and assessment of improvements thanks to texturing for the 3 types of designs and applications.
- Validated transfer to a fully automated process (pilot line) of large size electrodes manufacturing.
- Validation of the automatic manufacturing of MEAs (reproducibility on one selected electrode design, with a representative number of MEA).
- Validation of the automatic assembly of stack (with selected reference MEAs for Areva SE design).
- Assessment of the impact of processes and components' modifications on stack and system costs for the final optimized MEAs.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
mCHP: 43 % (H_2 reform./air) Large Power Plant: 50 % (H_2/air) Smart Grid: 47 % (H_2/O2)	Electrical efficiencies should be >45 % for power only units and >80 % for CHP units	Reference MEA tested In performance including current density distribution mapping	80 %	45 % 80 %	Performances at short stack level available for reference MEAs and gradient electrodes for H_2 and reformate/Air cases
mCHP: 40,000 h Large Power Plant: 20,000 h (without servicing the stack) Smart Grid: 40,000 h	lifetime requirements of 40,000 hours for cell and stack	Durability on reformate/Air on reference MEA (>3,000 h) Specific Accelerated Stress Test (AST) H_2/Air (600h) Post-ageing analyses	80 %	8,0000 hrs (Japanese systems)	Lifetime obtained at short stack level AST on H_2/Air (~300µV/h) Low degradation rate obtained in reformate /Air case (<20µV/h)
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
Reduced stack components costs	Reduced system costs	Automation of electrodes manufacturing on-going First modifications of electrodes performed	80 %		First cost assessment available for reference components only

MEGASTACK

Stack design for a Megawatt scale PEM electrolyser.

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	MEGASTACK
CALL TOPIC	SP1-JTI-FCH.2013.2.3: Large capacity PEM electrolyser stack design
START DATE	1/10/2014
END DATE	30/09/2017
PROJECT TOTAL COST	€3,9 million
FCH JU MAXIMUM CONTRIBUTION	€2,1 million
WEBSITE	http://www.sintef.no/Projectweb/megastack/

PARTNERSHIP/CONSORTIUM LIST

STIFTELSEN SINTEF, FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V, ITM POWER (TRADING) LIMITED, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES

MAIN OBJECTIVES OF THE PROJECT

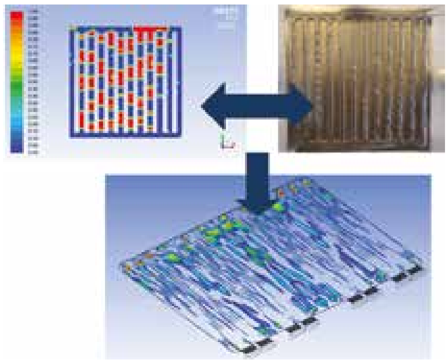
The main objective of MEGASTACK is to develop a cost efficient stack design for Megawatt-sized PEM electrolysers and to construct and demonstrate a prototype of this stack. The prototype will demonstrate a capability to produce hydrogen with an efficiency of at least 75 % (LHV) at a current density of 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.
- Mathematical stack model and single cell multiphase flow model completed.
- 1st generation stack design completed.
- Protoype production.

FUTURE STEPS

- Component level testing on single cell and short stack level.
- Further optimisation and validation of mathematical models.
- Evaluation of stack design by mathematical models.
- Stack construction and testing.



CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Further cost reductions of PEM electrolysers possible through manufacturing and supply chain improvements.
- More knowledge on micro-scale transport processes in MEAs and porous transport layers needed.
- MW scale PEM electrolyser design launched by ITM Power.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
2015 target: 10-20 % of H_2 demand produced via carbon free/carbon lean sources	Stack <€2,500/Nm³/hn lifetime in excess of 40,000 h 1,2 A/cm² with η >75 % (LHV)	<€2,500/ Nm³/h capacity	90 %		As this is a RTD project there is always a certain risk that project objectives are not achieved within the timeframe of the project.
2015 target: Cost of H_2 delivered at refuelling station <€5/kg (€0,15/kWh)			90 %	$3,64/kg ($0,057/kwh) (Giner DOE annual review 2013)	As this is a RTD project there is always a certain risk that project objectives are not achieved within the timeframe of the project.
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
Hydrogen production capacity of single stack >100 Nm³/h	60 Nm³/h	60 Nm³/h	100 %		
Modular stack cost <€2,500/Nm³/h capacity	€2,500/Nm³/h capacity	<€2,500/ Nm³/h capacity	100 %		
Stack availability >99 %	N/A	Not available, no stack constructed for testing.			Target too vague to be relevant KPI. How is "availability" defined?
Lifetime >40,000h	>40,000h	Not available, no stack constructed for testing.	95 %		

METSAPP

Metal supported SOFC technology for stationary and mobile applications

PANEL 4

Research activities for stationary applications

ACRONYM	METSAPP
CALL TOPIC	SP1-JTI-FCH.2010.3.1: Materials development for cells, stacks and balance of plant (BoP)
START DATE	1/11/2011
END DATE	31/12/2015
PROJECT TOTAL COST	€8 million
FCH JU MAXIMUM CONTRIBUTION	€3,3 million
WEBSITE	http://www.metsapp.eu/

PARTNERSHIP/CONSORTIUM LIST

DANMARKS TEKNISKE UNIVERSITET, SANDVIK MATERIALS TECHNOLOGY AB, TOPSOE FUEL CELL A/S, AVL LIST GMBH, CHALMERS TEKNISKA HOEGSKOLA AB, Karlsruher Institut fuer Technologie, THE UNIVERSITY COURT OF THE UNIVERSITY OF ST ANDREWS, ICE STROMUNGSFORSCHUNG GMBH, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, ELRINGKLINGER AG

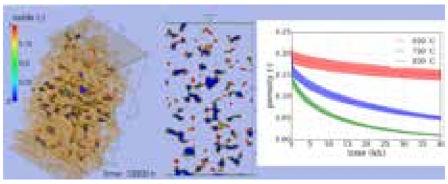
MAIN OBJECTIVES OF THE PROJECT

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) cell<0,5 Ωcm², 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 Ωcm², 650 °C.
- Robustness of 1-3 kW stack verified. – Cost effectiveness, industrially relevance, up-scale-ability illustrated.

PROGRESS/RESULTS TO-DATE

- New LSFNT based anode backbone developed and integrated into the cell, demonstrating significant stability improvement.
- Up-scalability demonstrated on cell level. Cells fabricated in sizes up >300 cm². More than 200 cells of 12 x 12 cm² size produced.
- A corrosion model was implemented, which describes the oxide growth and pore volume change influencing the diffusion in the microstructure.
- New interconnect coatings established, with highly improved properties and a self-healing capability allowing mass production before deformation.



- Extensive electrochemical characterisation was carried out, facilitating the extraction of model parameters that are validated.

FUTURE STEPS

- Demonstration at the stack level.
- Further improvement of the LSFNT based anode backbone microstructure and electrocatalyst (towards lower degradation).
- Further improvement of the infiltration process.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- If the achievements are verified on stacks, there is a high potential for special markets (mobile home, houseboat…), followed by APU.
- Increased effort and focus on computational modelling and simulation facilitates the development of concepts.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Improved durability for stationary applications, degradation	Degradation <0.25 %/kh	Degradation <1.5 %/kh	0 %	Degradation <1.5 %/kh	Further microstructure and material optimisation are expected to reduce degradation
Robustness of 1-3 kW stack verified	Not applicable	The stacks did not survive conditioning	0 %	Not available	Stack demonstration is possible with the current knowledge.
Cost effectiveness, industrially relevance, up-scale-ability illustrated	Ferritic stainless steel as alternative for Ni/YSZ	Successful demonstrated	100 %	Not available	
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
Cell performance	ASRcell <0.5 Ωcm², 650ºC	ASRcell <0.5 Wcm², 650ºC	100 %	ASRcell <0.5 Ωcm², 650ºC	ASRcell was reached down to 0,37 Ωcm², 650ºC
Cell optimized and produced in various sizes	Production in various sizes	Cells produced in various sizes. Feasibility study for footprint >300 cm² successful	100 %	Not available	
Modular, up-scaled stack design	Stack ASRstack <0.6 Wcm², 650ºC	The stacks did not survive conditioning	0 %	Not available	Stack demonstration is possible with the current knowledge.

MOBYPOST

Mobility with hydrogen for postal delivery

PANEL 1

Technology validation in transport applications

ACRONYM	MOBYPOST
CALL TOPIC	SP1-JTI-FCH.2009.4.1: Demonstration of fuel cell powered materials handling vehicles and infrastructure
START DATE	1/02/2011
END DATE	30/11/2015
PROJECT TOTAL COST	€8,2 million
FCH JU MAXIMUM CONTRIBUTION	€4,2 million
WEBSITE	http://mobypost-project.eu/

PARTNERSHIP/CONSORTIUM LIST

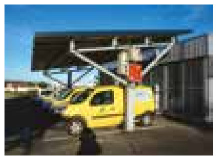
UNIVERSITE DE TECHNOLOGIE DE BELFORT MONTBELIARD, Steinbeis Innovation gGmbH, EUROPAISCHES INSTITUT ENERGIEFORSCHUNG ELECTRICITE DE FRANCE/UNIVERSITAT KARLSRUHE (TH), MAHYTEC SARL, E.D.I. PROGETTI E SVILUPPO S.A.S. DI DOVERI NICOLO' & C., LA POSTE SA, MES SA, INSTITUT PIERRE VERNIER, H2NITIDOR SRL, DUCATI ENERGIA SPA, ARIEMA ENERGIA Y MEDIOAMBIENTE SL

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 1,1kW low temperature PEMFC.
- 10 vehicles built and homologated/certified despite of misfit regulations.
- Each infrastructure built and producing 1,5 kg H_2 per day.
- Demonstration under real environmental conditions running with 5 vehicles and one infrastructure.



FUTURE STEPS

- Further exploitation of project results.
- Follow up projects to finalize the concept.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Niche market on which FCEV could have a high impact.
- Legal frame as well as standards are at the moment inexistent for such technologies (hydrides). Standardisation is necessary for an early market.
- Solar-to-wheel concept as well as the low pressure tank technology used could improve the public acceptance of the fuel cell technologies.
- Technology already well accepted by the postmen using it.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
10 FCEV specifically designed for postal delivery to be developed T	Target 2015: 500 industrial and off highway vehicles	10 vehicles designed, built and functional	100 %		The objectives 2015 are delayed to 2018.
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2009
Perform 1 year demonstration of the whole system under real conditions.	Demonstrate advantages of using FC in material handling vehicles	12 months demonstration at Audi court and 1 month at Perring.	55 %		The demonstration reached 100 % only at Audi court. Due to technical problems only 10 % was achieved at Perring. Nowadays the 10 vehicles are running at the two sites.
2 solar-production and refuelling infrastructure that are autonomous on energy over 1 year	Including coupling with H_2 infrastructure	The 2 infrastructures are functional	100 %		Time needed to find a new partner delayed considerably the commissioning of the second infrastructure, which minimises the time of its demonstration.
Achieve European certification of the vehicle. Identify the leakage in terms of RCS	Development of the certification procedures; identification of potential RCS needs	Certification of the of the vehicles achieved. No certification of the infrastructure needed	100 %	No certification existing for metal-hydride tanks. Certification obtained was an exemption by the French ministry for the demonstration period.	Certification of the hydrogen part more complicated because no regulation existing. Each of the 10 vehicle has its individual vehicle approval from French ministry.
Refuelling time around 3 h	Refuelling time according to the postmen activity	Refuelling time around 3 h	100 %		3 h are largely enough for such an application as postal delivery.
FC system efficiency (%) >40	FC system efficiency (%) >40	The experimental measurements highlight 45 %.	100 %		
H_2 price at pump (€/kg) <€13/kg	H_2 price at pump (€/kg) <€13/kg	Not already measured			
FC price < €4,000/kW	FC price < €4,000/kW	< €5000/kW	0 %		
(c) Other project objectives					
Ergonomics aspects of the vehicles	To be able to park as close as possible to houses or buildings, to be able to park on sidewalks,	With a vehicle width of 1m the vehicle is able to drive and to access on sidewalks.	100 %		
Road holding of the vehicle	Sharing the load on two rear wheels	The load variations don't affect stability of the vehicle.	100 %		

NANO-CAT

Development of advanced catalysts for PEMFC automotive applications

PANEL 2

Research activities for transport applications

ACRONYM	NANO-CAT
CALL TOPIC	SP1-JTI-FCH.2012.1.5: New catalyst structures and concepts for automotive PEMFCs
START DATE	1/05/2013
END DATE	31/01/2017
PROJECT TOTAL COST	€4,3 million
FCH JU MAXIMUM CONTRIBUTION	€2,4 million
WEBSITE	http://nanocat-project.eu/

PARTNERSHIP/CONSORTIUM LIST

COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, ASSOCIATION POUR LA RECHERCHE ET LE DÉVELOPPEMENT DES MÉTHODES ET PROCESSUS INDUSTRIELS – ARMINES, FUNDACION TECNALIA RESEARCH & INNOVATION, NANOCYL SA, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, C-TECH INNOVATION LIMITED, DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, VOLVO TECHNOLOGY AB

MAIN OBJECTIVES OF THE PROJECT

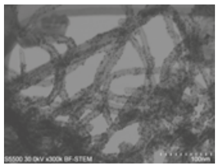
Nano-CAT proposes alternatives to the use of conventional catalyst and promotes nanostructured Pt based catalyst with a good activity and enhanced lifetime due to a better resistance to degradation. Nano-CAT will thus develop novel nanostructured on innovative supports (carbon nanotubes NCT and metal oxide).

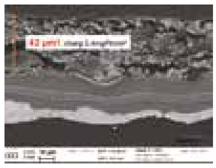
PROGRESS/RESULTS TO-DATE

- Synthesis of new support for electrocatalyst for PEMFC application.
- Deposition of homogeneously dispersed nanoparticle of Pt onto those new supports and ex-situ characterisation.
- Integration in MEA (cathode and anode). Validation of the robustness of new catalyst Pt/NCT, especially for bus application.

FUTURE STEPS

- Integration of the catalyst Pt/NTC in large area MEA for validation in short stack.
- Characterisation of Pt/NTC anode catalyst with low loaded cathode in MEA to prepare durable low loaded MEA.
- Organisation of a workshop to distribute results of the project results.





CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Anode degradation can be neglected when designing low loaded MEA and for aggressive current cycle.
- Use of NTC as catalyst support allows to stabilize the Pt particle size and the active area.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
0.1 gPt/kW @ max power	0.1 gPt/kW	0.5 gpt/kW	50 %	0.5 gPt/kW (GORE MEA)	MEA integrating Pt/NTC at anode for better durability. Decrease of cathode loading and test under harmonized EU condition
0.3 gPt/kW @ 55 % yield	0.1 gpt/kW	0.95 gPt/kW	50 %	0.64 gpt/kW (GORE MEA)	idem
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2012
1 W/cm^2 @ 1.5 A/cm^2	1 W/cm2 @ 1.5 A/cm^2	850 mW/cm^2 @ 1.5 A/cm^2	100 %	900 mW/cm^2 @ 1.5 A/cm^2 (GORE MEA)	Testing cond: 80 °C; 50 % RH, StH2: 1.2; Stair: 2, 1.5 bara; decrease of anode and cathode loading MEA from the project integrating Pt/NTC at the anode à decrease of degradation. Validate the durability using MEA with lower Pt loading at the anode and cathode.
(c) Other project objectives					
Development of new catalyst support, improved carbon nanotubes and metal oxide	Breakthrough approaches for novel catalyst	Use of CNT as support validated (see above); synthesis of metal oxide (SnO2/Sb) validated à same pore size distribution as carbon black and conductivity 0.1 S/cm	Target reach	Not applicable	Upscale of modified NTC for Pt deposition

NELLHI

New all-European high-performance stack: design for mass production

PANEL 4
Research activities for stationary applications

ACRONYM	NELLHI
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 DATE	1/05/2014
END DATE	30/04/2017
PROJECT TOTAL COST	€2,8 million
FCH JU MAXIMUM CONTRIBUTION	€1,6 million
WEBSITE	http://www.nellhi.eu/

PARTNERSHIP/CONSORTIUM LIST

AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE, AKTSIASELTS ELCOGEN, Elcogen OY, Teknologian tutkimuskeskus VTT Oy, FLEXITALLIC LTD, BORIT NV, SANDVIK MATERIALS TECHNOLOGY AB, CLAUSTHALER UMWELTTECHNIK INSTITUT GMBH

MAIN OBJECTIVES OF THE PROJECT

NELLHI combines European know-how in single cells, coatings, sealing, and stack design for mass production to produce a 1 kW SOFC stack with high performance at reduced temperature. The stacks are developed over 3 generations according to system integrators' requirements. The target application of the development is stationary combined heat and power production based on natural gas, and will form the basis for Elcogen Oy's commercial SOFC stack technology as well as enforce market penetration for component manufacturers Elcogen AS, Sandvik, Borit and Flexitallic.

PROGRESS/RESULTS TO-DATE

- Validation of the cell production line, with demonstrated equivalent performance of the 12 x 12 cm cells as compared to the original 10 x 10 cm cells.
- A new sealing material was developed combining sealing and thermal resistance properties with compliance, relaxing thickness tolerances.
- The interconnects design streamlines manufacturing processes, and have been incorporated in the shaping tools used in the project.
- Continuous improvements are being assessed in terms of the coating-substrate materials for in-operando performance.

FUTURE STEPS

- In-depth cell validation tests to increase the understanding and control of cell reactions evolving along the surface.
- Adapting seal design to streamline stack assembly process.

- Multiple design improvements need to be assessed in combined operation with focused troubleshooting for gen. 3 design.
- Dual-atmosphere tests of interconnect samples in stack-representative conditions.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Elcogen AS cells prove high performance at low temperature and high yield on new production line.
- Flexitallic seals prove to be highly flexible and can be engineered to multiple designs and operating requirements.
- Interconnect manufacturing is already geared for mass-manufacture, optimization required for reliable performance in operando.
- Excellent collaboration in the project synergizes efforts and maxi- mizes return without overlaps.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Stack's performance at 900 mV with 0.35 Acm-2 current density at 650 ºC with increased cell footprint. The stack's fuel utilization capability should be at least 75 %. (Second year)	MAIP: Efficiency 35-45 % (elec) 75-85 % (tot) for mCHP system stacks	Stack voltage ~900 mV @ 0.35 Acm-2 at 650 °C Demonstrated stack fuel utilization capacity of 85 %	100 %	References unavailable due to confidentiality of information	60 % stack efficiency achievable
Less than 0.2 % voltage loss in 1,000 hours and 0.5 % after 10 thermal cycles (enables >25,000 hours life-time)	Increase the electrical efficiency and the durability for (CH)P, while reducing costs	Less than 5mΩ.cm²/kh (9,000 hours experiment) demonstrated with unit cells	82 %	References unavailable due to confidentiality of information	Ongoing validation at stack level
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
920 mV @ 0.3 Acm-2 at 650 ºC with new cells. Stack fuel utilization capability >75 %	AIP2013: increase performance, power density, and efficiency (not quantified)	Stack voltage ~910 mV @ 0.3 Acm-2 at 650 °C Demonstrated stack fuel utilization capacity of 85 %	100 %	References unavailable due to confidentiality of information	Optimization of multiple design improvements for design freeze and final generation in 2017
Stack production yield over 95 %	AIP2013: reduce materials and manufacturing cost (not quantified)	Stack production yield for the project use has been 100 %	100 %	References unavailable due to confidentiality of information	More stacks have to be built in order to gain exact production yield figure.
(c) Other project objectives					
Improvement in seal material and designs for slender low cost manufacturing	not applicable	10-fold increase in seal compliance with unaltered sealing and thermal resistance properties	100 %	Company internal references	Optimization of multiple design improvements for design freeze and final generation in 2018
Optimization of material-coating combinations for robustness in performance and in manufacturing	not applicable	2-fold increase in durability for ex-situ tested material-coating combinations	100 %	Company internal references	Optimization of multiple material improvements for design freeze and final generation in 2017

NEWBUSFUEL

New Bus ReFuelling for European Hydrogen Bus Depots

PANEL 1

Technology validation in transport applications

ACRONYM	NEWBUSFUEL
CALL TOPIC	FCH-01.6-2014: Engineering studies for large scale bus refuelling
START DATE	1/06/2015
END DATE	31/12/2016
PROJECT TOTAL COST	€2,4 million
FCH JU MAXIMUM CONTRIBUTION	€2,4 million
WEBSITE	www.newbusfuel.eu

PARTNERSHIP/CONSORTIUM LIST

ELEMENT ENERGY LIMITED, ABENGOA HIDROGENO SA, ABERDEEN CITY COUNCIL*, AIR PRODUCTS PLC, AKERSHUS FYLKESKOMMUNE, BIRMINGHAM CITY COUNCIL, Vlaamse Vervoersmaatschappij De Lijn, EMPRESA MUNICIPAL DE TRANSPORTES DE MADRID SA, EVOBUS GMBH, H2 Logic A/S, HAMBURGER HOCHBAHN AG, HYDROGENICS GMBH, HYOP AS, INGENIEURTEAM BERGMEISTER SRL, ISTITUTO PER INNOVAZIONI TECNOLOGICHE BOLZANO SCARL, ITM POWER (TRADING) LIMITED, KUNNSKAPSBYEN LILLESTROM FORENING, LINDE AG, LONDON BUS SERVICES LIMITED, McPhy Energy Deutschland GmbH, THINKSTEP AG, RIGAS SATIKSME SIA, SIEMENS AKTIENGESELLSCHAFT, STUTTGARTER STRASSENBAHNEN AG, Vattenfall Europe Innovation GmbH, VIP VERKEHRSBETRIEB POTSDAM GMBH, WSW MOBIL GMBH

MAIN OBJECTIVES OF THE PROJECT

1. Produce 13 engineering studies to define optimal designs, H_2 supply routes, commercial arrangements and practicalities involved in refuelling high volumes of H_2 at busy bus depots across Europe.
2. Prepare a range of publically accessible design guideline reports based on analysis across the engineering studies.
3. Kick start the large scale bus deployment projects which are required for the next stage of commercialisation.
4. Disseminate results to a wider audience to ensure the challenge of H_2 fuelling for buses is not seen as a credible reason to delay engagement with the technology.

PROGRESS/RESULTS TO-DATE

- Completed 12 out of 13 feasibility studies.
- Held 9 dedicated working group sessions to promote sharing of information between study teams.
- Produced dissemination guidelines, a project logo and website.

FUTURE STEPS

- Finalise all 13 feasibility studies.
- Finalise all 13 engineering studies.
- Extract, aggregate and anonymise data from studies to prepare design guideline reports.
- Host industry workshop to disseminate project outputs in late 2016.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Industry partners have developed engineering studies with significant variation.
- Bus operators have prioritised maximum infrastructure availability and reliability through provision of sufficient redundancy in station designs.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:			MAWP 2014-2020
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:			AWP 2014
Depot designs capable of refuelling between 60 to 150 12 m buses, capacity of 1,000-4,000 kg/day	Consider fuelling station requirements for at least 75 – 150 buses operating from the bus depots	All designs are in-progress and due to be completed by end of July/August 2016	100 %
Consider range of technical solutions supplying H_2 to depots, including off and on-site production	Assess options: on-site (WE and SMR), and delivered (compressed, pipeline and liquid)	All feasibility studies collectively considered full range of supply options	100 %
Each study will assess CO_2 emission impact of the H_2 dispensed, using a commonly agreed methodology	Pathways to decarbonisation should be developed in line with local emission reduction pathways	All designs are in-progress and due to be completed by end of July/August 2016	100 %
'Standardised Reports' for each study will describe all requirements	Designs should focus on costs, components, approvals processes and practical implications	All standardised reports are due to be completed by end of July/August 2016	200 %
A cross cutting WP will determine common specifications and other common ground between studies	Opportunities for standardising components/specifications should be assessed across the depots	Nine cross cutting working group sessions have been held so far. Outputs due in September 2016	300 %

NOVEL

Novel materials and system designs for low cost, efficient and durable PEM electrolysers

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	NOVEL
CALL TOPIC	SP1-JTI-FCH.2011.2.7: Innovative Materials and Components for PEM electrolysers
START DATE	1/09/2012
END DATE	30/11/2016
PROJECT TOTAL COST	€5,9 million
FCH JU MAXIMUM CONTRIBUTION	€2,6 million
WEBSITE	https://www.sintef.no/Projectweb/NOVEL/

PARTNERSHIP/CONSORTIUM LIST

STIFTELSEN SINTEF, FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, AREVA STOCKAGE D'ENERGIE SAS, JOHNSON MATTHEY FUEL CELLS LIMITED, Teer Coatings Limited, BENEQ OY, PAUL SCHERRER INSTITUT, AREVA H2GEN

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/Nm³h-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.
- Membranes and MEAs with lower H_2 crossover and lower costs.
- Oxygen electrocatalysts with higher activity.
- Oxide coatings for Ti bipolar plates.
- Demonstrator stack under testing.

FUTURE STEPS

- Further testing of demontrator stack.
- Evaluation of conductive supports and microporous layers.
- Upscaling and process optimisation of bipolar plate coating process.

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.
- Further development of low cost materials and components are needed for PEM electrolysers.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
stack cost below €2,500/Nm³h-1 and a target lifetime in excess of 40,000 hours	Cost of H_2 delivered at refueling station €5/kg	>2,500/Nm³h-1 at a stack efficiency of 67 %	90 %	NOVEL hydrogen cost calculations show costs of delivered H_2 to be at €3,55/kg at an electricity price of €0,057/kWh. The overall cost target in the programme has been achieved.
efficiency of at least 75 % (LHV) a stack cost below €2,500/Nm³h-1 and a target lifetime in excess of 40,000 hours	1,5 t/d cap. 68 % eff €2,8 M/ (t/d)	>2,500/Nm³h-1 at a stack efficiency of 67 %	80 %	Efficiency target will not be reached. But is unnecessary in order to reach the overall programme objectives. Lifetime target will not be reached.
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				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	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	100 %	Increased mass activity has been reached, but catalysts have lower conductivity which is challenging when implementing them in electrolyser MEAs
Polymer membranes with improved conductivity, low gas crossover and high mechanical stability	Thinner, more conductive and reinforced PFSA membranes. Radiation grafted membranes.	Membranes with a higher ratio of conductivity vs hydrogen crossover has been developed	80 %	Long term stability of the membranes under high pressures of oxygen and the production of electrodes on the membranes with good performance
Alternative materials for bipolar plates and current collectors, replacing the use of titanium	Development of coatings. The goal is to reduce the contact resistance of Titanium	Decreasing the passivation of Ti to increase the lifetime of the electrolyser stack	60 %	The achievement of this target is challenging due to the very oxidative environment and the transient operation of PEM electrolysers.

ONSITE

Operation of a novel SOFC-battery integrated hybrid for telecommunication energy systems

PANEL 3

Technology validation in stationary applications

ACRONYM	ONSITE
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 & SP1-JTI-FCH.2012.3.5: System level proof of concept for stationary power and CHP fuel cell systems at a representative scale
START DATE	1/07/2013
END DATE	31/03/2017
PROJECT TOTAL COST	€5,5 million
FCH JU MAXIMUM CONTRIBUTION	€3 million
WEBSITE	http://www.onsite-project.eu/

PARTNERSHIP/CONSORTIUM LIST

CONSIGLIO NAZIONALE DELLE RICERCHE, ERDLE ERICH KONRAD, ERICSSON TELECOMUNICAZIONI, FIAMM ENERGY STORAGE SOLUTIONS SRL, HTceramix SA, BONFIGLIOLI VECTRON GMBH, INSTYTUT ENERGETYKI, HAUTE ÉCOLE SPÉCIALISÉE DE SUISSE OCCIDENTALE, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, STIFTELSEN SINTEF, DANMARKS TEKNISKE UNIVERSITET, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, MXPOLYMERS BV, BASIC MEMBRANES BV, L'AIR LIQUIDE S.A

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 and datacentres.

PROGRESS/RESULTS TO-DATE

- 2.5 kW SOFC subsystem realised and tested: 40 % electrical efficiency at 230 Vac, fed with natural gas.
- 5 kW SOFC / Battery hybrid system realised and tested in laboratory: 2.5 kW SOFC, 2.5 kW battery, telecom load at 48Vdc, grid connection 230 Vac.
- Final design of the sheltered 5 kW SOFC / Battery hybrid system.
- Final design of the 10 kW SOFC / Battery prototype.
- Site (Radio Base Station) for demonstration of the sheltered SOFC/Battery hybrid system selected.

FUTURE STEPS

- Site arrangement (Radio Base Station) for demonstration of the sheltered SOFC/Battery hybrid system.
- Realisation and test in laboratory of the sheltered 5 kW SOFC / Battery hybrid system.
- Demonstration at real site (Radio Base Station): at least 1,000 hours.
- Realisation and test in laboratory of the 10 kW SOFC / Battery hybrid system (including an adsorption heat pump).
- Project workshop.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Tests showed natural gas fed SOFC generator electrical efficiency = 40 %.
- 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

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAWP 2008-2013
FC system efficiency (%)	55 %+ (elec); 85 %+ (total)	40 % (elec); 85 % (total)	100 %	52-60 % of electrical efficiency (SOFC for on-grid Telecom/datacentre applications (Bloom energy – USA)
FC system cost (€)	€4,000/kW	N/A (cost evaluation not finalized yet)	100 %	
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2012
Development of Proof-of-concept prototype systems	Development of Proof-of-concept combining advanced components into complete, fully integrated system	5 kW SOFC / Battery hybrid system realised and tested in laboratory	100 %	SOFC generator for telecom and datacentres: 250 kW @ 480 V ac 60 Hz (Bloom energy – USA)
Final application and market assessment	Assessment of the fuel cell system's ability to compete with existing technologies	Demonstration of the prototype at a real site. A final Market evaluation is expected.	100 %	
(c) Other project objectives				
Prototype ability to exchange power with the grid	Not applicable	The developed bidirectional converters (DC/DC and DC/AC) enable the prototype power exchanging with the grid	100 %	
Prototype capable to operate in islanding mode	Not applicable	The developed bidirectional converters (DC/DC and DC/AC) enable the prototype islanding mode (increasing the supply availability)	100 %	

PECDEMO

Photoelectrochemical demonstrator device for solar hydrogen generation

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	PECDEMO
CALL TOPIC	SP1-JTI-FCH.2013.2.5: Validation of photoelectrochemical hydrogen production processes
START DATE	1/04/2014
END DATE	31/03/2017
PROJECT TOTAL COST	€ 3,3 million
FCH JU MAXIMUM CONTRIBUTION	€ 1,8 million
WEBSITE	http://pecdemo.epfl.ch/

PARTNERSHIP/CONSORTIUM LIST

HELMHOLTZ-ZENTRUM BERLIN FUR MATERIALIEN UND ENERGIE GMBH, ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE, TECHNION ISRAEL INSTITUTE OF TECHNOLOGY, DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, UNIVERSIDADE DO PORTO, EVONIK INDUSTRIES AG, SOLARONIX SA

MAIN OBJECTIVES OF THE PROJECT

To address the challenges of solar energy capture and storage, we will develop a hybrid photoelectrochemical-photovoltaic (PEC-PV) 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 1,000 h. In parallel we will work 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 photo-electrochemical (PEC) hydrogen production, and further strengthen Europe's leading position in this growing field.

PROGRESS/RESULTS TO-DATE

- Efficiency of 7,5 % achieved for small-area device based on BiVO4 and 3-HIT Si cell, 8 mA/cm^2 photocurrent achieved for Cu_2O nanowires.
- Large-area (50 cm^2) BiVO4 and Cu_2O photoelectrodes fabricated.
- Light management and power management strategies developed.
- Angled cell design developed that shows improved bubble transport, avoids need for selective membrane, and allows use of segmented electrodes.
- Process flow sheets constructed and analyzed for three hydrogen production scenarios, predicting overall systems efficiencies between 7,7-8 %.

FUTURE STEPS

- Efforts to improve the efficiency of large-area electrodes will be increased.
- Various approaches to improve the stability and lifetime will be pursued.
- First large-area modules will be constructed.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Improvements in efficiency are encouraging, modeling efforts show that target efficiencies can be reached.
- The efficiency of large-area electrodes is mainly limited by resistive (ohmic) losses.
- Combination of power management and active light management can result in efficiencies that exceed those of PV-electrolyzer systems.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET (%)	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2014-2020
PEC-PV tandem device with active area <50 cm^2, STH-efficiency 8 %, stable for more than 1,000 h	Development and testing of new hydrogen production pathways (not quantitative)	The best efficiency achieved so far is 7,5 % (HHV) for a <1 cm^2 device.			
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
Active area >50 cm^2	Active area >50 cm^2	Photoelectrodes of 50,4 cm^2 were fabricated.	100 %	9 cm^2 (est. individual panel size in EU ArtipHyction project)	
Solar-to-H_2 efficiency of 8 %	Solar-to-H_2 efficiency of 8 %	7,5 % for small area BiVO4 device, 5,3 % for large-area Cu_2O photocathode (no device tests yet)	90 %	9,7 % for nanowire BiVO4 with expensive GaAs/InGaAsP PV cell (Sci. Rep. 5:11141, 2015).	Ohmic losses in conducting substrates limit the efficiency of large-area cells.
1,000 h lab test	1,000 h lab test	Tests will start in M28	100 %		

PEMBEYOND

PEMFC system and low-grade bioethanol processor unit development for back-up and off-grid power applications

PANEL 3
Technology validation in stationary applications

ACRONYM	PEMBEYOND
CALL TOPIC	SP1-JTI-FCH.2013.4.4: Development of 1-30kW fuel cell systems and hydrogen supply for early market applications
START DATE	1/05/2014
END DATE	31/10/2017
PROJECT TOTAL COST	€4,5 million
FCH JU MAXIMUM CONTRIBUTION	€2,3 million
WEBSITE	http://pembeyond.eu/

PARTNERSHIP/CONSORTIUM LIST

Teknologian tutkimuskeskus VTT Oy, Powercell Sweden AB, GENPORT SRL – SPIN OFF DEL POLITECNICO DI MILANO, FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V, UNIVERSIDADE DO PORTO, GREATER LONDON AUTHORITY

MAIN OBJECTIVES OF THE PROJECT

PEMBeyond project aims to develop a bioethanol fuelled integrated PEMFC based power system for back-up and off-grid applications. Main targets include: – Using crude (80-95 %) 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 h system lifetime). Extensive techno-economic and life-cycle analyses are performed to ensure the concept attractiveness, further leading a roadmap to volume production.

PROGRESS/RESULTS TO-DATE

- Complete system specifications and hydrogen quality specifications defined.
- Reformate PEMFC stack design ready and stack supply started. Stack CO tolerance and cold start capability evaluated.
- Market Analysis for Telecom back-up systems completed, data collection for techno-economic and life-cycle analysis started.
- Fuel processor, Pressure Swing Adsorption (PSA) unit & FC system development/design completed. Subsystem assembly on-going.
- Complete system container acquired, transported to test site and installed with automation and control system.

FUTURE STEPS

- Functional testing of the subsystems: FP, PSA and FCS.
- Complete system integration, testing and field-trial.
- Development of ejector control system and evaluation in FCS scale.
- Completion of the techno-economic and life-cycle analyses.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- High interest from potential end-users. According to Market Analysis 60 % of telecom backup market can be served by system.
- Both local and EU level regulation affect significantly the telecom back-up market and the system requirements.
- Reformate PEMFC stack developed in the project capable of unassisted start-up from -25 °C.
- Very attractive non-noble metal based low-temperature water gas shift (LT-WGS) catalyst developed.
- No major technical obstacles foreseen at this point.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
1 new back-up power unit prototype built & field-tested	2015 target: 1,000 new UPS/back-up power units in the EU market	Subsystem design ready, assembly in progress.	100%		Subsystems sent to VTT. System integration from 09/2016, commissioning Q12017, then field trial.
System: <€3,3k/kW @>500 units/5 kW <€2,5k/kW @>500 units/25 kW	Cost: €1,5-2,5k/kW for industrial/ commercial units. Annual obj. €2,5 k/kW @ >500 units for FC & H_2 system (incl. H_2 generator)	€7,000/kW, estimated based on the current prototype	90%	Est. €8-10 k/kW for combined electrolyser/ PEMFC & €9k/kW for bioethanol	Cost red. potential on PSA unit & stack w/prod. to other markets not included yet. Further assessment of cost red. by elimination of overlapping control systems, cabinets, etc...
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
System: <€3,3k/kW @>500 units/5 kW <€2,5k/kW @>500 units/25 kW	FC & H_2 system cost €2,5 k/kW @ >500 units (incl. H_2 generator)	€7,000/kW, estimated based on the prototype	90%	Est. €8-10k/kW for combined electrolyser/ PEMFC & €9k/kW for bioethanol	Cost reduction potential on PSA unit and stack with production to other markets not included yet. Further assessment of cost reductions by elimination of overlapping control systems, cabinets, etc...
FC system efficiency >45%	FC system efficiency >45%	44%	100%		Optimization of stack operation, 2nd gen. MEAs
System lifetime >20,000 h	System/stack lifetime 20,000 h	Est. lifetime >5,000 h (fuel processor), >10,000 h (stacks, system)	90%	10,000 h est. for reformate system	No long-term durability testing in project, possible conclusions from 1,000 h field trial.
System efficiency >30 %	System efficiency >30 % w/integrated H_2 generator	~28% from data/simulations on subsystems: Fuel processor: 90 %, PSA: 80 %, FC system: 44 %	95 %		2nd gen. MEAs & FC system optimization for efficiency over 30 %, but CO level effect needs verification.
(c) Other project objectives					
Quality of bioethanol as primary fuel	Not applicable	Crude bioethanol (80-95 %), distilled but not purified	100%	Purified bioethanol	Bioethanol reformer design still in progress. No major problems foreseen.
Quality of H_2 used in PEMFC system: >98% H_2 , <25 ppm CO	Not applicable	Current MEAs can take 5 ppm CO in long term. Hygear PSA can reach <20 ppm.		Industrial grade 99.9% (non- reformate compatible systems)	~3 h of operation at nominal power, then at partial load w/increased CO tolerance. 2nd gen. MEAs & new in-project-developed adsorbent will help bridge the gap.
System operation ambient temp.: -25 °C to +50 °C	Not applicable	700 W 10-cell reformate S2 stack successfully cold started from -25 °C without external heaters.	100%	-5 °C	Stack cold start is key achievement. With 100-cell 7 kW stack, cold start-up is much easier to achieve.

PHAEDRUS

High pressure hydrogen all electrochemical decentralized refueling station

PANEL 2

Research activities for transport applications

ACRONYM	PHAEDRUS
CALL TOPIC	SP1-JTI-FCH.2011.1.8: Research & Development of 700 bar refuelling concepts & technologies
START DATE	1/11/2012
END DATE	31/10/2015
PROJECT TOTAL COST	€6,3 million
FCH JU MAXIMUM CONTRIBUTION	€3,5 million
WEBSITE	http://www.phaedrus-project.eu/

PARTNERSHIP/CONSORTIUM LIST

HYDROGEN EFFICIENCY TECHNOLOGIES (HYET) BV, ITM POWER (TRADING) LIMITED, H2 Logic A/S, RAUFOSS FUEL SYSTEMS AS, DAIMLER AG, SHELL GLOBAL SOLUTIONS INTERNATIONAL B.V., BUNDESANSTALT FUER MATERIALFORSCHUNG UND -PRUEFUNG, ASSOCIATION POUR LA RECHERCHE ET LE DÉVELOPPEMENT DES MÉTHODES ET PROCESSUS INDUSTRIELS – ARMINES, HOCHSCHULE ESSLINGEN, UNIRESEARCH BV

MAIN OBJECTIVES OF THE PROJECT

PHAEDRUS is developing an integrated 70MPa hydrogen fuelling station with reduced cost of ownership, building on high pressure electrolysis and novel Electrochemical Hydrogen Compression (EHC) technology and simplifying the system architecture through modelling and safety assessment.

PROGRESS/RESULTS TO-DATE

- Project has finished in Oct 2015.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- New concept for scalable 100 MPa HRS proven, enabling self-sustained infrastructure roll-out, fully compliant with existing standards (SAE J2601).
- Electrolyser producing hydrogen costing less than €7/kg inclusive of CAPEX and OPEX at 200 kg/day, mainly due to electricity cost (10c€/kWh used here).
- Electrochemical Hydrogen Compressor has high compression ratio >40, but cheapest systems configurations use booster above >50 MPa.

- Successful validation of the novel technology integration at small scale on-site at ITM, for the first time in the world, at 5 kg/day capacity.
- Modelling showed HRS configuration depends on the situation where economic feasibility in the short term, and significant cost down potential.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
HRS Capex 2015 target <1M€	Cascade system configuration simplified using new technology	HRS model is available as tool for optimal design before realisation	100 %	2010 at 200 kg/day: <1.5 M€	CAPEX Cost per daily dispensed H_2 around 10,000 €/kg is feasible
Hydrogen production CAPEX 2015 target: €3500 per Nm3/hr	Modular unit system, low membrane costs and Pt catalyst loadings	Components were validated, membranes and low catalyst loading evaluation complete	100 %	2010: 4,100€	Scalable unit validated at 5 kg/day, model shows large costs down potential with optimisation
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
Optimization of compression & storage systems with respect to cost, efficiency and capacity.	Balance component specifications in final system configuration	Components sized using model based on component test results and realistic costs	100 %		The optimum configuration is very dependent on the local situation considering supply, demand cycle and energy cost prices.
Compliancy	standardized compliance verification involving BAM evaluation	H_2 Logic developed a new refuelling control system that is adapted to the new SAE J2601 standard	100 %	SAE J2601	Full compliance with 200 kg/day capacity system
(c) Other project objectives					
Validation of new technology	Not applicable	Successful integration of critical components on-site at ITM	100 %	Novel achievement	First time PEM Electrolysers and EHC were validated together in the field at system level.
Modelled Hydrogen Price	Not applicable	<2015: 13. 7 €/kg	100 %	2010: 15-20 €/kg	>2015: 10.6 €/kg

POWER-UP

Field demonstration of large scale stationary power and CHP fuel cell systems

PANEL 3

Technology validation in stationary applications

ACRONYM	POWER-UP
CALL TOPIC	SP1-JTI-FCH.2012.3.7: Field demonstration of large scale stationary power and CHP fuel cell systems
START DATE	1/04/2013
END DATE	30/06/2017
PROJECT TOTAL COST	€13,6 million
FCH JU MAXIMUM CONTRIBUTION	€6,1 million
WEBSITE	http://project-power-up.eu/

PARTNERSHIP/CONSORTIUM LIST

AFC ENERGY PLC, AIR PRODUCTS PLC, G.B. INNOMECH LIMITED, ZENTRUM FÜR BRENNSTOFFZELLEN-TECHNIK GMBH, PAUL SCHERRER INSTITUT, FAST – FEDERAZIONE DELLE ASSOCIAZIONI SCIENTIFICHE E TECNICHE

MAIN OBJECTIVES OF THE PROJECT

A 500 kW_e 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

- Utilities and building completed.
- Alkaline fuel cell system installed and operational.
- Electricity fed and sold into the local grid.
- Automated stack assembly complete.
- Fuel cell production line upgraded.

FUTURE STEPS

- Operational data to confirm cost of ownership, system performance, and economic/environmental/social impacts.
- Automation of stack disassembly.
- Recycling of components.
- CE certification.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Upgrades to first generation fuel cell stack necessary and underway.
- Automation of fuel cell production has increased volumes without reducing quality.
- Scaled-up system design will be basis of future commercial product.
- Commercial interest in system from beyond Europe.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
500 kW_e by June 2017	>5 MW by 2015	1st KORE system installed	80 %	200 kW_e achieved in January 2016	2nd KORE system to be installed pending further tests and upgrades of 2nd generation stack
€3,000/kW is the target cost (CapEx and OpEx), using demonstration systems	€3,000/kW assuming supported deployment from 2013+	The first system had a number of one-off high-cost items which will not be repeated	100 %	€5,000/kW	Target cost for the post-funding period will be significantly lower
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2012
58-59 %	Conversion efficiency of 58 % (elec)	electrical efficiency of the fuel cell system has increased significantly	100 %	45 %	On track to achieve by end of project
Lifetime / duration of 15,000 h	Lifetime / duration of 15,000 h	several days of operation achieved	0 %	XX hours to be achieved in 2016	XX hours to be achieved until end of project

PROSOFC

Production and reliability oriented SOFC cell and stack design

PANEL 4

Research activities for stationary applications

ACRONYM	PROSOFC
CALL TOPIC	SP1-JTI-FCH.2012.3.2: Improved cell and stack design and manufacturability for application specific requirements
START DATE	1/05/2013
END DATE	31/10/2017
PROJECT TOTAL COST	€7,3 million
FCH JU MAXIMUM CONTRIBUTION	€3 million
WEBSITE	http://prosofc-project.eu/

PARTNERSHIP/CONSORTIUM LIST

AVL LIST GMBH, HTceramix SA, DYNARDO AUSTRIA GMBH, DANMARKS TEKNISKE UNIVERSITET, FORSCHUNGSZENTRUM JULICH GMBH, Karlsruher Institut fuer Technologie, IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE, TOPSOE FUEL CELL A/S

MAIN OBJECTIVES OF THE PROJECT

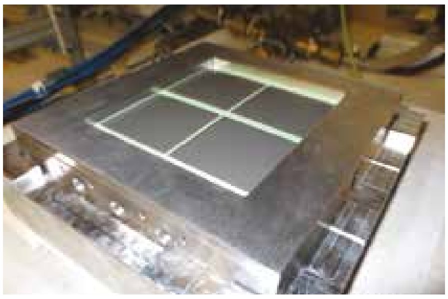
The PROSOFC project aims at improving the robustness, manufacturability, efficiency and cost of Topsoe Fuel Cell's state-of-the-art SOFC stacks so as to reach market entry requirements. The key issues are the mechanical robustness of solid oxide fuel cells (SOFCs), and the delicate interplay between 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

- First reliable multi-physics stack cell simulation models dedicated to subsequent statistical analysis successfully built.
- Mechanical characterization of SoA cells ongoing.
- Test of close-to-reality cell test equipment successfully carried out and validated by means of computational fluid dynamics (CFD).
- CFD simulation for full stack assembly established.
- 2nd workshop on mechanical investigations on SOFCs held.

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.



- Further test of close-to-reality segmented cell test equipment for methane operation.
- Implementation of failure modes which have been experimentally determined into the meta-model.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- SOFC exhibits complex multi-physics compared to other areas where COPRD has been applied; failure mode description is not trivial.
- Close-to-reality segmented cell test equipment well suitable for CFD model calibration.
- Discovery of a new phenomenon "accelerated creep".

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
Electrical efficiency (SOFC system) / 55 %+	ASR=600mOhm*cm^2	ASR=650mOhm*cm^2	75 %	Promising leads identified, but not yet realised
Lifetime/Durability (SOFC System)	Indirectly targeted by improving stack robustness			
Cost (SOFC system)	Indirectly targeted by cost reduction of stack			
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2012
Improved electrical efficiency	ASR=600mOhm*cm^2	ASR=650mOhm*cm2	75 %	Promising leads identified, but not yet realised
Better robustness, better lifetime, improved manufacturing methods	Identify major failure modes and link them to stack design and production using an statistical simulation approach Operation in real life environment >4,000 h	Major failure modes identified Statistical simulation model linked with stack model On-going stack tests	Failure mode: 90 % Statistical approach: 50 % 4,000 h test time reached: 90 %	Risk of discovering a new major failure modes based on on-going investigations cannot be avoided Reliability optimization: Development of stack model capable of addressing major failure modes as well as the application of the statistical approach progresses slower than anticipated Aggressive testing might provoke early failure
Cost reduction	Index 75 (M36)	Index 33	100 %	
Improved manufacturing methods / Stack scrap rate: 5 % by 2017	Yield rate: 95 %	Yield rate: 85 %	50 %	Reliability optimization needed to reach 95 % stack yield rate, but development of stack model capable of addressing major failure modes as well as the application of the statistical approach progresses slower than anticipated
Higher power density	Indirectly targeted by improved stack robustness			

PUMA MIND

Physical bottom up multiscale modelling for automotive PEMFC innovative performance and durability optimization

PANEL 2

Research activities for transport applications

ACRONYM	PUMA MIND
CALL TOPIC	SP1-JTI-FCH.2011.1.3: Improvement of PEMFC performance and durability through multi-scale modelling and numerical simulation
START DATE	17/12/2012
END DATE	16/12/2015
PROJECT TOTAL COST	€4 million
FCH JU MAXIMUM CONTRIBUTION	€2,2 million
WEBSITE	http://www.pumamind.eu/

PARTNERSHIP/CONSORTIUM LIST

COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, UNIVERSITA DEGLI STUDI DI SALERNO, AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS, HOCHSCHULE OFFENBURG, ECOLE NORMALE SUPERIEURE DE LYON, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, Simon Fraser University, VODERA LIMITED, IDIADA AUTOMOTIVE TECHNOLOGY SA, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

MAIN OBJECTIVES OF THE PROJECT

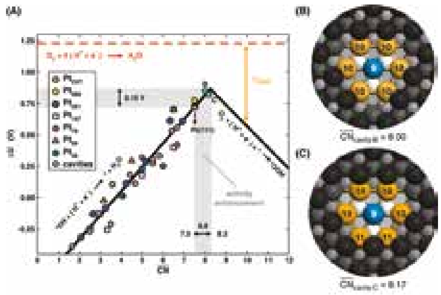
The objective of the project concerned the development of multi-scale modelling and numerical simulation tools for increasing the performance and durability of PEM fuel cells. These computer-based tools are to be validated through experimental work.

PROGRESS/RESULTS TO-DATE

- Activation Gibbs free energy barriers have been calculated in model environment conditions.
- A mesoscopic kinetic Monte-Carlo Code (KMC) devoted to study the catalyst reactivity has been developed.
- The Ostwald ripening degradation mechanism has been modelled and coupled with the performance model.
- The control-oriented ordinary differential equation (ODE) model is ready and performance indicators for online diagnostic have been derived from the model.
- Small-angle X-ray scattering (SAXS) experiments have been carried out. Trends for the water repartition have been transferred to the macromodels.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- A proof of concept has been reached by coupling various modelling scales in the field of multi-scale simulation for fuel cells.
- Mitigation strategies at the system level rely on design observers to estimate the key parameters to be considered for the control of the system.



- Atomistic approaches at the nanoscale are key to understand the underlying mechanisms.
- Based on the atomistic calculations effective parameters for the higher scales can be derived.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:		MAIP 2008-2013
Development of modeling tools for PEMFC performance and durability	Multi-scale modeling and simulation tools for increasing the performance and durability of PEMFC.	DFT calculation of adsorption energies on a Pt201 nanoparticule (Nano scale).
Development of modeling tools for PEMFC performance and durability	Multi-scale modeling and simulation tools for increasing the performance and durability of PEMFC.	Kinetic Monte Carlo of the adsorbed species in the electrochemical double layer.
Development of modeling tools for PEMFC performance and durability	Multi-scale modeling and simulation tools for increasing the performance and durability of PEMFC.	Development of a mechanistic catalyst degradation model (Ostwald Ripening).
Development of modeling tools for PEMFC performance and durability	Multi-scale modeling and simulation tools for increasing the performance and durability of PEMFC.	The reduced catalyst degradation model has been coupled with a performance model.
Development of modeling tools for PEMFC performance and durability	Multi-scale modeling and simulation tools for increasing the performance and durability of PEMFC.	Indicators have been derived from a control-oriented model for on-board diagnostic tools.
Development of modeling tools for PEMFC performance and durability	Multi-scale modeling and simulation tools for increasing the performance and durability of PEMFC.	Water repartition in the PEMFC has been investigated by Small Angle Neutrons Scattering.
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:		AIP 2011

PURE

Development of auxiliary power unit for recreational yachts

PANEL 1

Technology validation in transport applications

ACRONYM	PURE
CALL TOPIC	SP1-JTI-FCH.2011.4.4: Research, development and demonstration of new portable Fuel Cell systems
START DATE	1/01/2013
END DATE	30/06/2016
PROJECT TOTAL COST	€2,8 million
FCH JU MAXIMUM CONTRIBUTION	€2,8 million
WEBSITE	http://pure-project.eu/

PARTNERSHIP/CONSORTIUM LIST

HyGear Fuel Cell Systems B.V., DANMARKS TEKNISKE UNIVERSITET, CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS, JRC -JOINT RESEARCH CENTRE – EUROPEAN COMMISSION, SCHEEPSWERF DAMEN GORINCHEM BV

MAIN OBJECTIVES OF THE PROJECT

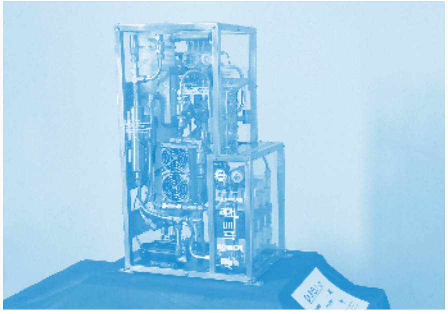
The objectives of the PURE project are to design, build and test an APU system for maritime applications. The system is fed by LPG and produces electricity of maximal 500 W using high temperature PEM stack Fuel cell technology. The objectives include: on board LPG fuel processor, Electrical power production of 50-500W. System weight target: 35kg/kW, System size target: 50 l/kW, System cost; €5,000/kW.

PROGRESS/RESULTS TO-DATE

- 2 system prototypes build and in testing campaign.
- Sulphur tolerant autothermal reformer (ATR): stable performance at 33 ppm S in LPG.
- Successful testing of 3D metal printed heat exchangers.
- Precious metal reduction of the MEA of 28 %.
- Successful preparation of binderless electrodes.

FUTURE STEPS

- Finalize testing of the system in environmental chamber.
- Finalize PURE project.



CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Significant improvement in size and weight of the system vs. State of the art.
- Cost reduced MEA's successfully stack and system.
- MEA's capable of running on ATR reformate (50 % H_2) need development.
- 3D metal printing of heat exchangers is successful but has opportunity for further improvements.
- Air cooled stack required to meet size specifications.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Development of miniaturized BoP for specific devices	Develop system targeting a total weight of 50l/kW and 25kg/kW	prototype has been built and results in 100kg/kW and 160 l/kW which is an improvement of 50 % vs SoA	50 %	160kg/KW and 380 l/kW (www.truma.com)	Targets not reached in prototype. Plan for reaching objectives for commercial units are identified
12,000-13,000 portable & micro FC on the EU market in 2015	2 prototypes with a cost outlook for the future systems	2 prototypes in testing campaign	100 %	No widespread integration of FC in maritime sector (DAM)	System design has outlook of €2400
Assessment of fuelling supply options	LPG based system	System proven to run on LPG	100 %	LPG available in maritime, recreational sector	Downscaling of the technology successful
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
Stack power max. 50-500 We net	stack power of 500 W	Stacks built and tested	100 %	500 W reformate stacks available	Reduction in precious metal of 28 % achieved with good performance.
Fuel processing on board	LPG Fuel processor module	System build and tested	100 %	No widespread integration of FC in maritime sector (DAM)	
(c) Other project objectives					
Sulphur tolerant ATR catalyst	N/A	catalyst has stable performance at 33 % S. Monoliths coated and built in prototype	100 %	This CERTH/ APTL catalyst is SoA in 2016: Stable performance at 33ppm S in LPG	
3D printed heat exchangers	N/A	hardware printed and integrated in prototype	100 %	first time this technology was used for this application	3D metal printing needs further investigation in printer settings. More development in size reduction of Heat exchangers possible

REFORCELL

Advanced multi-fuel reformer for fuel cell CHP systems

PANEL 4

Research activities for stationary applications

ACRONYM	REFORCELL
CALL TOPIC	SP1-JTI-FCH.2010.3.3: Component improvement for stationary power applications
START DATE	1/02/2012
END DATE	31/12/2015
PROJECT TOTAL COST	€5,4 million
FCH JU MAXIMUM CONTRIBUTION	€2,8 million
WEBSITE	http://www.reforcell.eu/

PARTNERSHIP/CONSORTIUM LIST

FUNDACION TECNALIA RESEARCH & INNOVATION, TECHNISCHE UNIVERSITEIT EINDHOVEN, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, POLITECNICO DI MILANO, STIFTELSEN SINTEF, ICI CALDAIE SPA, HyGear B.V., SOPRANO INDUSTRY, HYBRID CATALYSIS BV, Quantis Sàrl, JRC -JOINT RESEARCH CENTRE-EUROPEAN COMMISSION

MAIN OBJECTIVES OF THE PROJECT

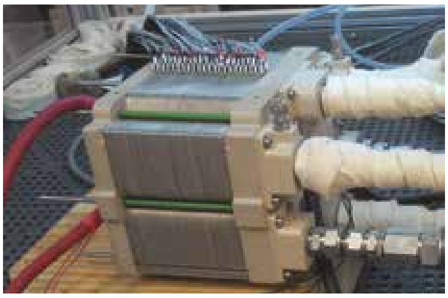
ReforCELL aims at developing a high efficiency PEM fuel cell micro Combined Heat and Power system (net energy efficiency >42 % and overall efficiency >90 %) based on a novel, more efficient and cheaper pure hydrogen production unit (5 Nm3/h), together with optimized design of the subcomponent for the Balance of Plant (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

- Fluidized bed membrane reactor (FBMR) concept validated at lab-scale (TRL 4) for Steam Methane Reforming (SMR) and Autothermal Reforming.
- Pilot reactor prototype including all BoP components assembled and tested.
- Models for the FBMR and complete Fuel Processor developed.
- Fuel cell stack prototype manufactured and validated.
- Design and selection of the components for the m-CHP system. Size scale-up, market, cost analysis and technological feasibility for sizes up to 50 kW_e.
- Life-Cicle Analysis and safety analysis of the novel m-CHP.

FUTURE STEPS

- N/A. Project has finished end 2015.



CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Novel catalyst, membranes and membrane reactors for autothermal reforming (ATR)/SMR has been developed and validated at lab-scale (TRL 4).
- Further developments are needed on the membranes to ensure the long-term durability over 550 -600 °C.
- CMR PEM m-CHP systems could improve the efficiency while reducing the cost due to the integration of the reforming and purification in one single unit.
- The new CMR PEM m-CHP system should be tested to achieved TRL6 as a first step before any testing in operational environment.
- Large scale production and/or intermediated size of the m-CHP system is needed to achieve the target of €5,000 1 kW_e + household heat.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Overall efficiency CHP units	>80 %	>90 %	0 %, project finished	93 Panosonic Household fuel cell	μ-CHP system not tested (partner in charge liquidated). 90 % feasible with appropriate heat exchanger sizing & insulation
Cost/system (NG-based μ-CHP, 1 kW_e + household heat).	Cost €10k/system (2015), €5k/system (2020)	€5,000 (1 kW_e + house heat)	100 %	This project is setting the actual state-of-art	Cost could be achieved for mass production or slightly higher m-CHP system sizes
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2010
Viable mass production	Mass prod. Technol. are considered	Mass production technologies are considered in the development	100 %		
Recyclability	LCA and safety study	LCA and safety study	100 %		LCA performed
(c) Other project objectives					
Novel catalyst synthesis	Not applicable	Catalyst developed, active @ lower temp. than foreseen (<600 °C).	100 %	State of the art catalyst	
Development of H_2 selective membranes	Not applicable	Metallic-supported ceramic membranes working at <550 °C	100 % (<550 °C)	State-of art membranes	Further developments needed for improved mech. properties + long term durability over 550-600 °C
Membrane Scale-up, processing issues	Not applicable	23 cm ceramic-supported membranes developed.	100 %	State-of art membranes	Further developments are needed develop longer membranes (i.e. >40 cm)
Membrane reactor	Not applicable	FBMR concept validated at lab scale (TRL 4) for SMR & ATR	100 %	State of the art	New CMR reactor to be tested for TRL6 as 1st step before testing in operational environment
Micro-channel membrane module	Not applicable	Concept validated @ lab scale (TRL4) for SMR. Tests w/integrated catalysts	100 %	State of the art	Further developments needed for up-scaled modules & better temp. stability (curr. ~500 °C)

SAPPHIRE

System automation of PEMFCs with prognostics and health management for improved reliability and economy

PANEL 4

Research activities for stationary applications

ACRONYM	SAPPHIRE
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 DATE	1/05/2013
END DATE	30/04/2016
PROJECT TOTAL COST	€3,2 million
FCH JU MAXIMUM CONTRIBUTION	€1,7 million
WEBSITE	https://sapphire-project.eifer.kit.edu/index.php/about

PARTNERSHIP/CONSORTIUM LIST

STIFTELSEN SINTEF, EIFER EUROPAISCHES INSTITUT FUR ENERGIEFORSCHUNG EDF-KIT EWIV, ECOLE NATIONALE SUPERIEURE DE MECANIQUE ET DES MICROTECHNIQUES, University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, ZENTRUM FUER SONNENENERGIE- UND WASSERSTOFF-FORSCHUNG, BADEN-WUERTEMBERG, DANTHERM POWER A.S, Ludwig-Boelkow-Systemtechnik GmbH

MAIN OBJECTIVES OF THE PROJECT

The Sapphire project aimed to develop a new type of controller for µCHP generators providing power and hot water for domestic use and run on natural gas. With fuel cells producing power, energy from natural gas is converted into electricity, more valuable than natural gas on an energy basis.

PROGRESS/RESULTS TO-DATE

- Demonstrated two systems for 6,000 h with minimal or no degradation.
- Achieved rejuvenation rates of up to 4 µV/h.
- Identified prognostic variables in equivalent-circuit model.
- Developed model-based and data-driven prognostics.
- Controllers to counteract dry-out, flooding, CO poisoning and hydrogen starvation.

FUTURE STEPS

- Roll-out of new controllers in new generation of µCHP units.
- Licensing of patents for control system.
- Follow-up project on automotive systems (Giantleap).
- Further research on stack rejuvenation.
- Improvement of stack designs for reduced degradation.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- A lot of voltage degradation is reversible by catalyst regeneration.
- Need more research on rejuvenation mechanisms, including side effects.
- Targets set by MAIP and AIP were attained.
- Electrochemical Impdenace Spectroscopy (EIS) can identify reliable prognostic variables.
- Air bleed in µCHP systems can be significantly reduced.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Stack lifetime	3,0000 hours	>5,0000 hours	100 %	8,0000 hours (Dodds et al.: Hydrogen and fuel cell technologies for heating: A review, Int. J. Hydr. En., 40 (2015), 2065-2083)	Degradation halted and even reversed for over 6,000 h in demonstration.
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2012
Stack lifetime	2,0000 hours	>5,0000 hours	100 %	8,0000 hours (Dodds et al.: Hydrogen and fuel cell technologies for heating: A review, Int. J. Hydr. En., 40 (2015), 2065-2083)	Degradation halted and even reversed for over 6,000 h in demonstration.
Additional cost of control system	€100/kW	€75/kW	100 %	N/A	No comparable values in literature

SCORED 2:0

Steel coatings for reducing degradation in SOFC

PANEL 4

Research activities for stationary applications

ACRONYM	SCORED 2:0
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 DATE	1/07/2013
END DATE	30/06/2017
PROJECT TOTAL COST	€3,7 million
FCH JU MAXIMUM CONTRIBUTION	€2,1 million
WEBSITE	http://www.birmingham.ac.uk/research/activity/scored/index.aspx

PARTNERSHIP/CONSORTIUM LIST

THE UNIVERSITY OF BIRMINGHAM, Teknologian tutkimuskeskus VTT Oy, ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE, AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE, Teer Coatings Limited, Turbocoating s.p.a., SOLIDPOWER SPA

MAIN OBJECTIVES OF THE PROJECT

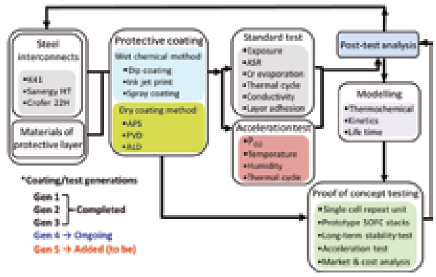
The SCoReD 2:0 will provide coated steel interconnects with improved properties with regard to oxide scale growth, chromium eva- poration, and contact resistance by optimising combinations of different steel qualities, including low-cost options, protective layer materials, and various coating methods. The main objective is to demonstrate stack lifetime of ca. 10,000 hours with coated interconnects. Influence of coating method, practicality, and cost of different coating techniques will be analysed to bridge the gap to industrialisation.

PROGRESS/RESULTS TO-DATE

- Sample choice and preparation, Test matrix established.
- First to fourth generation coatings tested.
- Systematic testing, analysis, and post-mortem analysis ongoing.
- Stack demonstration testing (proof-of-concept) ongoing.
- Fifth generation of coating in preparation.

FUTURE STEPS

- Continuation of stack testing and systematic analysis.
- Establishment of lifetime prediction model.
- Accelerated testing.
- Validation of lifetime prediction model with data obtained with accelerating tests.



CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Area Specofoc Resistance (ASR) values that are similar or lower than SoA were achieved.
- New types of surface treatment with protective coatings were evaluated – this might constitute a new approach at corrosion protection.
- New protective layer coating material with high electrical conductivity and sinterability is being evaluated.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
SOFC system life time (h)	30,000 (2020)	>3,000	100 %	>30,000	>10,000 will be proven within project
System cost (€/kW)	<2,000 (2020)	N/A	N/A	>6500 [1]	Interconnects are only one cost element of many, though, therefore no further statements can be made on stack cost
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
Manufacturing processes and quality control techniques for high performance and cost effective components	N/A	Six different coating methods applied including cost-effective and/or high quality techniques	100 %	N/A	Six different coating methods have been applied to optimise best combination(s) of interconnect steels and protective layer materials
Validation of lifetime, durability/ robustness, corrosion rate in application specific environments	N/A	Accelerated tests under development	100 %	N/A	Acceleration testing methods need to evaluate component lifetime within the project's nominal termination date

SECOND ACT

Simulation, statistics and experiments coupled to develop optimized and durable µCHP systems using accelerated tests.

PANEL 4
Research activities for stationary applications

ACRONYM	SECOND ACT
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 DATE	1/05/2014
END DATE	30/04/2017
PROJECT TOTAL COST	€4,6 million
FCH JU MAXIMUM CONTRIBUTION	€2,5 million
WEBSITE	http://second-act.eu/

PARTNERSHIP/CONSORTIUM LIST

COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, IRD FUEL CELLS A/S (INDUSTRIAL RESEARCH & DEVELOPMENT A/S), NEDSTACK FUEL CELL TECHNOLOGY BV, ICI CALDAIE SPA, POLITECNICO DI MILANO, DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, STIFTELSEN SINTEF, TECHNISCHE UNIVERSITAET GRAZ

MAIN OBJECTIVES OF THE PROJECT

To improve understanding of stack degradation and propose durability improvements for µCHP systems using H_2 or Reformate PEMFC or DMFC.
Analysing systems lifetime data to identify main causes for failure; Investigating degradation in cells and stacks; Developing and validating accelerated stress test (AST) and specific harsh tests; Developing in- and ex-situ analyses for identification and local resolution of mechanisms; Developing statistical approach and models, including reversible degradation and heterogeneities; Demonstrating improvements on tolerance to applications' relevant modes with modified components.

PROGRESS/RESULTS TO-DATE

- Manufacturing and delivery among partners of reference MEAs (from 25 to 220 cm²) for single cells and stack (8 to 75 cells).
- Ageing tests conducted in nominal or accelerated conditions on test stations or systems. >1,000 hrs or >6,000 hrs for stacks tested on the power plant.
- Local in-situ data (segmented cells in cells or stacks) and post ageing ex-situ analyses. Evolution of heterogeneities and ageing of MEA components.
- Development of degradation models about reversible mechanisms (PtOx formation, CO poisoning). Validation versus specific experiment or diagnostics.
- Identification of ideas for possible improvement at components level (new A or C catalysts, heterogeneous electrodes, modified gas diffusion layers – GDL).

FUTURE STEPS

- Delivery of new MEAs with modified catalysts or GDL. Definition and manufacturing of heterogeneous electrodes regarding local degradation.
- Implementation of new components and validation in cells or stacks following selected tests for H_2 or Reformate PEMFC or DMFC.
- Further implementation in cell models, consolidation and validation of degradation models describing reversible mechanisms and heterogeneities.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Clarification of reversible mechanisms. Simulation of PtOx formation/reduction or of CO poisoning, from inlet to outlet, depending on local conditions.
- Validation for DMFC and PEMFC of operation strategies against reversible losses (proposal of refresh procedures including stops or air starvation).
- Identification of differences in local degradation of catalysts due to heterogeneous operation (basis for design of new electrodes).
- Plan of the components modifications for the 3 types of FC and selection of the validation tests to complete the iterative process of improvement.
- Final demonstration of durability improvement at stack level (evidence of less performance losses during selected AST) with the last improved MEA.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Understanding of cell/stack degradation for H2 or Reformate PEMFC and DMFC	Degradation and lifetime fundamentals and typical operation environments	Experimental and modelling studies	90%	Mainly non reversible mechanisms already described in literature	Identification/mitigation of reversible degradation of PtOx formation. Identification/modelling of CO poisoning
>20,000 h for H_2 case thanks to core components modifications	Proposal of new/improved materials, aim of 40,000 h	Different catalysts proposed. Non homogeneous design identfied	80%	NA	Proposal of more CO tolerant catalyst and stable ORR catalyst layers.
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
Collection, production and statistical analysis of ageing data	Identify/quantify degradation and long-term failure mechanisms	Data available from ageing tests on DMFC and PEMFCs	90%	Mainly non reversible mechanisms already described in littérature	Many representative or AST tests (>1000 hours) on DMFC and PEMFC cells or stacks. Long term tests (>6000 hrs) on H2 full stack
Integration of improved core components for demonstrating lifetime improvement	Identify lifetime improvements, and verify these in existing cell and stack design	Tests of different anode or cathode catalysts on-going	80%	NA	Proposal of more CO tolerant catalyst and qualification of more stable ORR catalyst layers
Quantification by iterative loops. Verification of losses by AST	Quantification of mechanisms and verification of improvements	Definition of specifc ageing tests or AST.	100%	Generic AST already available for materials like cathode catalyst	Load cycles, start-up/shut-down, test of contaminants, potential cycles applied for quantification of degradation. Test of mitigation strategies against PtOx reversible mechanism

SElySOs

Development of new electrode materials and understanding of degradation mechanisms on Solid Oxide High Temperature Electrolysis Cells.

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	SElySOs
CALL TOPIC	FCH-02.1-2014: Research in electrolysis for cost effective hydrogen production
START DATE	2/11/2015
END DATE	1/11/2019
PROJECT TOTAL COST	€2,9 million
FCH JU MAXIMUM CONTRIBUTION	€2,9 million
WEBSITE	http://selysos.iceht.forth.gr/

PARTNERSHIP/CONSORTIUM LIST

FOUNDATION FOR RESEARCH AND TECHNOLOGY HELLAS, ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS, FORSCHUNGSZENTRUM JULICH GMBH, VYSOKA SKOLA CHEMICKO-TECHNOLOGICKA V PRAZE, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS, Prototech AS, PYROGENESIS SA

MAIN OBJECTIVES OF THE PROJECT

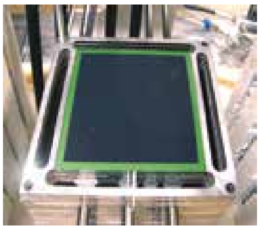
To improve/develop new, more efficient electrodes and understand the reaction mechanisms & processes that cause degradation on both SOEC electrodes combining experiments/theoretical modelling. To identify the design parameters to guide the development of new SOECs less prone to degradation with better performance and stability.

PROGRESS/RESULTS TO-DATE

- Modified SoA Ni-based and novel perovskite-type materials are under development/investigation as new electrodes for H_2O electrolysis.
- Advanced physicochemical characterization of the electrodes is in progress.
- The definition of the mathematical model for the H_2O electrolysis electrode is in progress.

FUTURE STEPS

- Fabrication of SOEC comprising the new H_2O electrode materials by applying SoA and novel techniques.
- Performance evaluation of single SOECs comprising SoA O2 electrodes and modified Ni-based H_2O electrodes.
- Performance evaluation of single SOECs comprising SoA O2 electrodes and novel perovskite-type H_2O electrodes.



- Investigation of the degradation phenomena/reaction mechanisms at the O2 electrode.
- Manufacture and testing of a first short SOE stack, under H_2O electrolysis conditions.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Development of new electrodes with better performance & lifetime.
- Development of a mathematical model accounting for all reactions taking place in a SOEC.
- Long-term operation of SOECs with the best combination of electrodes for at least 3000 h.
- Manufacture of stacks, which will operate for at least 2000 h under standardized conditions.
- Produced cells&stacks as a competitive&commercially viable advantage.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET (%)	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2014-2020
Long term system electrical eff >90 % (HHV)	72 % (HHV) in 2023	Data are not yet available	Data not yet available	74 % (HHV) for SoA H_2O electrolysis tech. Eff. could reach 101-108 % (HHV). FCH JU Report "Development of Water Electrolysis in the European Union"	Results not available yet
Improvement on the eff. degrdation rate	< 1 %/y in 2023	Data are not yet available	Data are not yet available	2 % - 5 %/y [1] MAWP, [2] J Power Sources 269 (2014) pp. 927-936, [3] FCH JU Report "Development of Water Electrolysis in the European Union"	Results not available yet
Increase of TRL	TRL = 5 in 2020	Data are not yet available	Data not yet available	TRL = 3	Results not available yet
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2014
New materials and component design less prone to degradation	Not applicable	Data are not yet available	Data are not yet available	Not applicable	Results not available yet
Understanding of degradation mechanisms	Not applicable	Data are not yet available	Data are not yet available	Not applicable	Results not available yet
(c) Other project objectives					
Reduction of electricity consumption by 10 %	Not applicable	Data are not yet available	Data are not yet available	53 kWh/kg H_2 (HHV) conventional electrolysis.[1] FCH JU Report "Develop. of Water Electrolysis in the EU", [2] Int. Energy Agency 2007 "H_2 Prod. & Distrib."	By 2025 or latest 2030 Results not available yet
Development of improved SOEC	Not applicable	Not applicable	Not applicable	Not applicable	Results not available yet

SMARTCAT

Systematic, material-oriented approach using rational design to develop break-through catalysts for commercial automotive PEMFC stacks

PANEL 2
Research activities for transport applications

ACRONYM	SMARTCAT
CALL TOPIC	SP1-JTI-FCH.2012.1.5: New catalyst structures and concepts for automotive PEMFCs
START DATE	1/06/2013
END DATE	31/05/2017
PROJECT TOTAL COST	€4,7 million
FCH JU MAXIMUM CONTRIBUTION	€2,5 million
WEBSITE	http://smartcat.cnrs.fr/

PARTNERSHIP/CONSORTIUM LIST

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, STIFTELSEN SINTEF, DANMARKS TEKNISKE UNIVERSITET, COMMISSARIAT A L ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, MXPOLYMERS BV, BASIC MEMBRANES BV, L'AIR LIQUIDE S.A.

MAIN OBJECTIVES OF THE PROJECT

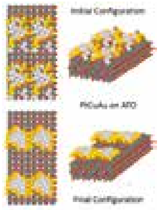
- New and innovative electrodes using tri-metallic low Pt-content (0.01 mg-2, 0.05g/kW) based catalyst nanoparticles and nano-structured layers (CL) combined with new and corrosion resistant metal-doped oxide-based materials (CL-conductivity in the range from 1 to 10 S/cm).
- Upscaling HT membranes proton 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 cm², 5,000 h durability).

PROGRESS/RESULTS TO-DATE

- 0.1mgPtcm-2 ternary catalysts AuPt3Ni, Cu have mass activity >Pt(60 A/gPt): >200 A/gPt @0.9V.
- Other ternary catalysts have mass activity >100 A/gPt: Pt50Au33Ni17 >Pt70Au15Pd15 >Pt50Au33Co17 @0.9V.
- 160 cm-2 large area MEA with sputtered core-shell Au@Pt3Ni 0.1 and 0.01 mgPtcm-2 cathode assembled.
- Density functional theory (DFT) simulations predict Au-Cu alloy and surface Pt structure on anodic titanium oxide substrate.
- Homogenous distribution of catalyst particles on support confirmed by transmission electron microscope analysis.

FUTURE STEPS

- Mass activity of sputtered 0.01 mgPtcm-2 ternary Au@Pt3Ni catalyst >100 A/gPt.
- 220 cm-2 MEA with AuPt3Ni ternary catalyst coated cathode.
- 5,000 h durability test with AuPt3Ni ternary catalyst cathode.
- Ministack (12 cells) with ternary catalyst AuPt3Ni cathode operation.



CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Performances of selected ternary catalyst are better than pure Pt and binary Pt-based catalysts. Pt3NiAu, Au@Pt3Ni provide the highest activities.
- Large area single cell and mini stack will be tested and performances increased at 120 °C.
- Large area HT membrane will be available with high proton conductivity (150 – 350 mScm-1 @150 °C).

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
25 cm² Single Cell performance of 1Wcm-2	25 cm² Single Cell performance of 1Wcm-2	0.7 Wcm-2	70 %	1Wcm-2	Large single cell (160 cm²) selection with new catalysts is scheduled for July 2016
100 cm² Single Cell performance of 0.9 Wcm-2 at EoL	160 cm-2 Single Cell performance of 0.9 Wcm-2 at EoL	Ongoing	Ongoing		
220 cm² short stack >2kWL-1	220 cm² short stack >2kWL-1	Ongoing	0 %	2kWL-1	Scheduled for November 2016
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
Exchange current density j0 >10-3 mA cm-2 with ternary catalyst. Reference Pt alone is 2.5 10-4	None	10-3 for Pt3NiAu, Pt3CoAu, Pt3CuAu at 0.1 mgPtcm-2	100 %	2.5 10-4	Pt3NiAu catalyst is chosen with jk maximum (12 mA cm-2), while Pt is 5.3

SOCTESQA

Solid oxide cell and stack testing, safety and quality assurance

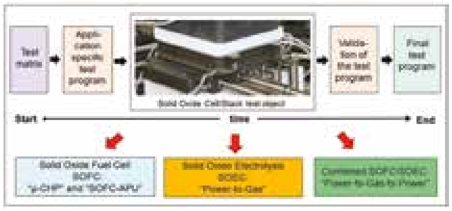
PANEL 6 Cross-cutting	
ACRONYM	SOCTESQA
CALL TOPIC	SP1-JTI-FCH.2013.5.4: Development of industry-wide uniform performance test schemes for SOFC/SOEC cells & stacks
START DATE	1/05/2014
END DATE	30/04/2017
PROJECT TOTAL COST	€3,2 million
FCH JU MAXIMUM CONTRIBUTION	€1,6 million
WEBSITE	http://www.soctesqa.eu/

PARTNERSHIP/CONSORTIUM LIST

DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, DANMARKS TEKNISKE UNIVERSITET, AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE, JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, EIFER EUROPAISCHES INSTITUT FUR ENERGIEFORSCHUNG EDF-KIT EWIV

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 addresses 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 application areas will be covered. Moreover, advanced characterization techniques, as electrochemical impedance spectroscopy, are integrated in the test programs. The test modules are experimentally validated on 5-cell solid oxide short stacks.



PROGRESS/RESULTS TO-DATE

- Ten important test modules addressing function, performance, durability and degradation were developed.
- Four applications specific test programmes for SOFC, SOEC and combined SOFC/SOEC were developed.
- Test modules and programmes were validated and optimised among the partners in two testing campaigns.
- Results of the different test modules show a very high reproducibility and consistency between the different test laboratories.
- SOCTESQA has established a close interaction with the main standards developing organisations, e.g. ISO, IEC and CEN/CENELEC.

FUTURE STEPS

- Optimization of test modules by a second validation campaign.
- Testing of stacks for SOFC APU application and validation of corresponding test modules.
- Finalization of the optimized test modules by round robin testing campaign.
- Sensitivity analysis of the operating conditions on the results.
- Synchronisation/Implementation of the project outcome to standards development organizations 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 stability of the inlet 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 in the test modules and programs.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Definition, development and experimental validation of testing procedures for SOFC/SOEC applications	Facilitating testing and certification procedures for fuel cell and hydrogen technologies	9 generic test modules and 4 application specific test programs have been developed and optimized	100 %	Only few documents exist, which address test procedures for SOFC or SOEC technology: "FCTESQA" project, IEC document (IEC 62282-7-2 TS Ed.1), "RELHY" project	Start up, j-V characteristics, Electrochemical impedance spectroscopy, Reactant gas composition and utilization, Temperature sensitivity, Operation under constant and varying current, Shut-down
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
Identification of the most relevant testing procedures and test protocols for Solid Oxide technology	Emphasis of cross-cutting issues: testing standards for SOFC and SOEC	All specifications, nomenclatures, test matrix and test modules and test programmes were defined	100 %	This project is setting the actual state-of the art	All corresponding Deliverables D2.1 (SOC Specifications), D2.2 (SOC Test Procedures), D3.1 (Test Matrix) and D3.2/D3.3 (Test programs for validation) have been uploaded to FCH-JU portal
Establishment of methodologies for the uniform collection, analysis and presentation of test data	Emphasis of cross-cutting issues: testing standards for SOFC and SOEC	A general master document (TM00) was developed, which is dedicated to general testing guidelines	100 %	This project is setting the actual state-of the art	TM00 contains guidelines which describe methodologies, collection, formulary, analysis and presentation of test data
(c) Other project objectives					
The test procedures will be developed in close interaction with national and international standard development organizations (SDOs)	Not applicable	Establishment of close interaction with standards developing organisations	100 %	Not applicable	Liaison with the main bodies currently working on regulations for hydrogen and fuel cell technologies: – ISO Technical Committee 197 – IEC TC105 (Creation of a new working group WG13) – CEN/CENELEC

SOL2HY2

Solar to hydrogen hybrid cycles

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	SOL2HY2
CALL TOPIC	SP1-JTI-FCH.2012.2.5: Thermo-electrical-chemical processes with solar heat sources
START DATE	1/06/2013
END DATE	30/11/2016
PROJECT TOTAL COST	€3,7 million
FCH JU MAXIMUM CONTRIBUTION	€1,9 million
WEBSITE	sol2hy2.eucoord.com

PARTNERSHIP/CONSORTIUM LIST

ENGINSOFT SPA, AALTO-KORKEAKOULUSAATIO, DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE, Outotec (Finland) Oy, Erbicol SA, OY WOIKOSKI AB

MAIN OBJECTIVES OF THE PROJECT

1) Development of the key hybrid plant components (SO_2-depolarized electrolyzer (SDE), solar-powered sulphuric acid 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

- Multi-cell SDE stack was constructed and tested in the lab for hydrogen and sulphuric acid co-production.
- Acid decomposition chamber, acid evaporator and gas handling were made and run in field demo tests at solar tower.
- Hybrid solar plant flowsheets were analysed and made available for dynamic conditions.
- Multi-objective design and optimization software tool was produced for any suitabel locations.
- Several BoP solutions were developed for the virtual plant model for specific locations.

FUTURE STEPS

- Final procesisng of SDE test data in different conditions.
- Release of DEMO tests of efficient catalysts for sulphuric acid cracking.
- Release of multi-objective optimization software of the SOL2HY2 plant.
- Starting the exploitation plan activities.

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 able to ensure continuous operation for H_2 production, with high-temperature solar power only used for acid cracking.
- 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

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET (%)	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Cost of H_2 delivered at refuelling station <€5/kg (€0,15/kWh)	Not directly addressed	Potential for decreasing of the hybrid cycle H_2 costs by €3-4/kg EXW	100 %		
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2012
Catalysts with better activities +30 %	Electrocatalysts with 50 % better efficiency vs. Pt/Pd	Catalyst load were decreased by 100-300 times	100 %		
Redox materials with doubled conversion rate	Redox materials not used	N/A	100 %		
Development of key components with enhanced efficiency in relevant scale	>0,5 MW at daily solar input 20 MWh	Plants design is made according to the program objectives	100 %		
(c) Other project objectives					
Electrolyser operational conditions	Not applicable	25 °C, 1 bar, 15-20 % acid, catalyst load <1 µg/cm²	100 %	70-105 °C, 1-50 bar, 50-70 % acid, catalyst load ~100-500 µg/cm²	Target reached in 2015

SOPHIA

Solar integrated pressurized high temperature electrolysis

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	SOPHIA
CALL TOPIC	SP1-JTI-FCH.2013.2.4: New generation of high temperature electrolysers
START DATE	1/04/2014
END DATE	31/03/2017
PROJECT TOTAL COST	€6 million
FCH JU MAXIMUM CONTRIBUTION	€3,3 million
WEBSITE	http://www.sophia-project.eu/

PARTNERSHIP/CONSORTIUM LIST

HyGear B.V., HTceramix SA, COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE, Teknologian tutkimuskeskus VTT Oy, ENGIE, SOLIDPOWER SPA

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

- Market analysis and case studies done.
- Solar receiver build and tested.
- Models developed and improved cell microstructure proposed and made.
- Cell, Single Repeating Units (SRUs) and stack tests done in electrolysis and co-electrolysis mode at atmospheric and pressurized conditions.
- SOE system designed and being build.

FUTURE STEPS

- Large area cell and stack testing.
- Degradation studies, and optimisation of electrode microstructure.
- Validate segmented test set-up.
- SOE system testing at 15 bar.
- Full system testing.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Hydrogen production using a solar powered HTE-system can be ecomically viable.
- For systems producing hydro-carbons the availability of CO_2 is not limiting, but the solar power is.
- Extensive microstructural models of the electrodes have been made.
- Electrolysis and co-electrolysis shown at elevated pressures.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
Proof of pupose (pOp)of a HT SOE system at kW size under realistic conditions.	Appropriate H_2 supply chain	Performance curves of several SRUs and stacks obtained		
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2013-1
Development of cells with tailored electrode microstructure and compositions	Develop cells for high current loads, high durability and reliability, high temperature	Cell performances close to 1 A/cm² at the thermoneutral voltage in steam and co-electrolysis modes	100 %	
Optimise cell structures for low degradation rate	Demonstrate low degradation rate (<0,5 % per 1,000 h)	Several long term cell experiments have been done with variable degradation rates	100 %	
develop different case studies as potential strategies for the concept industrial development.	Develop concepts for pressurised electrolysis for more economical systems	Fuel production via co-electrolysis SOEC and syngas upgrading has been studied.	100 %	

STACKTEST

Development of PEM fuel cell stack reference test procedures for industry

PANEL 6

Cross-cutting

ACRONYM	STACKTEST
CALL TOPIC	SP1-JTI-FCH.2011.5.4: Development of EU-wide uniform performance test schemes for PEM fuel cell stacks
START DATE	1/09/2012
END DATE	31/08/2015
PROJECT TOTAL COST	€5,6 million
FCH JU MAXIMUM CONTRIBUTION	€2,9 million
WEBSITE	http://stacktest.zsw-bw.de

PARTNERSHIP/CONSORTIUM LIST

ZENTRUM FUER SONNENENERGIE- UND WASSERSTOFF-FORSCHUNG, BADEN-WUERTEMBERG, COMMISSARIAT A L'ENERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES, DANMARKS TEKNISKE UNIVERSITET, DEUTSCHES ZENTRUM FUER LUFT – UND RAUMFAHRT EV, INSTYTUT CHEMII PRZEMYSLOWEJ IM. PROF. IGNACEGO MOSCICKIEGO, AALBORG UNIVERSITET, EWE-Forschungszentrum für Energietechnologie e. V., FUNDACION CIDETEC, FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V, JRC –JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, SYMBIOFCELL SA

MAIN OBJECTIVES OF THE PROJECT

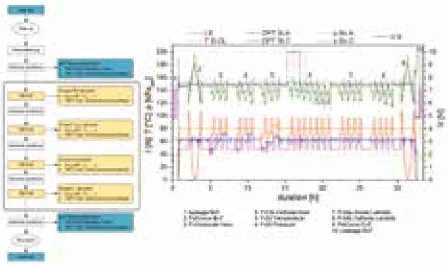
Propose and validate harmonized, and industrially relevant test procedures for PEM fuel cell stacks in form of generic test modules and application specific test programs.
Address functional / performance, endurance, and safety testing.
Interact with industry.

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 from the project web page.

FUTURE STEPS

- The project has ended in August 2015.
- A New Work Item Proposal on PEM-stack testing has been accepted in International Electrotechnical Commission Technical Committee-105.



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.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
Provide a methodology for PEM-stack performance, endurance, and safety / environmental tests	Provide a coherent framework to monitor progress	Generic test modules and application oriented test programs were published via the web-page	100 %	
Provide annually updated review of RCS relevant for PEM fuel cell stack testing	Maintain, consolidate and disseminate results of RCS and PNR activities	Corresponding reports were delivered. New work Item proposal in IEC-TC-105 accepted.	100 %	
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2011
Provide experimentally validated test procedures for performance, endurance and safety testing.	Development of harmonised testing protocols for PEM stacks.	Project is completed, test modules and test programs are available.	100 %	

STAGE-SOFC

Innovative SOFC system layout for stationary power and CHP applications

PANEL 3
Technology validation in stationary applications

ACRONYM	STAGE-SOFC
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 DATE	1/04/2014
END DATE	31/03/2017
PROJECT TOTAL COST	€3,9 million
FCH JU MAXIMUM CONTRIBUTION	€2,1 million
WEBSITE	http://www.stage-sofc-project.eu/

PARTNERSHIP/CONSORTIUM LIST

Teknologian tutkimuskeskus VTT Oy, SUNFIRE GMBH, ICI CALDAIE SPA, LAPPEENRANNAN TEKNILLINEN YLIOPISTO, ZACHODNIOPOMORSKI UNIWERSYTET TECHNOLOGICZNY W SZCZECINIE

MAIN OBJECTIVES OF THE PROJECT

The project aims to develop a 5 kWel 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

- The Proof-of-Concept system was designed based on extensive theoretical and experimental investigations.
- Optimized reforming units, heat exchangers, burners and power electronics were developed.
- Detailed market studies were done to define cost targets and operation strategies.
- Dissemination activities include participation in 22 exhibitions, participation in 12 conferences and publications of 15 research papers.
- Prototype 1 has been successfully started. System is in operation and works well. The experiences clearly verify the feasibility of the basic layout.

FUTURE STEPS

- Design of Prototype 2 will be finished in the beginning of July.
- Experimental work is still ongoing to finalize the design of the steam reformer.
- Prototype 2 will be operated 3,000 hours for final system validation.
- Optimization of the design, operation and manufacture of the system against market expectations.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Prototype 1 has been successfully started. System is in operation and works well. The experiences clearly verify the feasibility of the basic layout.
- System optimization ongoing: main targets will be simplification of layout and improvement of start-up process as well as dynamical operation.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
$\eta_{el,Sys}$ >45 % η_{Sys} >80 %	Efficiencies shall be >45 % for power only units and >80 % for CHP units	$\eta_{el,Sys}$ >45 % η_{Sys} >80 %	100 %	Stage-SOFC investigates an innovative system layout, where high electrical efficiencies can be achieved without water processing or anode off-gas recirculation. SoA cannot be directly compared	Extensive simulation has verified that the target will be met. Experimental verification has been done with first system prototype (PT). Development of an optimized Proof-of-Concept prototype ongoing
40,000 h stack lifetime	Lifetime requirement of 40,000 hours for cell and stack	>20,000 h achieved at stack and system level, investigations are ongoing	80 %	SoA are system results with more than 20,000 h lifetime. SUNFIRE stacks could achieve this in several µCHP systems of Vaillant	Stack development is a continuous process to achieve lifetime targets. However, long testing times are required and materials for cells and stacks are not finally frozen
40,000 h stack lifetime + Costs per Unit: €4,000/kW @ 100+ €2,000/kW @ 5	Improved performance, endurance, robustness, durability and cost	Work in progress, new materials tested, improvement of production	80 %	Cost targets not achieved yet with SOFC technology. Costs are currently in the range of €7,000-25,000/kW	Costs targets to be achieved by increase of power density, higher production volume and improved production technologies
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-1
5 kW complete prototype will be built and tested	Development of fully integrated advanced PoC systems	Design is ready. Prototype 1 has been successfully commissioned and operated	100 %	Power (>5 kW) and efficiency (>45 %el) targets have been achieved. This is a very encouraging result for this type or waterless system	Experiences from PT1 operation are currently used to design the final prototype
The PoC prototype is expected to be operated for at least 3,000 h	Successful duration of run times of several hundreds of hours	Tests with the first prototype have been finalized. Design of PoC ongoing	100 %		Since PT1 worked stable, it is expected that 3,000 h are reachable

SUAV

Microtubular solid oxide fuel cell power system developement and integration into a mini-UAV

PANEL 1

Technology validation in transport applications

ACRONYM	SUAV
CALL TOPIC	SP1-JTI-FCH.2010.4.5: Research and development on new portable and micro Fuel Cell solutions
START DATE	1/12/2011
END DATE	30/11/2015
PROJECT TOTAL COST	€3,7 million
FCH JU MAXIMUM CONTRIBUTION	€2,1 million
WEBSITE	www.suav-project.eu

PARTNERSHIP/CONSORTIUM LIST

HyGear Fuel Cell Systems B.V., ADELAN LTD, CATATOR AB, CONSIGLIO NAZIONALE DELLE RICERCHE, EADS DEUTSCHLAND GMBH, EADS UK Ltd., ERDLE ERICH KONRAD, THE UNIVERSITY OF BIRMINGHAM, ZACHODNIOPOMORSKI UNIWERSYTET TECHNOLOGICZNY W SZCZECINIE, SURVEY COPTER SAS

MAIN OBJECTIVES OF THE PROJECT

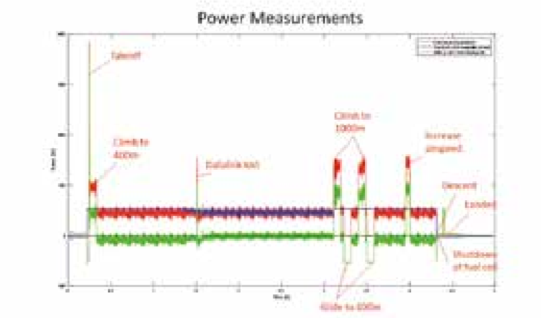
SUAV aims to design, optimise and build a 310W mSOFC stack, and to integrate it into a hybrid power system comprising the mSOFC stack and a battery.

PROGRESS/RESULTS TO-DATE

- A tubular mSOFC stack has been developed having a high power density better than 280 W/l.
- A low weight/low volume system has been designed; 3 kg and 3.3 l for a system providing more than 280 W at EoL.
- The power density of stack plus reformer subsystem is better than 110 W/kg.
- A hybrid system comprising an SOFC subsystem, a battery pack is developed capable of supplying power for a complete UAV flight.
- Various models have been developed. The models can be applied for the design of other hybrid systems.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- A low weight/low volume system has been designed.
- A hybrid system comprising an SOFC subsystem, a battery pack is developed.
- The developed technology can also be applied outside aerospace in other applications.



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:		MAIP 2008-2013
1 complete micro FC system with stack @250We (net) + backup stack as prototypes	12,000-13,000 portable and micro FC's	'Stack and system tested separately
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:		AIP 2010
System with 250 We net	Maximum power should be limited to 200We net	310 W is achieved for stack for a short time, is equivalent to a 280 W net system
Reformer catalyst development	Fuel Processing	Catalyst developed with sufficient efficiency to convert propane
2 250 We net stacks, with suitable fuel and air delivery manifolds	Stack	2 stacks made; 1 failed immediately, second produced of 310 W of power
Light weight – low volume balance of plant components	Balance of Plant	Light weight BoP designed. Heavier version build as this system will not be put in the UAV
FC-Battery Hybridization – control electronics – telemetry	Power electronics and controls integration	Hybridization and control done for complete system with commercial Fuel Cell subsystem.

SUSANA

Support to safety analysis of hydrogen and fuel cell technologies

PANEL 6
Cross-cutting

ACRONYM	SUSANA
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 DATE	1/09/2013
END DATE	31/08/2016
PROJECT TOTAL COST	€2,1 million
FCH JU MAXIMUM CONTRIBUTION	€1,1 million
WEBSITE	http://www.support-cfd.eu

PARTNERSHIP/CONSORTIUM LIST

Karlsruher Institut fuer Technologie, UNIVERSITY OF ULSTER, NATIONAL CENTER FOR SCIENTIFIC RESEARCH "DEMOKRITOS", JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION, HEALTH AND SAFETY EXECUTIVE, ELEMENT ENERGY LIMITED, AREVA STOCKAGE D'ÉNERGIE SAS

MAIN OBJECTIVES OF THE PROJECT

The project is built on the complementarities of expertise of leading European experts in the field of computational fluid dynamic (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 associated CFD modelling/simulations practice, through the development of the CFD Model Evaluation Protocol and specific databases.

PROGRESS/RESULTS TO-DATE

- Completion of SUSANA database and data sets (verification and validation problems).
- Development of best practice guidelines resulting from benchmarking exercises and expert workshop.
- Completion of a model evaluation protocol (MEP).
- Finalising of documentation on project results and database for publishing.
- Restructuring of project website to provide datasets and public deliverables as open source for the future.
- Incorporation of SUSANA database in major research activities and platforms those like H$_2$FC and HySafe.

FUTURE STEPS

- Final dissemination activities (publications on the final results and database in specific journals).
- Execution of two Webinars concerning the uses of SUSANA database and content.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- State of the art review on CFD protocols based on critical analysis and requirements to CFD models.
- Database based on multitude data sets on verification and validation problems, including reviewed publications and experimental data sets.
- Best practice guidelines resulting from benchmarking exercises.
- Model Evaluation Protocol.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Support to CFD applicable in FCH simulation	Database for CFD to support numerical simulation in FCH	Achieved	90 %		mainly achieved, data sets and/or reviewed publications for modelling and simulation regarding fuel cells generally not available
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2013-2
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	Achieved	100 %	State of the art review on international level. Development of protocols for safety analysis. Database of the suitable experiments incorporated into database	Achieved
Protocol containing procedures, recommendations and criteria	Critical analysis and requirements to physical and mathematical models and modelling procedures	Achieved	100 %	Protocols containing procedures, recommendations and criteria. Validation and Verification procedure. Best practice procedure ready to be discussed with international experts.	Achieved
(c) Other project objectives					
Simulation benchmarking and best practice guidelines	Not applicable	Achieved	100 %		Achieved
Model evaluation protocol (MEP)	Not applicable	Achieved	100 %	Model evaluation protocol in one of the first protocol which exists on that status	Achieved

SWARM

Demonstration of Small 4-Wheel fuel cell passenger vehicle Applications in Regional and Municipal transport

PANEL 1

Technology validation in transport applications

ACRONYM	SWARM
CALL TOPIC	SP1-JTI-FCH.2011.1.1: Large-scale demonstration of road vehicles and refuelling infrastructure IV
START DATE	1/10/2012
END DATE	31/12/2017
PROJECT TOTAL COST	€15,6 million
FCH JU MAXIMUM CONTRIBUTION	€6,8 million
WEBSITE	http://www.swarm-project.eu/

PARTNERSHIP/CONSORTIUM LIST

ELEMENT ENERGY LIMITED, RIVERSIMPLE LLP, H_2O E-MOBILE GMBH, GESPA GMBH, AIR LIQUIDE ADVANCED TECHNOLOGIES SA, THE UNIVERSITY OF BIRMINGHAM, COVENTRY UNIVERSITY ENTERPRISES LIMITED, BIRMINGHAM CITY COUNCIL, UNIVERSITE LIBRE DE BRUXELLES, UNIVERSITE DE LIEGE, JADE HOCHSCHULE WILHELMSHAVEN/OLDENBURG/ELSFLETH, EWE-Forschungszentrum für Energietechnologie e. V., UNIVERSITAET BREMEN, TUV SUD PRODUCT SERVICE GMBH, SERVICE PUBLIC DE WALLONIE, PLANET PLANUNGSGRUPPE ENERGIE UND TECHNIK GBR, DEUTSCHES FORSCHUNGSZENTRUM FUER KUENSTLICHE INTELLIGENZ GMBH, TUV SUD AG

MAIN OBJECTIVES OF THE PROJECT

The overarching objectives of the project are:

1. Deploy H_2 technologies in small low cost vehicle classes, demonstrating a complementary approach to H_2 vehicle drive trains – these vehicles are built in battery dominant hybrid mode. This is a novel approach, which optimises the cost, performance and energy efficiency of the vehicles.
2. Create new H_2 fuelling networks and seed three European regions for future commercial rollout.
3. Strong involvement of European research institutions and SMEs – by involving a range of SMEs and research partners in the development and deployment activities.

PROGRESS/RESULTS TO-DATE

- Two MicroCab Hydrogen Electric Vehicles (H_2EVs) are in operation in Coventry (UK) alongside a recommissioned HRS at Coventry University.
- The existing HRS at Birmingham University was recommissioned in early 2016, consolidating further the hydrogen refuelling network in the Midlands (UK).
- Another MicroCab H2EV has been transferred to ULB (BE) and is now in use on private test roads there for optimisation activities.
- Successful build of the Riversimple Mark2 Alpha prototype. The car is running and has been launched publicly in February 2016.
- The Air Liquide HRS has been commissioned in Belgium at the Toyota premises in Zaventem in April 2016. This is the 1st public HRS in Belgium.

FUTURE STEPS

- The MicroCab fleet will soon be completed by an additional 8 vehicles, including the newly developed HyLITE vehicles.
- The host city for the trial of 20 Riversimple cars in the UK has now been announced and the site planning for the refuelling is under preparation.
- Development and beginning of operation for the $H_2$0 e-mobile fleet.
- Commissioning of a Air Liquide HRS in Bremen.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- High interest from vehicles users and policy makers for alternative transport concepts.
- Local Authority support is key to success of siting activities for HRS planning.
- Key milestones will be achieved in the coming period with the vehicles and HRS demonstration activities starting in the three regions.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Vehicle Efficiency / energy consumption 1 kg/100 km	Vehicle Efficiency / energy consumption 1 kg/100 km	Observed	100 %	1 kg/100 km	Only 4 vehicles in operation so far from two suppliers
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
HRS Availability >95 %	HRS Availability >95 %	Achieved for Air Liquide Alternative Technologies HRS in Brussels	100 %	Availability >95 %	2 further new HRS will be commissioned
€10/kg for target hydrogen price dispensed at pump	€10/kg for target hydrogen price dispensed at pump	Achieved for Air Liquide Alternative Technologies HRS in Brussels	100 %	€10/kg for H_2 price dispensed at pump	2 further new HRS will be commissioned
HRS Efficiency of 50-70 %	HRS Efficiency of 50-70 %	HRS Efficiency of 50 %	100 %	HRS Efficiency of 50 %	2 further new HRS will be commissioned
>2,000 h lifetime initially, then 3,000 h	3,000 h lifetime	Under validation	100 %	6,000 h lifetime	Only 4 vehicles in operation so far from two suppliers
MTBF >1,000 km	MTBF >1,000 km	Under validation	100 %	MTBF >10,000 km	Only 4 vehicles in operation so far from two suppliers
Vehicle availability >95 %	Vehicle availability >95 %	Under validation	100 %	Availability >95 %	Only 4 vehicles in operation so far from two suppliers
Efficiency >40 % (NEDC)	Efficiency >40 % (NEDC)	Under validation	100 %	Efficiency >40 % (NEDC)	Only 4 vehicles in operation so far from two suppliers

T-CELL

Innovative SOFC architecture based on triode operation

PANEL 4

Research activities for stationary applications

ACRONYM	T-CELL
CALL TOPIC	SP1-JTI-FCH.2011.3.1: Next generation stack and cell design
START DATE	1/09/2012
END DATE	29/02/2016
PROJECT TOTAL COST	€3,4 million
FCH JU MAXIMUM CONTRIBUTION	€1,7 million
WEBSITE	www.tcellproject.eu

PARTNERSHIP/CONSORTIUM LIST

CENTRE FOR RESEARCH AND TECHNOLOGY HELLAS, FOUNDATION FOR RESEARCH AND TECHNOLOGY HELLAS, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE, AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS, MANTIS DEPOSITION LIMITED, Prototech AS, SOFCPOWER SPA

MAIN OBJECTIVES OF THE PROJECT

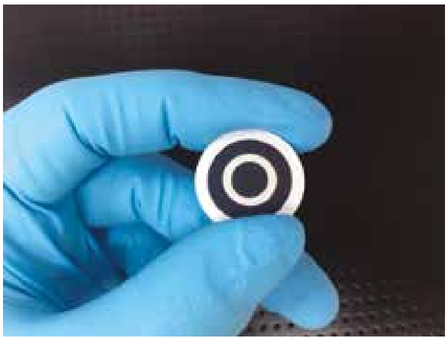
The project objective was the investigation of the synergetic effect of advanced Ni-based cermet anodes modified via doping with a 2nd or a 3rd metal in conjunction with triode operation, in order to control the rate of C deposition and S poisoning. A detailed mathematical model was developed to describe the triode mechanism thus enabling prediction of the behaviour of triode SOFCs as a function of cell design and operational parameters. Proof of the triode concept was provided through the development and performance evaluation of a prototype triode stack, consisting of 5 repeating units.

PROGRESS/RESULTS TO-DATE

- Preparation of complete triode cells utilizing standard and (Au, Mo nanoparticles) modified anodes using standard and magnetron sputtering methods.
- Complete physicochemical characterization of modified powder and electrodes.
- Assessment of the effect of triode operation on cell performance and carbon deposition rate.
- Development and verification of a simple model describing the dependence of fuel cell and auxiliary circuit potential.
- Design, construction and operation of a 5-cell triode stack.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- The synergy between Au-Mo-Ni regarding electrocatalytic stability under methane steam reforming has been proven (MSR).
- 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 au- xiliary electrode is crucial for triode performance.
- Proof of the triode stackability through the development and evaluation of a prototype triode 5-cell SOFC stack operating in MSR.



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:				MAIP 2008-2013
Electrical efficiency / >55 % (natural gas fueled in presence of ~30ppm sulphur)	Electrical efficiency (natural gas and biogas fuels) / 55 %	Finished	100 %	The tests in button cells revealed electrical efficiency exceeding 55 %; remarkable performance enhancement (~20 % increase in power output) has been realized by triode operation
Stack lifetime / 40,000 hrs	Durability/Reliability (stack lifetime) / 20,000 hrs	Finished	100 %	Triode operation results in 40-50 % lower carbon deposition rate
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:				AIP 2011
Development of cells with novel, triode architecture	New architectures, adaptation of cell and/or stack designs to specific applications	Finished	100 %	Delivery of triode cells and short stack with standard and (Au, Mo nanoparticles) modified anodes using standard and magnetron sputtering methods
Development of modified Ni-based materials with enhanced carbon and sulphur tolerance	New materials and/or strategies to improve tolerance to contaminants	Finished	100 %	Development of advanced, carbon and sulfur tolerant Au and Mo modified Ni-based cermet anodes
Development of modified Ni-based materials with enhanced carbon and sulphur tolerance	Improved tolerance to contaminants with respect to state of art FCs	Finished	100 %	Triode operation results in 40-50 % lower carbon deposition rate
Electrical efficiency / >55 %	Improved electrical efficiency over the state of the art / >50 %	Finished	100 %	The tests in button cells revealed electrical efficiency exceeding 55 %; remarkable performance enhancement (~20 % increase in power output) has been realized by triode operation

TriSOFC

TRISOFC

Durable solid oxide fuel cell tri-generation system for low carbon buildings

PANEL 3
Technology validation in stationary applications

ACRONYM	TRISOFC
CALL TOPIC	SP1-JTI-FCH.2011.3.4: Proof-of-concept fuel cell systems
START DATE	1/08/2012
END DATE	31/07/2015
PROJECT TOTAL COST	€2,7 million
FCH JU MAXIMUM CONTRIBUTION	€1,4 million
WEBSITE	www.trisofc.com

PARTNERSHIP/CONSORTIUM LIST

THE UNIVERSITY OF NOTTINGHAM, KUNGLIGA TEKNISKA HOEGSKOLAN, THE UNIVERSITY OF BIRMINGHAM, INSTITUTO DE ENGENHARIA MECANICA, GETTFUELCELLS INTERNATIONAL AB, Vestel Savunma Sanayi A.S., PRZEDSIEBIORSTWO INNOWACYJNO-WDROZENIOWE COMPLEX SP ZOO, SWEREA IVF AB, INEGI – INSTITUTO DE CIENCIA E INOVACAO EM ENGENHARIA MECANICA E ENGENHARIA INDUSTRIAL

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.

PROGRESS/RESULTS TO-DATE

- Desiccant unit simulation complete.
- 1100W/cm^2 achieved- 12W power output from 2 cell stack.
- Integration of 250We microtubular SOFC tri-generation system.
- Microtubular SOFC efficiency ~ 12 % Overall Trigeneration efficiency ~ 24 %.

FUTURE STEPS

- Develop and demonstrate long term performance of single component LT SOFC membranes.
- Develop and demonstrate long term performance of single component LT SOFC stacks.
- Develop prototype LT SOFC fuel cell.
- Demonstrate long term (>1 year) SOFC trigeneration system.
- Investigate low cost/high volume manufacture of single component SOFC membranes and stacks.

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.
- A single component low temperature SOFC cell and stack have been proved in lab condition.
- Demonstrated integration of 250We microtubular SOFC.
- Single component fuel cells working at low temperatures (500-600C) will enable cost reductions in BoP and improvement in performance.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Power range	200-1500 We	250 We	100 %	1500 We	The project has met the minimum power output, however the single component LT SOFC has demonstrated 1100W/cm^2 and 12W from 2 cells
Efficiency	35 % to 45 % (elec) 75 % to 85 % total	Testing of microtubular SOFC tri-generation 12 % elec – 48 % total.	80 %	45 % elec – 75 % overall	The electrical efficiency of the microSOFC was very low at ~ 12 %, but trigeneration more then doubled overall efficiency
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2008
Durability	30,000 h	100-300 h	80 %	30,000 h	a single component LT SOFC cell has operated at over 100h and the trigeneration system using a microSOFC has been operating for over 3 months (300h) with no degradation in performance
Costs	€2,000/kW	€2,500-4,000/kW	80 %	€1,750-2,100/kW	costs reflect manufacture of single/lab scale membranes and stacks. Mass manufacture and scales of production will reduce costs to target

UNIFHY

Unique gasifier for hydrogen production

PANEL 5

Hydrogen production, distribution and storage: research and validation

ACRONYM	UNIFHY
CALL TOPIC	SP1-JTI-FCH.2011.2.3: Biomass-to-hydrogen (BTH) thermal conversion process
START DATE	1/09/2012
END DATE	31/03/2016
PROJECT TOTAL COST	€3,4 million
FCH JU MAXIMUM CONTRIBUTION	€2,2 million
WEBSITE	http://www.unifhy.eu/

PARTNERSHIP/CONSORTIUM LIST

UNIVERSITA DEGLI STUDI GUGLIELMO MARCONI – TELEMATICA, UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA, UNIVERSITA DEGLI STUDI DELL'AQUILA, HyGear B.V., AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE,L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE, UNIVERSITE DE STRASBOURG, ENGINEERING, PROCUREMENT & CONSTRUCTION UG, PALL FILTERSYSTEMS GMBH, AIR LIQUIDE ADVANCED BUSINESS

MAIN OBJECTIVES OF THE PROJECT

To develop a cost-competitive, efficient and sustainable thermochemical biomass-to-H_2 (BTH). To develop feedstock analysis, indirectly & oxygen biomass gasification with integrated catalytic hot gas conditioning; Water Gas Shift (WGS) with low pressure catalytic ceramic foams; Pressure Swing Adsorption (PSA); Portable Purification System (PPS); techno-economic, LCA and business & exploitation analysis.

PROGRESS/RESULTS TO-DATE

- Conceive a cost competitive/efficient/sustainable system to produce H_2 from biomass.
- 6 representative feedstock characterized.
- Designed/built/operated 0.1 MW indirectly heated and 1MW gasification pilot plants with hot gas conditioning.
- Designed/built/operated PPS, integrating ZnO, WGS and PSA reactors coupled to the plant.
- Simulation/optimization, techno-economic, LCA and business& exploitation analysis done.

FUTURE STEPS

- Developments on the hot gas conditioning tar removal systems.
- Increasing BTH thermal conversion process eff. via additional methane reforming and/or sorbents.
- Decreasing PPS cost.
- Conducting demonstration in real and operational environment.
- Increasing the pilot plants number and the operative hours.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Catalytic filter candles tests showed 99 % w particulate removal; low-pressure drop; gas yields and H_2 increase; CH4, tar and NH3 decrease.
- New Fe-Cu/Foam allowed efficient (43 %) WGS at low pressure.
- Stable and continuous 1 MW and PPS tests lasting more than 12 h, achieving 99,99 % of concentration.
- The economic and LCA analysis showed that H_2 target cost/emissions are reachable.
- The analysis of Safety, RCS showed that BTH permitting procedures/standards are missing.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAIP 2008-2013
Europe at the forefront of BTH thermal conversion technologies	Number of plants	2 gasifiers + 1 PPS built and operated	100 %	0 (no industrial-scale plant [1])	Only few hours of continuous H_2 production
Eff. >70 % (simulated)	Eff.>64 % (for all BTH conversion)	38 % (exp.)-50 % (sim.)	75 %	54 % (speculative and for size >35 tH_2/day) [2] 50 % (speculative and for 1,5-35 tH_2/day size) [3]	Sim. eff. is based on experimental data & industrial configuration at best parameters
50-500 kg/d production capacity	1,5 t/d	36-360 kg/d, best scenario	100 %	35-160 t/d (speculative centralised) [2] 1,5-30 t/d (speculative distributed) [3]	Project results based on best scenario. Distributed generation advantages make convenient lower size
€3 M/(t/d)	€3,8 M/(t/d)	€2-22 M/(t/d) for 3,6-0,3 t/d	100 %	€4,2 M/(t/d) [3], €0,8 M/(t/d) [2]	Decrease 02 production. Intensifying the process. Increase catalyst lifetime
H_2 cost delivered to HRS <€5/kg (€0,15/kWh)	H_2 cost delivered to HRS €5/kg (MAIP 2014-20: €13/kg)	€2-10/kg (indirectly heated 10-0,1 MW)	100 %	€4,7/kg (speculative >1,5 t/d) [3], €1,8/kg (speculative >35 t/day) [2]	The results coming from best scenario
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AIP 2011
Feedstock analysis	Feedstock analysis	Lignocellulosic equivalent, agro-industrial and wood waste cheaper	100 %		
<20 y (160kh) av. >95%.	Durab. >10 y (80kh), av. >95%	10-20 y with maintenance items	50 %	Gasifier durab./av. known, unknown for the WGS and PSA fed by wood gas	Evaluate the purification system durab. and plant av. The tests done dont reach the target.
LCA analysis (ILCD compliant)	LCA/LCI analysis (ILCD compliant)	LCA/LCI analysis was conducted. 0,0134 kg CO_2/MJH2	100 %	0,002 kg CO_2/MJH2 farmed and waste wood (-0,055-0,0185) kg CO_2/MJH2 forestry and agricultural waste [4]	Best scenario results, agro-industrial residues deal with cultivation operation

VOLUMETRIQ

Volume Manufacturing of PEM FC Stacks for Transportation and In-line Quality Assurance

PANEL 2

Research activities for transport applications

ACRONYM	VOLUMETRIQ
CALL TOPIC	FCH-01.2-2014: Cell and stack components, stack and system manufacturing technologies and quality assurance
START DATE	1/09/2015
END DATE	31/08/2018
PROJECT TOTAL COST	€5 million
FCH JU MAXIMUM CONTRIBUTION	€4,9 million
WEBSITE	http://www.volumetriq.eu/

PARTNERSHIP/CONSORTIUM LIST

UNIVERSITE DE MONTPELLIER, JOHNSON MATTHEY FUEL CELLS LIMITED, SOLVAY SPECIALTY POLYMERS ITALY S.P.A., BAYERISCHE MOTOREN WERKE AKTIENGESELLSCHAFT, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS, ELRINGKLINGER AG, PRETEXO

MAIN OBJECTIVES OF THE PROJECT

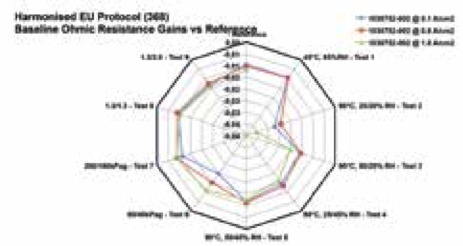
VOLUMETRIQ is developing an EU-centric supply base for PEM fuel cell stacks and their key components with volume manufacturing capability and embedded quality control at its heart. The stack and components are based on automotive PEM fuel cell technology which is presently TRL5 for component manufacturing approach and concepts. The project will deliver a TRL7 stack and component design, at TRL7 manufacturing maturity, a consistent stack power of 90 kW, and demonstrated cost reduction.

PROGRESS/RESULTS TO-DATE

- Automotive fuel cell stack requirements have been produced.
- Test protocols that will be used to generate membrane, MEA and stack performance data have been agreed upon and validated.
- Reinforcement and ionomer dispersion materials for baseline membrane and MEA development have been produced and supplied.
- A new pilot level continuous membrane casting line to produce VOLUMETRIQ membranes by volume manufacturable processes has been introduced.
- Baseline MEAs fabricated with project baseline materials demonstrate beginning of life power density of 2.0 A/cm^2 at 0.60 V in single cell testing.

FUTURE STEPS

- Complete amendments transferring stack activity to Elring Klinger (EK), and coordination activity to CNRS, following withdrawal of Intelligent Energy.
- Revise deliverable reports on stack and stack component requirements and test procedures affected by different stack operating conditions at EK.
- Re-open cross-checking activity of test results between single cell hardware to ensure consistency with results at stack development partner.



- Develop and supply new improved reinforcement and ionomer dispersion materials for first generation improved membranes and MEAs.
- Develop and test first short stack.

CONCLUSIONS, MAJOR FINDINGS AND PERSPECTIVES

- Superior mechanical properties of reinforced membranes using project reinforcements developed in MAESTRO over incumbent ePTFE is confirmed.
- BoL current density of 2.0 A/cm^2 at 0.60 V with project baseline MEAs allows confidence that project target of 2.5 A/cm^2 at 0.60 V can be reached.
- Stack development schedule unfortunately impacted by withdrawal of IE.
- Project duration to be increased by 6 months with alignment of all WP activities with the stack manufacturing schedule.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROJECT OBJECTIVES / TARGETS	CORRESPONDING PROGRAMME OBJECTIVE / QUANTITATIVE TARGET (SPECIFY TARGET YEAR)	CURRENT PROJECT STATUS	PROBABILITY OF REACHING INITIAL TARGET	STATE OF THE ART 2016 – VALUE AND REFERENCE	COMMENTS ON PROJECT PROGRESS / STATUS
(a) Project objectives relevant to multi-annual objectives (from MAIP/MAWP) – indicate relevant multi-annual plan:					MAWP 2014-2020
Cost reduction: €100/kW (2020)	Reduce the FC systems production cost for transport applications	Not scheduled any stack costing work	100%		N/A
Durability: 5,000 h	Increase FC systems lifetime for transport applications	Not yet scheduled any durability testing	100%	3 930 h to 10% - https://goo.gl/C9qp8X	Target is to demonstrate the capability to reach 5,000 h on an automotive drive cycle
(b) Project objectives relevant to annual objectives (from AIP/AWP) if different than above – indicate relevant annual plan:					AWP 2014
Components form part of a manufacturing study in order to improve and optimise processes.	Design and manufacturing methods simplification of cell components, cells and stacks	Manufacturing studies underway	100%		
TRL 7: Cell component and stack manufacturing technology	Cell and stack design improvements that have been validated =>TRL 5	Progress in components formulation	100%		
Develop volume manufacturing capability/qualit controls	Improve manufacturing methods	Pre-existing manufacturing methods being used by partners.	100%		
Investigate the parameters of the key cell components influencing durability, yield, cost	Testing and validation of critical manufacturing sub-processes	Activity initiated	100%		
Review of processes and identification of failure modes	Identification of manufacturing failure modes and implementation of manufacturing control plans	Activity to start year 2	100%		With resulting control plans put in place

EG-AA-17-001-EN-N

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