PROGRAMME REVIEW
REPORT 2014

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

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FCH JOINT UNDERTAKING

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PROGRAMME REVIEW REPORT 2014

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PROGRAMME REVIEW

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INTRODUCTION

1.1 FUEL CELL AND HYDROGEN TECHNOLOGIES CONTRIBUTING TO EU GOALS

The European Union (EU) has set itself ambitious long-term targets for its energy system. In October 2014, the European Council concluded European targets for 2030 comprising an increase in the share of renewable energy, improvements in energy efficiency, and dramatic reductions in greenhouse gas (GHG) emissions. They follow on from the earlier commitment made in the 20-20-20 plan extending and strengthening targets to 2030, as shown in Figure 1 below:

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

20-20-20 Goals by 2020		EU 2030 Targets*
20 % increase in renewables 20 % increase in efficiency 20 % decrease in GHG emissions	→	27 % renewable energy 27 % improvement in energy efficiency 40 % reduction in GHG emissions

*European Council Conclusions of 23/10/2014

In addition to these energy targets, the EU recognises the need to support the security of the energy supply, through greater use of indigenous resources, and to ensure more sustainable economic development and economic competiveness. The latter aspect has assumed greater importance with the continuing economic challenges faced by Europe as a whole, whilst the former has taken on greater urgency following the recent events beyond Europe's borders.

Innovative technologies have been recognised for their role in changing energy systems to meet these targets. The European Strategic Energy Technology Plan (SET-Plan) identifies eight sets of technologies with a role to play in a future sustainable European energy system. Fuel cell and hydrogen technologies represent one of these, as shown in below.

Fuel Cells and Hydrogen (FCH) technologies are in a unique position in that they can be used in both energy and transportation systems and, through the use of green hydrogen as a fuel, can provide zero-emission solutions to a range of challenges. Moreover, hydrogen provides a means of short- and longer-term energy storage, thereby allowing for flexibility in the time and geographical shift of energy production and use. As an energy vector, hydrogen also enables the shift of energy from one sector, such as power production, to other sectors, notably transportation fuels. These features of FCH make them complementary to the other technologies, for instance by providing a bridge for intermittent renewable sources, such as wind and solar, and various end-uses.

FIGURE 02 | EUROPEAN STRATEGIC ENERGY TECHNOLOGY PLAN

1.2 THE ROLE OF THE FCH JU: FROM FP7 TO HORIZON 2020

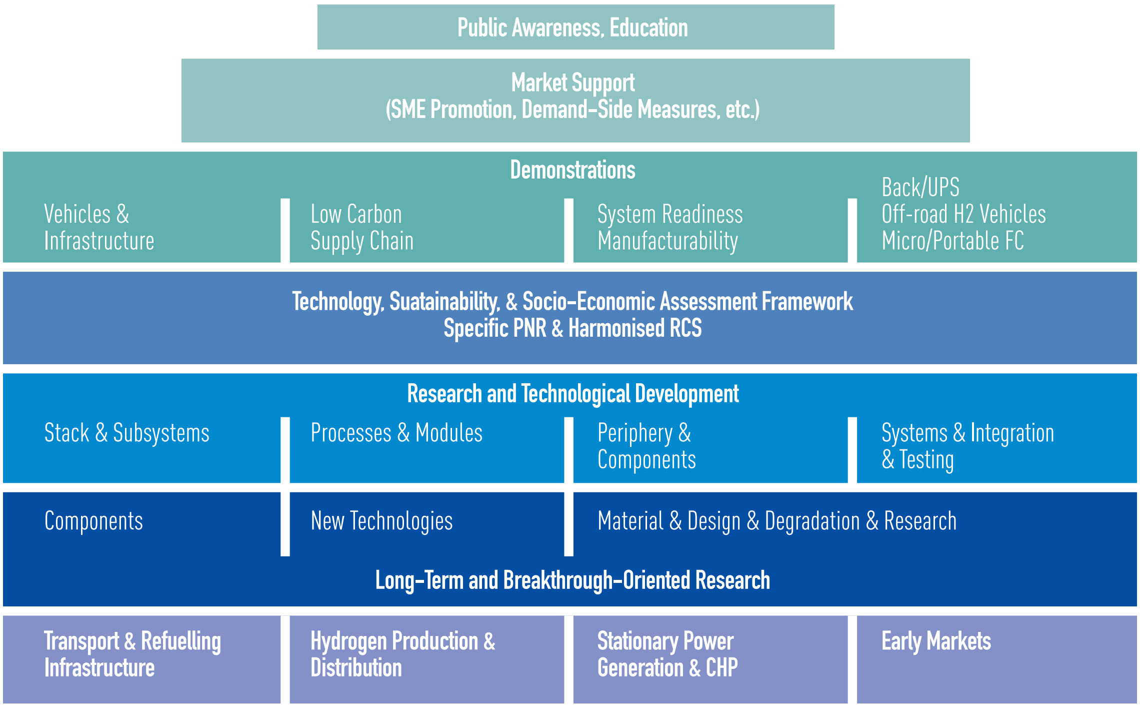
The Fuel Cells and Hydrogen Joint Undertaking (FCH JU) was established as a public-private partnership by the European institutions in May 2008 following Council Regulation (EC) 521/2008. This Regulation recognised both the role of FCH technologies in the provision of longer-term solutions to Europe's energy challenges and the leading activities worldwide of European industry, including SMEs, and research institutes in innovation and commercialisation. The budget for 2008-2013 amounted to around EUR 940 million, jointly funded by the European Commission and Europe's fuel cell and hydrogen industry and research communities.

With these funds, the FCH JU has carried out a research and technology development (RTD) programme, associated with the EU's Seventh Framework Programme. This is supporting basic and applied research and demonstration activities across a range of applications in the transportation and energy sectors, as well as in hydrogen production, distribution and storage, and early markets, with further cross-cutting activities (supporting the commercialisation of FCH applications, e.g. safety, regulations, codes and standards ((RCS)), pre-normative research ((PNR)), socio-economic analysis, as well as education and training).

Multi-Annual Implementation Plan and Multi-Annual Work Programme

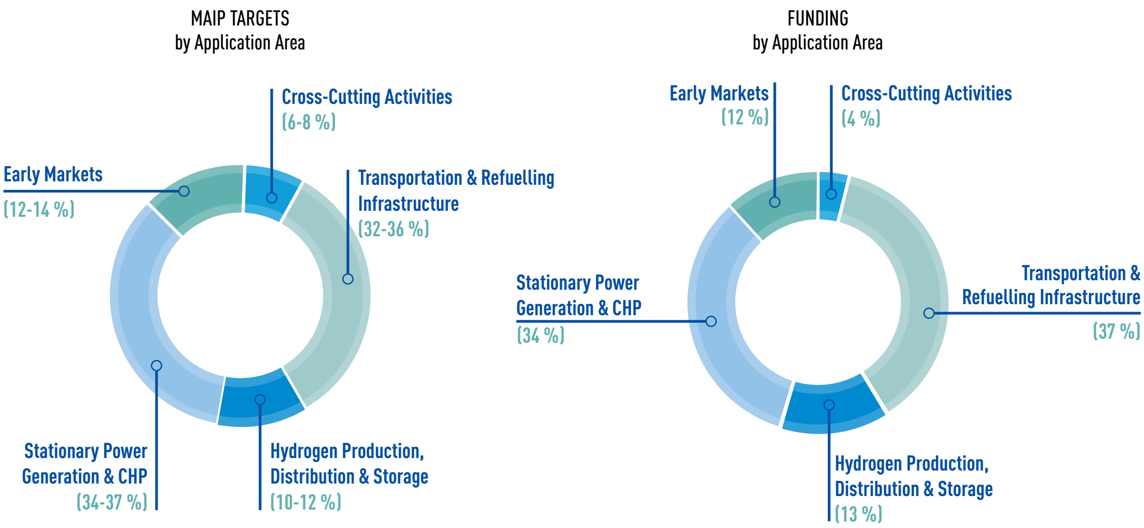
This programme has been designed and carried out by and in cooperation with the stakeholders: industry, including SMEs, research centres and universities, together with the Member States and Associated Countries, and regions and municipalities in Europe. The Multi-Annual Implementation Plan (MAIP) has been the FCH JU's primary strategy document, setting out the scope and details for basic, breakthrough and applied research and demonstration across the application areas, as shown in Figure 3.

FIGURE 03 | FCH JU ACTIVITIES UNDER THE MULTI-ANNUAL IMPLEMENTATION PLAN (MAIP) 2008-13



The MAIP has supported projects which are funded 50/50 by the FCH JU through grants and by industry and research organisations through in-kind contributions. FCH JU grants are awarded through a process of competitive calls for proposals. The FCH JU issued seven calls for proposals during its first phase (2008-2013)[1]; of these, 42 proposals had been completed by 2014.

FIGURE 04 | PLANNED DISTRIBUTION OF FUNDS ACCORDING TO APPLICATION AREA AND ACTUAL EXPENDITURE UNDER FCH JU (2008-13)



1 The first call of the second phase of the FCH JU (2014-20) was launched in mid-2014 and at the time of the 2014 PRD had yet to complete the evaluation phase; consequently, projects had not been selected.

Following the success of the initial programme, the FCH JU was renewed in June 2014, under Council Regulation (EC) 559/2014 as part of Horizon 2020. The budget is now set at EUR 1.33 billion, with activities focusing on two innovation pillars: transportation and refuelling infrastructure, and energy – supported by cross-cutting activities. The two innovation pillars continue to support the range of application areas, but with greater focus on those that can be widely deployed within the 2020 time frame.

The objectives and scope of the second phase of the FCH JU are set out in the Multi-Annual Work Programme (MAWP), which replaces the MAIP. The process of awarding grants through a competitive call procedure remains the same.

The structure of the MAWP is shown in Figure 5 below, illustrating the breadth of activities expected across the two innovation pillars. The transportation and refuelling infrastructure pillar includes some early market activities, whilst the energy pillar encompasses hydrogen production and distribution, stationary power generation and CHP, together with some early market activity.

FIGURE 05 | FCH 2 JU ACTIVITIES UNDER THE MULTI-ANNUAL WORK PROGRAMME 2014-20

TRANSPORT

- Road vehicles
- Non-road mobile vehicles and machinery
- Refuelling infrastructure
- Maritime, rail and aviation applications

ENERGY

- Fuel cells for power and combined heat & power generation
- Hydrogen production and distribution
- Hydrogen for renewable energy storage including blending in natural gas grid

CROSS-CUTTING ISSUES

(e.g. standards, consumer awareness, manufacturing methods, studies)

Activity within the two pillars comprises: long-term and breakthrough- oriented research; research and technological development; specific pre-normative research and harmonised RCS; and demonstrations. These are supported by cross-cutting activities, including market support measures, public awareness and education, and various assessments and non-specific PNR and RCS.

An assessment of the distribution of the FCH JU funds for the period 2008-2013 is shown in Figure 4, which uses the pre-MAWP terminology for the four application areas. This shows that the actual spend by application has been in line with the proposed distribution, with the exception of cross-cutting activities.

Beneficiaries/participants

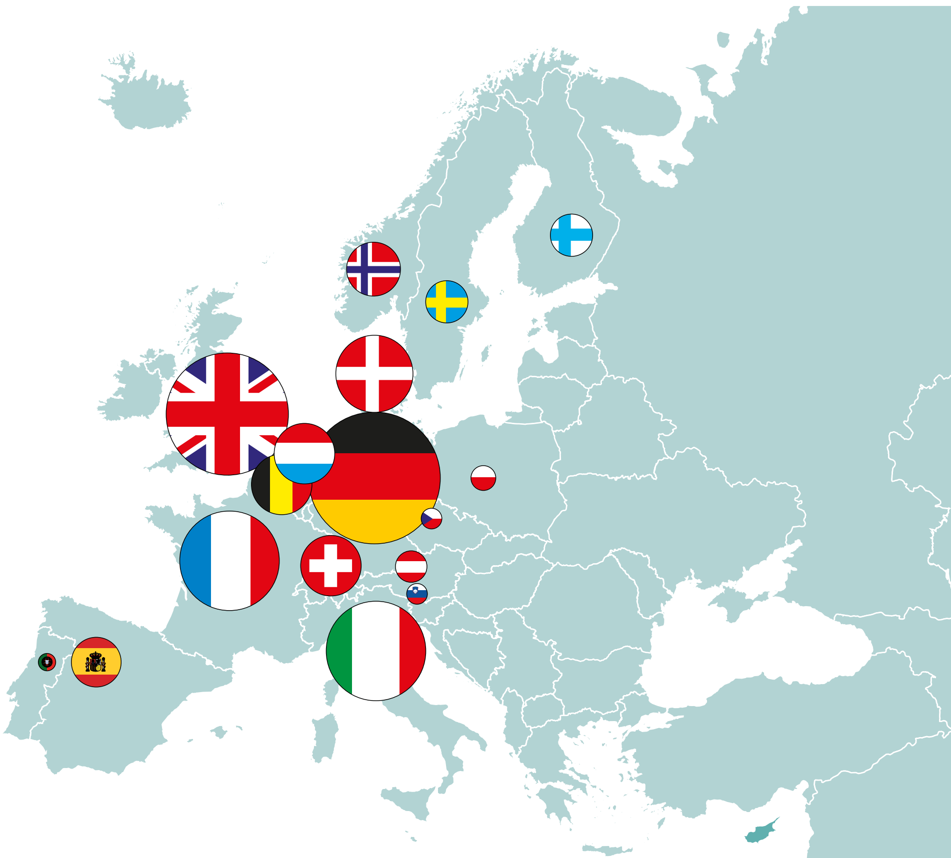
To date, the FCH JU programme has supported projects involving a total of 1266 participants. Of these, 545 are unique beneficiaries, some of which are represented in more than one project. Participant types include:

- Industry – 192 (35 %)
- SMEs – 154 (28 %)
- Research organisations – 149 (27 %)
- Higher education institutes – 20 (4 %)
- Others – 30 (6 %)

The relative proportion of funds allocated to beneficiaries follows a similar order and magnitude, with industry receiving 32 % of funds, SMEs receiving 28 %, and research organisations a relatively higher proportion at 32 % of funds.

These participants come from 22 Member States plus several Associated Countries, such as Switzerland and Norway, as shown below. The highest numbers of beneficiaries are located in the largest Member States, such as Germany, United Kingdom, Italy and France.

FIGURE 06 | GEOGRAPHICAL DISTRIBUTION OF PROJECT PARTICIPANTS ACROSS EUROPE



1.3 THE 2014 FCH JU PROGRAMME REVIEW

The 2014 Review is the fourth review of the FCH JU project portfolio. The reviews began in 2011, following a recommendation arising from the interim evaluation of the FCH JU which identified the need to ensure that the FCH JU project portfolio as a whole fulfilled the objectives of the MAIP, which subsequently became the MAWP.

An international team of leading experts in the FCH field undertakes each review based on:

- The achievements of the portfolio against the strategic objectives and content of the FCH JU's MAIP/MAWP and the AIP/AWPs, as set out for the transportation and energy innovation pillars and the cross-cutting category;
- The extent to which the portfolio meets the FCH JU's remit for promoting the horizontal activities of RCS, PNR, safety, life-cycle and socio-economic analysis, education and training, and public awareness;
- The portfolio's effectiveness in promoting linkages and co-operation between projects, and between FCH JU-supported projects and those supported by other European instruments, the Member States and internationally.

Review panels

The 2014 review comprised six panels covering a total of 114 projects. Each panel covered between 10 and 24 projects, as shown in Table 1 below. The objective was to assess projects within each panel as a sub-portfolio (within the FCH JU portfolio) and not as individual projects, although examples of individual projects representing good practice were highlighted.

TABLE 01 | PANELS FOR THE 2014 REVIEW

PILLAR/ACTIVITY	PANEL NAME	TOPICS
Transport	1. Transport Demonstration	Projects supporting the demonstration of FCH applications in the transportation pillar
	2. Transport RTD	Projects in the transportation pillar supporting basic and applied research
Energy	3. Energy – Proof-of-concept and demonstration	Projects in the energy pillar supporting proof-of-concept and demonstration in a range of applications
	4. Energy RTD – Fuel Cells	Projects focused on fuel cells, primarily basic and applied research in the energy pillar
	5. Hydrogen Production, Distribution and Storage	RTD projects for hydrogen production, distribution and storage issues in the energy pillar
Cross-cutting	6. Cross-cutting	Projects for the range of cross-cutting issues which support the energy and transportation pillars

A team of 18 experts from Europe and USA undertook the review both prior to and during the Programme Review Days (PRD) on 10 and 11 November 2014 in Brussels. Central to the review was the FCH JU's Scientific Committee, which performed the role of rapporteur for the various PRD sessions.

A minimum of three reviewers were assigned to each panel to undertake a desk-based remote review of the portfolio of projects in their panel, using information provided by the projects themselves, according to a format designed by the Programme Office, together with publicly available project information. Each project also prepared a poster, outlining its objectives, targets and achievements to date. All the reviewers in each panel reviewed all the projects in that panel and reported their findings which were then amalgamated into a single consensus panel report.

The projects included in the review are those in the portfolio that had started to be implemented before June 2014, but excluded those that had already finished before the previous review in 2013. The selection of projects to give presentations during the PRD itself was based upon recommendations from the panel reviewers, with a focus on the quality and achievements of the individual projects, in particular those that had finished and could thus provide valuable lessons learnt for ongoing projects.

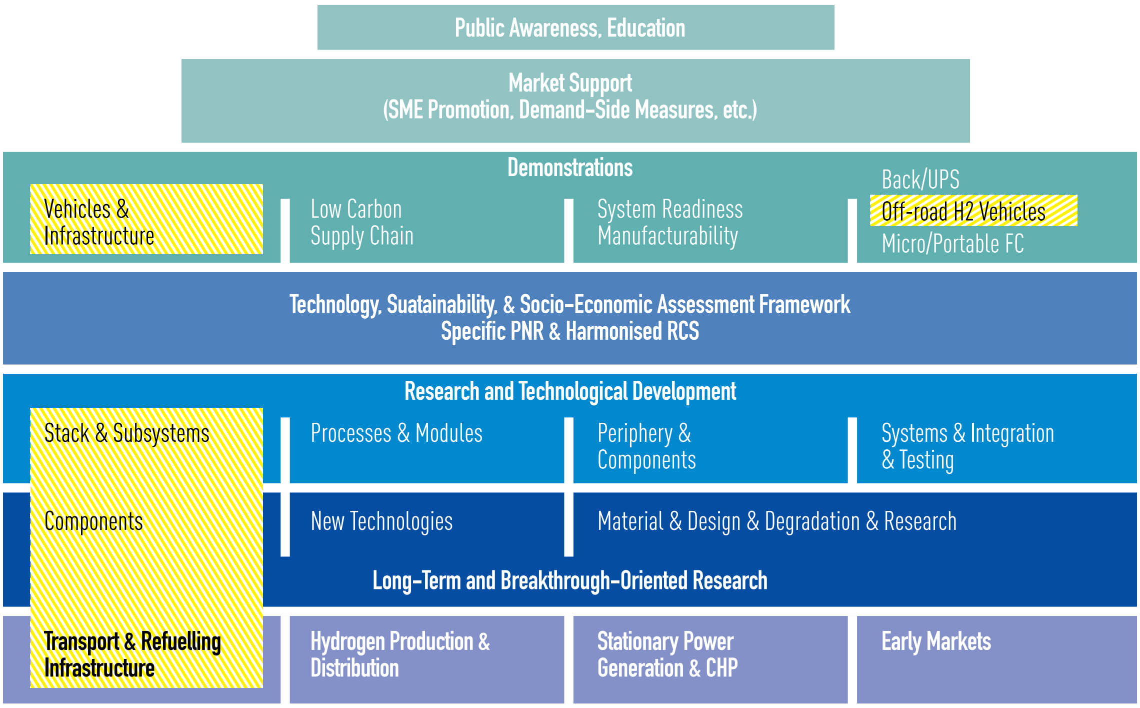
The following report is a general synthesis of the panel reviews organised into the energy and transport and refuelling infrastructure pillars plus cross-cutting activities.

02
TRANSPORT PILLAR

2.1 OBJECTIVES

The objective of the transport pillar is the acceleration of the commercialisation of FCH technologies for use in a range of transport applications, primarily road transport. FCH technologies have a critical role to play in the decarbonisation of Europe's transport sector. Green hydrogen combined with fuel cells provides the means to achieve a zero-emissions transport sector. The second phase of the FCH JU will build on the results from the first, while focusing on reducing the production costs of fuel cell systems and increasing their lifetime so that they are competitive with conventional incumbent technologies. These systems will contribute directly to successful commercialisation, alongside the expansion of hydrogen refuelling infrastructure across Europe.

FIGURE 07 | TRANSPORTATION ACTIVITIES WITHIN THE FIRST PHASE OF THE FCH JU HIGHLIGHTED IN BOXES

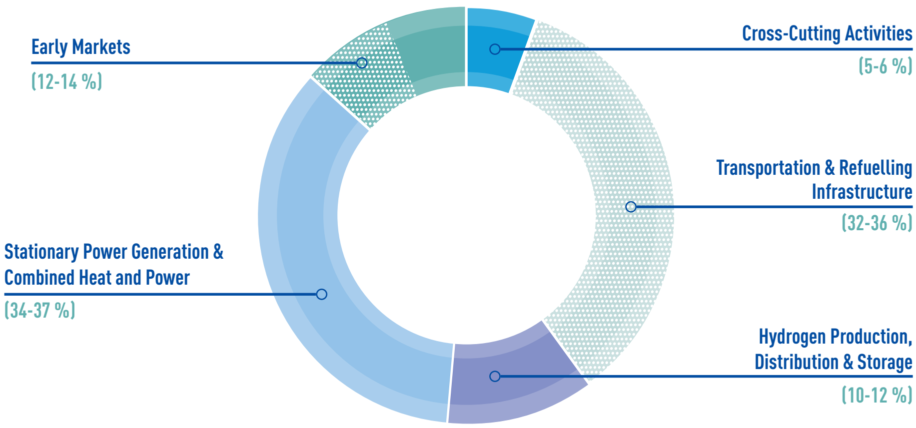


2.2 BUDGET

For the period 2008-2013, the FCH JU's MAIP (Multi-Annual Implementation Plan) set a budget for transportation and refuelling infrastructure activities (excluding off-road vehicles) of between 32 % and 36 % of total spend.

Under the second phase of the FCH JU, the MAWP foresees that 47.5 % of the programme budget is dedicated to the transportation pillar, which will cover the same activities as mentioned above.

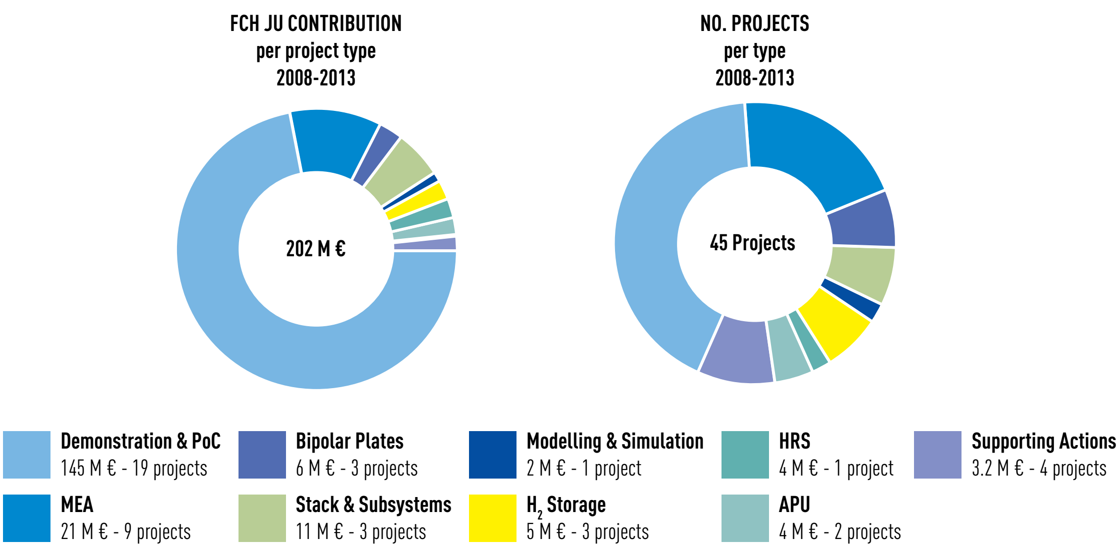
FIGURE 08 | PLANNED FCH JU BUDGET DISTRIBUTION PER ACTIVITY AREA UNDER FCH JU (2008-2013) SHOWING THE DELINEATION OF THE TRANSPORT PILLAR



The transport and refuelling infrastructure pillar of the new FCH 2 JU programme (2014-20) includes the previous (2008-13) programme's transport and refuelling infrastructure activity area (indicated by the patterned sections in Figure 8) plus a portion of the early markets activity area (namely the section covering off-road vehicles).

Forty-five projects have been supported under transportation and refuelling infrastructure activities, 19 of which comprise demonstration and proof-of-concept activities, which effectively form the bulk of the budget, accounting for over two-thirds of the budget for this sector.

FIGURE 09 | TRANSPORTATION PROJECTS BY VALUE (€) AND NUMBER



2.3 FOCUS AREAS AND ACHIEVEMENTS

Transportation activities are conducted within four main sectors:

- Road-vehicle development and deployment, including fuel cell cars and buses
- Non-road vehicle and machinery deployment, e.g. material handling vehicles (MHVs)
- Refuelling infrastructure development and expansion
- Fuel cell applications in marine, rail and aviation applications, e.g. auxiliary power units (APUs).

The individual activities within both the demonstration and research components of the FCH JU are aligned around these sectors.

2.3.1 DEMONSTRATION

Focus areas

The FCH JU work programme identifies the following focus areas for demonstration projects in the transportation and refuelling infrastructure:

- Cars: build up the number of fuel cell vehicles on the road in Europe
- Buses: reduce cost of vehicles and improve fuel economy
- MHVs: demonstrate the business case for these applications
- APUs: validate the technology and identify markets
- Refuelling infrastructure: develop the necessary infrastructure at a competitive cost.

The focus is to demonstrate and test the durability, robustness, reliability, efficiency and sustainability of technologies, and ease of customer use, with a view to taking the technology to full commercialisation.

FCH 2 JU will also advance its strategy in four key application areas:

- Fuel cell cars: the opportunity to work alongside four of the leading national mobility strategies in Germany, Scandinavia, France and the UK
- Fuel cell buses: advancing the strategy work that began with the Bus Commercialisation Study which was published in December 2012 (see section 5.1), working on ways to realise a 2020 vision for fuel cell buses
- APUs: consolidate work on the current applications and identify further early market opportunities in the transportation sector
- MHVs: a new strategy to be developed around a study of the sector and its opportunities.

The FCH JU has supported 18 transport demonstration projects in the seven[2] calls from 2008-2013.

TABLE 02 | TRANSPORT DEMONSTRATION PROJECTS SUPPORTED BY THE FCH JU (2008-2013)

	NUMBER OF PROJECTS			
CATEGORY	FINISHED	LIVE	TO START	TOTAL
Cars	1	3		4
Buses		3	1	4
MHVs		4		4
APUs	1	5		6
Refuelling infrastructure	(included in demonstration projects above)			
TOTAL	2	15	1	18

Achievements

Substantial progress has been made towards large-scale deployment of fuel cell vehicles in Europe, with the achievements illustrated in Figure 10.

FIGURE 10 | TRANSPORT DEMONSTRATION PROJECTS FUNDED UNDER THE FCH JU (2008-13)

> 200 cars | > 60 buses | > 400 MHV | 4 APU applications

> 40 filling points

- More than 200 cars will be demonstrated on Europe's roads in a number of Member States via four projects: H2MOVES (finished), HYTEC, SWARM and HYFIVE. Since H2MOVES, the first demonstration project:
  - the numbers of vehicles/per project has increased (to 100 cars under HYFIVE, the most recent project)
  - Hydrogen refuelling station (HRS) installations/per project have risen (HYFIVE will install six stations)
  - cost per vehicle has been reduced.
- To date, more than 45 buses have already been deployed across Europe in three projects: CHIC, High V.LO City and HYTRANSIT. An additional 20 buses will be deployed under a fourth project, 3EMOTION, which will start in 2015.
- As with the car demonstrations, these projects have shown:
  - a reduction in cost per bus over time
  - an improvement in fuel consumption
  - an expansion of the geographical coverage across Europe.

2 One call per year for the period 2008-12 and two calls in 2013.

- More than 400 MHVs are planned for use across the Member States in four projects: HyLIFT-DEMO (finished), MobyPost, HyLIFT-Europe and HAWL. These projects will result in:

  - an increase in the number of MHVs deployed
  - improvements in system readiness and cost
  - the development of business models for the European context.

- Four APU applications are being developed and validated in six projects: FCGEN, DESTA, SAPIENS, PURE, HYCARUS and SAFARI; these projects have advanced the technical readiness of various fuel cell technologies, whilst also working on identifying market opportunities.

- To date, 20 hydrogen filling points have been installed and are being operated in association with demonstration projects; a further 20 to 30 are planned for installation in ongoing projects.

2.3.2 RESEARCH

Focus areas

The FCH JU work programme has identified the following focus areas for fuel cell and hydrogen transportation-related research (including APUs):

- Membranes: activities to develop and improve membranes for transportation cells and stacks

- Catalysts: improvements to raise performance levels and reduce costs

- Bipolar plates: developments and improvements to materials for better performing components

- Manufacturing and process development: activities to support the near-term production of components and subsystems

- Methodology and tools: creation and development of modelling and other tools to help industry to undertake projects

- System and balance of plant (BoP) components: development and improvement of components for better performance and/or reduced cost

- Advanced refuelling components and storage: activities to develop the hydrogen refuelling process alongside storage options.

In addition, the gas diffusion layers (GDL) area was included *post hoc* in the research programme.

The aim is to advance research and technological development of fuel cell stack and subsystems, while conducting longer-term, breakthrough-oriented, research into fuel cell components.

Achievements

Transport research achievements under FCH JU-funded projects cover all focus areas:

- A broad range of approaches for membranes, catalysts and GDL are being investigated within nine projects: PEMICAN, ARTEMIS, IMPACT, IMMEDIATE, IMPALA, CATHCAT, CATAPULT, NANOCAT and SMARTCAT

- In the field of bipolar plates, research into the development of advanced coatings for better performance and/or lower cost is being conducted in three projects: STAMPEM, IRAFC and COBRA

- Stack research is under way in three projects with the aim of establishing a world-leading European stack platform: AUTOSTACK, LIQUIDPOWER and AUTOSTACK-CORE

- One modelling project, PUMAMIND, is investigating cell-level function

- H_2 storage research is being treated in three projects, dealing separately with solid state and CGH_2 storage with a view to enhancing performance and storage capacities: SSH2S and COPERNIC, as well as HYCOMP which is looking at composite cylinder design

- One advanced hydrogen refuelling system project, PHAEDRUS, is researching several system aspects, such as electrochemical compression, PEM electrolysis and advanced dispensers.

The majority of these projects originated in the 2011 and 2012 AIPs and consequently are expected to make an impact post-2015.

In terms of budget, 48 % of funds have been allocated to projects for membrane electrode assemblies (MEAs), and 20 % for stack and research and innovation. The other categories account for 32 %. The research area coverage is shown in Table 3.

TABLE 03 | DISTRIBUTION OF FCH JU TRANSPORT RESEARCH PROJECTS ACROSS THE VARIOUS MAIP AREAS

MAIP R&D AREAS	MEA									Bipolar Plates			Stack & Subsystems			Modelling & Simulation	H2 storage			HRS	APU	
	PEMICAN	ARTEMIS	CATHCAT	IMMEDIATE	IMPACT	IMPALA	CATAPULT	SMARTCAT	NANOCAT	IRAFC	STAMPEM	COBRA	AUTOSTACK	LIQUID POWER	AUTOSTACK-CORE	PUMAMIND	SSH2S	HYCOMP	COPERNIC	PHAEDRUS	SUAV	HYPER
Membranes	X	X	X	X	X			X		X			X		X							
Catalysts	X	X	X	X	X		X	X	X	X			X	X	X						X	
GDL				X	X	X							X		X							
Bipolar plates										X	X	X	X		X							
Manufacturing & process development											X		X	X	X				X		X	X
Methodology & Tools	X	X			X	X	X							X		X		X				
BoP components														X			X		X		X	X
HRS (advanced)																				X		

2.4 REVIEW FINDINGS

2.4.1 DEMONSTRATION

Fifteen demonstration projects in the transportation pillar were reviewed during the 2014 review exercise. Four projects were added to the 11 reviewed in 2013, and are shown in Table 4 below. Those indicated in bold gave oral presentations during the PRD.

TABLE 04 | LIST OF THE DEMONSTRATION PROJECTS REVIEWED

PROJECT NAME	DESCRIPTION
CHIC	Deployment of fuel cell hybrid buses, plus H_2 refuelling infrastructure in five phase 1 cities; plus learning from phase 0 cities
DESTA	Demonstration of European solid oxide fuel cells (SOFC) APU for trucks
FCGEN	Development and demonstration of proof-of-concept fuel cell auxiliary unit on-board a truck
HAWL*	Demonstration of hydrogen fuel cell forklift trucks in logistics warehouses
High V.LO City	Implementation of a fleet of 14 fuel cell hybrid buses in three regions across Europe, plus H_2 production and refuelling infrastructure
HyCARUS	Design of generic PEM hydrogen-air fuel cell systems for use in aircraft
HYFIVE*	Deployment of 110 FCEVs and six HRS in three European regions
HyLIFT-DEMO	Deployment of fuel cell H_2 systems for MHVs, notably forklifts
HyLIFT-EUROPE	Expansion of deployment of fuel cell H_2 systems for MHVs
HyTEC Review	Demonstration of up to 30 new H_2 vehicles in Denmark and the UK in three classes: taxis, passenger cars and scooters
HYTRANSIT*	Demonstration of fuel cell hybrid buses in Aberdeen, Scotland, with an emphasis on longer-distance routes
PURE	Development of fuel cell APUs for recreational marine applications
SAFARI*	Design and development of SOFC APUs for trucks using liquid methane to provide power, heating and cooling for driver's cab
SAPIENS	Development and deployment of SOFC APU for recreational vehicles
SWARM	Deployment and operation of 100 fuel cell vehicles and three refuelling stations across three Member States

* Projects added to the review portfolio in 2014

Relevance to MAIP and AIP objectives

The 2014 Review findings indicate that the portfolio of demonstration projects in the transportation pillar is well balanced between buses, cars and MHVs, and supported by activities in the APU field. It notes that the addition of further projects from the 2013 AIP calls (HYTRANSIT, HAWL and HYFIVE, together with SAFARI APU) strengthens this portfolio. On the whole, overlaps and gaps are minimal, whilst successive demonstration projects for buses and cars build upon earlier projects. Infrastructure development for hydrogen refuelling is integral to a number of these projects. However, the reviewers observed a lack of projects in the heavy transport fields, notably rail.

Reviewers found self-assessment against the state of the art for these projects was unsatisfactory. Projects were either unable to provide a credible assessment of their technology compared to developments in Europe and internationally, or did not fully understand the request for information from the Programme Office. A number of recommendations were made for future annual reviews to ensure that better and more information is made available. Nevertheless, reviewers were able to identify leading activities in the area of bus and demonstrations.

The greatest concern expressed by the reviewers was the shortfall in the unit volumes of vehicles likely to be deployed in these projects when compared to the targeted deployment outlined in the projects. HYFIVE will make good progress in addressing the number of cars on the road, but the number of MHVs falls well short of that originally forecast by projects and with what has been achieved in North America.

Buses

As in 2013, the 2014 portfolio of bus demonstration projects builds on the experience gained in previous projects under former EU Framework Programmes and the first phase of the FCH JU. These are among the most effective projects within the FCH JU's transportation portfolio. The bus fleets under FCH JU projects collectively form the world's largest, a position which will be strengthened with the addition of the HYTRANSIT project from the 2013 call for proposals. Nonetheless, reviewers stated that further bus projects are required to demonstrate that both capital and operational costs can be reduced.

The issues highlighted by the reviewers were similar to those in 2013, but also included:

- lack of available buses for deployment from European original equipment manufacturers (OEMs), which may slow these projects down
- the need to continue to work on bus availability and reliability at levels equivalent to those in the incumbent and other new hybrid technologies, e.g. diesel/electric
- the inherent complexity of projects which are very ambitious in attempting to integrate bus deployment with HRS and electrolysis for grid-balancing activities.

Cars, MHVs and APUs

Demonstration projects involving fuel cell cars are well represented, with the addition of HYFIVE potentially strengthening this portfolio.

The reviewers' greatest concern was for the activities in the MHV field, where deployment numbers fall significantly short of the numbers predicted. Paradoxically, progress in this 'early market' area may be held back by the failure to prove the total cost of ownership (TCO) with potential end-users, and the lack of maturity in European solutions. For example, there is a concern that in some projects fuel cell efficiency is not yet known, even though these are demonstration projects. A call has gone out for a review of this field alongside the consideration of an initiative to draw together all European efforts in this area to determine how best to proceed. This observation reflects similar concerns expressed in 2013.

Development of APUs under the FCH JU programme is taking place over a range of complementary projects for road transport, leisure and aerospace applications. Satisfactory progress is being made and some good value chains are being developed. However, a view remains that this field could benefit from more coordination and better planning to achieve maximum impact.

Recommendations

Reviewers suggest that the FCH JU identifies weaknesses and strengths within the portfolio and determines where best to invest for the future. They also propose a coordinated roll-out of hydrogen refuelling infrastructure, and efforts to secure cost reductions by fostering and exploiting the complete value chain for FCH stacks and vehicles. The reviewers raised the possibility of HRS infrastructure being decoupled from the deployment of fuel cell electric vehicles (FCEVs) in order to focus on the development requirements of HRS. However, there are likely to be cost and utilisation issues for the developers of such potentially 'isolated' infrastructure.

Complementarity with other projects/programmes

Most projects have a degree of interaction with other projects in the portfolio, which is often through common partners. Indeed, the mutual learning and information sharing apparent in the bus and car demonstration projects is largely based on a core of common partners. This shared learning is very positive in areas such as hydrogen infrastructure development and bus or car deployment issues.

Linkages and interaction between projects seem to be weaker in the APU and MHV areas.

Collaboration and coordination with non-FCH JU projects at the national and international level is less encouraging. Coordination is recommended with other European programmes, for example TEN-T. It is also recognised that close links with similar programmes will benefit learning. Good examples at the national level are CHIC and HYFIVE, which have links with the German, Italian and UK programmes, and HYLIFT EUROPE, which is working with the German NOW MHV group. International co-operation is much less encouraging and further work is required to ensure that efforts to build and utilise linkages are maximised.

Horizontal and dissemination activities

On the whole, the review findings on project dissemination activities and exploitation plans were positive. Most projects are making credible progress with these horizontal aspects, with car projects considered the most likely to be able to influence public awareness and acceptance. These, together with bus projects, are actively using a range of communication channels. Conference presentations and papers are the most widely used means, although the impact of these is not clear. More positive is the fact that eight of the 16 projects are holding workshops, which are seen as a very effective way of disseminating results to key stakeholders – examples include a joint truck/APU workshop. Given that these are demonstration projects, it is not surprising that few patents are expected.

Activity in the areas of training and education, and safety and RCS is somewhat mixed. In general, more training and education activities could be undertaken, with more projects following the example of CHIC, High V.LO City and HYTRANSIT in targeting key stakeholders – for example, first responders to accidents and maintenance operatives. In terms of safety and RCS, once again there are some good activities among the projects, especially those concerned with bus demonstration, whilst HYLIFT DEMO and DESTA are developing potentially valuable best practice guides and handbooks.

Exploitation plans

Exploitation and commercialisation plans are best developed and executed by the car and bus demonstration projects, the APU projects less so.

2.4.2 RESEARCH

The review of the research project portfolio comprised the 20 projects shown in Table 5. This builds on the 13 reviewed in 2013, although only one started in 2014. Those highlighted in bold made oral presentations during the PRD.

TABLE 05 | LIST OF TRANSPORT RESEARCH PROJECTS REVIEWED

PROJECT NAME	DESCRIPTION
ARTEMIS	Development of new MEA based on phosphoric acid doped alternative polybenzimidazole-type polymers
AUTOSTACK-CORE	Development of best-in-class automotive stack hardware with superior power density and performance whilst meeting commercial target costs
CATAPULT	New catalyst structures and concepts for automotive power trains using ultra-thin film coatings on novel nano-structured supports
CATHCAT	Development of new MEA, operating at 100°C with an emphasis on the cathode side
COBRA*	Development and industrialisation of new metallic bipolar plate coatings demonstrating a higher corrosion resistance, lower electrical resistance and lower price
COPERNIC*	Increasing the maturity and competitiveness of CGH_2 manufacturing processes
HYCOMP*	Definition of design requirements and testing procedures for composite cylinders
HYPER*	Development and demonstration of a portable power pack with an integrated modular FC and hydrogen storage system
IMMEDIATE	High performance MEA with thermal stability up to 160°C through materials development and process optimisation
IMPACT	Development of MEA with ultra-low Pt loading and improvement of lifetime combined with investigation of degradation phenomena and mechanisms
IMPALA	Improvement of MEA performance through four levels and durability via development of improved GDL
LIQUIDPOWER	Fuel cell systems and hydrogen supply for early markets
NANO-CAT	Reducing Pt loading of catalyst structures by development of Pt alloys as well as innovative Pt free (bio-inspired) structures
PEMICAN	Development and manufacture of MEAs with reduced platinum costs
PHAEDRUS*	Development and validation of a high-pressure hydrogen for electrochemical decentralised refuelling station
PUMA-MIND	Development of predictive durability modelling tool as a function of components composition and operating conditions
SMARTCAT	Development of new and innovative electrodes using tri-metallic low-Pt content based catalyst nano-structured layers
SSH2S*	Development of solid state hydrogen storage coupled with HTPEMFC for an automotive application
STAMPEN	Research and development of improved stability and reduced costs of bi-polar plates through use of durable coatings materials
SUAV*	Development of micro-tubular SOFC power system and integration into a mini-UAV

*Projects reviewed in 2014 review exercise, but not in 2013.

Relevance to MAIP and AIP objectives

The reviewers found a high degree of alignment between the 20 projects in the transportation research portfolio and the FCH JU's strategy and objectives, as set out initially in the MAIP and now in the MAWP. Thirteen of the projects were related to the automotive proton exchange membrane fuel cells (PEMFCs), and 10 of these to catalyst or MEA development, reflecting the importance of these technology areas to the sector in terms of performance improvement and cost reduction. Further projects address bipolar plate development and hydrogen storage capacity, but there is only one on hydrogen refuelling challenges.

Although the portfolio as a whole is relevant, and addresses the FCH JU's key technology areas, the reviewers observed that the individual projects which are coming to an end are not achieving the objectives or successes originally planned. As a result, there is a concern that the FCH JU's overall 2015/2020 targets in the transportation RTD sector will not be achieved, and that further research projects will probably be required in the FCH 2 JU programme.

Following on from the above, reviewers noted the difficulty in identifying the achievements of projects and suggested that, namely for finished projects, the reporting could follow a "success stories" format (brief descriptions of original objectives and actual results) to enable a better understanding of the actual achievements and any further work that is still required. This approach would be particularly useful for stakeholders with an interest in specific projects.

There still appears to be a significant level of fragmentation in the efforts being made by the sector. One proposed initiative is to use the AUTO-STACK project as a focus for future efforts and co-ordination in the area of PEMFC technology research and innovation. Reviewers were also keen to see more research emphasis on components and systems.

The issue of progress among the research projects is reflected in their assessment against the state of the art where, at best, projects are achieving results comparable to those from international projects. Nevertheless, reviewers noted that 'there is a clear risk that development is too slow to meet the 2015 target(s)'. Thus, they have recommended that the FCH JU reviews the portfolio and individual projects to identify the improvements required to ensure that Europe can be at the forefront of research in the transportation sector.

In terms of portfolio gaps, there are a number of areas where greater focus is required:

- The durability and robustness of fuel cells in real-world operations
- Encouraging more feedback from demonstration project results to be relayed to FCH JU research efforts
- Advanced near-to-market component solutions to balance an overemphasis on basic research in the area
- Contributions to cost reduction
- Hydrogen refuelling activities should be expanded to address the challenges readily apparent in the hydrogen infrastructure and HRS fields.

A reasonable degree of overlap was noted among the projects and a call made for enhanced co-ordination and collaboration to benefit the portfolio and minimise duplication. Once again, AUTO-STACK could provide 'valuable leadership' in coordination and collaboration for the portfolio as a whole.

Reviewers found industry involvement and/or guidance to be lacking in projects, with the result that there is considerable emphasis on basic research, which may be of long-term relevance, but of little or no value to the immediate short- and medium-term challenges. Clusters of different stakeholders in projects, for example in an advisory board function, could help the overall focus of the portfolio. CATAPULT is seen as an exemplary project in the area of industry participation and relevance.

Complementarity with other projects/programmes

Projects were found to have developed good linkages and synergies with one another and with other national and international projects and programmes; thus, they appear to be learning from each other which is accelerating progress.

With the exception of two projects in the portfolio, they all claim to interact with other projects, and many partners are building on work undertaken in previous Framework Programmes and the first phase of the FCH JU. As regards links with national projects, STAMPEM and CATAPULT both point to national funding for complementary research activities. However, only five projects mention international linkages, highlighting the need to encourage co-organisation and/or participation in international workshops – for example, in the US Department of Energy (DoE) programmes.

Horizontal and dissemination activities

Cross-cutting, dissemination and exploitation activities were found to be underdeveloped across the portfolio. There is some evidence of projects undertaking education and training activities through the involvement of postgraduate students, and conference presentations and reports, but more emphasis on these aspects is deemed necessary – guidance from the Programme Office on the effective integration in projects of various types of education and training activities would be welcome. For example, raising public awareness is more appropriate for demonstration and innovation projects, whilst conferences and presentations should be able to point to the benefits of this research activity, for example through shared learning.

Reviewers also noted the seemingly poor record in the fields of safety and RCS, patent applications, and exploitation of the results by industry. Consideration of safety and RCS are seen as 'rather weak'. In addition, there is a view that being at the forefront of technology development also requires leadership in the field of patents – few projects mention possible patent applications.

Exploitation plan

The expected exploitation of their results by the projects is somewhat weak, with few demonstrating a credible exploitation plan and route to market for their developments. This may reflect the basic research and innovation nature of many of the projects, which may have a longer-term relevance. However, this finding does highlight the issue of the portfolio's short- and medium-term relevance and the need for greater industry involvement and/or guidance in research projects.

03 ENERGY PILLAR

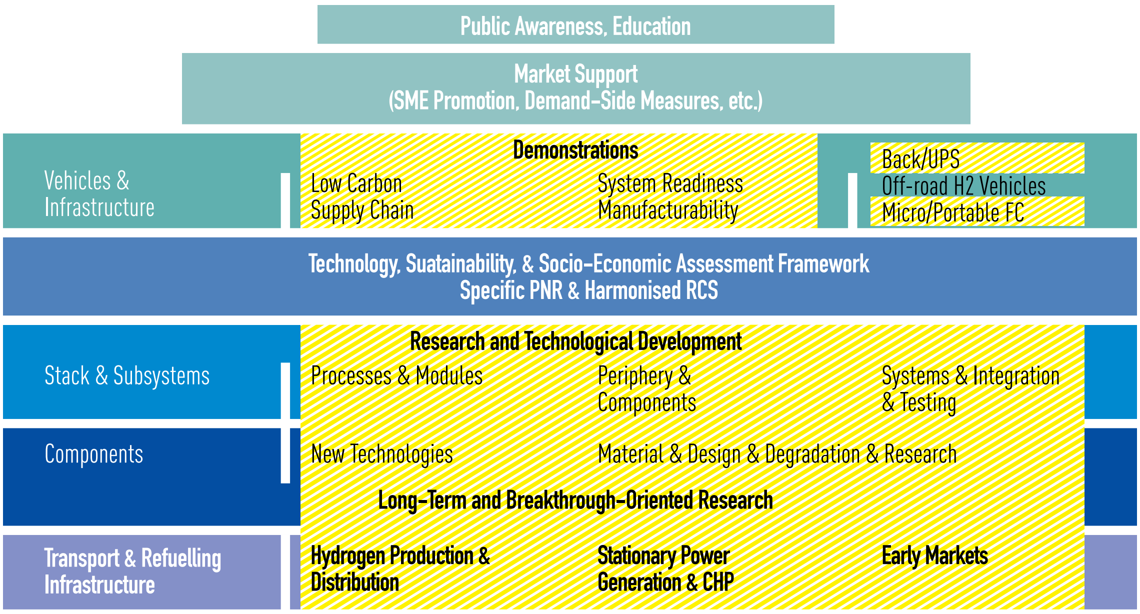
3.1 OBJECTIVES

The objective of the energy pillar is to accelerate the commercialisation of FCH technologies in the fields of fuel cells for stationary applications (including CHP and, where relevant, cooling, power-only systems as well as small-scale back-up/UPS solutions and portable fuel cell systems) and for technologies for hydrogen production, storage and distribution. Consequently, this pillar is responsible for developing and demonstrating a number of different FCH technologies, and tends to be less concentrated than the transportation pillar.

The aim in the field of fuel cells is to advance the technologies (fuel cell stacks, BoP and complete systems) to the point where they are able to compete effectively with current power and heat-generation technologies. The objectives for hydrogen production, storage and distribution are three-fold:

- To develop and demonstrate hydrogen production using electrolysis with renewable power for energy storage and grid balancing
- To develop low-carbon hydrogen production from other resources, e.g. direct solar and biological
- To develop and demonstrate technologies for hydrogen storage, handling and distribution to efficiently and effectively distribute hydrogen throughout the energy value chain.

FIGURE 11 | ACTIVITIES WITHIN THE ENERGY PILLAR HIGHLIGHTED IN BOXES

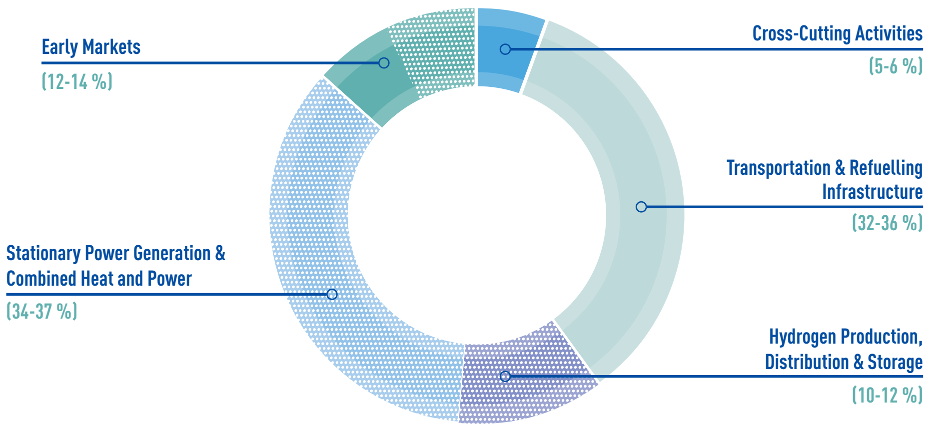


3.2 BUDGET

The energy pillar was allocated a budget in the FCH JU's MAIP of 44-49 % of the total budget for the period 2008-2013 (excluding early market applications) comprising: 34-37 % for fuel cells for stationary power, 10-12 % for hydrogen generation, distribution and storage. Added to that is a portion of the 12-14 % budget allocation for early markets.

Under the MAWP, the corresponding budget allocation for the energy pillar as a whole is 47.5 % of the total budget for the period.

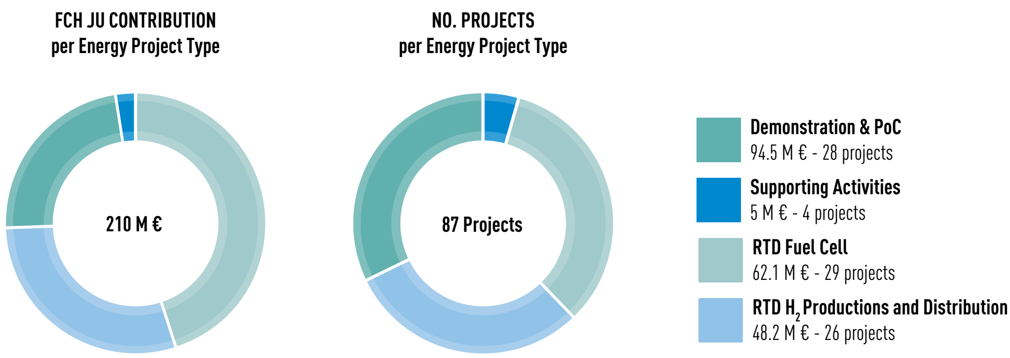
FIGURE 12 | PLANNED FCH JU BUDGET DISTRIBUTION PER ACTIVITY AREA UNDER FCH JU (2008-2013) SHOWING THE DELINEATION OF THE ENERGY PILLAR



The energy pillar includes the following activity areas (see patterned sections of Figure 12): stationary power generation and combined heat and power, hydrogen production and storage, and a portion of the early markets activity.

Under the energy pillar, 87 projects have been supported by the FCH JU from the calls from 2008-2013, covering research, demonstration projects, proof-of-concept (including components, diagnostics and control), and supporting activities.

FIGURE 13 | ENERGY PROJECTS BY VALUE (€) AND NUMBER



3.3 FOCUS AREAS AND ACHIEVEMENTS

3.3.1 DEMONSTRATION

Focus areas

Energy demonstration activities focus on the following three areas:

1. Stationary power and CHP applications of fuel cells:

    - Field demonstrations of micro-CHP and larger-scale power and CHP units: to establish a demonstration programme within Europe, alongside programmes supported by the Member States

    - Proof-of-concept of fuel cell systems and BoP components, and diagnostics and monitoring subsystems: supporting technologies through a programme of activities for proof-of-concept and validation projects.

2. Hydrogen production and storage

    - Demonstrations of hydrogen production and distribution technologies: supporting both the development of existing electrolyser-based production, but also more innovative renewable-based technologies capable of producing 'green hydrogen' at both large and small (distributed) scales

    - Demonstration of hydrogen storage technologies: supporting technologies capable of storing hydrogen at a range of scales from small tank storage to large-scale underground storage, and in a variety of forms: gaseous, liquid and solid states.

3. Early markets

    - Demonstration of small-scale fuel cell systems for power for a range of back-up and remote locations.

Achievements

The energy pillar comprises eight demonstration projects which have had significant achievements in a number of fields:

- Micro-CHP fuel cell systems: over 100 micro-CHP units have been installed in seven EU Member States, with a total of more than 1000 units planned to be installed as a result of FCH JU (2008-13) activities – a major achievement in relation to the MAIP targets for 2015

- Industrial CHP projects totalling more than 1.5 MW in capacity are being installed in Germany, a positive step towards achieving the MAIP cost-reduction targets through economies of scale

- Back-up power projects should see the deployment of over 30 fuel cell systems

- Electrolyser projects with capacity as large as 1 MW are being implemented, in combination with intermittent renewable energy resources, too.

These projects are also contributing to learning and development related to:

- Operation in different climates, using different technologies and routes to market
- Increased volumes of production with benefits for cost-reduction targets
- Improved durability of units in the field.

In addition, the 20 proof-of-concept, components and diagnostic projects cover a range of technology developments with learning benefits for a number of fuel cell technologies and systems (including ASSENT, CATION, REFORCELL, LOTUS, SAPPHIRE, SOFCOM, FLUMABACK, DECODE, TRI-SOFC). These have all contributed to improvements in electrical efficiency and the durability of fuel cell systems.

3.3.2 RESEARCH ON FUEL CELLS

Focus areas

FCH JU-supported research activities for fuel cells have focused on the following areas:

- Materials: materials for fuel cells, components and storage devices
- FCH performance phenomena: improved understanding of phenomena affecting performance of FCH technologies (e.g. degradation)
- Cell and stack design and production: manufacturing and process development for cells and stacks.

To this end, the FCH JU has supported 29 projects to date on the fuel cell issues mentioned above. These include both basic and more advanced research.

Achievements

The primary achievements to date include:

- Materials: improved performance of existing materials and development of new materials for fuel cells and stacks in four projects, e.g. membranes and MEAs with improved mechanical properties (e.g. MAESTRO, ENDURANCE); new materials for low-temperature SOFC (e.g. SCOTAS-SOFC, EVOLVE) including a promising new ceramic anode material; and a low-cost catalyst system for alkaline fuel cells and steel coatings for reducing degradation
- Fuel cell performance phenomena: improved understanding of degradation and lifetime fundamentals through five projects, e.g. PEM stacks with lifetimes of 20 000 hours or more (e.g. STAYERS), development of accelerated testing regimes for PEM FC, and SOFC cells and stacks (e.g. SOFC LIFE, PREMIUM ACT); modelling of degradation mechanisms (ROBANODE), and lifetime prediction methodologies (DEMMEA)
- Cell and stack design: next-generation cell and stack design – 14 projects developing new cell and stack designs for SOFC, alkaline and PEM FC technologies (LASER-CELL, METSAPP, METPROCELL, T-CELL, DEMSTACK, RAMSES, CISTEM, EURECA, PROSOFC, KEEPEMALIVE, LOLIPEM, MATISSE, MCFC-CONTEX, ONSITE)

- Fuel cell cost and component issues: a range of six projects address various cost and production issues for SOFC and PEM technologies with a view to lowering the cost through materials and components (e.g. DURAMET, MMLRC-SOFC, SCORED 2.0), specific components and system issues (e.g. SECOND ACT), and systems integration (ALKAMMONIA, IRMFC).

3.3.3 RESEARCH ON HYDROGEN PRODUCTION, DISTRIBUTION AND STORAGE

Focus areas

The focus areas for this topic are:

- Hydrogen production through electrolysis: development of a range of technologies, some with a short-term focus, e.g. alkaline and PEM, and others with a longer-term focus, e.g. SOEC/high temperature

- Innovative hydrogen production methods: development of technologies with long- term potential for sustainable hydrogen production, including concentrated solar, photo-electrochemical and biomass/biological

- Innovative reformers: reformer development for hydrogen production from a range of different pathways including biogas, renewable energy and diesel/biodiesel sources

- Hydrogen storage and distribution**:** materials, designs and development of hydrogen storage capability, plus hydrogen filling technologies for vehicles.

Achievements

A total of 26 projects have been supported by the FCH JU in this particular area:

- Electrolysers: 10 projects are being implemented focusing on: development of alkaline electrolysers with advanced membranes in the RESelyser project; development of PEM electrolysers and stacks aiming for MW-scale commercial units in NOVEL and MEGASTACK respectively; high-temperature electrolysis developments which include SOEC electrodes operating at 700°C, with 15 % increase in performance (ADEL); power-to-gas (HELMETH); integration with renewable energy sources, in NEXPEL, SOPHIA, PRIMOLYZER; diagnostics and monitoring in the project INSIDE; as well as the ELECTRA, ELECTROHYPEM projects

- Innovative H_2 production: seven projects are being carried out, focusing on: production of 1-10 kg H_2 per day with thermophilic fermentation processes (HYTIME); photochemical hydrogen production with initial targets of 5 % sunlight to H_2 conversion factors (ARTIPHYCTION, PECDEMO); use of concentrated solar for hydrogen production (SOL2HY2); continuous production of hydrogen from biomass (UNIFHY); as well as HY2SEPS-2 and HYDROSOL-3D

- Innovative reformers: this area comprises three projects: one on advanced catalysts for steam reforming at 400-500°C (COMETHY); one on diesel and biodiesel reforming (NEMESIS2+) with a 50N3m/H_2 prototype; and another on biogas reforming capable of up to 250 kg of hydrogen/day (BIOROBUR)

- Hydrogen storage issues: this includes projects focusing on solid-state storage of hydrogen using boron-hydride-based materials (BOR4STORE) and magnesium-based materials (EDEN) compatible with SOFC; H_2 delivery with 400-bar composite tanks (DELIVERHY); as well as IDEALHY and ISH2SUP.

These projects have been supported by studies on electrolysers, energy storage and green hydrogen production procured directly by the FCH JU Programme Office (see section 5).

3.4 REVIEW FINDINGS

3.4.1 DEMONSTRATION

The review of demonstration projects (including proof-of-concept and balance of plant components, and diagnostics and monitoring subsystem projects) comprised 25 projects, as listed in Table 6 and 7 below. Those highlighted in bold made oral presentations during the PRD:

TABLE 06 | LIST OF ENERGY DEMONSTRATION PROJECTS REVIEWED

PROJECT NAME	DESCRIPTION
Don Quichote	Demonstration of new qualitative innovative concept of hydrogen production from wind turbine electricity
ELYGRID	Improvements to integrate high-pressure alkaline electrolysers for electricity/H_2 production from renewable energies to balance the grid
ENE.FIELD	European-wide field trials for residential fuel cell micro-CHP
FCpoweredRBS	Demonstration project for power supply to telecom stations through FC technology
FITUP	Fuel cell field test demonstration of economic and environmental viability of portable generators, back-up and UPS power system applications
POWER-UP	Demonstration of alkaline fuel cell system with heat capture
SOFC-PACT	Development and deployment of integrated fuel cell and micro-CHP systems, remotely controlled from a central point in real time

TABLE 07 | LIST OF PROOF-OF-CONCEPT, COMPONENTS AND DIAGNOSTICS PROJECTS REVIEWED

PROJECT NAME	DESCRIPTION
Asterix3	Assessment of SOFC CHP systems built on HTCERAMIX 3 technology
BEINGENERGY	Integrated low-temperature methanol steam reforming and HTPEMFC
CATION	Cathode subsystem development and optimisation
D-CODE	DC/DC converter-based diagnostics for PEM systems
DESIGN	Degradation signature identification for stack operation diagnostics
DIAMOND	Improvement of the performance, reliability, maintenance scheduling of SOFC-CHP systems by developing advanced controls and diagnostic tools
FERRET	Design of a flexible reformer in terms of catalyst membranes and control for different natural gas components
FLUMABACK	Fluid management component improvement for back-up fuel cell systems
FLUIDCELL	Development of an advanced high-performance, cost-effective bioethanol micro-CHP cogeneration FC system for decentralised off-grid applications
HYDROSOL-PLANT	Demonstration of a CO_2-free hydrogen production and provision process and related technology using a two-step thermochemical water-splitting cycle harnessing concentrated solar radiation
LOTUS	Low-temperature SOFC for micro-CHP application
NELLHI	Integration of mass production techniques for all key components for a 1kW SOFC stack in an all-European supply chain

PROJECT NAME	DESCRIPTION
PEMBEYOND	Development of a cost-competitive, energy-efficient and durable integrated PEM-based power system operating on low-grade bioethanol back-up and off-grid generation
ReforCELL	Advanced multi-fuel reformer for CHP fuel cell systems
SAPPHIRE	System automation of PEMFC systems with prognostics and health management for improved reliability and economy
SOFCOM	Demonstration of the use of biofuels as renewable fuels in high-efficiency electrochemical CHP generators
STAGE-SOFC	Development of proof-of-concept prototype of a new SOFC concept for small-scale CHP and off-wgrid applications
TriSOFC	Durable SOFC tri-generation system for low-carbon buildings

Relevance to MAIP and AIP objectives

On the whole, the project portfolio was found to be relevant to the requirements set out in the MAIP and the individual AIPS. The relevance of a few projects is more difficult to understand, either because the projects themselves are very complex and ambitious or they are poorly described. In these cases, their value within the project portfolio is questionable.

Of greatest concern to the reviewers was the extent to which the portfolio and the individual projects within it are achieving their objectives. The reviewers noted that whilst some projects have only just started and are thus not expected to have any results, there are several projects in the portfolio that are either severely delayed or simply have not been able to meet their targets, with little evidence of remediation activity. This is the case for several projects that have either reached or are due to reach the end of their contract. Overall, reviewers estimated that one-fifth of the projects were likely to realise their original stated objectives. They questioned both the capability of the projects themselves, as well as the cost and performance targets set out in the MAIP, believing that these should be revised to be more realistic. For example, more detailed targets broken down by the component level would be welcome, although this is very difficult for such a wide range of technologies and applications.

Reviewers also expressed concern that there is little likelihood that the cost targets and unit deployment numbers set out in the MAIP will be achieved, although it should be noted that the latter are EU-level targets. They noted that when cost reductions are dependent on volume production, the failure to meet deployment targets has an impact on the ability to achieve higher production volumes and hence lower costs necessary to enhance competitiveness.

Assessment of the portfolio against the state of the art is mixed. There are examples of very good projects, such as ReforCELL, whilst other projects have either not provided information on this aspect of the review, or are unaware of the state of the art. This feature of the review needs to be improved, possibly assisted by an effort by the FCH JU to identify and set out the state of the art for various technology categories.

Overlaps and duplication in the portfolio are easier to identify than gaps. Reviewers expressed concern about the relatively large number of projects focusing on CHP, especially those using SOFC technologies, as well as projects on diagnostics. It is not clear whether project efforts can be combined, but such an action would improve the value of the FCH JU portfolio.

Complementarity with other projects/programmes

The complementarity of the projects reviewed is mixed. A number are based on work undertaken in previous, publicly supported projects, be they supported by the FCH JU, under prior Framework Programmes or at the national level. Furthermore, some projects operating in conjunction with national programmes have the benefits of leveraging learning and resources.

Nonetheless, links with other projects elsewhere are almost totally limited to bilateral relations between individual partners, rather than between one project and another. This is very true of relations both between and within the FHC JU portfolio where interactions could be improved. More disappointing is the fact that linkages at the international level are poor – it is believed that European efforts could benefit from activities undertaken in other countries, such as Japan, South Korea or the USA. The review found that more could be done to encourage and foster collaboration at the European and international levels.

Horizontal and dissemination activities

The project portfolio presented limited information on horizontal and dissemination activities. Activities in the fields of safety, regulations, codes and standards is evident in projects, especially in the demonstration projects, as opposed to the proof-of-concept, components, diagnostics and control projects where much less priority is given to these issues. Training and education receive similar limited attention from projects, one common activity being the recruitment and employment of PhD or postgraduate students.

It was felt that the dissemination activities were too restricted to the European technical community, with an emphasis on papers for journals and conferences but little in the way of public dissemination. Nevertheless, there are good examples of activities pursued by SOFC-PACT and ENE.FIELD, for example. Very few patents have been reported by projects.

Exploitation plans

Overall, based on the information provided by the projects, the review found the information provided on exploitation plans was disappointing. Projects provided little or no information, or plans that were unrealistic and not credible. This may reflect a misunderstanding by the projects of the FCH JU requirements as there are examples of good, credible exploitation plans, for example those provided by CATION and FERRET, while other projects point to efforts to continue activities after the FCH JU support ends, which is encouraging. However, the overall impression is that for a portfolio of demonstration projects this is a significant weakness that the FCH JU should address immediately both for existing and future projects. Future reviews could benefit from a more prescriptive information request template.

3.4.2 RESEARCH ON FUEL CELLS

A total of 24 projects were reviewed as part of the project portfolio focusing on research into fuel cells. These are listed below in Table 8 below; those highlighted in bold made oral presentations during the PRD:

TABLE 08 | LIST OF DEGRADATION PROJECTS REVIEWED

PROJECT NAME	DESCRIPTION
ALKAMONIA	Proof-of-concept of ammonia fuelled alkaline FC for remote power applications
CISTEM	Construction of improved high-temperature PEM MEAs and stacks for long-term stable modular CHP units
DEMSTACK	Understanding the degradation mechanisms of a HTPEMFC stack and optimisation of the individual components
DURAMET	Improvement of the durability and cost-effective components for new-generation solid polymer electrolyte direct methanol FC
ENDURANCE	Improvement of the durability and reliability of SoA stacks and cells by more efficient materials
EVOLVE	Evolved materials and innovative design for high-performance, durable and reliable SOFC cell and stack
EURECA	Development of next generation of micro-CHP systems based on advanced PEM stack technology

PROJECT NAME	DESCRIPTION
IRMFC	Development of portable internal reforming methanol HTPEMFC system
LASERCELL	Innovative cell and stack design for stationary industrial applications using novel laser processing techniques
MAESTRO	Improvement of mechanical properties of low-equivalent-weight state-of-the-art perfluorosulfonic acid membranes with chemical and thermal processing
MCFC CONTEX	MCFC catalyst and stack component degradation and lifetime, fuel gas contaminant effects and extraction strategies
METPROCELL	Development of innovative proton conducting fuel cells (PCFCs) and implementation of cost-effective fabrication routes
METSAPP	Development of novel cells and stacks based on a robust and reliable scalable metal-supported technology for stationary and mobile applications
MMLCR-SOFC	Working towards mass-manufactured, low-cost and robust SOFC stacks
ONSITE	Operation of a novel SOFC-battery integrated hybrid for telecommunication energy systems
PREMIUM ACT	Predictive modelling for innovative unit management and accelerated testing procedures of PEMFC
PROSOFC	Production and reliability-orientated SOFC cell and stack design
RAMSES	Developing an innovative, high-performance, robust, durable and cost-effective SOFC based on metal-supported cell concept
SCORED 2.0	Steel coatings for reducing degradation
SCOTAS SOFC	Sulphur, carbon re-oxidation-tolerant anodes and anode supports for SOFC
SECOND ACT	Simulation, statistics and experiments coupled to develop optimised and durable micro-CHP systems using accelerated tests
SOFC LIFE	SOFCs integrating degradation effects into lifetime prediction models
STAYERS	Stationary PEM fuel cells with lifetimes beyond five years
T-CELL	Innovative SOFC architecture based on triode operation

Relevance to MAIP and AIP objectives

In general, the reviewers found the portfolio of projects to be well aligned with the objectives of the MAIP and AIP, concentrating on the durability/lifetime and cost issues of different fuel cell technologies. The portfolio addresses these issues for SOFC (11 projects), PEM (10 projects), AFC (2 projects) and MCFC (1 project) technologies. The emphasis is on mainstream small-to-medium scale CHP applications with minor efforts towards telecoms and portable uses. The reviewers stated that the portfolio's increased focus on durability and degradation issues was welcome, and requested the research community be encouraged to work with industry on key generic issues such as those carried out in Japan.

The reviewers estimated that 25 % of the effort focused on basic research, 50 % on applied research and a further 25 % on proof-of-concept, which could either be included in this portfolio or in the previous one for demonstration projects. This range of activities represents a spread of risk across more industry nearer-to-market-focused projects (e.g. LASERCELL, SCORED 2.0 and MMLCR-SOFC), and those which are high-risk, longer-term basic research projects promising innovative and more radical solutions to the technology challenges, but with little prospect of any impact before 2020. The exceptions are projects investigating the more basic aspects of durability and lifetime prediction which potentially have a wider, nearer-term impact (e.g. STAYERS, SOFC LIFE and DEMSTACK).

As in previous reviews, the presence of more basic research activities in the portfolio was welcomed by the reviewers who noted that these are crucial for Europe's long-term research and innovation efforts, and that adequate future funding is necessary for these activities. Nevertheless, careful consideration needs to be given to the degree of effort directed towards next-generation technologies and resistance to fuel contaminants, such as carbon, sulphur and biogas. This could be helped by conducting a review of the role of alternative fuels to give the FCH JU a clear strategy in this area.

Within the portfolio there is evidence of overlap in two general areas: high-temperature PEM-focused projects (e.g. CISTEM, DEMSTACK and DURAMET) and metal-supported SOFC projects (METPROCELL, METSAPP and RAMSES). Such fragmentation and duplication should be addressed by the FCH JU because although the approaches are different, the similarity in the projects' objectives is such that learning and innovation would be enhanced by more formal collaboration and coordination. Projects tackling generic issues could be one way to address this issue in future.

In contrast, gaps in the portfolio are less evident than in previous reviews, with manufacturing activities now represented.

Assessment of the portfolio against the international state of the art is mixed: 50 % of the projects were considered to be leading or internationally competitive. Although it is clear that the FCH JU is fostering a large and capable research activity within Europe, improvements are still necessary to increase the portfolio's relevance and impact. Furthermore, the self-evaluation of projects against this criterion would be improved by providing guidance on what the SOA is and how to define it so as to enable a better comparison of the projects within the portfolio.

Complementarity with other projects/programmes

There is evidence that the interactions and linkages between projects in the portfolio are improving over time. The continuity of research themes is evident, with current projects building on earlier ones from the FCH JU and EU Framework Programmes. Further, complementarity within the FCH JU portfolio seems to be improving, as is the sharing of results and findings, especially through workshops, and the simple fact that individual businesses or research institutes are participating in several projects. However, there are still opportunities for improvements through a more formal clustering of projects and feedback from demonstration projects aimed at these fuel cell research projects, for example from the ENE.FIELD project.

The reviewers found that about a third of projects are explicitly linked with Member State national programmes and/or projects, whilst most have some interaction with national activities, usually through individual project partners. As such, complementarity with national programmes is good.

International relationships were much less obvious – only a few projects had formal partners from outside Europe, e.g. DURAMET and MCFC CONTEX. This reflects the European nature of the FCH JU programme, although there is still room for improvement as regards the FCH JU projects being able to access learning and share results internationally, as indicated by the poor assessment given by many portfolio projects on the international state of the art.

Horizontal and dissemination activities

In general, assessment of the horizontal and dissemination activities undertaken by the portfolio of projects is good, although there is room for improvement. Although not a main focus of the projects, there has been some development and sharing of protocols on safety, regulations, codes and standards, such as DURAMET, SOFC LIFE and DEMSTACK. Nevertheless, work is still needed in this field of activity and stronger relationships could be nurtured among relevant cross-cutting projects.

Training and education efforts are much better, with nearly all projects recruiting a new PhD and/or early-career postdoctoral researchers. In addition, workshops and summer schools have been organised.

Dissemination activities are more varied. Dissemination to the technical community both within Europe and internationally is impressive: several projects list more than 10 conference reports or presentations and five or more papers in high-quality journals, and most projects have organised or are planning open workshops. To date, the number of patents is disappointingly low with just five for the entire portfolio.

Public awareness activities are not a priority for the portfolio, but this is not surprising for what is, in effect, a basic and applied research portfolio of limited interest to the general public. Additional efforts beyond the usual websites are evident in some projects, such as press releases and published articles. Recommendations made by the reviewers include more informative websites with more content and better links.

Exploitation plans

The prospects for exploiting the project results were found to be extremely varied. Projects aligned with industry requirements and focusing on applied research, such as MAESTRO, LASERCELL and SCORED 2.0, were found to have credible plans with good prospects for exploitation in the next few years. However, projects with a more basic research focus had poor plans which were highly unlikely to benefit industry. Whilst the exploitation plans themselves could be improved, the prospects for success will be driven by the alignment with industry and whether or not the results can be usefully applied in the short to medium term. Furthermore, the reviewers noted that there was often inconsistency between the progress a project claimed to have made and the prospects for commercialisation.

Reviewers noted that it was disappointing that industry and SMEs were managing just five of the 24 projects, calling into question whether or not the projects were aligned to the needs of industry. Furthermore, longer-term, more innovative projects tend to have poor commercialisation prospects beyond the medium term because industry is not in a position to adopt radically different technologies, partly due to limited resources, but also because of the apparent risk. In addition, the average three-year term of projects is insufficient for radical approaches to be adequately assessed and adopted by industry.

Reflecting the finding above, the reviewers recommended that, where possible, more industry-led projects be supported, whilst exploitation plans in general need to be more realistic.

3.4.3 RESEARCH ON HYDROGEN PRODUCTION, DISTRIBUTION AND STORAGE

The review of the portfolio of research projects focused on hydrogen production, distribution and storage included 20 projects. These cover a range of objectives in the broad hydrogen research field and are shown in Table 9 below; those highlighted in bold made oral presentations during the PRD:

TABLE 09 | LIST OF HYDROGEN PRODUCTION, DISTRIBUTION AND STORAGE PROJECTS REVIEWED

PROJECT	DESCRIPTION
ADEL	Development of cost-competitive, energy-efficient and sustainable hydrogen production based on CO_2-free energy sources
ARTIPHYCTION	Development and improvement of novel nano-structured materials for photo-activated processes as well as chemical systems for highly efficient low-temperature water splitting using solar radiation
BIOROBUR	Biogas robust processing with combined catalytic reformer and trap
BOR4STORE	Fast, reliable and cost-effective boron-hydride-based high-storage capacity solid-state hydrogen storage materials
COMETHY	Intensification of hydrogen production processes, developing innovative compact and modular steam reformer to convert reformable fuels to pure hydrogen and adaptable to several heat sources
DELIVERHY	Assessing high-capacity trailers composed of composite tanks with respect to weight, safety, energy efficiency and greenhouse gas emissions
EDEN	Realisation of high-density H_2 storage system in solid-state material for stationary and portable applications
ELECTROHYPEM	Development of cost-effective components for PEM electrolysers with enhanced activity and stability to reduce stack and system costs and improve efficiency

PROJECT	DESCRIPTION
ELECTRA	Development of scalable fabrication of robust tubular HTE cells with proton conducting electrolytes
HELMETH	Proof-of-concept of a highly efficient power-to-gas with methane and by thermally integrating high-temperature electrolysis with methanation
HYTIME	Construction of a prototype process based on fermentation of biomass for delivering 1-10 kg hydrogen per day and to develop a bio-hydrogen production system
HYTRANSFER	Avoiding cooling and overheating during all hydrogen transfer processes
HYUNDER	Assessment of potential actors and relevant business cases for hydrogen underground storage
NEMESIS2+	Development of small-scale hydrogen generation prototype capable of producing 50Nm^3 per hour from diesel and biodiesel at refuelling stations
NOVEL	Development and demonstration of an efficient and durable PEM water electrolyser utilising new materials that have been developed
PECDEMO	Development of a hybrid photoelectrochemical/photovoltaic tandem device for light-driven water splitting
RESELYSER	Development of high-pressure, highly efficient, low-cost alkaline water electrolyser that can be integrated with renewable energy power sources (RES) using an advanced membrane concept, highly efficient electrodes and a new cell design
SOPHIA	Development of a new generation of solar integrated pressurised HT electrolysis
SOL2HY2	Demonstration of hydrogen production through the realisation of Outotec® open and hybrid sulphur cycles using solar energy
UNIFHY	Development of a biomass steam gasification process coupled to syngas purification to produce pure hydrogen from biomass

Relevance to MAIP and AIP objectives

This portfolio of 20 projects covers the most relevant aspects of sustainable hydrogen production and hydrogen transportation and storage. They all address, to a greater or lesser extent, the MAIP and MAWP objectives, as well as the AIPs associated with the annual calls. The reviewers noted the need to ensure that the FCH JU's objectives were aligned with Europe's green energy and smart energy ambitions.

The projects range from RCS-focused activities, through to basic and applied research activities, for electrolysis, for example. There is some activity on proof-of-concept and pilot-scale prototypes. Whilst some of these projects are built upon previous work supported by the FCH JU or EU Framework Programmes, there will be a need for demonstration projects in future, such as for electrolysis developments, to show that the technologies are feasible and commercially relevant. This will have to be balanced with continued 'frontier research' for scientific and technical breakthroughs.

There are no apparent gaps in the range of projects in the portfolio at this stage, other than that described above for demonstration projects in due course. Any overlap and duplication of activities between projects is limited. Where projects are similar in terms of objectives, for example, fuel-processing catalysts or materials and components for PEM electrolysers, the approaches are different. Nevertheless co-operation between such projects is recommended to ensure that learning is shared and synergies are maximised.

As in other portfolios, the assessment of projects versus the state of the art is limited. The self-assessments made by more than half the projects is generic and too limited in detail to allow the reviewers to make comparative assessments. Only four projects make an adequate self-assessment of activities compared to the international state of the art. Where there is enough information for an assessment there is evidence of some internationally competitive work. However, overall the reviewers stated that this aspect of the review must be improved in the future. As part of this, a better and more prescriptive guidance on SoA for projects provided by the FCH JU would benefit the review process, as would an assessment of the SoA undertaken or supported by the FCH JU, for example, a knowledge management observatory.

Complementarity with other projects/programmes

Complementarity with other projects and programmes within the portfolio is better than previous years. Many of the projects (e.g. ADEL, SOPHIA, NEMISIS2+, NOVEL) build on the results of projects previously funded by the FCH JU or EU Framework Programmes. This continuity in learning and ideas is encouraging for the sector as a whole and the FCH JU. This benefit is enhanced by the fact that a number of participants are involved in related or relevant projects, either within the FCH JU portfolio or projects at the national Member-State level. Further improvements are evident in the organisation of workshops on common subjects between different projects in the portfolio.

More formal interactions between projects within the portfolio and those in other European or Member-State programmes are less evident than expected, although this situation is improving, reflecting a growing interest in the area. As such, there is evidence of co-funding in some projects e.g. Scandinavian countries, and joint workshops are also being held – for example, RESELYSER and ELYGRID held a joint workshop with the German NOW programme.

International interactions are more limited: some projects are linking to activities with the IPHE, e.g. SOPHIA, and the US DoE, e.g. SOL2HY2, while others have links with projects in other countries, e.g. South Africa, India and Mexico, either with projects directly or through individual project partners.

Overall, given the growing interest in the hydrogen sector, generally speaking there is room for improvement in both complementarity and relationships with other projects and programmes at the European and international levels. Joint workshops have a role to play here, but more formal linkages with national programmes may be required by the FCH JU to ensure that the benefits of joint learning and funding are maximised.

Horizontal and dissemination activities

The review of the horizontal and dissemination activities undertaken by the portfolio projects found a good range of different actions. Safety and RCS were considered to be the most relevant to hydrogen storage and transport projects. Progress had been made by both DELIVERHY and BOR4STORE, identifying barriers to the use of high-pressure trucks for H_2 transport in the former, while the latter was able to harmonise material-testing procedures.

Training and education activities tend to focus on the recruitment and employment of PhD students and/or postdoctoral researchers. Several projects have had inputs in or developed course content for MSc or other students, or are organising 'schools' for PhD and graduate students – for example, BIOROBUR. The reviewers noted that the transfer of knowledge to the education sector is an important aspect of supporting the commercialisation of FCH technologies, although this would be better undertaken by cross-cutting projects than individual research or demonstration projects.

The portfolio's dissemination activities are evidenced by the presentations made at conferences, reports, and workshops undertaken. Most projects have provided papers for conferences, although the dissemination value of presentations is limited. Of greater value are the workshops being undertaken alone or jointly by almost half of the portfolio. Publications in recognised journals are a good way of disseminating the results of more research-focused projects, such as BOR4STORE, ADEL, EDEN and ELECTROHYPEM. In contrast, across the entire portfolio, only four patents have been applied for with one more under preparation.

Actions by the portfolio to address public awareness are limited, with an emphasis producing a website. While some are useful, others provide little information or are not updated on a regular basis, thereby limiting their value. The reviewers recommended more action in this area, although research-focused projects may be of little interest to the general public, as against specific stakeholder groups.

Exploitation plan

The exploitation plans for this portfolio of projects tend to be outlines and general statements rather than details on the plans required to take results or developments to the market place. The lack of such plans was identified as the portfolio's main weakness. However, although of poor quality overall, it is apparent that much depends on the evolution of the hydrogen economy over the medium to longer term. Thus, partners in some projects have plans to integrate project results into their future products in the medium term. The prospects for using more basic/applied activity results in future developments and demonstrations are on a time horizon of five or more years for commercially relevant demonstrations. Even where projects have more generic activities with implications for RCS, it is not expected that these results will feed into the RCS frameworks for two to three years after the end of the project. Nonetheless, the reviewers believe that more work is needed to improve the understanding of the prospects for commercialisation and the development of better exploitation plans through guidance and the dissemination of best practices.

04 CROSS-CUTTING

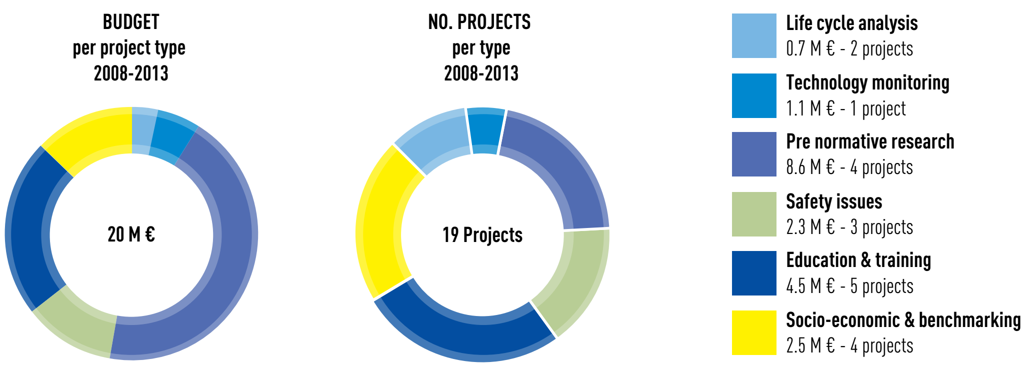
4.1 OBJECTIVES

Cross-cutting FCH JU projects support the commercialisation activities of the two FCH JU pillars, transportation and energy. They are critical to the overall FCH JU strategy and portfolio, as initially set out in the MAIP and now the MAWP. The portfolio's primary goals are to support commercialisation through market support measures, including: PNR and harmonised RCS, and safety; to raise public awareness and support educational activities in the field of FCH technologies for the range of stakeholders, in addition to Europe's students; to undertake technology, environmental, energy and socio-economic assessments; and to develop tools to help in monitoring the implementation of the FCH JU research and demonstration programme.

4.2 BUDGET

A budget of between 5 % and 6 % was allocated under the MAIP for cross-cutting projects (see Figure 8 and 12). The cumulative funds for cross-cutting projects from 2008 to 2013 are shown in Figure 14.

FIGURE 14 | CROSS-CUTTING PROJECTS BY VALUE (€) AND NUMBER



Nineteen projects have been supported by EUR 20 million of FCH JU funds, or just under 5 % of the FCH JU budget for 2008-2013. The vast majority of funding went to PNR projects, with smaller sums for education and training, safety issues and socio-economic studies and benchmarking. The remaining amounts have funded life-cycle analysis and technology-monitoring projects.

In addition to those supported strictly within the cross-cutting activity, further cross-cutting projects have been supported within the energy and transportation pillars.

4.3 FOCUS AREAS AND ACHIEVEMENTS

Focus areas

The cross-cutting project portfolio has been formulated to support the following (with emphasis on the first two):

- Safety: understanding safety issues associated with the deployment and adoption of FCH technologies in the various applications, e.g. transportation and stationary CHP, with an emphasis on technical safety, including but not limited to, PNR

- PNR: research into aspects of FCH technologies which are essentially pre-competitive and of interest to the industry as a whole

- Education and training: actions to provide education and training for both the FCH sector, including but not limited to, scientists, engineers, technicians and for decision/policy-makers outside the sector, as well as the professional education sector

- RCS: projects that develop the necessary regulations, codes and standards for the deployment of FCH technologies, often in conjunction with the safety and PNR activities above

- Social acceptance and public awareness: general public conferences and workshops, brochures, public 'show rooms', such as museum displays; addressing and informing local authorities, certification bodies, 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

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

Achievements

The FCH JU has supported 19 cross-cutting projects over the first phase (2008-13).

These projects have provided the following positive outcomes:

- Safety: assessment of best practice for CFD in safety analysis; assessing efforts to ensure that FCH technology is safe; and EU/USA joint collaboration on H_2 sensors

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

- Education and training: vocational training; training for regulators and public safety experts; international curriculum on FCH technologies; and hydrogen emergency response training for first responders

- Socio-economic: understanding social acceptance of hydrogen technologies across Europe and a study to design a European framework for green hydrogen guarantees of origin.

4.4 REVIEW FINDINGS

The ten ongoing cross-cutting projects reviewed are listed in Table 10 below; those highlighted in bold made oral presentations during the PRD:

TABLE 10 | LIST OF CROSS-CUTTING PROJECTS REVIEWED

PROJECT	DESCRIPTION
	SAFETY PROJECTS
HYINDOOR	PNR for safe indoor use of fuel cells and hydrogen systems
MATHRYCE	PNR for metallic components exposed to hydrogen fatigue
FIRECOMP	Modelling the thermo-mechanical behaviour of high-pressure vessels in composite materials when exposed to fire conditions
HYPACTOR	Provision of recommendations for regulations, codes and standards regarding qualification of composite overwrapped pressure vessels and procedures for periodic inspections
Stack test protocols	
STACKTEST	Development of PEM fuel cell stack reference test procedures for industry
SOCTESQA	Development of standardised industry-wide test protocols for SOFC and SOEC assembly units according to different system applications
	HYDROGEN STANDARDS
HYCORA	Provision of information to lower the costs of hydrogen fuel quality assurance
	GENERIC H_2 SAFETY TOOLS
H2TRUST	Development of H_2 safety expert groups and due diligence tools for public awareness and trust
SUSANA	Support to safety analysis of hydrogen and fuel cell technologies
	H_2 SENSOR PROJECT
H2SENSE	Cost-effective and reliable sensors for facilitating the safe use of hydrogen

Relevance to MAIP and AIP

This is a strong portfolio of projects which supports the commercialisation of FCH technologies in the transportation and energy pillars. It represents an improvement on previous years when there were too few cross-cutting projects. Projects address five broad areas:

- specific safety issues for hydrogen, e.g. PNR for safe indoor use and for metallic hydrogen components
- hydrogen standards
- generic hydrogen safety issues
- hydrogen sensors
- fuel cell stack test protocols.

As such, all projects are aligned with MAIP and MAWP objectives for the cross-cutting activity and contribute to these objectives, although progress within individual projects is difficult to quantify.

There is variable industry involvement in some projects: some have a very good balance between industry and research, while others are wholly or predominantly research-orientated with implications for the relevance and accessibility of their work to the FCH industry in Europe.

There are gaps in the current portfolio which are known to have been addressed in previous reviews of past portfolios. The most notable concerns the lack of projects addressing the core education and training activity, although individual projects are undertaking some of this activity, to a greater or lesser extent. Furthermore, there is no support for SMEs as regards developing the supply chain for FCH technologies. The greatest concern is that the portfolio will require further relevant PNR projects in the coming years; thus, it is important that the FCH JU can ensure that the opportunities for such projects are made available in future AWPs.

As noted above, the projects represent a good spread of activities in the cross-cutting area, and tend to complement each other rather than overlap or duplicate. For example, SCOTESQA and STACKTEST address SOFC and PEM technologies, respectively, whilst FIRECOMP, HYPACTOR and MATHRYCE focus on different aspects of hydrogen safety for containers.

Assessment of the portfolio's state of the art is that, generally speaking, it is at the cutting edge of scientific and technical activity, in particular within a European context, although less so internationally. Some work has been undertaken on aspects of the projects in the USA, Canada and Japan, for example, as regards the safe indoor use of hydrogen and fuel cell systems, hydrogen fatigue, and performance testing for automotive standards. In other areas, there are existing standards, such as ISO 14687-2 for hydrogen fuel quality. Nevertheless, on the whole the projects demonstrate considerable novelty in terms of state of the art.

Reflecting the positive view of the portfolio, the reviewers recommended that the portfolio be reviewed regularly to identify substantive gaps in terms of education and training and awareness, plus other areas as and when results and lessons learned become available. This should be complemented by recommendations made by the projects themselves which identify any weaknesses and gaps as they undertake their work. Further, they recommended that the FCH JU should develop more specific targets and metrics against which the progress of cross-cutting activities and projects can be measured. These need to go beyond simply listing conferences attended or publications – for example, the number of workshops held or businesses engaged would provide some level of information on the projects' added value.

Complementarity with other projects/programmes

Evidence for complementarity and synergies with other projects and programmes in Europe and internationally is mixed. Projects operating in relative isolation from the wider community, both at the European and international level, are unlikely to maximise on the benefits coming from their work which, for cross-cutting projects, is a prime reason for their activity. It is disappointing that there is limited evidence that projects are making conscious, planned efforts to maximise collaboration and synergies. Nonetheless, good examples of potentially very valuable relationships at the European and international level are evident in some projects.

Many of the projects describe extensive and strong links with other projects either within the FCH JU portfolio or with projects from previous EU framework Programmes, such as FP6. Evidence of strong linkages between the current portfolio projects focused on hydrogen containers, e.g. FIRECOMP and HYPACTOR, and between those focused on testing protocols, e.g. STACKTEST and SOCTESQA, and others in other programmes, e.g. FCTESTNET and FC TESQA, is encouraging. There are also more informal links between projects at the partner level with the same partners involved in a range of projects.

Evidence of linkages and relationships with projects in national programmes in other Member States is generally limited to individual partner level. It is not clear what, if any, efforts are being made by projects to formally link to other programmes and projects within Europe's Member and Associated Countries. Conversely, international relationships and complementarity are evident in the majority of projects. This either takes the form of links to international standards committees, e.g. SOCTESQA, or to relationships with other country programmes, e.g. USA, Japan and Canada. Several projects are working closely with these other countries – for example, MATHRYCE with Japan and the USA – whilst others have a formal collaboration with entities from other countries, such as SOCTESQA with Singapore.

The sharing of results and learning appears to be weak. There is evidence that some projects are making use of other FCH JU and European projects, as well as international standards committees and fora, to share their learning and results. Such proactive sharing is likely to lead to good levels of dissemination. However, there are also projects which appear to be taking a very passive approach to sharing, relying upon publications and conferences at best, and generally failing to demonstrate any sharing with other projects.

Reviewers recommended a greater effort be made to ensure that projects collaborate outside the FCH JU portfolio. This is important for those focused on standards which should have mandatory formal links to the international FCH community setting and reviewing standards. In addition, the evaluation of projects should place more emphasis on the active sharing of learning and results – projects failing this criterion should not be supported. Finally, there may be a case for the mandatory use of procedures developed in these projects – for example, test procedures to be used by FCH JU projects within the pillars – although these will have to be agreed by industry.

Horizontal and dissemination activities

Generally speaking, the horizontal and dissemination activities undertaken or planned by the 10 projects are good. There will be considerable benefits for safety, regulations, codes and standards, but less so for training and education. The benefits for dissemination will probably be much more variable and will vary considerably on a project basis. The emphasis some projects put on conference papers and publications may have less of an impact on the community than the workshops and other activities certain projects are pursuing or have planned to engage industry.

A number of the projects are focusing on safety aspects of FCH technologies – for example, indoor use of hydrogen, hydrogen sensors and safety of hydrogen containers. These are already engaged with or plan to be engaged with the RCS communities in Europe and globally: for example, H2SENSE is working with a similar initiative in the USA. It is also the case that projects are focused on pushing forward the state of the art regarding safety aspects, such as HYPACTOR for composite overwrapped pressure vessels. One area for improvement is the development of a uniform process for projects to engage with the standardisation and regulation development process; at present, it is not clear how projects will achieve this important activity.

There are no projects focused simply on training and education per se. There is a degree of training and education in a number of projects, but by and large this is not specifically highlighted in any of the cross-cutting projects reviewed. However, the previous prominence of these training and education projects in the cross-cutting portfolio should be noted.

Some projects have undertaken considerable dissemination activity. A number of the project websites developed are seen potentially as very useful gateways to the issues, information and results from the projects themselves. There would appear to be a dichotomy between projects focused on conference presentations and papers, and those with a greater emphasis on workshops, especially for experts and industrial end-users. Where conference presentations have been made, their value for dissemination purposes is questionable, especially since some projects seem to be presenting early in the project's lifetime when there are few if any results available. However, it is encouraging that some projects, even though they are essentially PNR, have a good representation in industry, and are seeking to further engage with it through industry advisory boards and workshops, for example, SOCTESQA and STACKTEST.

Projects show varying levels of interest/activity in publications. It tends to be research/academic-led projects in which considerable emphasis is placed on academic publications and conferences, although rarely in peer-reviewed journals. The value of such passive and academic-focused dissemination activities to the FCH industry and businesses remains questionable.

There is no evidence that these projects will lead to patents. Indeed, as cross-cutting activities, it would be surprising if this were to be the case. Similarly, public awareness is not the aim of any project, with the exception of H2TRUST which aims to develop safety expert groups and due diligence tools for public awareness and trust.

Exploitation plans

There is mixed evidence regarding the likelihood that these projects will have a significant impact on the commercialisation of FCH technologies. Where projects are industry led or have a substantial industry involvement there is some confidence that their results will be adopted by industry or will benefit industry's commercialisation effort. However, several projects display weak industry involvement and are overwhelmingly focused on dissemination rather than exploitation, with poor plans for any future use of the results and an emphasis on passive and academic dissemination activities via conferences and papers. This calls into question whether or not and how the results of PNR projects, in particular, are being exploited, primarily over the longer term.

More effort is required to ensure that the results of these important cross-cutting projects are available for use by industry and, where appropriate, feed into RCS activities in Europe and internationally. Engagement with industry as the ultimate end-user of the projects is critical; one means of achieving this is through a greater use of workshops and industry advisory groups, although other methods should also be considered. Credible exploitation plans are required from all projects.

Finally, in the longer term, there is concern as to whether and how the project results and lessons learned are made available once the project has been completed – for example, the sustainability of websites and their contents once a project has finished.

05
FCH JU-FUNDED STUDIES

The FCH JU has financed and supported a number of studies in the FCH field. These studies concern specific applications for FCH technologies and aim to:

- Provide an understanding of the technical feasibility and market potential of these technologies
- Establish their competitive and cost position vis-à-vis other technologies
- Develop plans for accelerating commercialisation.

Four ongoing studies were presented at the 2014 Review:

- Commercialisation Strategy for Fuel Cell Electric Buses in Europe
- Fuel Cell Distributed Generation Commercialisation Study
- Commercialisation of Energy Storage in Europe
- Financing Study

The studies were carried out by leading global consultancies, contracted according to a competitive bidding process, to ensure high-quality, relevant and actionable outcomes. They were undertaken in collaboration with relevant stakeholders from industry and end-users, as well as other actors from industry associations and policy bodies[3].

5.1 COMMERCIALISATION STRATEGY FOR FUEL CELL ELECTRIC BUSES IN EUROPE

The study aims to identify locations to implement large-scale fuel cell (FC) bus demonstration projects and support implementation. It follows an earlier 2012 study, 'Urban buses: Alternative Power Trains for Europe' undertaken in 2012, which identified FC buses as providing the most operationally flexible and zero-emissions option for future clean urban transport. The main disadvantage was that FC buses cost 217 % more than diesel buses.

The current study seeks to mobilise European bus operators to commit to between 500 and 1000 buses for demonstration between 2017 and 2020 with a view to achieving cost reductions and proving the business case in advance of a roll-out from 2020 onwards.

3 Once published, the studies can be accessed on the FCH JU website at http://fch-ju.eu/studies

A coalition of 30 industry and public stakeholders, comprising bus operators, bus manufacturers and providers of hydrogen and hydrogen infrastructure, has been created to support the study. The coalition shares learning and experiences to identify operational requirements and solutions, and reduce capital costs.

The initial findings/outcomes:

- Although the cost premium of FC buses compared to alternatives will fall significantly, it will still be 11 % higher by 2030; deploying more buses earlier will support cost-reduction scale effects

- By autumn 2014, it had been established that a total of 267 FC buses were needed to be deployed from 2017 to 2020, with 20-30 buses per location; this number will increase as other locations firm up their plans. The work also identified a requirement for further support for project validation and cost assessment

- A storyline setting out the case for FC buses: deployment of FC buses will enable political commitments to decarbonise public transport; they will reduce urban emissions; they are the most operationally flexible of the zero-emission technologies; and they will reduce the external costs of public transport.

The study and work will continue to close the gap in terms of FC bus numbers – by seeking increased commitments from bus operators and localities – so that the final total will be closer to 500-1000 by 2020, and 8000 to 10 000 by 2025. The work will also analyse price sensitivities, prepare joint procurement activities (letters of intent), and disseminate know-how and lessons learnt.

5.2 FUEL CELL DISTRIBUTED GENERATION COMMERCIALISATION STUDY

The objective of this study is to establish a common view on the future market potential of distributed generation, and to understand the various technologies available, their potential applications, prospects and business opportunities, and to document and disseminate findings to decision-makers in industry and the policy community.

This study is supported by a coalition of 20 members of the fuel cell industry, mostly stationary fuel cell developers, and 15 other stakeholders in adjacent industries, research institutes, the public sector and associations.

This is the most comprehensive assessment of the commercialisation potential of stationary fuel cells undertaken in Europe, focusing on four different markets and six generic fuel cell types. It is carrying out comparisons with 30 other technologies under three energy scenarios.

The study sets out the potential role of stationary fuel cells in future energy systems. The analysis, which is being conducted for three segments (residential, commercial and industrial), shows that stationary fuel cell technologies have a clear emissions reduction advantage plus the lowest net energy costs, although capital costs are currently too high.

The initial findings/outcomes include:

- Residential: the addressable market for FC CHP of approximately 2.5 million units/annum exists in core European countries, with 1 million units each in Germany and the UK foreseen by 2030. In this application, FC CHP units produce 30 % less CO_2 than condensing boilers and completely eliminate NOx. It is estimated that FCH units could be cost competitive when a cumulative production of 100 000 units per company is achieved

- Commercial: there is an annual market potential of 7.5 to 10.3 GW of installable capacity for units of 5 kW to 400 kW in the commercial heating market. In these applications, FC units could reduce CO_2 emissions by 40 %, whilst a reduction in capital costs, enabling these units to become competitive, would be possible when a cumulative production of 1000 units per company is achieved

- Industrial: an annual market of 2.4 GW of installed capacity for FC units above 400 kW is possible. Again, these units would produce less CO_2 and NOx than competing technologies. An individual cumulative production per company of 300 MW would be required to become cost competitive with gas engines.

The study considers three levers to unlock the benefits of stationary fuel cells: reducing capital costs and hence price levels; further performance improvements; and establishing an appropriate policy framework. The first is a function of production and learning curves; opportunities for further improvements to stationary FC performance do exist, although engaging with policy-makers and influencing policy framework will first require a commitment from industry to reduce costs and improve technology performance. Such actions could enable implementation plans to be drawn up with the objective of a technology roll-out and industrialisation between 2015 to 2020 for residential and industrial segments, and up to 2030 for the commercial segment.

5.3 COMMERCIALISATION OF ENERGY STORAGE IN EUROPE

The objective of this study is to assess the role and commercial viability of energy storage, including power-to-power, power-to-heat and power-to-hydrogen for use outside of the power sector.

The study recognises the role that FCH technologies could play in future energy storage options using hydrogen as a vector between growing intermittent renewable energy power generation (estimated to grow from 11 % in 2014 to 27-40 % by 2030 and 33-65 % by 2050) and power, heat and hydrogen as a fuel for use in transportation.

A coalition of over 30 organisations in the power and energy sectors has been set up, and includes OEMs and fuel and gas suppliers. The work is aimed at policy-makers, regulators, investors, OEMs and utilities to help them understand energy storage options and set out a business case, along with actions, to improve the competitiveness of energy storage.

Two questions are addressed:

1. What role will storage play in long-term RES integration in the 2030-2050 horizon?

2. What are the short-term, early market opportunities for storage and the actions required to achieve these?

The study methodology comprises undertaking assessments in three countries and one region of different energy systems based on industry-accepted storage and electrolyser cost predictions.

Initial findings/outcomes include:

- The demand for power-to-power to provide time-shift energy storage could grow tenfold by 2050

- The demand for storage is highest in island energy systems, e.g. Greek islands, and lowest in countries with high hydropower, e.g. Sweden

- Conversion to heat and heat storage will absorb some of the excess RES power, but additional conversion of excess power to hydrogen for use outside the power sector would be required for all the excess to be used

- Back-up non-RES power production will still be required

- Commercially viable opportunities for storage are available in the short term

- Regulatory change is key for developing a viable business case for energy storage.

5.4 A ROAD MAP FOR FINANCING HYDROGEN REFUELLING STATIONS

The objective of this study is to address the issue of financing the roll-out of HRS networks in Europe and the role of different potential stakeholders in such a road map. These stakeholders include: industrial strategic investors, e.g. car OEMs, hydrogen suppliers and HRS builders and operators; public authorities; and public and private finance providers. The study was conducted in collaboration and consultation with two national hydrogen mobility coalitions from Germany and the UK, alongside the FCH JU and European Investment Bank, whilst also consulting with a number of European banks and financing institutions.

Against a background of positive movement towards commercialisation of FCEVs from 2015 onwards, the national hydrogen mobility initiatives in Germany, UK, Scandinavia and France have identified a need for over 600 HRS by 2023. However, such a network will require an estimated investment of EUR 600 million and to date no road map to deliver this funding has been developed.

Although a relatively small sum in the context of the potential of hydrogen mobility in the longer term, nevertheless this represents a considerable amount for private finance, given the associated risks. The success of any investment will need to contend with the rate of FCEV roll-out by OEMs, the underutilisation of initial HRS, net present value (NPV) calculations of between 10 and 15 years, and first mover disadvantage where early investors are unable to gain any advantage over later investors. In the absence of any credible plan to tackle these issues, private investment in the HRS network will be very difficult.

In assessing the issues and options, the study has identified a step-by-step approach to HRS network development and investment that can generate a viable business over time in both the UK and Germany. This approach comprises three phases:

1. A pre-bankable phase when HRS network development is supported by committed strategic investors and the public sector through government actions;

2. A transition phase which is supported by specific financing instruments available from public sector finance institutions, such as public development banks, and possibly private equity investors, allowing HRS to build up a successful business and credit history;

3. A bankable phase when the HRS network and FCEV fleets are of sufficient size to generate consistent profitable sales of hydrogen enabling normal private financing by commercial banks and infrastructure investors.

This road map could also be used in other national mobility initiatives.

The study identifies roles for governments, strategic investors and public finance in the initial deployment and growth phases of hydrogen mobility in Europe.

The role of strategic investors is critical in that they will need to provide FCEV sales commitments which will ensure that the market develops as forecast. It is apparent from the modelling that deviations from such forecasts adversely impact the business case through lower revenue lines.

The study also notes that the part played by governments can go beyond regulation to 'kick-start' HRS roll-out through the provision of a mix of favourable loans and/or grants, along with concessions or guarantees which encourage other stakeholders to make the necessary early HRS investment.

06
CONCLUSIONS

6.1 OVERVIEW

The 2014 Review has found that overall the FCH JU portfolio is strong and aligned with the principles of the MAIP. It comprises a range of basic and advanced research projects, along with demonstration projects that focus on the goal of commercialising FCH technologies in both the transportation and energy pillars. This portfolio is strengthened by a range of strategic commercialisation studies commissioned by the FCH JU over the last few years.

A number of projects are world leading – for example, the bus demonstration projects and materials research projects in the fuel cell field – and offer promising prospects for both near- and longer-term real-world applications.

In looking at the trends, it is apparent that the portfolio has been both strengthened and improved since the reviews started in 2011. Now, more projects are aligned to industrial need, links between industry and the research community are stronger, and there is evidence of better management and reporting. Furthermore, projects are largely complementary with few obvious gaps, and limited overlaps and duplication.

However, it is inevitable in such a large programme that projects and specific research and demonstration areas remain which are relatively weak in terms of coherence and alignment with the FCH JU's goals, as well as some projects that are unlikely to meet their original targets. Consequently, there are still areas for improvement.

6.2 PARTICIPATION IN THE FCH JU PROGRAMME

The FCH JU has been successful in coordinating a broad range of entities, from both the research community and industry, which are able to contribute to the challenging objective of commercialising FCH technologies. The portfolio of 155 projects includes 545 beneficiaries representing all except six of the EU's Member States.

The industry focus of the research and demonstration programme is evident in that 35 % of participants are large industrial businesses, whilst another 28 % are SMEs, emphasising the innovative and entrepreneurial character of the FCH JU portfolio. At the same time, the inclusion of research and higher education research institutes, comprising 31 % of participants, points to the substantial basic and breakthrough research capability available in the programme.

The involvement of greater numbers of regions and municipalities in demonstration projects is evidence of the relevance of FCH-technology-based solutions to the energy and emissions challenges that exist at the regional and local community levels, for example, clean urban transport. This involvement also shows the leverage effect of the FCH JU's investment in projects, drawing in investment from other entities outside of the Undertaking's public and private members.

6.3 FCH JU PORTFOLIO OF ACTIVITIES

The FCH JU portfolio comprises a balance of projects ranging from basic, breakthrough and applied research, and demonstrations. Thus, early commercialisation opportunities are being pursued through demonstration projects, whilst basic and applied research projects are providing a better understanding of the issues affecting FCH technologies, and breakthrough projects are identifying the technologies necessary in the longer term.

Within the transport pillar, demonstration activities for both buses and fuel cell cars are laying the foundations for accelerating deployment in the coming years. These projects are backed up by the research portfolio seeking to improve individual cell and stack materials, components and designs to reduce cost and enhance performance.

The energy pillar has a broader range of research projects, whilst the demonstration projects are improving over time. Research projects in the portfolio are generating international state-of-the-art developments and progress in the fields of materials for both PEMFC and SOFC technologies, whilst a number of projects are focused on cost reduction through improvements in manufacturing. As with transportation, there is a demand for more feedback from demonstration activities for research.

In the sphere of hydrogen production, the FCH JU portfolio is improving electrolyser performance and alternative hydrogen production routes, targeting better integration of Europe's indigenous renewable energy sources into the energy system.

The FCH JU's cross-cutting project portfolio has continued to expand from a relatively limited effort in the early years. A growing number of projects are focusing on pre-normative research relevant to a wide range of businesses.

6.4 LESSONS LEARNT AND RECOMMENDATIONS

The lessons arising from the 2014 Review are very similar to those that coming from earlier reviews, in particular the need to ensure that projects are relevant to the requirements of industry and commercialisation. The potential benefits of the widespread deployment of fuel cell transport, stationary fuel cells and hydrogen production and logistics are substantial and all efforts should focus on realising this potential to the benefit of Europe and its communities.

Technical targets need to be reviewed and improved – they should be ambitious and relevant, as well as measurable. They should include technical targets – for example, performance targets for systems, subsystems and components – and cost targets. Such targets would enable a better assessment of the progress of the projects and the portfolio as whole.

Better feedback of information and data from demonstration projects for research would improve the relevance and focus of the research community's work. At present, there is limited or delayed feedback to the research community which impacts programme efficacy and efficiency.

Where appropriate, shared learning and collaboration within the portfolio, with other European and Member State projects and with the rest of the world, would help build up the knowledge base in Europe. It would also avoid unnecessary investment in 'reinvention and rediscovery'. This shared learning will help accelerate progress towards commercialisation.

The cross-cutting portfolio would benefit from further projects and efforts, as planned in the MAWP, on safety and RCS issues. In the run-up to pre-commercial deployment and then commercialisation these issues, along with education and training, are key areas for focus by the FCH 2 JU on market preparation.

Finally, in terms of management and reporting, continued improvement is required by individual projects. Better reporting against targets will help to determine whether specific projects are on target and, if not, what remediation actions are planned or being undertaken. Similarly, state-of-the-art assessments must be improved to ensure that valuable resources are focused on internationally competitive demonstration and research projects.

6.5 OUTLOOK FOR THE FCH JU

The FCH JU made considerable progress under FP7 in developing a strategy for accelerating the commercialisation of FCH technologies and then enacting this through a comprehensive research and demonstration programme. Significant achievements have been made to date, but further work is required under the Horizon 2020 programme.

Further developments in technology are necessary to improve performance and reduce costs. Total cost of ownership is critical in determining the overall attractiveness of FCH technologies to end-users, especially individual consumers. The FCH programme now includes projects focused on bringing the cost of products down, by improving materials and components and/or manufacturing developments – these will need to continue and grow.

As noted above, market preparation activities in the fields of safety and RCS, and education and training are an important part of the process of commercialising FCH products. These activities need to be maintained and strengthened where appropriate.

The FCH JU, industry and research also needs to work with other entities to leverage investment and develop the financing initiatives necessary for the next stage of FCH technology deployment. The studies supported by the FCH JU have begun the process of developing shared visions with a range of stakeholders from industry, government and communities. The next step is to realise these visions in collaboration with these and other stakeholders.

GLOSSARY

AC	Associated Country
AFC	Alkaline Fuel Cells
AIP	Annual Implementation Plan
AWP	Annual Work Plan
APU	Auxiliary Power Unit
BoP	Balance of Plant
CFD	Computational Fluid Dynamics
CHP	Combined Heat and Power
CGH2	Compressed Gaseous Hydrogen
CO_2	Carbon Dioxide
DC	Direct Current
DoE	Department of Energy (USA)
EC	European Council
EU	European Union
FP6	Sixth Framework Programme for Research and Technological Development
FP7	Seventh Framework Programme for Research and Technological Development (2007-2013)
FC	Fuel Cell
FCH	Fuel Cell and Hydrogen
FCH JU	Fuel Cell and Hydrogen Joint Undertaking (2008-13)
FCH 2 JU	Fuel Cell and Hydrogen 2 Joint Undertaking (2014-20)
FCEV	Fuel Cell Electric Vehicle
GDL	Gas Diffusion Layer
GHG	Greenhouse Gas
GW	Gigawatt

H_2	Hydrogen
HRS	Hydrogen Refuelling Station(s)
HT	High Temperature
HTPEMFC	High-Temperature Proton Exchange Membrane Fuel Cells
HTE	High-Temperature Electrolyser
IPHE	International Partnership for Hydrogen in The Economy
ISO	International Organization for Standardization
KW	Kilowatt
M	Million
MAIP	Multi-Annual Implementation Plan
MAWP	Multi-Annual Work Plan
MCFC	Molten Carbonate Fuel Cells
MEA	Membrane Electrode Assemblies
MHV	Material Handling Vehicles
μCHP	Micro-Chp
MW	Megawatt
NEW-IG	European Industry Grouping
Nm^3	Normal Cubic Metre
NOx	Nitrogen Oxide
NPV	Net Present Value
OEM	Original Equipment Manufacturer
PCFC	Proton-Conducting Fuel Cell
PEMFC	Proton Exchange Membrane Fuel Cells (also referred to as PEM)
PNR	Pre-Normative Research
PRD	Programme Review Days
Pt	Platinum
PV	Photovoltaic
RCS	Regulations, Codes and Standards
RES	Renewable Energy Sources

RTD	Research and Technology Development
SET-Plan	Strategic Energy Technology Plan
SME	Small and Medium-Sized Enterprises
SoA	State of The Art
SOEC	Solid Oxide Electrolyser Cell
SOFC	Solid Oxide Fuel Cells
TEN-T	Trans-European Networks - Transport
TCO	Total Cost of Ownership
UAV	Unmanned Aerial Vehicle
UPS	Uninterruptable Power Supply
UK	United Kingdom
USA	United States of America (also referred to as US)

SECTION 02

PROJECT POSTERS

ADEL

Advanced Electrolyser for Hydrogen Production with Renewable Energy Sources

CALL TOPIC	New generation of high-temperature electrolyser
START-DATE	1 January 2011
END-DATE	31 December 2013
TOTAL BUDGET	€4,155,776
FCH JU CONTRIBUTION	€2,043,518
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: HTceramix-SOFCpower

Partners: Accelopment AG, Commissariat à l' energie atomique et aux energies alternatives, Deutsches Zentrum fuer Luft- und Raumfahrt (DLR), Europaisches Institut für Energieforschung, Eidgenoessische Materialpruefungs- und forschungsanstalt, Abengoa hydrogeno, HyGear BV, Fundacion IMDEA Energia, JRC, Topsoe Fuel Cell A/S, Empresarios Agrupados Internacional SA.

PROJECT WEBSITE/URL

www.adel-energy.eu

PROJECT CONTACT INFORMATION

Olivier Bucheli

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MAIN OBJECTIVES OF THE PROJECT

ADEL aimed at developing a new steam electrolyser concept. The approach was to lower the electrolyser operating temperature to increase its lifetime and to couple flexibility with thermal sources. The challenge is to maintain satisfactory performance and to optimise the energy transformation efficiency at the level of the complete system, including the heat and power source. Efforts comprised materials, cell and stack development and their testing under conditions derived from the renewable energy availability, the design of electrolyser units including the balance of plant components, and the conceptual integration of such units in case studies.

PROGRESS/RESULTS TO DATE

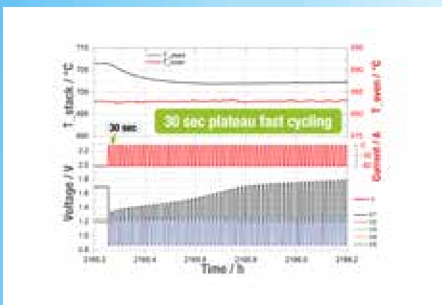
- The demonstration of high-performance SOE technology, compatible with intermittent power sources, with a reasonable durability.
- Detailed modelling of intermediate temperature electrolyser system (ITSE) and development of control strategies for coupling with intermittent renewable power and heat sources.
- Detailed flow-sheeting of complete H_2 production plants coupling ITSE with renewable heat and power sources, and cost analysis of the most promising combinations.
- The specifications of a demonstrator coupling an advanced electrolyser with a solar tower.

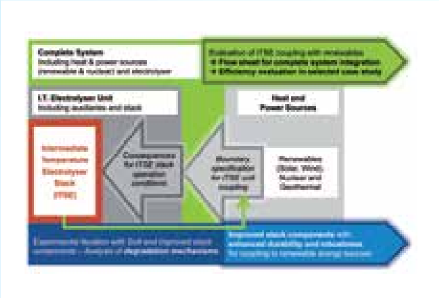
FUTURE STEPS

Project completed

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- The developed 2nd generation components show improved performance. Electrolyser stacks generally behave very well under load cycling conditions, but their base degradation rates remain above the project goal.
- System modelling shows that the electrolyser operating temperature (700°C vs 800°C) has little impact on efficiency and cost. The initial design temperature of 600°C is too low for SOE from a materials performance side. Pressurised operations have also limited impact so long as sweep air is used, as savings are offset by air pressurisation. As a consequence, optimised durability and performance are the critical couple to optimise, independent of electrolyser operating temperature.
- The allothermal source of heat is mainly required for steam generation. Consequently a large variety of heat sources can be considered. High-temperature coupling provides limited efficiency gains given the increased complexity and cost.
- High-temperature electrolysers present very high power conversion efficiencies, decent load-following capabilities and high capital costs. Different opportunities for electrolysis were controversially discussed:
    - Grid balancing cases compete with smart grids as strong alternative;
    - Chemical storage (power to gas) as alternative for energy transport in the context of power-lines congestion or seasonal electricity storage with increased solar electricity production;
    - Distributed hydrogen production for fuel-cell cars, although H_2 is currently seen more as a chemical than an energy carrier. Synthetic fuels derived from co-electrolysis using CO_2 would couple renewable energy to standard energy markets more directly.
- Hydrogen production costs with high-temperature electrolysis from renewable energy sources are in the range €6-17/kg calculated for four scenarios and are not yet fully competitive. The major cost is still the stack related to the limited lifetime. Another big cost element is the equipment for harvesting renewable energy.





CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	H_2 price at pump	<€5/kg (€0.15/kWh)	<€5/kg	€6-17/kg calculated for four scenarios
AIP	Current density of SOEC	2 A/cm²	2 A/cm² (<2V)	1.33 A/cm2 @ 700°C, 1.3V
AIP	Stack degradation under relevant operating conditions	<1% /1,000 hours	<1% /1,000 hours, steam conversion >60%	1-5%/1,000h at thermo-neutral voltage, no additional degradation upon load cycling

ALKAMMONIA

Ammonia fuelled alkaline fuel cells for remote power applications

CALL TOPIC	System-level proof of concept for stationary power and CHP fuel-cell systems at a representative scale
START-DATE	1 May 2013
END-DATE	30 April 2016
TOTAL BUDGET	€2,870,896
FCH JU CONTRIBUTION	€1,962,548
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: AFC Energy.

Partners: Acta, Universität Duisburg-Essen, Zentrum für Brennstoffzellentechnik, UPS Systems, Paul Scherrer Institut, European Hydrogen Association.

PROJECT WEBSITE/URL

alkammonia.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

1. Develop an ammonia cracker that uses a combustion process to provide the heat for the dissociation process
2. Develop a 3-5kW stack
3. Develop an AFC balance of plant
4. Compliance with all relevant fuel-cell regulation and CE marking directives
5. Demonstrate cost competitiveness of the integrated 3-5kW proof-of-concept system against other technologies competing in the same target market(s)
6. Demonstrate three months continuous operation of the system using liquid ammonia
7. Analysis of the environmental and socio-economic impacts of the proof-of-concept system

PROGRESS/RESULTS TO DATE

- High-level design complete
- Basic thermodynamic model of ammonia cracker and fuel cell complete and used to define subsystem parameters
- Cracker burner and cracker catalyst testing and validation underway
- Life-cycle analysis model complete
- Fuel-cell testing with ammonia complete and short-stack testing imminent on dedicated test rigs

FUTURE STEPS

- Completion of single fuel-cell tests, and testing of short fuel-cell stacks using $NH_3/H_2/N_2$ mix gas
- Cracker prototype design completion and testing
- Power conditioning build
- Further development and refinement of the fuel-cell/cracker thermodynamic model
- Refinement of the LCA model

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Single-cell fuel cell tests using $NH_3/H_2/N_2$ resulted in performance variations compared to pure hydrogen fuel stream. However, variations in performance within acceptable tolerance will be acceptable for system lifetime.
- Determined burner technology for cracker: (catalytic burner rejected; flame burner selected for next phase).
- Efficiency calculations have shown that the fuel utilisation of the fuel-cell stack requires improvement, which the partners intend to achieve through modifications to fuel-cell flow-field design.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	AFC cost of system €/kW	€4,000/kW (mid-term 2015) €2,000/kW (long-term 2020)	Decreased BoP system costs: €2,500 (2012) €1,500 (2016)	On target to achieve
MAIP	AFC system – volume in the European market	100+ units (mid-term 2015) 50,000 units (long-term 2020)		n/a
MAIP	AFC system efficiency	55% elec; 85% total (mid-term 2015) 60% elec; 90% total (long-term 2020)	Cracker efficiency: 80% (2012); 85% (2016) AFC stack efficiency: <60% (2012); >60% (2016)	Currently, efficiency is slightly below this target, but partners expect to significantly increase fuel utilisation through modifications to plate design (already partially achieved) and will bring the efficiency into line with the targets.
MAIP	System durability/ reliability	- 30,000h (long-term 2020)	>2,190h (2016)	Untested as a complete system at present

ARTEMIS

Automotive PEMFC Range extender with high TEMperature Improved meas and Stacks

CALL TOPIC	Next-generation European MEAs for transportation applications
START-DATE	1 October 2010
END-DATE	31 October 2015
TOTAL BUDGET	€2,822,692
FCH JU CONTRIBUTION	€1,747,884
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Centre national de la recherche scientifique (CNRS)

Partners: Commissariat à l'energie atomique et aux energies alternatives (CEA), Nedstack, Fundaçion Cidetec, Centro Ricerche FIAT (CRF), Politecnico di Torino.

PROJECT WEBSITE/URL

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

PROJECT CONTACT INFORMATION

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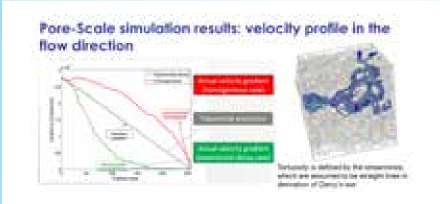

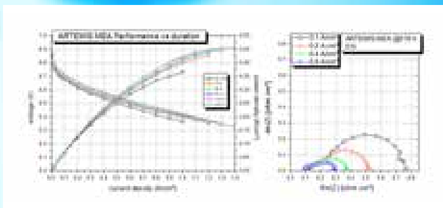

MAIN OBJECTIVES OF THE PROJECT

The purpose of ARTEMIS is to develop and optimise alternative materials for a new generation of European MEAs to be integrated into a 3kWe high-temperature PEMFC stack. The MEAs will be based on alternative polybenzimidazole-type membranes and improved catalytic layers providing low catalyst loading and high efficiency at high temperature as well as a high tolerance to pollutants (CO, H_2S). Modelling tools will help the understanding of degradation mechanisms and failure modes, and will lead to increased durability and lifetime of the system.

PROGRESS/RESULTS TO DATE

- Complete set of protocols defined + range-extender protocol
- Membrane + catalysts + plate materials development
- MEA and electrodes fabrication methodology defined
- Stack design achieved
- Modelling tools have provided input to the catalyst layer structure and acid loss mitigation strategies

FUTURE STEPS

- Second generation MEA integration in a 0.3kWe stack
- Development of a final generation of high-temperature (HT) materials components
- Refinement of the materials preparation methodology
- HT MEA elaboration at pilot scale

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Already achievable performances equal commercial HT MEAs with project anode GDE and commercial catalyst
- ARTEMIS will produce and propose state of the art materials, MEAs and top of the line HT stack products
- Potential for up-scaled materials production
- HT stack implementation as a range-extender in transport applications
- High potential for commercialisation

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	New materials for high-temperature MEAs and stacks	Membrane, catalyst, GDE, plate materials development	Membrane and plate materials components satisfy defined specifications at M18	Membrane and plate materials components satisfy defined specifications at M18
MAIP	2014 target high-temperature operation	Operation @ 130°C and beyond	Operate @ 160°C and 180°C	Materials operate up to 180°C
AIP	Quantitative target MEA	First generation MEA performance; 0.3W/cm² @ 1 A/cm²	0.35-0. 4W/cm² achieved @ 1 A/cm²	0.45W/cm²
AIP	Quantitative target membrane	Conductivity >0.1 S/cm @ operation temperature	0.15 S/cm achieved @ 140°C	0.1 S/cm
AIP	Performance of commercially available MEA	0.4W/cm² @ 1 A/cm²	0.5W/cm²@ 1 A/cm²	0.45W/cm²

ArtipHyction

Fully artificial photo-electrochemical device for low temperature hydrogen production

CALL TOPIC	Low-temperature H_2 production processes
START-DATE	1 May 2012
END-DATE	30 October 2015
TOTAL BUDGET	€3,641,842
FCH JU CONTRIBUTION	€2,187,040
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Politecnico di Torino

Partners: HySyTech srl, Commissariat à l'energie atomique et aux energies alternatives, Chemical Process Engineering Research Institute, Solaronix SA, Lurederra Foundation for Technical and Social Development, Tecnologia Navarra de Nanoproductos SL, Pyrogenesis SA.

PROJECT WEBSITE/URL

www.artiphyction.org

PROJECT CONTACT INFORMATION

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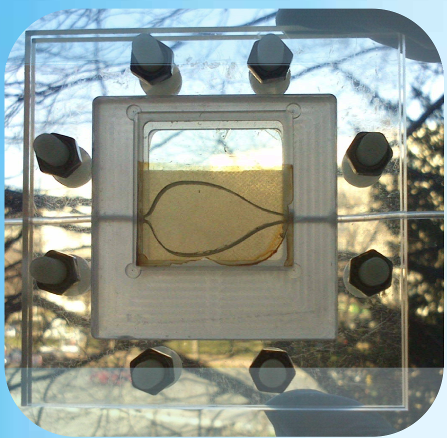


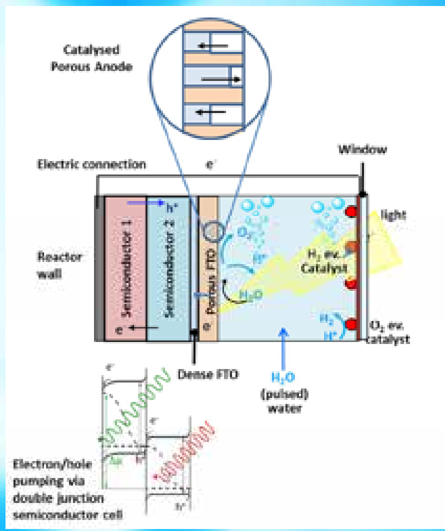
MAIN OBJECTIVES OF THE PROJECT

The project aims at developing a photo-electro-chemical reactor for H_2 production capable of 5% conversion of solar energy into hydrogen (LHV) with:

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

PROGRESS/RESULTS TO DATE

- Anodic and cathodic (photo) electro-catalysts identified and providing satisfactory activity in non-optimised form
- Transparent conducting oxide precursors, powders and porous layers developed as electrode main structures supporting the electro-catalysts
- Pulsation effect of the electrolyte assessed
- Final prototype design selected



FUTURE STEPS

- Optimise catalysts
- Optimise electrodes
- Build and test the final prototype

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

The partnership is confident that the progress accomplished so far as well as the selected prototype design should allow the fulfilment of the efficiency target.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Scale-up to cost-effective capacity, as well more cost-efficient, high-performance materials for renewables-based H_2 production	Applications ranging from 100W for domestic use (ca. 3 g/h H_2 equivalent) to 100kW (ca. 3 kg/h H_2 equivalent) for commercial use.	Test the smallest scale of the range aside	N/A yet (will be tested by month 42)
AIP	Sun-to-hydrogen conversion efficiency	5%	5%	2,5% efficiency achieved
AIP	Durability	10,000h	10,000h	N/A (prototype will be tested for 1,000h at the end of the project)

Asterix3

Assessment of SOFC CHP systems built in the technology of HTceramics

CALL TOPIC	Proof-of-concept fuel-cell systems
START-DATE	1 January 2011
END-DATE	31 December 2014
TOTAL BUDGET	€3,096,000
FCH JU CONTRIBUTION	€1,361,000
OTHER CONTRIBUTION(S)	Danish EUDP €180,000

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Dantherm Power A/S

Partners: HT ceramics, EIFER, CNR ITAE.

PROJECT WEBSITE/URL

http://asterix3.eu/

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

The Asterix3 project aims to develop a proof-of-concept micro-CHP system based on SOFC technology with progress beyond state-of-the-art and towards market requirements. The requirements are used to create a design specification for all subsystems and finally for the proof-of-concept system. Each separate subsystem has its own objectives simulated and optimised for the proof-of-concept system in order to reach longest possible lifetime, high system efficiency, and the ability to compete on investment cost with traditional technologies.

PROGRESS/RESULTS TO DATE

- Subsystem "HoTbox™" has been modified in crucial points
- The first system has been built and documented
- HAZOP of total system have been performed
- Integration of Hotbox has been performed and the system started up

FUTURE STEPS

- Testing is to start up in the coming months at EIFER and CNR ITAE
- Three more systems are to be built
- Further software developments are to be initiated
- Development of integrated electronic anode protection to be initiated

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- The first prototype system has now been running problem-free for 150 hours.
- Efficiency and lifetime/degradation tests are to follow in the coming months

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP/AIP	Degradation and lifetime	Not quantified	>1,000 hours in system	N/A (test not finalised)
MAIP/AIP	Electrical peak efficiency net AC	Not quantified	<35%	N/A (test not finalised)
MAIP/AIP	Electrical efficiency (nominal average)	Not quantified	<30%	N/A (test not finalised)
MAIP/AIP	Total efficiency of the system	Not quantified	<90%	N/A (test not finalised)

Auto-Stack CORE

Automotive Fuel-Cell Stack Cluster Initiative for Europe II

CALL TOPIC	Next generation European automotive stack
START-DATE	1 May 2013
END-DATE	31 August 2016
TOTAL BUDGET	€14,715,530
FCH JU CONTRIBUTION	€7,757,273
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: ZSW, Germany

Partners: Belenos, BMW, CEA, DANA, Fraunhofer, JRC, FFCCT, PSI, Powercell, Solvicore, Symbio FCell, VW, Volvo.

PROJECT WEBSITE/URL

www.autostack.zsw-bw.de

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

- Development of an automotive PEM fuel-cell stack fulfilling the specifications set out in the Auto-Stack project (GA 245142) in three evolutions.
- Evolutions 1 and 2 will be designed, built and tested in hardware, evolution 3 will be designed.
- Key components will be developed to automotive standards.
- Component development will be done on an industrial manufacturing concept.
- Cost-engineering will be carried out as a cross-cutting activity to make sure the design meets automotive targets.

PROGRESS/RESULTS TO DATE

- Target specification and design for evolution 1 stack and components established
- Test-plan established and agreed for short and full-size stack
- Comparative assessment of short-stack test benches via round robin test carried out
- Tool design for evolution 1 started
- Cost engineering task started

FUTURE STEPS

- Stack evolution 1 component manufacturing & stack integration
- Stack evolution 1 testing
- Refinement of cost-engineering
- Start of stack evolution 2 design

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Consortium established and working
- Component design and matching completed
- Design based on industrially validated materials and components

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	MAIP Topic 3.4.1 Priority research, development and demonstration activities, Topic T02	-	Action will be taken to integrate the currently fragmented PEMFC stack research and development activities within Europe and to establish European leadership in the transportation fuel-cell stack industry through close cooperation between automotive OEMs, supply industry, and research institutes in the context of a European «cluster».	Consortium established and working
AIP	AIP 2012 Next generation European automotive stack	Power 95kW >2 kW/kg >2kW/L >5,000h	Development of an automotive PEM fuel-cell stack fulfilling the target specification	Testing to be done

BeingEnergy

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

CALL TOPIC	Research, development and demonstration of new portable fuel-cell systems
START-DATE	1 September 2012
END-DATE	31 August 2015
TOTAL BUDGET	€4,214,423
FCH JU CONTRIBUTION	€2,245,244
OTHER CONTRIBUTION(S)	National Fuel Cell Programme of Tekes (Finnish Funding Agency for Innovation) funds 18.6% of VTT budget.

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Universidade do Porto

Partners: Deutsches Zentrum für Luft- und Raumfahrt (DLR), Teknologian Tutkimuskeskus (VTT), SerEnergy A/S, Consiglio Nazionale delle Ricerche (ITM-CNR), Universidad Politecnica de Valencia, Inovamais - Serviços de Consultadoria em Inovação Tecnológica SA, Rhodia Operations.

PROJECT WEBSITE/URL

http://www.beingenergy.eu/

PROJECT CONTACT INFORMATION

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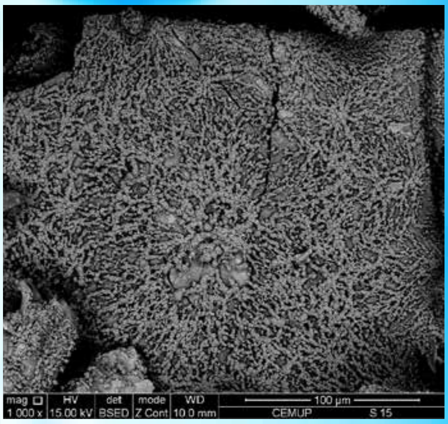


MAIN OBJECTIVES OF THE PROJECT

- Synthesising, characterising, and optimising catalysts for low-temperature methanol steam reforming (LT-MSR, 180°C) and developing strategies for industrial preparation of the selected catalysts.
- Development, characterisation and optimisation of a cell-reactor for the LT-MSR.
- Integration, characterisation and optimisation of the low-temperature methanol steam-reforming reactors with a high-temperature polymer electrolyte membrane fuel cell (HT-PEMFC).
- Development, characterisation and optimisation of the LT-MSR/HT-PEMFC 350We prototype.

PROGRESS/RESULTS TO DATE

- The best Cu-based catalyst developed is more active than G66 MR from Süd Chemie, about 1.7 times more active (W/F^0 = 30 kg·mol^{-1}·s), and produces less than 1,000 ppm of CO at working conditions.
- A very active Pd/ZnO catalyst has been obtained which is four times more active than the $Cu/Zn/Al_2O_3$ catalyst G66 MR from Süd Chemie.
- The reformer simulator is completed and reformer loaded with first catalyst was studied.
- Simulator predicting experimental results of combined unit was developed.
- A newly-developed bipolar plate material was tested and the fuel-cell stack lifetime has increased.

FUTURE STEPS

- Characterisation of selected Pd-based and Cu-based catalysts
- Further optimisation and full characterisation of best performing in-house catalyst $Cu/ZrO_2/Al_2O_3$
- Develop a CO_2 selective reactor
- Develop new energy-integrated power supply using a liquid thermal fluid
- Investigate different start-up strategies

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Development and characterisation of a new and more active catalyst for the methanol steam-reforming reaction – 1.7x more active and producing <1,000 ppm of CO at 180°C.
- Development of bipolar plates integrating a heat-exchange circuit for a liquid thermal fluid.
- Development of an efficient heat-exchange system between the reformer and the fuel cell stack based on a liquid thermal fluid.
- Development of a PPS-based bipolar plate for high-temperature fuel cells and development of PPS bipolar plates for integrated cellular-reformer and fuel cell, benefiting the heat transfer between both reactors and the compactness.
- Fast start-up based on fuel burner and an efficient heat-exchange system.

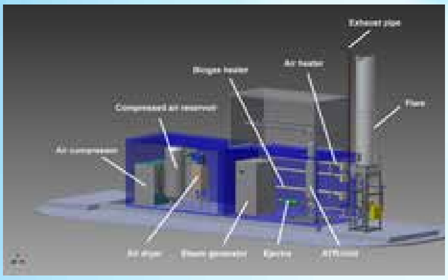
CONTRIBUTION TO THE PROGRAMME OBJECTIVES

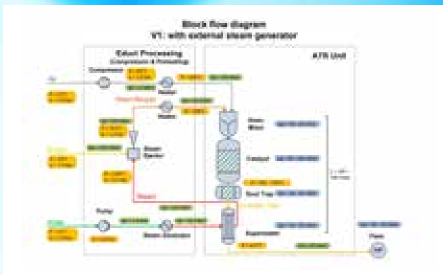
SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Lower emissions and use of multiple fuels	N/A	Methanol as fuel	N/A
AIP	Electrical efficiency	30%	>35%	>35%
AIP	Lifetime including 100 start-stop cycles	1,000h	>1,000h	Lifetime of fuel reached 8,000 hours
AIP	Specific size and weight	35 kg/kW and 50 L/kW	<35 kg/kW and <50 L/kW	N/A

BioRobur

Biogas robust processing with combined catalytic reformer and trap

CALL TOPIC	Biogas reforming
START-DATE	1 May 2013
END-DATE	30 April 2016
TOTAL BUDGET	€3,909,726
FCH JU CONTRIBUTION	€2,486,180
OTHER CONTRIBUTION(S)	





PARTNERSHIP/CONSORTIUM LIST

Coordinator: Politecnico di Torino

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

PROJECT WEBSITE/URL

http://www.biorobur.org

PROJECT CONTACT INFORMATION

debora.fino@polito.it

MAIN OBJECTIVES OF THE PROJECT

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

PROGRESS/RESULTS TO DATE

- BioRobur specifications fixed
- Design and adaptation of equipment for parallel and transient testing of reformer and trap catalyst achieved
- Procurement characterisation and promotion of catalysts for the ATR reactor and trap
- Optimal design of cellular materials defined through fluid-dynamic, FEM and heat-transfer calculations
- Optimal micro- and macro-structural design of trap accomplished

FUTURE STEPS

- Cellular ceramic support and catalysts for ATR reforming and catalytic trap screened and evaluated
- Catalysts kinetics, mechanistic and ageing analyses control strategy defined
- Detailed models for single units of fuel processor
- LCA analysis

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Based on screening catalysts results for the ATR reactor, some catalysts and supports have been proposed to BioRobur concept.
- Filter materials obtained and characterised for pressure-drop and particle-capture efficiency with different particle sizes.
- Feed system control strategy, including biogas pre-treatment defined.
- In-situ support self-transformation and hydrothermal crystallisation on SiSiC supports investigated.
- CFD simulations of the micro-structural design of the cellular material accomplished.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
AIP	Nominal production rate of pure hydrogen (kg/day)	50-250	100	N/A (test not finalised)
AIP	CO concentration at the reformer exit (vol%) (dry basis)	<10	<10	N/A (test not finalised)
AIP	Biogas to hydrogen conversion efficiency (%)	>65%	>65%	N/A (test not finalised)
AIP	Materials costs for a 50 Nm^3/h hydrogen production rate (€)	<€250,000	€150,000	N/A (test not finalised)

BOR4STORE

Fast, Reliable and Cost-effective Boron Hydride-based high-capacity Solid-State Hydrogen Storage Materials

CALL TOPIC	Novel H_2 storage materials for stationary and portable applications
START-DATE	1 April 2012
END-DATE	30 September 2015
TOTAL BUDGET	€4.070,000
FCH JU CONTRIBUTION	€2.300,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Helmholtz-Zentrum Geesthacht GmbH

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

PROJECT WEBSITE/URL

www.bor4store.eu

PROJECT CONTACT INFORMATION

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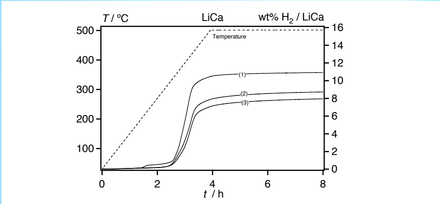
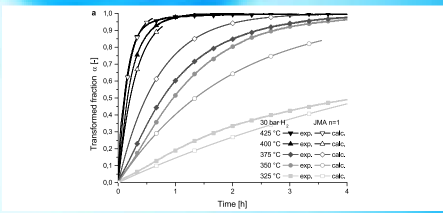


MAIN OBJECTIVES OF THE PROJECT

Development and testing of novel, optimised and cost-efficient boron hydride-based hydrogen storage materials with superior performance (materials capacity more than 8 wt.% and 80 kg H_2/m^3) for SOFC applications. Integration and experimental validation of the performance of a solid state hydrogen storage tank (containing ca. 10 kg storage material, ca. 1 kg H_2) with an SOFC in different conditions of operation.

PROGRESS/RESULTS TO DATE

- Characterisation of a range of different high-capacity boron hydride-based hydrogen storage materials.
- Characterisation of thermodynamic, kinetic and cycling properties. Scientific understanding of solid-state reactions during hydrogenation.
- Selection of most suitable material for storage tank: LiBH4/ MgH_2 RHC: ca. 10 wt.%, ca. 100 kg H_2/m^3. Reaction enthalpy ca. 32 kJ/(mol H_2). Loading time @ 50 bar <1h. Suitable temperature of operation 350°C-600°C, ie. suitable for SOFC application.
- Establishment of simulation model of integrated SOFC-metal hydride tank systems. Analysis of different options for heat transfer between SOFC.
- Different variants P&ID of integrated system established.



FUTURE STEPS

- Further investigation of rate-limiting steps and cyclability of storage materials with a focus on in-situ techniques.
- Optimisation of additives and nanoscaffolds for materials with improved properties compared to selected tank material.
- In silico optimisation of thermal integration.
- Construction and testing of prototype of 1.3 kW SOFC-metal hydride tank system.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Promising boron hydride-based materials systems exist, suitable for construction of solid-state hydrogen storage integrated with SOFC, SOEC or other high-temperature applications.
- Mechano-chemical processing of storage materials possible below €1/kg.
- Main cost factor: cost of raw materials used for storage materials synthesis => cheaper routes for synthesis of boron containing compounds from e.g. borax ores have to be developed.
- Use of waste and recycling alloys (e.g. Mg, Al) as feasible route to reduce cost.
- Simulation of material in storage tank and thermal integration with SOFC developed. Optimisation of thermal integration can be achieved by simulation.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
AIP	Capacity	Storage materials with capacities ≥6 wt.%, ≥60 kg H_2/m^3	Capacities of >80 kg H_2/m^3 and >8 wt.%	Capacity 100 kg H_2/m^3, 9-10 wt.% on materials basis
AIP	Temperature of operation	Reversibly releasing hydrogen at operating temperatures compatible e.g. with PEM FC, HT PEM FC or SOFC/MCFC	Release temperature 450°C (compatible with SOFC)	Release temperature 350°C-450°C
AIP	Loading and unloading speed	Appropriate hydrogen loading and unloading Kinetics for the envisaged application	Loading time <1h	Loading time <1h in materials testing, loading time of storage tank tbd.
AIP	Validation	Small-scale prototype storage systems with significantly improved storage capacity compared to compressed gas storage (≥4 wt.%, ≥40 kg H_2/m^3)	Same	Storage system under construction

CATAPULT

novel CATAlyst structures employing Pt at Ultra Low and zero loadings for auTomotive MEAs

CALL TOPIC	New catalyst structures and concepts for automotive PEMFCs
START-DATE	1 June 2013
END-DATE	30 November 2016
TOTAL BUDGET	€4,678,599
FCH JU CONTRIBUTION	€2,255,690
OTHER CONTRIBUTION(S)	TEKE (Finnish funding agency) €233,000

PARTNERSHIP/CONSORTIUM LIST

Coordinator: University Montpellier 2

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

PROJECT WEBSITE/URL

http://www.catapult-fuelcells.eu

PROJECT CONTACT INFORMATION

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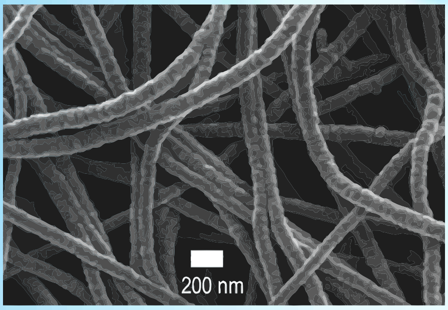

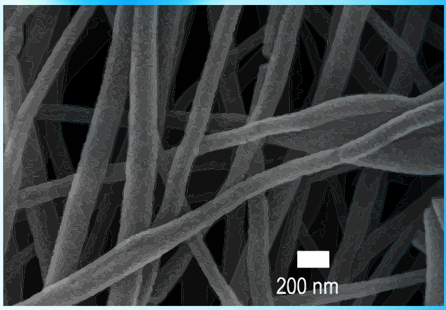

MAIN OBJECTIVES OF THE PROJECT

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

PROGRESS/RESULTS TO DATE

- Protocols developed for materials and MEA characterisation and participation in the harmonisation of protocols initiative.
- Corrosion-resistant electrospun electronically conducting nanofibre and nanotubular oxide supports developed.
- Pt films deposited by atomic layer deposition display mass activity of 0.2 A/mg.
- Novel non-platinum group metal catalysts developed that display higher mass activity than state-of-the-art.
- DFT force-field developed for investigation of ORR on Pt surfaces. Pt-support tie-layers selected by computational modelling.
- International workshop programmed on ultra-low and non-PGM fuel-cell catalysts «Challenges towards zero platinum for oxygen reduction», 12-15 April 2015. www.efcd2015.eu

FUTURE STEPS

- Intensify efforts to obtain ultra-thin continuous Pt films on corrosion-resistant supports by atomic layer deposition and alternative, electrochemical deposition approaches.
- Further develop methodology for electrochemical characterisation and understanding of novel extended Pt layer catalysts.
- Develop and test first MEAs using nanofibre-supported extended Pt films.
- Optimise the synthesis route to most prospective non-PGM catalysts and initiate activity on development of hybrid PGM/non-PGM catalysts.
- Determine structure/reactivity relation of the ORR on low index Pt surfaces and on nanoparticles, including the effect of defects, using molecular dynamics calculations.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

CATAPULT is a very ambitious project covering development of novel nanostructured architectures for fuel-cell catalyst materials, extremely challenging technical targets for the new materials and MEAs, as well as a level of scale-up. If the project reaches even some of its objectives the potential impact, and the potential for commercial exploitation, are very high.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	FC system lifetime (h)	>5,000h	1,000h (accelerated protocol)	Planned in Year 3
AIP	Pt specific power density (g/kW)	<0.1	Mass activity 0.44 A/mg Pt	Mass activity 0.2 A/mg Pt
AIP	MEA power density	≥1.0 W/cm^2 at 0.67 V	≥1.0 W/cm^2 at 0.67 V	Too early to assess

CATHCAT

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

CATHCAT

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

CALL TOPIC	Next-generation European MEAs for transportation applications
START-DATE	1 January 2013
END-DATE	31 December 2015
TOTAL BUDGET	€3,088,328
FCH JU CONTRIBUTION	€1,895,862
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: TU München

Partners: JRC, Université de Poitiers, DTU, Chalmers UT, University of Padova, Ion Power, Forth Institute, Toyota Motor Europe.

PROJECT WEBSITE/URL

www.cathcat.eu

PROJECT CONTACT INFORMATION

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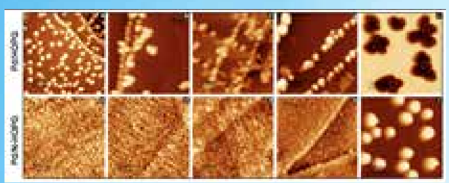
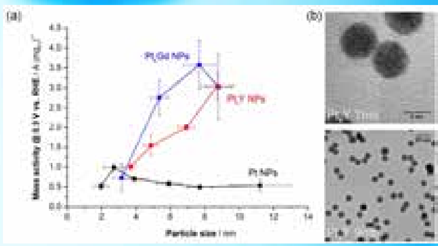


MAIN OBJECTIVES OF THE PROJECT

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

PROGRESS/RESULTS TO DATE

- The OH-binding energies for Pt alloys with Y, La, Ce, Pr, Nd, Sm, Gd, Dy, Tm and Tb and for Pd alloys with Ce, Tm, Y, Nd and Sm were calculated, and most promising compositions identified.
- Polycrystalline Pt-rare earth alloys (RE = Gd, Dy, Ce, La) were studied. An activity enhancement by a factor of 3-5 compared to pure Pt and excellent stability were observed.
- Mass activities of Pt_xGd and Pt_xY three times larger than for Pt and larges at particle diameters of ~7 nm.
- Chemical and electrochemical experiments for large-scale synthesis of these catalysts underway, with first promising results obtained and first MEA tests underway.
- Modified support materials like N-doped mesoporous carbon show beneficial influence on catalytic activity of Pt and Pd nanoparticles.



FUTURE STEPS

- Extension of DFT studies on Pd-based catalysts
- In-depth studies of existing and addition of new methods for up-scaling Pt/Pd rare earth element catalyst nanoparticles
- Comprehensive half-cell characterisation of new catalysts supported on advanced support materials
- Single-cell studies with respect to performance and stability

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Pt-rare earth alloys represent a group of improved catalysts permitting a reduction of noble metal content of MEAs by a factor of >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.
- Chemical preparation of these catalysts challenging but possible.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
AIP	Pt loading	<0.15g/kW	<0.1 g/kW	N/A (test not finalised)
AIP	BOL efficiency	>55%	>55%	N/A (test not finalised)
AIP	BOL power	>>1W cm^{-2} @ 1.5 A cm^{-2}	>>1W cm^{-2} @ 1.5 A cm^{-2} 1.5 A cm^{-2}	N/A (test not finalised)
MAIP	Lifetime	>5,000h	>5,000h	N/A (test not finalised)

CATION

Cathode Subsystem Development and Optimisation

CALL TOPIC	Component improvement for stationary applications
START-DATE	1 January 2011
END-DATE	30 June 2014
TOTAL BUDGET	€7,108,506
FCH JU CONTRIBUTION	€2,625,789
OTHER CONTRIBUTION(S)	Finnish national (Tekes) support for VTT is €230,000

PARTNERSHIP/CONSORTIUM LIST

Coordinator: VTT Technical Research Centre of Finland.

Partners: Wärtsilä Finland Oy, AVL List GmbH, Topsoe Fuel Cells A/S, Bosal Research NV, Centro per lo Sviluppo della Sostenibilità dei Prodotti. *Wärtsilä's partnership was ended after M18. Convion Oy participates as a follow-up partner.

PROJECT WEBSITE/URL

http://cation.vtt.fi/

PROJECT CONTACT INFORMATION

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jari.kiviaho@vtt.fi

MAIN OBJECTIVES OF THE PROJECT

The main project objectives are to evaluate different process alternatives and find optimal process and mechanical solutions for the cathode and stack subsystems with the aim of having commercially feasible and technologically optimised subsystem solutions ready for future ~ 250kWe atmospheric SOFC systems.

With this novel cathode subsystem solution the new 250kWe SOFC system should reach 55% electrical efficiency, and achieve 40,000 hours of lifetime with over 90% availability. Simultaneously the capital investment cost has to be decreased as low as €2,000/kW for industrial use to achieve a break-through on commercial markets.

PROGRESS/RESULTS TO DATE

- The balance of stack testing, hotbox validation and subsystem validation have all been achieved.
- New tools have been designed and tested to optimise heat exchanger core, laser welding and automated assembly process.
- An ejector-based solution has been modelled, designed and tested successfully. This ejector-based solution is suitable cost-effective solution for large-scale systems.

FUTURE STEPS

The project ends in June 2014. In the future, all partners will continue the developing work according to their own strategies for commercialising stack, stack modules and whole systems.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Based on the design-to-cost analyses carried out in the project, a good understanding on the economies of scale was achieved. As a result, it can be concluded that with certain additional stack-related development steps a commercially feasible system having an investment cost (excluding stacks) of less than €2,000/kW can be achieved.
- At commercial level, it can be also concluded that SOFC systems present a lower total lifecycle cost than micro-turbines both for industrial and household applications, thus guaranteeing both environmental and economic sustainability of the SOFC technology.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Electrical efficiency >45% for power-only units	45%	55%	Achieved
MAIP	Lifetime: 40,000 hours for cell and stack	40,000h	prove 40,000h is possible	Achieved: 40,000h testing not possible within this project
MAIP	Competitive costs	€2,500/kW	<€2000/kW capital investment cost (excluding stacks)	There are no commercial products on the market yet. However calculations show that competitive cost target can be achieved.

CHIC

Clean Hydrogen in European Cities

CALL TOPIC	Large-scale demonstration of road vehicles and refuelling infrastructure II
START-DATE	1 April 2010
END-DATE	31 December 2016
TOTAL BUDGET	€81,800,000
FCH JU CONTRIBUTION	€26,000,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Daimler Buses – EvoBus.

Partners: 10 transport companies, eight industrial partners, seven research and consultancy partners.

PROJECT WEBSITE/URL

www.chic-project.eu

PROJECT CONTACT INFORMATION

h2businfo@chic-project.eu

MAIN OBJECTIVES OF THE PROJECT

- Implement clean urban mobility in five major EU regions through the deployment of 26 hydrogen fuel cell-powered buses and the enlargement of H2 infrastructure systems.
- Facilitate the development of clean urban public transport systems in at least 14 new EU regions.
- Collaboration, transfer and securing of significant key learning from previous fuel-cell projects to the CHIC stakeholders.
- Greater community understanding of "green" H2-powered fuel-cell buses, leading to increased political acceptance and commitment.

PROGRESS/RESULTS TO DATE

- 53 fuel-cell buses are on the road in day-to-day passenger service.
- The vehicles are able to satisfy the daily demands of urban bus routes without returning to the depot.
- The high-throughput 350-bar H2 stations deployed in the project have delivered over 98% availabilities and filling times of under 10 minutes.

FUTURE STEPS

- Showing reliability and availability of this hydrogen technology during day-to-day operation.
- Dissemination of the project results in workshops for interested Phase 2 cities.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

The CHIC project is a demonstration project where buses from different manufacturers are evaluated with different fuel-cell suppliers and an appropriate H2 infrastructure. The buses and the hydrogen refueling stations are integrated in the daily public service to show their reliability, availability and also to identify the possible need of technical improvement. This technology is well accepted by bus drivers and passengers.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
H2-Infrastructure				
AIP	H2 fuelling capacity	200 kg/day	200kg/day	All Phase 1 cities have reached the required refuelling capacity
AIP	Availability of H2 refuelling station	98%	98%	>98% based on operation time
AIP	H2 OPEX (operational expenses)	<€10/kg	<€10/kg	All available OPEX figures from the Phase 1 sites currently exceed €10/kg target. This is partly due to low capacity factors of the units for on-site generation and therefore likely to improve with expected higher availabilities of the buses.
AIP	H2 purity and vehicle refuelling time	According to SAE or analogous specification	According to SAE or analogous specification	Not all contaminants can currently be measured with the accuracy stipulated
AIP	H2 production efficiency	50-70%	50-70%	Actual values between 54% and 59%
Additional target	Replacement of diesel fuel		500,000 litres	Phase 0 cities: 2,874,965 litres (as at April 2014);
Fuel-cell buses				
AIP	Fuel-cell lifetime	>6000h	>6000h	5880h/bus (as at April 2014) including buses which just started in Bolzano and Milan
AIP	Fuel-cell bus availability	>85%	>85%	67% based on operation time (as at April 2014)
AIP	H2 consumption	<11-13kg/100km depending on drive cycle	<13kg/100km depending on drive cycle	12.5 kg/100km (only FC buses) (as at April 2014)
Additional target	Minimum running distance of fleet		2.75 million km	6.49 million km (as at April 2014)
Additional target	Minimum operation hours of fleet		160,000 km	299,875h (as at April 2014)

CISTEM

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

CALL TOPIC	Cell and stack degradation mechanisms and methods to achieve cost reduction and lifetime enhancements, System-level proof of concept for stationary power and CHP fuel-cell systems at a representative scale
START-DATE	1 June 2013
END-DATE	31 May 2016
TOTAL BUDGET	€6,097,180
FCH JU CONTRIBUTION	€3,989,723
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: NEXT ENERGY • EWE-Forschungszentrum für Energietechnologie

Partners: Danish Power Systems Ltd, Inhouse engineering GmbH, Eisenhuth GmbH & Co KG, University of Castilla-La Mancha, Institute of Chemical Technology Prague, ICI Caldaie SpA, Oel-Waerme-Institut GmbH.

PROJECT WEBSITE/URL

http://www.project-cistem.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

Key issue of CISTEM is the development of durable HT-PEM based 4kW stack modules (including reformer) suitable for larger CHP systems up to $100kW_{el}$. The modular concept will be investigated in a hardware-in-the-loop test bench with one module physically installed and the others emulated by software. The development strategy starts on the single component level and rises up to complete CHP system. R&D includes the most important components like MEAs, bipolar plates, reformer system and the final CHP unit design with all necessary balance-of-plant components.

PROGRESS/RESULTS TO DATE

- Improved efficiency of 20% on MEAs has been reached
- Proposed durability of 1,000h with improved MEAs has been achieved
- Large-area MEAs with 200 cm^2 active area are in operation in short-stack testing
- Overall gross electrical efficiency calculated to be 42%
- Durability tests under new operating conditions show promising results to extend the desired lifetime

FUTURE STEPS

- Short stack performance and durability evaluation
- Manufacturing of full stack components
- Tests of new reformer design for modulation capabilities and overall efficiency improvement
- Simulation of CHP system operation and performance requiring regional European operational strategies

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Project progress is in the desired time frame
- FC electrical efficiency has been improved to more than 40% by different measures
- First results from short-stack long-term testing support improved durability of the FC stack

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Small-scale commercial application range 5-50kW and mid-scale industrial range		Up to 100kW	BoP component specifications finished Short-stack evaluation started
MAIP	Electrical efficiency	>40%	Up to 45%	42% gross efficiency calculated
MAIP	Lifetime	>20,000h	Extended lifetime up to 40,000h	Currently under investigation: 10,000h durability test on components in progress
AIP	Increased knowledge on degradation and failure mechanisms	MEA and BPP degradation	Accelerated stress testing on MEAs to access lifetime predictions is still in progress	Accelerated stress tests predict improvement in lifetime. 10,000h BPP material test is still in progress
AIP	PoC prototype modular CHP system based on HT-PEM technology	Realisation of one module, consisting of two 4kW HT-PEM stacks and one reformer, in a H-i-L- environment		Short stack has been designed. BoP component specifications finished.

COBRA

COatings for BipolaR plAtes

CALL TOPIC	Research & development on bipolar plates for PEM fuel cells
START-DATE	1 April 2014
END-DATE	31 March 2017
TOTAL BUDGET	€3,809,234
FCH JU CONTRIBUTION	€2,339,595
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Commission à l'énergie atomique et aux énergies alternatives (CEA)

Partners: Borit, Impact Coatings, SFC, CIDETEC, INSA Lyon.

PROJECT WEBSITE/URL

www.cobra-fuelcell.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

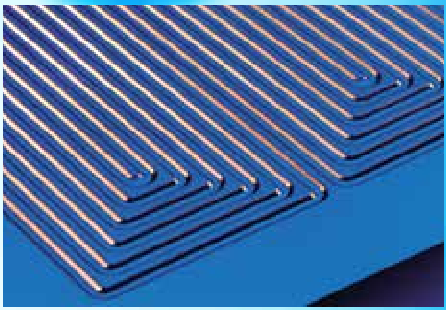
The COBRA project aims to develop best-of-its-class bipolar plates for automotive stacks with superior corrosion resistance (corrosion <1µA/cm²), higher conductivity (<25mOhm.cm²) and durability (>5000h), while meeting commercial target cost (price <€2.5/kW). The project is multidisciplinary with joint efforts of specialists from various areas: chemistry, physics, material science, fuel-cell engineering. The COBRA consortium combines the collective expertise of bipolar plate and coating suppliers, system integrators and research institutes thus removing critical disconnects between stakeholders.

PROGRESS/RESULTS TO DATE

- Reference plate manufacturing

FUTURE STEPS

- Reference plates field testing
- Post-mortem analysis
- Innovative manufacturing process and coatings developments
- New plates manufacturing
- New plates field testing



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

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

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Durability	>5,000h	>5,000h	N/A (test not finalised)
AIP	Corrosion, anode (µA/cm²)	<10	<10	N/A (test not finalised)
AIP	Corrosion, cathode (µA/cm²)	<10	<10	N/A (test not finalised)
AIP	Areal specific resistance (mΩ.cm²)	<25	<25	N/A (test not finalised)
AIP	Cost (for production of 500,000 units)	<€2.5/kW	<€2.5/kW	N/A (study not finalised)

CoMETHy

Compact Multifuel-Energy to Hydrogen converter

CALL TOPIC	Development of fuel-processing catalyst, modules and systems
START-DATE	1 December 2011
END-DATE	30 November 2014
TOTAL BUDGET	€4,927,884
FCH JU CONTRIBUTION	€2,484,095
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: ENEA

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

PROJECT WEBSITE/URL

www.comethy.enea.it

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

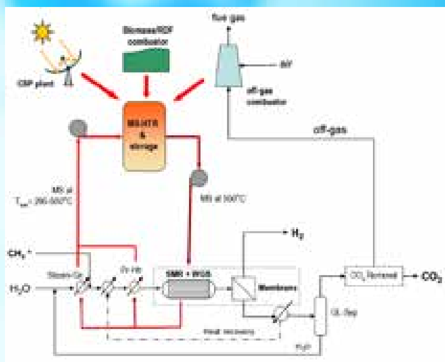
CoMETHy aims to develop a flexible membrane reformer operating at low temperatures (<550°C), to convert different fuels (methane, ethanol, etc) and adaptable to different heat sources (solar, biomass, fossil). Molten salts (MS) are used to collect and store the heat from concentrating solar plants (CSP) or alternative sources like biomass or refuse-derived fuel (RDF). This MS stream provides the process heat to the steam reformer, steam generator, and other unit operations. This low-temperature steam reforming (400°C-550°C rather than conventional 850°C-950°C) allows material cost reduction and leads to a compact device for multi-fuelled hydrogen production.

PROGRESS/RESULTS TO DATE

- Advanced multi-fuel catalysts for methane/biogas and ethanol steam reforming at 400°C-550°C have been developed with enhanced heat transfer, low pressure drops, satisfactory catalytic activity.
- Suitable Pd-based hydrogen selective membranes have been identified and tested.
- Innovative molten salts-heated membrane reformer concepts have been designed.
- Tests at bench-scale of reactor prototypes successfully achieved under representative operative conditions.
- Preliminary process simulation and evaluation obtained.

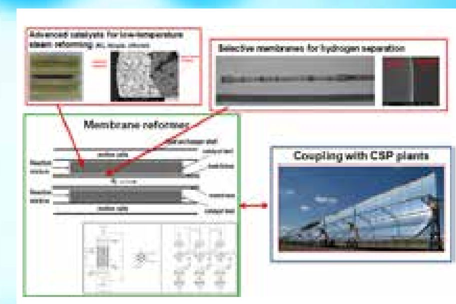
FUTURE STEPS

- Construction and testing of a pilot membrane reformer (at least 2 Nm³/h of pure hydrogen production) for proof-of-concept.
- Technical-economic optimisation of the process under different operative conditions.
- Completion of the Pd membranes development (specifically SS-supported membranes).



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- CoMETHy is successfully achieving its objectives.
- Besides the specific application to solar reforming, CoMETHy's findings have impact on catalyst and membrane technology, innovative reactor design, and small reformers.



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Supply up to 50% of the hydrogen energy demand from renewable energy sources for decarbonisation of transport with CO_2-lean or CO_2-free hydrogen	Up to 50% from RES	38%-100%	Solar Steam Methane Reforming (SMR) allows CO_2 emission reduction rate of 38%-53% with respect to the traditional route. The use of biofuels (biogas, bioethanol) as feedstock allows 100% hydrogen production from RES Bench-scale tests already demonstrated the feasibility of the process. Pilot-scale demonstration, components durability and economic assessments are in progress
AIP	For decentralised production technologies more cost-efficient, high-performance materials (e.g. membranes)	Centralised SMR (CCS ready) efficiency >72% Decentralised biogas SMR efficiency >67%	>70%	Process evaluations and preliminary assessments lead to SMR efficiency (LLV base) >70% when the plant capacity is >5,000 Nm³/h
AIP	Scalability from 2 to 750 Nm³/h (hydrogen production rate)	From 2 to 750 Nm³/h	>2 Nm³/h	The shell-and-tube heat exchanger configuration considered in all CoMETHy designs will ease scalability from 2 Nm³/h (as in the proof-of-concept) to 750 Nm³/h or more Reactor design completed and scalability demonstrated thanks to the modular technology developed in CoMETHy. Proof-of-concept with a pilot reformer yet to be achieved
AIP	Reforming catalyst system should exhibit enough shift activity to reduce CO concentration below 10 vol% (dry basis) to reduce shift catalyst quantity	<10vol% (CO concentration)	<10vol% (CO concentration)	In the "low" temperature steam reforming technology developed in CoMETHy water-gas shift reaction occurs simultaneously to steam reforming, with final outlet CO concentration even lower than 3 vole%, avoiding the need for shift reactors Reduction of reformer heat duty combining steam reforming and water-gas shift into a single stage at 400°C-550°C: outlet CO content < 5%vol is achieved in catalyst tests

COPERNIC

COst & PERformaNces Improvement for Cgh2 composite tanks

CALL TOPIC	Compressed hydrogen on-board storage (CGH2)
START-DATE	1 June 2013
END-DATE	31 May 2016
TOTAL BUDGET	€3,400,000
FCH JU CONTRIBUTION	€2,000,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator : CEA

Partners : RAIGI, SymbioFCell, GHR, WRUT, Seifert &Skinner & Associates, H2Logic.

PROJECT WEBSITE/URL

www.project-copernic.com

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

- Increasing the maturity and competitiveness of innovative CGH2 manufacturing processes evolving from classical automotive manufacturing technologies or concepts.
- Decreasing costs while improving composite quality, manufacturing productivity and using optimised composite design, materials and components.
- All-in-one innovative high-pressure tank component.
- Assessment of structural health monitoring (SHM) for compressed overwrapped pressure vessels (COPV).

PROGRESS/RESULTS TO DATE

- Public/private website with monitoring dashboard operational
- Final specifications toward market requirements
- First choices of alternative materials and composite design architecture
- Review of manufacturing technology improvement axis

FUTURE STEPS

- Conclusion on enhanced materials characterisation
- Tanks using selected enhanced materials
- Conception and modelling of optimised tanks
- All-in-one fully integrated on-tank valve with pressure regulation and safety management

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

At month 12, the main Copernic project activities concern:

- Comparative assessment of different performance/cost improvement strategies for CGH2 composite cylinders;
- Assessment of non-destructive methodologies to provide structural health monitoring of COPV;
- Certification of an innovative fully integrated on-tank valve.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP AA1	Design and test criteria for high-pressure composite		Contribution to the advancement of relevant test methods by generation of accurate data material and processes sensitivity to tank performance and safety	Testing protocols defined with respect to standards and modelling activities Testing activities just started
AIP 2012	Development activities on materials		Assess alternative materials with the target to improve performance/cost ratio	First choice of alternative materials selected
AIP 2012	Lower cost production processes		Assess manufacturing technology improvement strategies Reduce cost of metal bosses by a factor of 5	Ongoing comparative assessment of conventional Vs innovative winding technologies First choices of equipment improvement actions selected, under implementation on pilot line (increased productivity).
AIP 2012	Improved complete tank systems and related components characterised by reduced weight and volume Pressure regulators, valves, sealing...	Gravimetric system density>4.8	- Improved composite designs for 15% weight savings - Increased gravimetric storage density system >4.8%wt - 20-30% cost reduction for innovative pressure components	- State-of-the-art completed - Material characterisation for improved hydrogen tightness - Pressure device under definition - Reference tank selected
AIP 2012	On- or off-board diagnosis systems for containers		Develop and assess non-destructive evaluation methods for structural health monitoring of COPV	Definition of an optical fibre-based strategy for SHM First trials of SHM to monitor stresses during manufacturing of composite vesselsufacturing of composite vessels

D-CODE

DC/DC COnverter-based Diagnostics for PEM systems

CALL TOPIC	Operation diagnostics and control for stationary applications
START-DATE	1 March 2011
END-DATE	31 May 2014
TOTAL BUDGET	€2,215,767
FCH JU CONTRIBUTION	€1,173,818
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Università degli Studi di Salerno

Partners: European Institute for Energy Research, Université de Franche-Comté, Dantherm Power A/S, CIRTEM, Bitron SpA, Inno TSD SA.

PROJECT WEBSITE/URL

http://www.d-code-jti.eu/

PROJECT CONTACT INFORMATION

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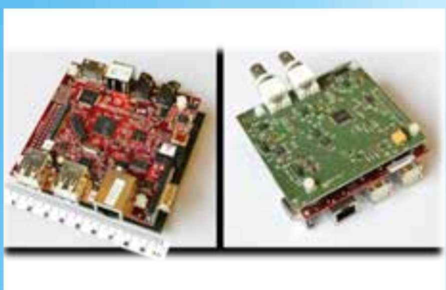
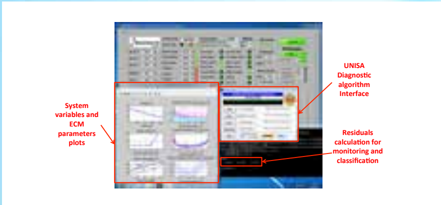
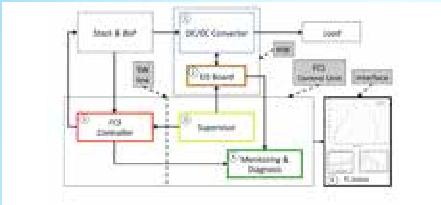




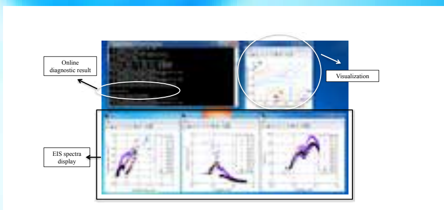


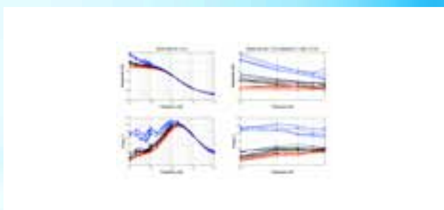
MAIN OBJECTIVES OF THE PROJECT

The main objective of D-CODE is to develop a diagnostic tool, made of hardware and software parts and based on the electrochemical impedance spectroscopy (EIS) concept. Its aim is to give direct and meaningful information about the FC systems status during real operations and to transpose the EIS from lab-scale to on-board applications. Using a dedicated DC/DC converter and an EIS board, designed and manufactured within the project framework, on-board EIS spectra are gathered. These measurements are treated by diagnostic algorithms, developed following model- and knowledge-based approaches, to infer on the system status.

PROGRESS/RESULTS TO DATE

- Specific EIS board and DC/DC converters (low-voltage and high-voltage) for EIS on-board measurements have been manufactured and successfully tested in lab environment on PEMFC systems.
- Specific diagnostic algorithms have been developed for low- and high-temperature PEMFC systems.
- Lab environment validation for the low-temperature PEMFC systems (TRL 4).
- Proof-of-concept reached for high-temperature PEMFC systems (TRL 3).





FUTURE STEPS

- The methodological process conceived in the D-CODE project can be converted into an industrial instrument for the design and manufacture of EIS-based diagnosis tools not only for PEMFCs but also for other FC technologies (i.e. SOFC) and other electrochemical devices (e.g. battery).
- A specific activity for stack and system identification under mimicked faults for both diagnosis algorithms development and testing can be settled.
- Test on a field campaign the monitoring and diagnosis algorithms.
- Use the system status detection for control strategy update as well as for degradation analysis (lifetime prediction).

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- The definition of advanced EIS-based algorithms for FC state-of-health monitoring and diagnosis is a first step towards the development of prognosis algorithms.
- The findings provide increased knowledge on the potential offered by advanced diagnostics and an on-field deployable diagnostic tool and related hardware.
- The obtained results give further awareness about the close interaction between diagnosis and state-of-health evaluations to support significant research fields concerning increased PEM lifetime targets (i.e. prognosis for residual lifetime evaluation).

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Development of control and diagnostic tool	New reliable control and diagnostics tools both at a component and at system level leading to step-change improvements over existing technology in terms of performance, endurance, robustness, durability and cost	New diagnostics tool relying on the implementation of on-board electrochemical impedance spectroscopy of polymer electrolyte fuel-cell systems, with the transportation of EIS measurements from lab-scale to on-field	Design, assembly and on-line testing of DC/DC converter and EIS board with diagnostic algorithms implemented for on-board measurements and diagnosis
AIP	System technology	Activities are open to all technologically mature stationary fuel-cell stack types and application	RS485, CAN-BUS and TCP/IP protocols, already implemented by Dantherm Power, will be considered as standard references	DANTHERM DBX2000 backup-system tested for LT PEMFC; SERENERGY Serenus 166 Air C tested for HT PEMFC

DeliverHy

Optimisation of Transport Solutions for Compressed Hydrogen

CALL TOPIC	Feasibility of 400b+ CGH_2 distribution
START-DATE	1 January 2012
END-DATE	31 December 2013
TOTAL BUDGET	€1,247,773
FCH JU CONTRIBUTION	€719,501
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Ludwig-Bölkow-Systemtechnik GmbH

Partners: Air Liquide Advanced Business, CCS Global Group, H2 Logic A/S, Raufoss Fuel Systems, Norwegian University of Science and Technology (NTNU).

PROJECT WEBSITE/URL

www.deliverhy.eu

PROJECT CONTACT INFORMATION

Reinhold Wurster,
Ludwig-Boelkow-Systemtechnik GmbH

coordinator@deliverhy.eu

MAIN OBJECTIVES OF THE PROJECT

- Evaluation of safety and cost-related effects caused by the introduction of composite materials trailers.
- Safety factors for well-built pressure vessels can be reduced compared to current requirements while maintaining adequate risk levels.
- Identification and rationale of needed changes in regulations, codes & standards (RCS) and preparation of an action plan.
- Initiation of a dialogue with selected national authorities about these changes.

PROGRESS/RESULTS TO DATE

- Delivery frequencies of CGH_2 truck trailers can be reduced threefold
- Transport-related CO_2 emissions can drop by 75%
- Delivery costs for new CGH_2 trailers can compete with LH2 delivery costs

FUTURE STEPS

- Improve the chance of better market uptake
- Explore a better understanding and approach, based on testing (RTD)
- Back up the scientific principles described by DeliverHy could be subject of further study

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Delivery frequencies of compressed gaseous hydrogen (CGH_2) truck trailers can be reduced by a factor of 3.
- Delivery costs for new CGH_2 trailers are competitive with liquid hydrogen (LH_2) delivery costs for distances up to 500 km (one-way).
- Optimal trailer concept strongly depends on hydrogen refuelling stations' (HRS) size and delivery distance.
- DeliverHy will have been successful, when probabilistic qualification approaches as described in DeliverHy are implemented into international RCS.
- This can be 2-3 years after substantiated recommendations from the DeliverHy project have been published.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	e.g. FC system lifetime	>5,000h	>10,000h	N/A (test not finalised)
AIP	Assessment of safety implications using composite material and higher storage pressure	SF <3.0	Identification/definition of applicable safety factors (from SF=3.0 -> SF=2.25) and pressure limitations	
AIP	Comparison of state-of-the-art 20 MPa infrastructure with 40 MPa+ equipment in order to determine strengths/weaknesses of 40 MPa+ truck delivery technology The comparison should focus on: materials and components behaviour, lifetime assessment, cost comparison and energy consumption taking into account the combination with on-site infrastructure for 70 MPa refuelling systems	>40MPa	52.5 MPa identified as most suitable Analysis performed regarding usable hydrogen delivered	
AIP	Assessment of technical and cost issues for such trailers including impact on energy efficiency and GHG emissions		Performed energy efficiency, economic and environmental analysis	
AIP	Identification of issues regarding RCS and way forward for facilitating the use of high-pressure trucks		RCS barriers and necessary changes identified • Process for reduction of high safety factor required for transportable carbon composite vessels • Acceptance of tubes/cylinders with water capacity exceeding 450 L (as of ISO 17519 for permanently mounted cylinders) initiated	

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

DeMStack

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

CALL TOPIC	Cell and stack degradation mechanisms and methods to achieve cost reduction and lifetime enhancements
START-DATE	1 May 2013
END-DATE	30 April 2016
TOTAL BUDGET	€2,576,615
FCH JU CONTRIBUTION	€1,495,680
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Institute of Chemical Engineering Sciences, Greece.

Partners: Fundación CIDETEC, Institute of Chemical Technology Prague, Advent Technologies SA, Joint Research Centre (JRC) Institute for Energy, Helbio SA and Prototech A/S.

PROJECT WEBSITE/URL

demstack.iceht.forth.gr

PROJECT CONTACT INFORMATION

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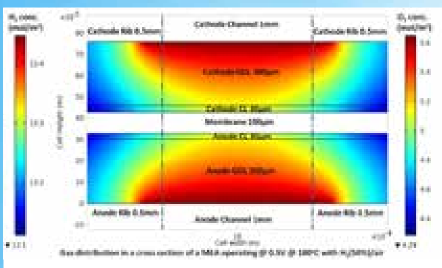

MAIN OBJECTIVES OF THE PROJECT

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

PROGRESS/RESULTS TO DATE

- Scaling-up of the component materials of the MEAs (PEMs and electro-catalysts) has been performed.
- Different designs for the bipolar plates and materials used are being explored.
- Research for further improvement of the electro-catalyst performance and stability is ongoing.
- Mathematical modelling that will assist the bipolar plate designs is in progress.

FUTURE STEPS

- DeMStack aims at a wider temperature operating window (160°C-200°C) through the incorporation and optimisation of efficient, robust materials and architectures for the stack components.
- Lower Pt loadings (reduced by a factor of two) are expected through the optimisation of the electro-catalyst structure.
- Two separate stack designs will be explored. Validated and effective architectures of flow fields on bipolar plates will be incorporated.
- Understanding of the functional operation and degradation mechanisms of the FC stack will lead to targeted modifications and to a reliable product.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- The incorporation of catalytic membranes reactors in the PEM fuel-cell micro-CHP systems could improve the efficiency while reducing the cost by the integration of reforming and purification in a single unit (working at lower temperature) and the optimised design of the subcomponent for the BoP.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	FC stack cost (€/kW)	4,000	<3,000	N/A (materials are now being scaled up, tested and selected)
AIP	FC stack lifetime	20,000h	5,000h (accelerated basis)	N/A (test not performed yet)
AIP	FC system electrical efficiency	35-45% (for power units)	>45%	>45% (already validated efficiency using preliminary designs)

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

DESIGN

Degradation signature identification for stack operation diagnostic

CALL TOPIC	Operation diagnostics and control for stationary power applications
START-DATE	1 January 2011
END-DATE	30 June 2014
TOTAL BUDGET	€3,266,000
FCH JU CONTRIBUTION	€1,746,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Commissariat à l'énergie atomique et aux énergies alternatives (CEA)

Partners: European Institute for Energy Research(EIFER), UNISA, Ecole polytechnique fédérale de Lausanne, Hygear Fuel Cell Systems, HTC, EBZ.

PROJECT WEBSITE/URL

www.design-sofc-diagnostic.eu

PROJECT CONTACT INFORMATION

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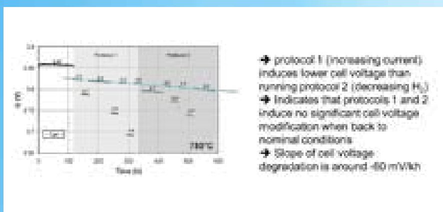


MAIN OBJECTIVES OF THE PROJECT

Provide sound diagnostic method for insidious phenomena that slowly accelerate the degradation at commercial stack level, through understanding of local responses of sub-stack elements.

Main project outputs expected:

1. Identification of relevant sensors and signals to be monitored to diagnose full stack degradation phenomena;
2. Data analysis methodology to be applied to measured signals;
3. Set of characteristic signatures for the different degradation phenomena at local and stack level, to be compared with actual sensor signal to diagnose long-term degradation conditions;
4. Recommendations for operation recovery, once a degradation condition is identified at cell, SRU or stack level.

PROGRESS/RESULTS TO DATE

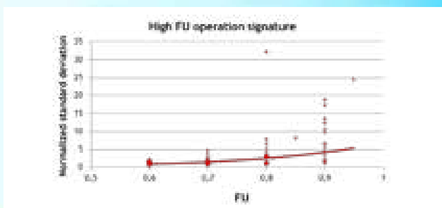
- A new diagnostic methodology has been developed for one selected harsh operating condition (high fuel utilisation) generating two patents (one pending and one published) and two congress presentations (FDFC2013 and EFCF2014).
- The developed methodology appears to be most promising but has not been evaluated as a prediction tool yet.

FUTURE STEPS

- Not relevant, project finished.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- This innovative approach has allowed many improvements on the fuel-cell tests rigs and protocols and on the reliability of experimental data at all scales from cells to stacks.
- The project ambition was high and its implementation has required more rigorous tests, SOFC operations and data analysis. It has highlighted difficulties that are generally not publicly shared and, by solving some of them within the consortium, the DESIGN project has paved the way to alternative analytical and experimental analysis and detection of degradation mechanism.
- Most targets have been reached in the case of one selected degradation mechanism and will be up-scaled in the FCH JU 2013- DIAMOND.
- IP protection: patent in process at UNISA; patent published at CEA.



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
AA3 Stationary power generation & CHP A3 Stationary power generation & CHP/MAIP	Compete with existing and future energy conversion technologies	Achieve the principal technical and economic specifications necessary for stationary fuel-cell systems to compete with existing and future energy conversion technologies	Development of diagnostic tool for in situ fine-tuning of cell/stack operation conditions will pave the way to SOFC stack reliability and durability as already observed with other mature competing technologies	80%
	Control and diagnostics tools	Deliver reliable control and diagnostics tools both at a component and at system level	The main target of the project is to deliver a diagnostic methodology able to serve as the basis for a diagnostic tool as the stack level	50%
	Use of multiple fuels	Include the use of multiple fuels	Hydrogen and synthetic reformate are tested in the project	100%
	Lifetime increase	Include a lifetime increase up to 40,000h	Early detection of identified degradation mechanisms will allow avoiding failure by modifying operation parameters thereby increasing substantially cell/stack lifetime. In addition, recommendations will be provided for recovery strategies for later detection	100%
2009 Topic: 3.3 Call 2009/AIP	Novel diagnostics	Novel diagnostics to identify potential failures, including in-operation diagnostic tools for cell/stack	Identification of relevant sensors and signals to be monitored to diagnose full stack degradation phenomena	100%
	Improved prediction; failure avoidance	Improved prediction and avoidance of failure mechanisms	A data analysis methodology to be applied to measured signals and to diagnose degradation mechanisms	40%
	Diagnostic and services tools	Tools for improved diagnostics and services	A set of characteristic signatures for the different degradation phenomena at local and stack level, to be compared with the actual sensor signal to diagnose long-term degradation conditions	100%
	Strategies (cell recovery; stack performance)	Development of strategies for recovery of cell and stack performance	Recommendations for recovery strategies once a degradation condition is identified at cell, SRU or stack level are an outcome of the project	80%

DESTA

Demonstration of 1st European SOFC Truck APU

CALL TOPIC	Auxiliary Power Units for Transportation Applications
START-DATE	1 January 2012
END-DATE	31 December 2014
TOTAL BUDGET	€9,841,007
FCH JU CONTRIBUTION	€ 3,874,272
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: AVL List GmbH

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

PROJECT WEBSITE/URL

www.desta-project.eu

PROJECT CONTACT INFORMATION

Jürgen Rechberger
juergen.rechberger@avl.com

MAIN OBJECTIVES OF THE PROJECT

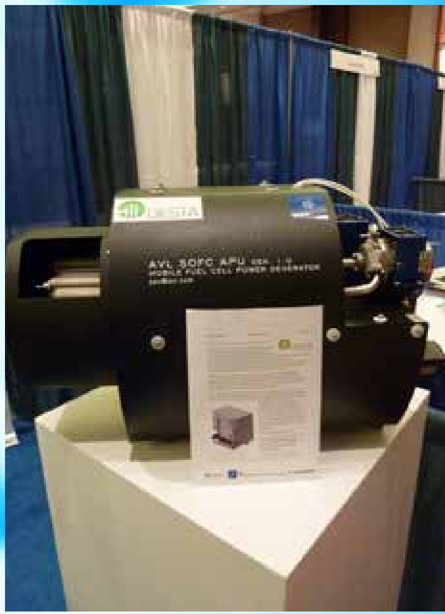
Demonstration of the first European SOFC APU on a Volvo HD truck; one-year testing of 6 APU systems (3 of Eberspächer and 3 of AVL); development and assembly of the final DESTA SOFC APU system, merging the most promising approaches of AVL and Eberspächer SOFC APU concepts; significant improvements of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

PROGRESS/RESULTS TO DATE

- Eberspächer and AVL system benchmark done, ongoing testing to gain system experience
- Electrical efficiency of 30% and net power of 3kW reached on US road fuel
- Significant stack improvements
- Final DESTA system (truck demonstrator) design available
- Truck demonstrator tests started

FUTURE STEPS

1. DESTA truck demonstrator validation tests
2. Lifetime and reliability validation tests including vibration & salt spray
3. Truck integration and testing on US HD truck



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Promising results during the tests of 6 APU systems have been achieved.
- Major breakthroughs towards operation on sulphur containing US diesel fuel and packaging size.
- Operation of SOFC APUs for several thousand hours with high efficiency on real diesel fuel.
- Truck integration scheduled for 2nd half of 2014.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
	Electric system efficiency	35%	35%	30%
	Anticipated lifetime	>20,000h	>5,000h	1,000h
	Emissions reduction	Less than current	75%	N/A

DIAMOND

Diagnosis-aided control for SOFC power systems

CALL TOPIC	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 April 2014
END-DATE	31 March 2017
TOTAL BUDGET	€3,613,488
FCH JU CONTRIBUTION	€2,101,808
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Hygear.

Partners: Commissariat à l'énergie atomique et aux énergies alternatives, Teknologian Tutkimuskeskus VTT, Universita degli Studi di Salerno, Htceramix SA, INEA Informatizacija Energetika Avtomatizacija doo, Institut Jozef Stefan.

PROJECT WEBSITE/URL

PROJECT CONTACT INFORMATION

Ellart de Wit

Ellart.dewit@hygear.nl

MAIN OBJECTIVES OF THE PROJECT

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

PROGRESS/RESULTS TO DATE

N/A

FUTURE STEPS

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

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

N/A

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Electric efficiency	35%-45%	50%	N/A
MAIP	Durability	30,000h	10 years, >85,000h	N/A
AIP	Advanced controls and diagnostics	Capable of optimising efficiencies	Strategies to guarantee optimal operation	N/A
AIP	System life >10 years for smaller-scale applications	>10 years for smaller-scale application	10 years	N/A

Don Quichote

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

CALL TOPIC	Demonstration of MW capacity hydrogen production and storage for balancing the grid and supply to a hydrogen refuelling station
START-DATE	1 October 2012
END-DATE	30 September 2017
TOTAL BUDGET	€4,900,000
FCH JU CONTRIBUTION	€2,900,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Hydrogenics Europe NV.

Partners: Hydrogen Efficiency Technologies BV, WaterstofNet vzw, Etablissementen Franz Colruyt NV, TUV Rheinland Industrie Service GmbH, Joint Research Centre (JRC), PE International AG, Icelandic New Energy Ltd, Federazione delle Associazioni Scientifiche e Techniche (FAST).

PROJECT WEBSITE/URL

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

PROJECT CONTACT INFORMATION

Johan Seykens (Hydrogenics Europe NV)
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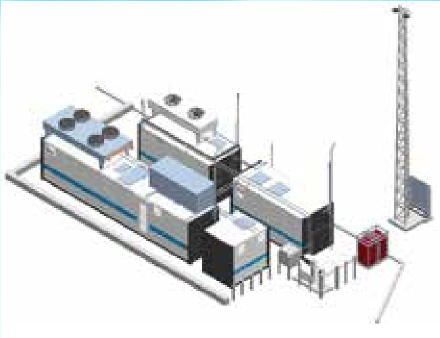
MAIN OBJECTIVES OF THE PROJECT

The Don Quichote project stepwise complements and expands components of an existing hydrogen refuelling system in Halle, Belgium, with innovative, more efficient components, fuel-cell technologies and electrochemical hydrogen compressor/expander technology, integrating them with a renewable energy source, thereby realising a renewable energy storage capacity based on hydrogen. The hydrogen is used to refuel mobile applications and to produce electricity for the grid. The whole system is tested and evaluated in performance, environmental, regulatory, economic and business potential terms. This project combines targets on increasing renewable electricity, grid balancing, sustainable mobility and the use of clean hydrogen in a concrete way.

PROGRESS/RESULTS TO DATE

- Permit for new Don Quichote technologies requested
- PEM electrolyser system assembled
- LCA analysis performed
- Existing RCS mapped
- Operational data existing system gathered
- Insights in operational characteristics of national electricity market gathered



FUTURE STEPS

- Implementation of Don Quichote technologies onsite
- Testing and evaluation
- Business-case development

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

The first conclusions will be drawn after the Don Quichote technologies are implemented on site (2014), and after the preliminary testing and evaluation activities has been performed (2015).

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	CORRESPONDING PROJECT OBJECTIVES/ TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO-DATE	PROBABILITY OF FINAL TARGET ACHIEVEMENT (%)	EXPLANATION OF PROBABILITIES <100%
MAIP objectives				
Efficiency (WtT) >55 %	DQ: electrolyser 69% compressor 85%	Stack qualified at FAT	100%	
Cost of hydrogen delivered <€15/kg	<€13/kg		100%	
Hydrogen quality ISO/DIS 14786-2 compliant	ISO/DIS 14786-2 compliant	Stack qualification/compressor TBD	100%	
Availability	>95%	To be started	100%	Growing pains during start up to be expected
Operation within project >2500 hours	>25,000h	To be started	95%	Operational hours available to demonstrate availability. Amount of hydrogen to be produced will depend on business case for re-electrification
Durability >10 years	10 years	To be started	50%	Depends on business model – cost of electricity and hydrogen use in order to demonstrate lifetime
AIP objectives				
"...develop a portfolio of sustainable hydrogen production ..."	Wind as well as solar electricity (different dynamics, fluctuations, sizes)	Power-based (energy supply side) steering of electrolyser demonstrated	100%	Installed and tested
"R&D in innovative hydrogen production and supply chains "	Alkaline as well as PEM electrolyser	PEM stack construction passed factory acceptance PEM electrolyser constructed and ready for certification and testing First of its kind, ready for up-scaling to MW scale	100%	Ready for certification and factory acceptance testing
"R&D in innovative hydrogen production and supply chains "	Mechanical as well as electrochemical compressor	Proof of concept of electrochemical compressor	100%	Technology selection for up-scaling. Reliability question marks.
"... storage and distribution processes which can meet an increasing share of the hydrogen demand for energy applications "	Modular systems for hydrogen storage	Installed and tested carbon-fibre storage solution	100%	On-site integration going on
"... storage and distribution processes which can meet an increasing share of the hydrogen demand for energy applications "	End-user of hydrogen for transport (e.g. fork-lifts) as well as controllable load	Fork-lift base extension (not in scope), infrastructure adaptions in permitting process	100%	Possible questions/iterations that will impact timing

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

DURAMET

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

CALL TOPIC	Components with advanced durability for direct methanol fuel cells
START-DATE	1 December 2011
END-DATE	30 November 2014
TOTAL BUDGET	€2,956,874
FCH JU CONTRIBUTION	€1,496,617
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Consiglio Nazionale delle Ricerche (CNR-ITAE).

Partners: Centre national de la recherche scientifique (CNRS), Fuma-tech Gesellschaft fuer Funktionelle Membranen und Anlagentechnologie mbH, Centro Ricerche FIAT scpa (CRF), Technische Universität München, IRD Fuel Cells a/s, Politecnico di Torino, Pretexo, Joint Research Centre (JRC-IET).

PROJECT WEBSITE/URL

http://www.duramet.eu

PROJECT CONTACT INFORMATION

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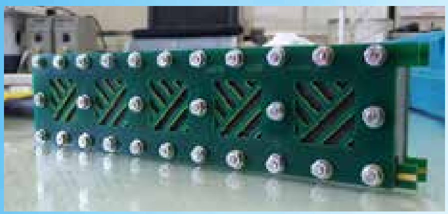


MAIN OBJECTIVES OF THE PROJECT

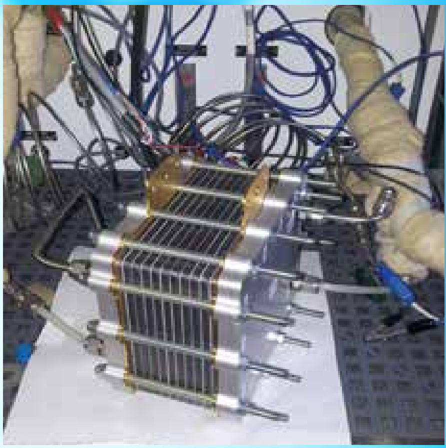
The Duramet project deals with enhanced direct methanol fuel cells (DMFCs). DMFCs working at low and intermediate temperatures (up to 130°C-150°C) have been postulated as suitable systems for power generation from portable power sources, remote and micro-distributed energy generation as well as for auxiliary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

PROGRESS/RESULTS TO DATE

- Innovative membranes with enhanced conductivity and reduced cross-over for wide temperature operation have been developed.
- Enhanced nanosized ternary electro-catalysts demonstrated .
- Membrane-electrode assembly (MEA) performance of 250 mW cm^{-2} achieved at 130°C (1 mg cm^{-2} noble metal loading).
- Passive mode portable ministack (1W) demonstrated.
- High-temperature APU stack (200W) demonstrated.

FUTURE STEPS

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



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

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

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

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

EDEN

High Energy Density Mg-Based metal hydrides storage system

CALL TOPIC	Novel H2 storage materials for stationary and portable applications
START-DATE	1 November 2012
END-DATE	30 September 2015
TOTAL BUDGET	€2,653,574
FCH JU CONTRIBUTION	€1,524,900
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Fondazione Bruno Kessler

Partners: MBN Nanomaterialia SPA, Cidete Ingenieros SL, Matres ScrL, Panco GmbH, Universidad de la Laguna, Joint Research Centre (JRC–IET).

PROJECT WEBSITE/URL

www.h2eden.eu

PROJECT CONTACT INFORMATION

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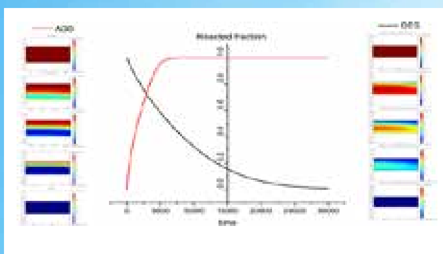
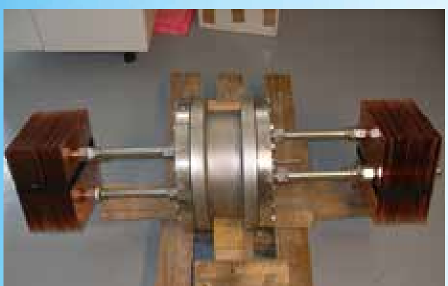
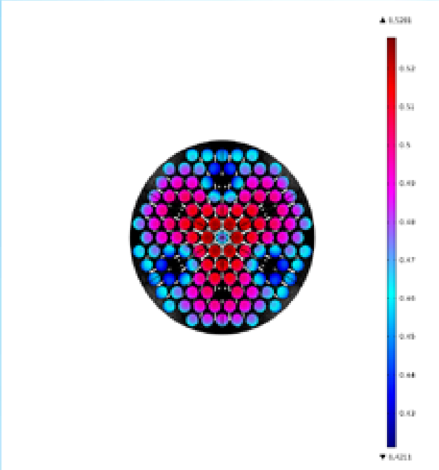




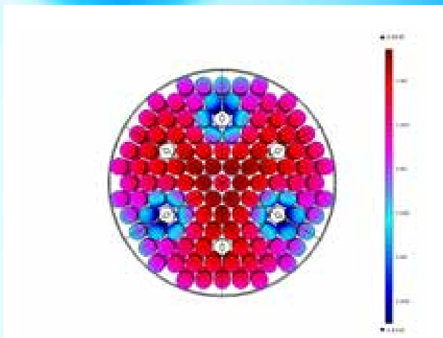


MAIN OBJECTIVES OF THE PROJECT

EDEN project is developing an integrated system for solid-state H2 storage realised through: 1) an optimised fast-reacting Mg-based hydride, 2) a newly designed tank with 3) full thermal and hydrogen management in connection and integration with a SOFC. It will be interlinked to an energy supply system able to match intermittent energy sources with local energy demand (buildings, small dwellings) in stationary applications.

PROGRESS/RESULTS TO DATE

- The improved material has been realised both with standard and sputtered catalysts added.
- Design of storage tank integrated with all thermal and hydrogen management components, modelled to release more than 1.5 litres per minute.
- Development and realisation of intermediate storage tank, to fully validate the storage material.
- System-integration layout comprised of all auxiliaries to properly manage hydrogen and thermal power between the hydrogen tank and the SOFC.



FUTURE STEPS

- Test and validate material in intermediate storage tank
- Realise the full-scale storage tank
- Integrate storage tank with auxiliaries and SOFC system
- Test the integrated system and validate at lab-scale
- Demonstrate the integrated system in a real environment

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- The Mg-metal hydride has been demonstrated to have about 7.0% weight of storage capacity and a reaction kinetic able to release 2.0 litres per minute of hydrogen.
- Innovative catalyst addition process realised, qualified and first samples realised and validated with improved reaction kinetic.
- The tank has been realised integrating innovative layout with enhanced transfer medium as expanded natural graphite and heat pipes.
- Problems at the boundary of the hydrogen tank and the SOFC have been identified and solutions are proposed for integration in the first prototype.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Stationary storage (of H2 from renewable electricity) by 2015	5t	N/A	N/A
AIP	Hydrogen storage capacity	>6% w	>6% w	7% w
AIP	Tank system storage capacity	>4% w	4% w	N/A (test not finalised)
AIP	Compatibility with FC systems	Any FC	SOFC	Confirmed
	Long-term run cost	<€500/kg	€300/kg	N/A (test not finalised)

ELECTRA

High temperature electrolyser with novel proton ceramic tubular modules of superior efficiency, robustness and lifetime economy

CALL TOPIC	New generation of high-temperature electrolyser
START-DATE	3 March 2014
END-DATE	2 March 2017
TOTAL BUDGET	€3,788,979
FCH JU CONTRIBUTION	€2,240,552
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: University of Oslo.

Partners: CSIC, SINTEF, Marion, PROTIA, Abengoa Hidrigeno, CRI.

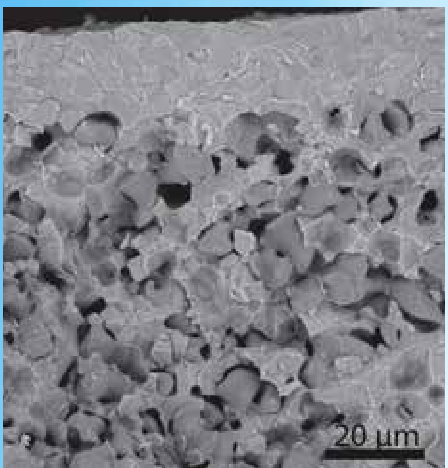
PROJECT WEBSITE/URL

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

PROJECT CONTACT INFORMATION

Professor Truls Norby, Univ.

truls.norby@kjemi.uio.no



MAIN OBJECTIVES OF THE PROJECT

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

PROGRESS/RESULTS TO DATE

- Material strategies decided
- Production of first generation tubes started
- Stability and compatibility tests started
- Common measurement protocol established
- Design of high-pressure steam measurement reactor completed

FUTURE STEPS

- Development and production of second and third generation segmented tubes
- Deposition and characterisation of candidate oxygen electrodes
- Build and commission measurement rigs at relevant partners
- Electrolysis tests of first and second generation tubes
- System design and techno-economic studies for process integration with renewable power sources

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

Work progress as planned at Month 3

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Unit capacity	~1.5 t/day	250 L_n/hour	N/A
MAIP	Efficiency	68%	68%	N/A
AIP	Cell and stack properties	I >1 Acm-^{2} Area-specific resistance <1Ωcm^2	I >1 Acm-^{2} ASR <1Ωcm^2	N/A
AIP	Degradation rate	<0.5% per 1,000 hours	<0.5% per 1,000 hours	N/A
AIP	Durability	Pressure tolerance under realistic conditions	Long-term operation at 20 bar. Robust solutions for lifetime economy	N/A
AIP	Module power	kW range	Multi-tubular module of ~1kW	N/A
AIP	Co-electrolysis proof-of-concept	85-90% efficiency	Syngas and DME production 85% efficiency	N/A

ELECTROHYPEM

Enhanced performance and cost-effective materials for long-term operation of PEM water electrolysers coupled to renewable power sources

CALL TOPIC	Innovative materials and components for PEM electrolysers
START-DATE	1 July 2012
END-DATE	30 June 2015
TOTAL BUDGET	€2,842,312
FCH JU CONTRIBUTION	€1,352,771
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Consiglio Nazionale delle Ricerche (CNR-ITAE)

Partners: Joint Research Centre (JRC-IET), Centre national de la recherche scientifique (CNRS), Solvay Specialty Polymers Italy spa, ITM Power (Trading) Ltd, Tozzi Renewable Energy.

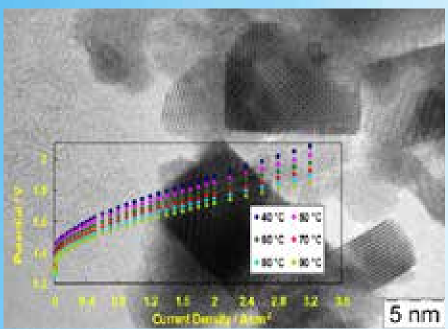
PROJECT WEBSITE/URL

http://www.electrohypem.eu

PROJECT CONTACT INFORMATION

Dr Antonin Salvatore Aric' Consigliore National dell Recherché

Tel. +39090624237 Fax. +39090624247



MAIN OBJECTIVES OF THE PROJECT

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

PROGRESS/RESULTS TO DATE

- Innovative membranes with enhanced conductivity and reduced hydrogen cross-over for wide temperature operation have been developed.
- Enhanced nanosized solid solution mixed oxide electro-catalysts demonstrated.
- Membrane-electrode assembly (MEA) performance of 1.8 V at 3 A cm-^{2} achieved at 130°C (1.5 mg cm-^{2} noble metal loading).
- MEA performance decay with time ~8 µV/h (1200h test)
- Power consumption of 3.9 kWh/Nm$_3$ H_2 at 0.3-0.5 Nm^3/h.

FUTURE STEPS

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

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- In order to be competitive within the field of decentralised hydrogen production, the PEM electrolyser must be reasonably cheap; moreover, it should be compact, characterised by high durability and capable of producing hydrogen at high efficiency and at suitable pressure.
- Enhanced materials and components (catalyst, membranes and MEAs) have been developed providing performance better than state-of-the-art at lower precious metal loading.
- Novel materials are now validated in stacks of 0.5 -1 Nm^3 H_2/h capacity and promising efficiency levels have been achieved.
- These devices are promising for small-scale applications especially under operation with renewable power sources.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Cost-competitive, high energy efficient and sustainable hydrogen production	Cost-efficient low-temperature electrolysers	Development of enhanced performance and cost-effective materials for long-term operation of PEM water electrolysers coupled to renewable power sources	High-performance novel membranes and electrodes with cost-effective characteristics have been demonstrated
AIP	PEM electrolyser capacity	Hydrogen production capacity >1 Nm^3/h	Innovative electrolyser with rated production capacity >1 Nm^3/h	Innovative electrolyser with production capacity 0.3-0.5 Nm^3/h
AIP	PEM electrolyser stack efficiency/ energy consumption	Efficiency of 75% (LHV)	Stack energy consumption <4 kWh/Nm^3 H2 @ 1 Nm^3 h^{-1}	Stack energy consumption 3.9 kWh/Nm^3 H2 at 0.3-0.5 Nm^3 h^{-1}
AIP	PEM electrolyser durability/stability	High stability at constant load	Voltage increase <15 µV/h at 1 A cm^{-2}	Stability >1,200h 8 µV/h
AIP	PEM electrolyser capital costs	Stack cost <€2,500/Nm^3 H_2 in series production	Aimed stack cost <<€2,500/Nm^3 H_2 using novel membranes and electro-catalysts	Cost-effective novel membranes and electro-catalysts demonstrated

ELYGRID

Improvements to Integrate High Pressure Alkaline Electrolysers for Electricity/H2 production from Renewable Energies to Balance the Grid

CALL TOPIC	Efficient alkaline electrolysers
START-DATE	1 November 2011
END-DATE	31 October 2014
TOTAL BUDGET	€3,752,760
FCH JU CONTRIBUTION	€2,105,017
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: FHA

Partners: IHT, EMPA, Areva, Forschungszentrum Jülich, VITO, Lapesa, Inycom, Ingeteam, CEA.

PROJECT WEBSITE/URL

www.elygrid.com

PROJECT CONTACT INFORMATION

Coordinator: Foundation for Hydrogen in Aragon

info@hidrogenoaragon.org

MAIN OBJECTIVES OF THE PROJECT

ELYGRID aims at contributing to reduce the total cost of hydrogen produced via electrolysis coupled to renewable energy sources, mainly wind turbines, and focusing on MW-size electrolyses (from 0.5MW and up). The objectives are to improve the efficiency related to the complete system by 20% and to reduce costs by 25%. The work will be structured in cell improvements, power electronics and balance of plant (BoP).

PROGRESS/RESULTS TO DATE

- New materials for membrane development selected
- 2.6MW power electronics prototype commissioned
- New mechanical design gas separators and mechanical parts (cost reduction)
- First tests at big scale (1,600 mm membrane diameter)
- RCS assessment and market studies developed

FUTURE STEPS

- Finish testing at lab scale (130 mm)
- Assessment of new topology power electronics
- Finish plug & play design and control system
- Tests with new materials at big scale (1,600 mm membrane diameter)
- Finish LCA, cost model and manufacturing assessment

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- New technology tested shows promise results
- High-capacity units could be produced increasing the current density
- New power electronics based on IGBTs
- New plug & play design and control system could reduce the total cost of ownership of this technology

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	2015 target: Unit capacity	1.5 tonne/d	3 tonne/d	3 tonne/d
AIP	Efficiency	80% HHV (0.75 A/cm^2)	90% HHV (0.5 A/cm^2)	78% HHV (0.4 A/cm^2)
AIP	Durability	10-year lifespan	10-year lifespan	It will depend on the membrane used
AIP	Modular system cost	€3000/Nm^3	25% cost reduction	In progress. This target will be reached

ENDURANCE

Enhanced Durability materials for Advanced stacks of New solid oxide fuel Cells

CALL TOPIC	Improving understanding of cell & stack degradation mechanisms
START-DATE	1 April 2014
END-DATE	31 March 2017
TOTAL BUDGET	€4,414,192
FCH JU CONTRIBUTION	€2,556,232
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Università degli Studi di Genova

Partners: SOFCPOWER SpA, Marion Technologies, Fundacio Institut de Recerca de l'Energia de Catalunya, Deutsches Zentrum für Luft und Raumfahrt, Institute of Electrochemistry and Energy Systems - Bulgaria Academy of Sciences, Centre national de la recherche scientifique, Commissariat à l'énergie atomique et aux énergies alternatives, Schott AG, HTceramix SA, Ecole polytechnique fédérale de Lausanne, Università di Pisa.

PROJECT WEBSITE/URL

www.durablepower.eu (domain under registration)

PROJECT CONTACT INFORMATION

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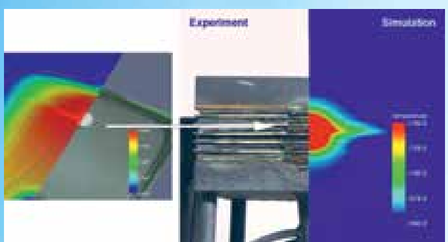

MAIN OBJECTIVES OF THE PROJECT

This project aims to improve the durability and reliability of SoA stacks and cells by:

- Using more efficient materials
- Introducing early warning signals triggering counterstrategies
- offering a reliable predictive model for performances and degradation processes.
- Endurance stacks should resist:
- in harsh conditions with high water vapour in gases
- minimum of 50 cycles from room to operating temperature
- Minimum of 100 cycles idle to load.
- Knowledge improvement:
- Failure modes and effect analyses (FMEA) implementation
- Risk rate of single and combined degradation
- Advanced predictive modelling.

PROGRESS/RESULTS TO DATE

1. Cells are under investigation (e.g. 3D tomography) to understand the degradation of electrodes during operation.
2. A SoA-operated stack and segmented stack are opened and micro-samples distributed to partners for materials characterisation. One SoA segmented stack is actually under operation for cross-check with modelling.
3. Electrochemical performances from the same cells are treated for models refining process.Collection of data from SoA-operated stack and segmented stack. Live evaluation of a segmented stack under operation.
4. A first set of 10 cycles from room to operating temperature on MIC-sealing (two differing formulations) - MIC samples.

FUTURE STEPS

1. Ageing, electrochemical testing and post-experiment characterisation of micro-samples replicating those from the operated SoA stacks (one complete and one segmented) in order to corroborate the previous interpretation and models.
2. Draft of a first list of failure modes with related risk rate.
3. Fully operative book of samples database and handbook of experiments and data.
4. Introduction of first materials, designs and tests improvements.
5. Dissemination: design of template for content collection to share among the consortium for the serious game «ZEM: zero energy-miles» (tentative title), in order to fill in contents. Each partner is requested to participate actively in this part. October 2014: game design, definition of the game concept and mechanics; February 2015 alpha internal release.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

1. At month 3, the SoA of failure modes is being defined and will be ready. This is a fundamental step for further activities like the introduction of early warning output signals (EWOS).
2. The SoA predictive and descriptive models are undergoing refining processes. The aim is to minimise further changes and to maximise the statistical validation so as to improve the prediction over the long term.
3. The standard operating conditions are correct for the electrochemical tests on components. Non-standard operating conditions (e.g. increase of water vapour concentration in fuel) are fixed and used for samples replicating critical zones of a stack or critical interfaces.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	2015: Cost for industrial/commercial units	€1,500-€ 2,500/kW	The project seeks to improve durability and reliability. The cost/kW is related to the manufacturing volume of the SMEs involved, and is not a project target	N/A (test not finalised)
AIP	Relevant degradation and failure mechanisms over the long term	Identify, quantify and document them	• Failure modes and effect analyses (FMEA) • Risk rate of single and combined degradation • Advanced predictive modelling	5%
AIP	Improved long-term performance achieved by adjustments to materials, design and manufacturing processes	Evidence based on statistically conclusive data	Collection of data from SoA-operated stack and segmented stack. Live evaluation of a segmented stack under operation	5%
AIP	Improved robustness to cycling and transient operating conditions	Harsh environments	Tests will be performed: • high water vapour in gases • minimum of 50 cycles from room to operating T • minimum of 100 cycles idle to load	4%
AIP	Development of accelerated testing strategies for specific failure modes	They must be backed by modelling or specific experiments to verify the method(s) used	Statistically validated predictive modelling verified with fragmented stacks and near-real-life tests (i.e. at fully operating and working conditions) on micro-samples replicating sensitive interfaces/interphases of the stack.	2%

ene.field

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

CALL TOPIC	Field demonstration of small stationary fuel-cell systems for residential and commercial applications
START-DATE	1 September 2012
END-DATE	31 August 2017
TOTAL BUDGET	€53,000,000
FCH JU CONTRIBUTION	€26,000,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: COGEN Europe

Partners: BAXI Innotech, Bosch Thermotechnik, Ceres Power Limited, Dantherm Power, Elcore, RBZ, SOFCpower, Vaillant, Dolomiti Energia, British Gas, Element Energy, GDF SUEZ, ITHO Daalderop, HyER, Imperial College of Science, Technology and Medicine, Development Centre for Hydrogen Technologies (DCHT), Environment Park, Politecnico di Torino, DBI, Energy Saving Trust, Gas- und Wärme-Institut Essen, Danmarks Tekniske Universitet (DTU), European Institute for Energy Research (Eifer), DONG Energy, Hexis.

PROJECT WEBSITE/URL

www.enefield.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

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

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

PROGRESS/RESULTS TO DATE

- The field trials started in September 2013
- Information packs for householders in 12 different languages
- Regional workshops took place (Spain, Italy and Germany)
- Establishment of a utility working group and another for regulations codes and standards (RCS)
- Field-support report of state-of-the-art with regard to field support arrangements, training and certification and EU supply chain report

FUTURE STEPS

- 2011-2014 - Deployment of the field trials in Austria, Belgium, Denmark, France, Germany, Luxembourg, Ireland, Italy, Netherlands, Slovenia, Spain and the UK
- 2015 - Data analysis – aggregation of the data form the trials first report
- 2015 - Analysis of the field support and barriers.
- 2015 - Development of an environmental life-cycle and costs assessment
- 2016 - Establish a commercialisation framework

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Contract agreement with field trial partners has taken longer than expected
- An implementable consistent monitoring scheme has been put in place.
- Awareness of the project has been built up (and will continue) with outreach to a range of target groups and potential supporters.
- Production volume is a serious limiting factor for the successful development of the supply chain

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Number of units	1,000	1,000	50 (installations ongoing)
AIP	Confidence by redundancy	>25 identical units in the range of 1-10kWe	39–174 identical units from each manufacturer	Installations ongoing
AIP	Progress towards economic lifetime	target of 8-10 years	Systems are expected to achieve a lifetime greater than 10,000 hours without stack replacement, with most units expected to achieve >20,000 hours	Installations and monitoring ongoing
AIP	Life-cycle costs and environmental sustainability assessment	Deliver a full LCC/LCA	Deliver a full LCC/LCA	The work has started and will be finalised in 2016
AIP	Efficiency (electrical)	>35%	>35%	N/A no data yet
AIP	Overall efficiency (LHV)	>85%	>85%	N/A no data yet

EURECA

Efficient Use of Resources in Energy Converting Applications

CALL TOPIC	Next generation stack and cell design
START-DATE	1 July 2012
END-DATE	30 June 2015
TOTAL BUDGET	€6,314,505
FCH JU CONTRIBUTION	€3,557,295
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Next Energy

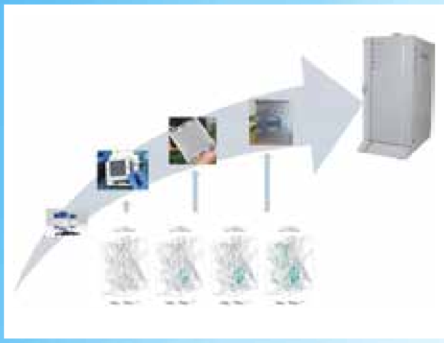
Partners: CEA, CEGASA, CIDETEC, Eisenhuth, FORTH, Fraunhofer ISE, Inhouse, University of Belgrade.

PROJECT WEBSITE/URL

www.project-eureca.com

PROJECT CONTACT INFORMATION

Dr. Alexander Dyck
info@project-eureca.com



MAIN OBJECTIVES OF THE PROJECT

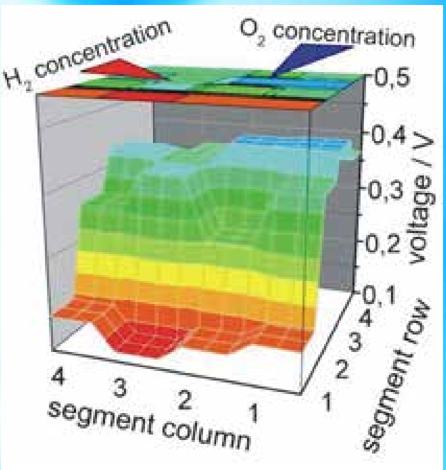
The EURECA team develops the next generation of µ-CHP systems based on advanced PEM stack technology. The idea is to overcome the disadvantages of complex gas purification, gas humidification and the small temperature gradient for the heat exchangers in a heating system. In the EURECA project we will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

PROGRESS/RESULTS TO DATE

- Membrane development
- Catalyst development
- MEA development and fabrication
- Stack and system design optimisation
- Design-to-cost approach

FUTURE STEPS

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



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Efficient energy supply
- Improvement of CO tolerance with increasing T and RH
- Middle-temperature fuel cells are a reasonable bridge between high- and low-temperature ones
- Influence from components to system costs and properties shapes the development strategy

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Cost of €4,000-€5,000/kW	€4,000-€5,000/kW	<€3,000/kW	<€5,000/kW
AIP	New architectures, adaptation of cell and/or stack designs to specific applications and system designs			Stacks are under construction and further tests to achieve overall project goals.
AIP	Design to cost			Cost assessment is on-going
AIP	Simplification of design and manufacturing of cells, stacks and/or stack modules			The second stage fuel gas purification will not be removed
AIP 2011 (P74)	Efficiencies	35% based on integrated reformer solution)		Efficiency analysis is ongoing
AIP 2011 (P74)	Lifetime	>10,000h (stack) >20,000h (system)		The estimated runtime from simulation
AIP 2011 (P74)	Costs	<€3,000/kWel (hydrogen fuel cell system)		Cost assessment is ongoing

EVOLVE

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

CALL TOPIC	Next-generation stack and cell design
START-DATE	1 November 2012
END-DATE	31 October 2016
TOTAL BUDGET	€5,805,374
FCH JU CONTRIBUTION	€3,105,093
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Deutsches Zentrum für Luft- und Raumfahrt

Partners: Alantum Europe GmbH, ARMINES, Ceramic Powder Technology AS, Consiglio Nazionale delle Ricerche, Institut Polytechnique de Grenoble, SAAN Energi AB, Ceramic Coating GmbH.

PROJECT WEBSITE/URL

www.evolve-fcell.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

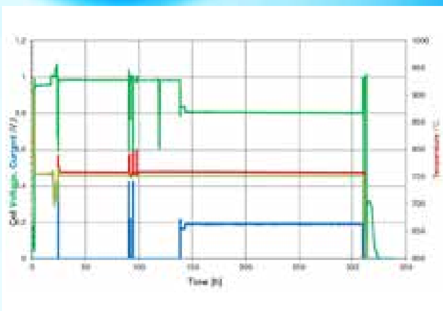
Beyond state-of-the-art, EVOLVE aims at the demonstration and development of a new SOFC architecture, combining both benefit from previous cell architectures, the so-called anode-supported and metal-supported cells, while addressing the issues related to these specific architectures. The concept EVOLVE is based on a hybrid metal/ceramic support where metal is able to create an alumina oxide layer and ceramic shows high electronic conductivity level, without any nickel as structural component and targets a lifetime over 30,000 hours. The final objective is to demonstrate this technology up to stack level.

PROGRESS/RESULTS TO DATE

- Feasibility of cell architecture demonstrated with first prototype
- No quantifiable degradation observed over 300h under polarisation of full cell and of the anodic system over 1,000h in hydrogen
- Understanding the anodic behaviour of perovskite system
- Development of thin electrolyte coatings (3μm)

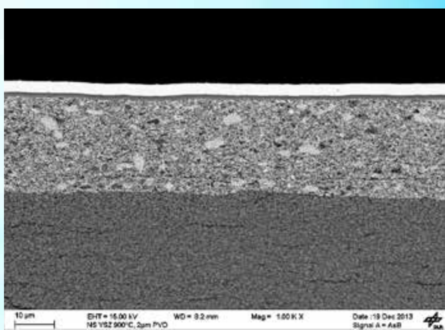
FUTURE STEPS

- Lifetime assessment of the metal foam
- Refinement and optimisation of the conditioning parameter for optimising current collection in substrate
- Manufacturing of improved microstructure for the anodic compartment
- Assessment of the thin electrolyte technology
- Testing and lifetime assessment of the improved EVOLVE cells



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Cell architecture has been demonstrated
- Compatibility between the materials has been developed
- No quantifiable degradation has been measured in the anodic system over 1,000h
- Development of thin electrolyte technology
- Perspective: manufacturing of cells with enhanced performance



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	2020 target: must sustain repeated on/off cycling (CHP unit)		50	Not yet evaluated
MAIP	2020 target: (CHP unit) lifetime expected >20,000 hours	>20,000 hours	Lifetime of cell and stack >30,000 hours Degradation rate of cell voltage below 0.25% per 1,000 hours with H_2 as fuel	No quantifiable degradation in H2 – 3%H20 over 1,000 hours measured on symmetrical cells with LST-CGO impregnated with 5wt%Ni as anode material under polarisation.
AIP 2011	Improved tolerance to contaminants with respect to state-of-the-art FCs		Degradation rate of cell voltage below 1.5% per 1,000 hours in syngas (with H_2S)	Not yet evaluated Nickel amount reduced to 5wt% of the active anode material. Ni free catalysts under investigation
AIP 2011	Improved cycling capability of several hundred cycles from room temperature to operating temperature	100	50 on/off cycles with less than 5% total degradation in cell voltage	Not yet evaluated
AIP 2011	Improved start-up time	From room temperature to 30% of power rating in less than one hour	Heating rate of 25K/min for thermal cycles	Under evaluation
AIP 2011	Decreased material consumption		Demonstrate up-scalability of cells & ese realistic model cost analysis, establish processing sequences and practices for cell components to attain optimal cost-to-quality ratio	Reduction from 100μm to 3μm the thickness of the electrolyte required for comparable gas tightness at level 50mm x 50mm Implementation of thin-film coating technology (EB-PVD) in replacement of plasma spraying (VPS)

FCGEN

Fuel Cell based On-board Power Generation

CALL TOPIC	Auxiliary power units for transportation applications
START-DATE	1 November 2011
END-DATE	31 October 2014
TOTAL BUDGET	€10,338,414
FCH JU CONTRIBUTION	€4,342,854
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Volvo Technology AB.

Partners: Powercell Sweden AB, Forschungszentrum Juelich GMBH, Institut Jozef Stefan, Centro Ricerche Fiat SCPA, Institut fuer Mikrotechnik Mainz GmbH, Johnson Matthey PLC, Modelon AB

PROJECT WEBSITE/URL

www.fcgen.com

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

The main objective of the FCGEN project is to develop and demonstrate a proof-of-concept complete polymer electrolyte membrane fuel cell based 3kW (net el.) auxiliary power unit (PEMFC-APU) in a real application, on-board a truck.

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

PROGRESS/RESULTS TO DATE

- System design for best component integration and heat management
- Vehicle interface and communication
- Component manufacturing and testing and BoP component purchasing, optimisation and testing
- Control system architecture, development and testing
- Fuel processor integration and commissioning

FUTURE STEPS

- Fuel processor module testing
- Integration of FC stack and corresponding components in the APU system and test the APU in laboratory environment
- Vehicle integration and testing of the PEMFC-APU on-board a truck

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Development of a successful system design and packaging model which enables the integration of the PEMFC-APU system components in an efficient way.
- All system components (developed within the project and purchased) are successfully tested at project partners' laboratories.
- The PEMFC-APU control system is developed and tested on system components.
- The fuel processor module has been integrated successfully and is currently under testing.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	APU system efficiency	Demonstrations of increased efficiency of on-board power generation and reduced CO_2 emissions and local pollutions	System efficiency ~30% Emissions: sulphur <10 ppb Carbon monoxide <25 ppm Non-methane hydrocarbons <1 ppm	Not demonstrated yet as the system is under development Demonstrated during single component testing
MAIP	Development of fuel cell-based APU systems for mobile applications	Research, development and proof-of-concept demonstration of APU systems for on-board power generation	Develop and demonstrate a PEMFC-APU on-board a truck	PEMFC-APU system is currently under development
MAIP	Fuel processing of logistic fuels	Demonstrated fuel processing technology for logistic fuels	Design the fuel processor module to handle logistic fuels	Fuel processor module with sulphur-tolerant reformer and desulphurisation unit downstream from the reformer is developed and is currently under testing
AIP	Vehicle demonstration of auxiliary power units	• Research, development and proof-of-concept demonstration of APU systems for on-board power generation. • Demonstrated feasibility of using logistic fuels and demonstrated fuel processing technology for logistic fuels • Defined requirements for fully integrated systems in the specific application.	Develop and build a stand-alone PEMFC-APU system which can handle low-sulphur logistic fuels and demonstrate the performance of the system on-board a truck	An APU system consisting of a fuel processor module, a PEM fuel-cell stack module and a control system is developed. Currently the fuel processor together with the control system is under testing in laboratory environment.

FC-powered RBS

Demonstration Project for Power Supply to Telecom Stations through FC technology

CALL TOPIC	Demonstration of industrial application readiness of fuel-cell generators for power supply to off-grid stations, including the hydrogen supply solution
START-DATE	1 January 2012
END-DATE	31 December 2014
TOTAL BUDGET	€10,591,649
FCH JU CONTRIBUTION	€4,221,270
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Ericsson Telecommunication Italy

Partners: Dantherm Power AS, GreenHydrogen DK APS, MES SA, Joint Research Centre (JRC), Università degli Studi di Roma Tor Vergata.

PROJECT WEBSITE/URL

www.fcpoweredrbs.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

Field trials in 14 live radio base-station sites and lab test in two research centres. Demonstrate to the TLC operators the possible advantage, in terms of TCO, associated with power off-grid RBS with a new system combining renewable sources to replace the diesel generator.

PROGRESS/RESULTS TO DATE

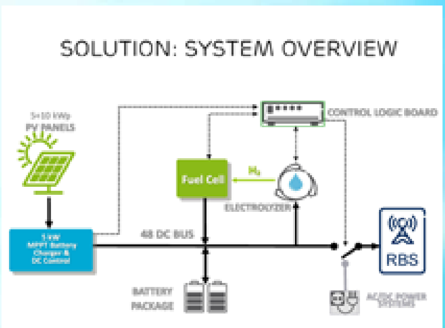
- Benchmarking test executed and provisional TCO calculated
- Authorisation process completed and field roll-out on-going in main TLC Italian operators
- Solution completed and smart metering O&M implemented
- H2 supply solution and safety procedures
- Training and dissemination activities

FUTURE STEPS

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

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- The project results will give an immediate answer with respect to the market readiness of the proposed solution.
- The consortium would expect that if the TCO is demonstrated to be in line with expectation a proper market proposition may be already available.
- O&M processes and procedures are essential for the successful penetration of the FC technology into TLC market.



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Number of kW installed	100MW	About 80kW	N/A (test not finalised)
AIP	H2-based solution to replace diesel/life cycle assessment	TCO comparison	TCO calculation based on a real business case model	TCO tool ready to be filled with real values and live tests results
AIP	Live TLC sites powered by FC		18 sites	Half of the planned radio sites installed ready for operation within two large TLC operators
AIP	FC deployed according to TLC operational requirements		Installations compliant with official regulation and TLC constraints	All the live sites have been assessed according to standard certification rules and operators' requirements

FERRET

A Flexible natural gas membrane Reformer for m-CHP applications

CALL TOPIC	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 April 2014
END-DATE	31 March 2017
TOTAL BUDGET	€3,074,356
FCH JU CONTRIBUTION	€1,736,091
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Eindhoven University of Technology

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

PROJECT WEBSITE/URL

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

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

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

FERRET will:

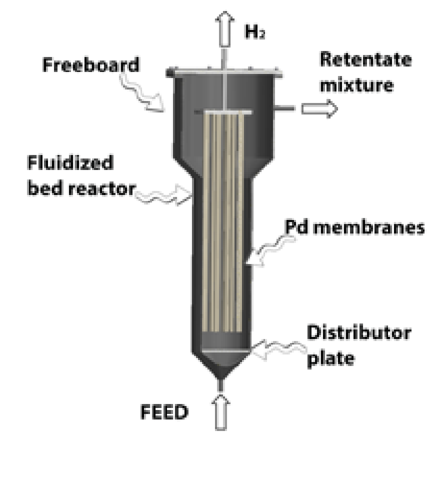
- Design a flexible reformer in terms of catalyst, membranes and control for different natural gas compositions;
- Use hydrogen membranes to produce pure hydrogen and help with shifting all the possible H_2 production reactions towards the desired products, thus reducing side reactions;
- Scale up the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

PROGRESS/RESULTS TO DATE

- First membranes developed
- First generation catalyst developed

FUTURE STEPS

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



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

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

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Overall efficiency CHP units	>80%	>90%	N/A
MAIP	Emissions and fuels	Lower emissions and use of multiple fuels	Flexibility to use different natural gas qualities Reduced CO_2 emissions compared to conventional reformers	N/A
MAIP	Cost per system (1kWe + household heat).	2015 target: cost €10,000 per system (1kWe + household heat)	€5,000 (1kWe + house heat)	N/A
AIP	Proof-of-concept of CHP applications at laboratory scale.	Proof-of-concept of CHP applications within laboratory.	TRL 4 – technology validated in lab	N/A
AIP	Durability	Several hundred continuous operating hours	1,000h of operation at nominal power output	N/A

FireComp

Modelling the thermo-mechanical behaviour of high-pressure vessels, made of composite materials when exposed to fire conditions

CALL TOPIC	Pre-normative research on fire safety of pressure vessels in composite materials
START-DATE	1 June 2013
END-DATE	31 May 2016
TOTAL BUDGET	€3,543,498
FCH JU CONTRIBUTION	€1,877,552
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Air Liquide

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

PROJECT WEBSITE/URL

www.firecomp.info

PROJECT CONTACT INFORMATION

Lucas Bustamante Valencia
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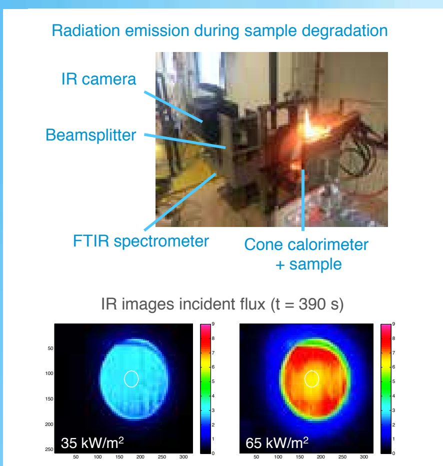


MAIN OBJECTIVES OF THE PROJECT

The main objective of FireComp is to better characterise the conditions for improving the performance to fire of composite cylinders. Experimental work will be carried out to improve the understanding of heat transfer mechanisms, thermal degradation, combustion and the loss of strength of composite high-pressure vessels in fire conditions. Then the modelling of the thermo-mechanical behaviour of these vessels will be set up. The model will be validated by full-scale fire tests. Different applications will be considered: automotive application, stationary application, transportable cylinders, bundles and tube trailers.

PROGRESS/RESULTS TO DATE

- A classification of fire scenarios as a function of the heat flux produced in the surface of vessels for hydrogen systems has been carried out: inputs for the bonfire have been released.
- The manufacture of samples for laboratory tests has been conducted in an industrial facility; it represented a challenge overcome in the project.
- The thermal degradation of composite showed to have one step under nitrogen atmosphere (pure pyrolysis phenomena) and four steps under air (pyrolysis and oxidation phenomena).
- The thermal properties of the composite shown to vary with the exposure to fire while the radiation properties versus temperature showed to be somehow stable.
- The mechanical tests showed that the evolution of the maximum stress is proportional to the thickness of sample & the energy of fire exposure.

FUTURE STEPS

- Measurement of thermal aggression: determine if a link between the surface temperature and received flux can be established for cylinders in fire (November 2014).
- Assess the rigidity evolution versus the fire exposure and the orientation of the fibres (December 2014).
- Conduct bonfire test on metallic and composite cylinders (full scale) (December 2014).
- Measure the combustibility parameters of the composite (February 2015).
- Develop multi-scale models of thermal decomposition of the composite (December 2015).

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- The atmosphere (oxygen from air) has a critical influence on the decomposition mechanism of composite in fire.
- Measurement of the radiation properties of the composite showed that the emissivity coefficient of the composite is 0.91 (no transmission and thus no internal radiation) at high temperature.
- The temperature of glass transition of the composite resin has a critical role in the decay of the mechanical properties of composite at high temperature.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

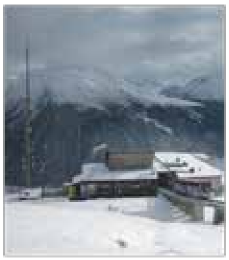
- Development of an understanding of the evolution of the composite material when exposed to fire conditions
- Validation of this model by an experimental programme where pressure vessels are subject to fire conditions with application of a specified pressure relief curve.
- Spread into regulations and standards working groups inputs to better define the reference bonfire tests for composite pressure vessels.

FITUP

Fuel-cell field test demonstration of economic and environmental viability for portable generators, back-up and UPS power system applications

CALL TOPIC	Portable generators, back-up and UPS power systems
START-DATE	1 November 2010
END-DATE	30 April 2014
TOTAL BUDGET	€5,289,900
FCH JU CONTRIBUTION	€2,475,825
OTHER CONTRIBUTION(S)	






PARTNERSHIP/CONSORTIUM LIST

Coordinator: Electro Power Systems

Partners: Future-E, Environment Park, Lucerne UASA, Unido Ichet (ended on 31 December 2012), JRC, TüV SUD, Swisscom, Wind, Betriebskommission Polycom Nidwalden, Università di Roma Tor Vergata, Bilgi University.

PROJECT WEBSITE/URL

http://fitup.engr.bilgi.edu.tr/

PROJECT CONTACT INFORMATION

Ilaria Rosso

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MAIN OBJECTIVES OF THE PROJECT

The project demonstrates technical viability and economic maturity of fuel-cell UPS systems compared to conventional back-up power sources (batteries/diesel generators). 19 market-ready fuel-cell systems from two suppliers with power levels in the 3-12kW range have been produced and installed as UPS back-up power sources at customer sites across Europe (Italy, Switzerland, and Turkey), conducting a wide set of field and benchmarking tests proving:

- Reliability greater than 95%
- Response time less than 5 minutes
- 1,500 hours and 1,000 cycles of system lifetime in benchmark tests and no considerable performance deterioration for the on-field systems.

PROGRESS/RESULTS TO DATE

- A total of 10,397 start-stop cycles have been tested for total 6,573 hours of back-up power without interruption
- Average reliability of all systems tested in the project is 99.4%
- response time for all systems is 0 minutes
- expected lifetime reached both in terms of cycles and operating hours

FUTURE STEPS

- N/A

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Technical viability and reliability of back-up fuel-cell systems have been proven in the field.
- LCA analysis shows that FC back-up system is an environmental friendly solution compared with battery and diesel UPS.
- TCO analysis performed on FC back-up system deployed in the project demonstrates that FC has a lower cost than both diesel and battery UPS on a horizon of 12 years.
- Proposal for a uniform certification procedure for FC back-up and UPS power systems achieved.
- Increased awareness and acceptance of fuel-cell technology as a viable alternative to conventional power systems thanks to dissemination activities (participation in trade fairs, public events) and project website.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Technology readiness	To show the technology readiness of back-up power and UPS systems	To show the technology readiness of back-up power and UPS systems	Combining all the tests in the project, a total of 10,397 start-stop cycles have been tested on 19 back-up fuel cell systems. Systems responded to 10,332 of these cycles successfully to provide 6,573 hours of back-up power without interruption. The average reliability of all systems tested in the project reaches 99.4%. Technology readiness of back-up fuel-cell systems has been proven.
MAIP	Deployment	To create basis for volume-buildup that can help reduce cost and pave way for a commercial market introduction	TCO analysis in LCA as comparison criteria	Total cost of ownership of the deployed fuel-cell systems showed that the FC UPS has a lower cost than both diesel and battery UPSs on a horizon of 12 years, which is the expected lifetime of the system for the intended application. The break-even point for the selected utilisation scenario (90 operating hours) is between the seventh (diesel) and eighth (battery with two hours of autonomy) year. In order to improve FC UPS marketability, effort should be made to reduce the CAPEX, stating the low relative importance of OPEX.
AIP	Deployment	Deployment of a statistically relevant number of FC back-up units, i.e. 5 to 10 units per project	19 systems deployed	19 systems deployed
AIP	Reliability	Reliability 100%	Reliability 95%	99,4%
AIP	Response time	Response time of less than 5 min	<5 min	0 min
AIP	Reliability	Number of start-stop cycles	1,000	1,000
AIP	Lifetime	Lifetimes greater than five years	>1,500 hours	>1,500 hours
AIP	Cost	Target system cost €5,000/kW	€5,000/kW	€5,500/kW (including hydrogen generators)

FluidCELL

Advanced m-CHP fuel CELL system based on a novel bio-ethanol fluidised bed membrane reformer

CALL TOPIC	Proof of concept and validation of whole fuel-cell systems for stationary power and CHP applications at a representative scale 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 April 2014
END-DATE	31 March 2017
TOTAL BUDGET	€4,193,549
FCH JU CONTRIBUTION	€2,492,341
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Fundación Tecnalia Research & Innovation.

Partners: Eindhoven University of Technology, Commissariat à l'énergie atomique et aux énergies alternatives, Politecnico di Milano, University of Salerno, Porto University, ICI caldaie SPA, HyGear BV, Quantis Sàrl.

PROJECT WEBSITE/URL

www.fluidcell.eu

PROJECT CONTACT INFORMATION

José Luis Viviente

Joseluis.viviente@tecnalia.com

MAIN OBJECTIVES OF THE PROJECT

FluidCELL aims to provide proof-of-concept of an advanced high-performance, cost-effective bio-ethanol micro-CHP co-generation FC system for decentralised off-grid applications.

The system will be based on:

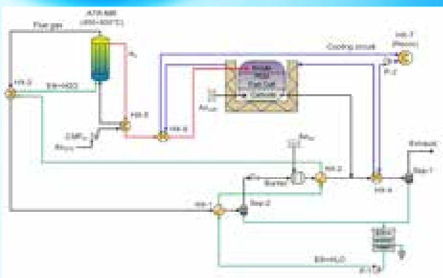
- Design, construction and testing of an advanced bio-ethanol reformer for pure hydrogen production (3.5 Nm3/h) based on catalytic membrane reactor in order to intensify the process of hydrogen production through the integration of reforming and purification in one single unit; and
- Design and optimisation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

PROGRESS/RESULTS TO DATE

- First membranes developed
- Industrial requirements for bio-ethanol-powered fuel-cell CHP system

FUTURE STEPS

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



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

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

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Overall efficiency CHP units	>80%	>90%	N/A
MAIP	Emissions and fuels	Lower emissions and use of multiple fuels	Bio-ethanol as fuel (instead of natural gas)	N/A
MAIP	Cost per system (1kWe + household heat).	2015 target: Cost €10,000 per system (1kWe + household heat) 2020 target: €5,000 per system (1kWe + household heat)	€5,000 (1kWe + house heat)	N/A
AIP	Proof-of-concept of CHP applications within laboratory.	Proof-of-concept of CHP applications within laboratory	TRL 4 – technology validated in lab	N/A
AIP	Durability	several hundred hours of continuous operating	1,000h of operation at nominal power output	N/A

FluMaBack

Fluid Management component improvement for back up fuel cell systems

CALL TOPIC	Component Improvement for stationary power applications
START-DATE	1 July 2012
END-DATE	30 June 2015
TOTAL BUDGET	€4,440,464
FCH JU CONTRIBUTION	€2,773,700
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Electro Power Systems

Partners: Domel, Tubiflex, Environment Park, Jožef Stefan Institute, Foundation for the Development of New Hydrogen Technologies in Aragon, NedStack Fuel Cell Technology BV, Onda, University of Ljubljana – Faculty of Mechanical Engineering, Joint Research Centre (JRC-IET).

PROJECT WEBSITE/URL

www.flumaback.eu

PROJECT CONTACT INFORMATION

Ilaria Rosso

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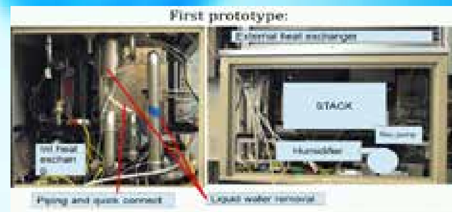
MAIN OBJECTIVES OF THE PROJECT

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

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

The goals of the project:

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

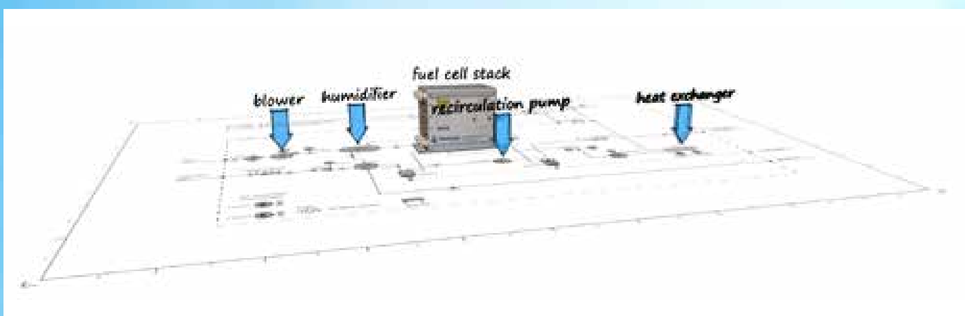


PROGRESS/RESULTS TO DATE

- Project website is running; guidelines for dissemination strategy are prepared and executed
- First iteration prototypes of humidifier, heat exchanger, air blower and hydrogen pump were manufactured and tested
- Manufacturing of 2nd iteration of prototypes is in progress
- Testing of system performance is in progress
- Life-cycle assessment study of BoP components manufacturing/assembly and system operation is prepared
- Mathematical model of system performance is set up

FUTURE STEPS

- Testing of BoP components lifetime
- Testing of entire systems (3kW and 6kW units) with new BoP components
- Life-cycle assessment of system's end of life
- Costs of production for system with new BoP components will be evaluated
- Market analysis for BOP components and fuel-cell systems



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Major milestones are met.
- Development of first release of humidifier, air blower, hydrogen blower and heat exchanger has been achieved.
- Humidifier and air blower reach most of the project target even in the first release and further optimisation will be performed in the second release. Development activities of hydrogen blower are in progress in order to guarantee project target.
- Development of heat exchanger was stopped.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP 2008-2013	Cost system €/kW – mid-term 2015	€1,500/kW	€214/kW cost of BoP components developed inside the project	Final cost not yet fully evaluated
MAIP 2008-2013	Durability/reliability – mid-term 2015	10,000h	20,000h	Durability of new components is to be tested
AIP 2011	Lifetime of stationary systems	80,000h	<40,000h	Durability of fuel-cell systems is to be tested
AIP 2011	Component life and maintenance cycle	Component life and maintenance cycle consistent with system life up to 10 years for small-scale applications	Lifetime of BoP components: 20,000h, consistent with just one maintenance cycle in 10-year life of back-up system	Durability of new components is to be tested
AIP 2011	BoP electrical efficiency	>90% for system <10kWe	Target blower efficiency, the most power consuming component: 30%	25% blower efficiency
AIP 2011	Novel designs and optimisation of non-stack components		Novel design and optimisation of air blower, hydrogen blower, humidifier and heat-exchanger	Mainly done for air blower, humidifier, in progress for hydrogen blower, stopped for heat-exchanger

H2Sense

Cost-effective and reliable hydrogen sensors for facilitating the safe use of hydrogen

CALL TOPIC	Hydrogen safety sensors
START-DATE	1 June 2013
END-DATE	31 August 2014
TOTAL BUDGET	€785,290
FCH JU CONTRIBUTION	€380,348
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: BAM Federal Institute for Materials Research and Testing

Partners: JRC-IET, Applied Sensor GmbH, Sensitron Srl, UST Umweltsensortechnik GmbH, Zentrum für Sonnenenergie und Wasserstoff-Forschung Baden-Württemberg.

PROJECT WEBSITE/URL

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

PROJECT CONTACT INFORMATION

Dr. Thomas Hübert - thomas.huebert@bam.de

MAIN OBJECTIVES OF THE PROJECT

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

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

PROGRESS/RESULTS TO DATE

- Market survey on commercial hydrogen sensors and sensor platforms is available.
- Classification of hydrogen sensor applications and identification of correlated performance requirements is performed.
- Approaches to overcome commercialisation barriers have been suggested.
- Inter-laboratory testing of commercial off-the-shelf hydrogen sensors and comparison of results has been carried out.

FUTURE STEPS

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

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

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

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

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

H2TRUST

Development of H_2 Safety Expert Groups and due diligence tools for public awareness and trust in hydrogen technologies and applications

CALL TOPIC	Assessment of safety issues related to fuel cells and hydrogen applications
START-DATE	1 June 2013
END-DATE	30 November 2014
TOTAL BUDGET	€1,208,416
FCH JU CONTRIBUTION	€796,678
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Matgas 2000 AIE.

Partners: Air Products PLC, European Hydrogen Association, (Federazione delle Associazioni Scientifiche e Techniche), Solvay Speciality Polymers Italy, Politecnico di Milano, McPhy Energy SA, SOL SpA, Ciaotech S.r.l, Technische Universiteit Eindhoven.

PROJECT WEBSITE/URL

www.h2trust.eu

PROJECT CONTACT INFORMATION

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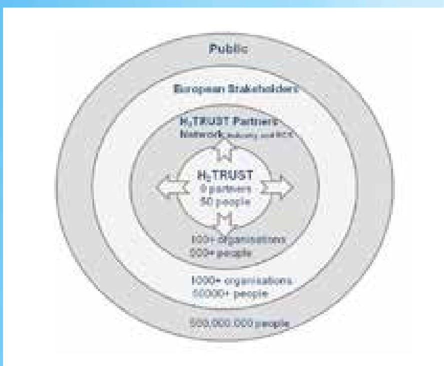

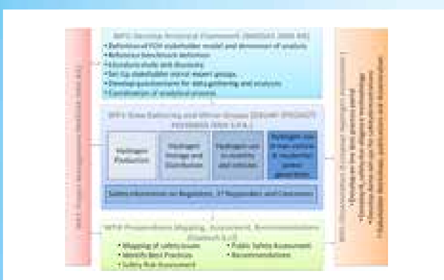

MAIN OBJECTIVES OF THE PROJECT

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

PROGRESS/RESULTS TO DATE

- The analytical framework has been developed, including the information-gathering processes (questionnaires, procedures, tools) for the whole project, the definition of a reference benchmark, a stakeholder mirror expert group, and an online database that will be updated periodically.
- The dissemination of this project has been done through participation in conferences such as ICHS2013, EFC13, idHea, as well as in the Programme Review Days 2013, in addition to the project webpage (h2trust.eu/).
- An info-gathering process has been carried out in WP3, taking into account data from existing industries in different sectors.
- The data collected from stakeholders (questionnaires, surveys, interviews) have been analysed, together with additional information from desk-research and results from EU-funded projects and other initiatives, to map the safety issues, identify best practices, and make a safety risk assessment as well as a public safety assessment and recommendations (WP4).

FUTURE STEPS

- The methodology for risk assessment (Task 4.3) has been designed and developed, taking into account all the areas for hydrogen applications considered in the project. From this, the basis for development of online H_2 safety due-diligence tool (Task 5.2) has been initiated.
- Regarding dissemination (WP5), in addition to the website and the participation in conferences, a kit (brochure, book, banner and video) will be prepared, together with an online tool enabling FCH stakeholders to rapidly analyse and assess a particular H_2 application.
- The online best practice portal is being implemented with additional features and tools (Task 5.1), i.e. crawler, advanced search, online forum form, etc.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- We have detected a good acceptance of the project by H_2 researchers & similar projects.
- A website has been created to disseminate the results, which includes a periodically-updated database.
- WP2 (Develop an Analytical Framework) has been finished and the corresponding report submitted.
- WP3 (Data Gathering and Mirror groups) and WP4 (Preparedness Mapping, Assessment and Recommendations) proceed according to the description of work in the grant agreement.
- Dissemination activities have been carried out to maximise the diffusion of this knowledge to the widest possible audience, including stakeholders, industries and the public in general.

HAWL

Hydrogen And Warehouse Logistic

CALL TOPIC	Demonstration of substitution of battery electric forklifts by hydrogen fuel-cell forklifts in logistics warehouse
START-DATE	1 September 2013
END-DATE	31 August 2016
TOTAL BUDGET	€8,523,185
FCH JU CONTRIBUTION	€4,278,555
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Air Liquide

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

PROJECT WEBSITE/URL

www.hawl-project.eu

PROJECT CONTACT INFORMATION

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helene.schueller@airliquide.com

MAIN OBJECTIVES OF THE PROJECT

HAWL aims at deploying 200 fuel-cell-powered forklift trucks in two/three logistics warehouses and demonstrating competitiveness (productivity), technical maturity and user acceptance of the technology in Europe, as an alternative to operating battery-powered trucks.

PROGRESS/RESULTS TO DATE

- One-week demo performed at site 1
- Specifications of the solution (fuel cells, forklift trucks, hydrogen refilling station) for site 1 are defined
- HRS lay-out defined and validated for site 1
- French local administration issue site 1 operating permit

FUTURE STEPS

- Civil works for the HRS installation will start in summer 2014 on site 1.
- Commissioning of HRS is planned in Q4 2014 and 10 fuel-cell-powered forklifts will be deployed by the same time for a six-month test phase.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- MS1 has been realised
- Decision MS4
- French administration may publish reference code on HRS installation and H_2 in warehouse distribution by end-summer 2014, facilitating and accelerating local authorisations and permits.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Total cost of FC system (at early volume production) for FC >3kW:	<50 units/<€3,500/kW	<€3,000/kW	Achieved (€2,000/kW for class 2 equivalent capacity of 15kWh and class 3 forklift trucks equivalent capacity of 7.5kWh)
AIP	System lifetime (with service/stack refurbishment)	Not defined	>7,500h	Achieved
AIP	FC system efficiency (%)	>40%	>45%	Not measured yet. Will be assessed in Q4 2014
AIP	Refuelling time	3 min	3 min	Achieved

HELMETH

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

CALL TOPIC	New generation of high-temperature electrolyser
START-DATE	1 April 2014
END-DATE	31 March 2017
TOTAL BUDGET	€3,809,972
FCH JU CONTRIBUTION	€2,529,352
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Karlsruhe Institute of Technology

Partners: Politecnico di Torino, Sunfire GmbH, European Research Institute of Catalysis AISBL, Turbo Service Torino spa, National Technical University of Athens, DVGW - German Technical and Scientific Association for Gas and Water.

PROJECT WEBSITE/URL

TBA

PROJECT CONTACT INFORMATION

Dimosthenis Trimis

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MAIN OBJECTIVES OF THE PROJECT

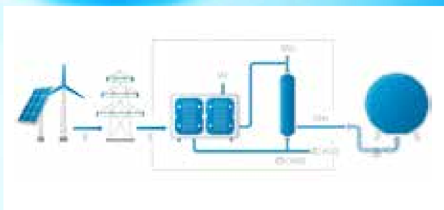
The objective of the HELMETH project is the proof-of-concept of a highly efficient power-to-gas (P2G) technology with methane as a chemical storage and by thermally integrating high-temperature electrolysis (SOEC technology) with CO_2 methanation. The aim is to prove and demonstrate that high-temperature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

PROGRESS/RESULTS TO DATE

- The project started a few months ago and first results on system specification and conceptual design are internally available.

FUTURE STEPS

- Confirmation of total efficiency >85% by detailed process simulations
- Fixing system concept and setting system specifications
- Design and construction of pressurised SOEC module
- Selection and optimisation of cost-effective catalysts for high CH4 selectivity and high heat transfer rates
- Elaboration of business cases for various operating scenarios of the power-to-gas unit including re-powering of natural gas



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- We expect to reach the first milestones in the next year as planned.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
AIP- SP1-JTI-FCH.2013.2.4	Development of cells and stacks designed for high-temperature and high current density, pressurised conditions	High-temperature (800°C-1,000ºC), high current density (>1 A/cm^2), pressurised conditions	High-temperature (800°C-1000 ºC), high current density (>1 A/cm^2), pressurised conditions	Development in process
AIP- SP1-JTI-FCH.2013.2.4	Manufacture of dedicated HTE cells and stacks for use in large systems for the conversion of electricity from renewable sources and from nuclear power, i.e. large-area cells	Manufacture of dedicated HTE cell	HELMETH will deliver a proof-of-concept towards this direction. Large systems are the development focus of the involved industrial partners; especially SUNFIRE. Concerning large-area cells a modular approach with more cell elements on a common interconnector frame is followed	Work on this part of the HELMETH project has not started yet
AIP- SP1-JTI-FCH.2013.2.4	Demonstration of a HTE system of kW-size under realistic conditions	Demonstration of HTE system of kW-size under realistic conditions with degradation rates around 1%/1,000h (0.5%/1,000h for short-stack tests)	HELMETH will demonstrate the feasibility of a 10-15kW-class system with degradation rates around 1%/1000h (0.5%/1000h for short-stack tests)	Degradation tests in HELMETH project have not yet started
AIP- SP1-JTI-FCH.2013.2.4	Proof-of-concept for co-electrolysis, syngas production and final chemical product, and validation of efficiency figures. Total efficiencies are expected in the 85%-95% range	Total efficiencies are expected in the 85%-95% range	Conversion efficiencies >85% from electricity to methane	Conceptual design and detailed process simulations for the electrolyser and methanation module and their thermal integration are in progress

High V.LO City

Cities speeding up the integration of hydrogen buses in public fleets.

CALL TOPIC	Large-scale demonstration of road vehicles and refuelling infrastructure III
START-DATE	1 January 2012
END-DATE	31 December 2016
TOTAL BUDGET	€31,586,671
FCH JU CONTRIBUTION	€13,491,724
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Van Hool nv

Partners: Riviera Trasporti, Dantherm Power, Solvay, VVM De Lijn, Waterstofnet, HyER, DITEN, Regione Liguria, FIT Consulting, Aberdeen City Council, Ballast Nedam.

PROJECT WEBSITE/URL

www.highvlocity.eu

PROJECT CONTACT INFORMATION

Paul Jenné

Paul.Jenne@vanhool.be

MAIN OBJECTIVES OF THE PROJECT

In HighV.LO City, a fleet of 14 FC buses will be demonstrated in 3 regional sites: Sanremo, Antwerp and Aberdeen. Each site is also equipped with a new hydrogen refuelling infrastructure. Together with this demo, the hydrogen centres of excellence are initiated. These centres disseminate their experience, the TCO realised and contribute in the standardisation of hydrogen refuelling infrastructure. They also facilitate in policies on environmental, health, energy, efficiency, social and economic benefits. Finally, actions are undertaken to increase awareness, promotion and a broader adoption of hydrogen buses.

PROGRESS/RESULTS TO DATE

- All 14 FC buses are delivered and are certified by local traffic authorities.
- Fuel consumption has been measured in a TUV certified SORT test (unique for fuel-cell buses!).
- Refuelling station using industrial by-product from Solvay plant is operational in Antwerp.
- Refuelling station with on-site electrolysis is being installed in Aberdeen. Finalisation is foreseen in November 2014.
- Refuelling station with on-site electrolysis and possible delivery in tube trailers is planned in Sanremo. Finalisation is foreseen in February 2015.

FUTURE STEPS

- Operations will start during summer 2014.
- With the start of operations, the centres of excellence are launched.
- During operations, both the buses and refuelling stations are monitored in an automated way. Reports are generated on a monthly base.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

Although the project is still at half-way, some conclusions can be indicated:

- The FC bus technology is upgraded towards a level that is in line with the MAIP objectives;
- Start of operations has been delayed due to both long tender procedures and difficulties in finalising co-funding.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Bus fleet quantity	500 buses at 10 EU sites (at least 7 new ones)	14 FC buses at 3 new EU sites	9 buses to Sanremo and Aberdeen are delivered – the buses for Antwerp will be delivered mid-2014
MAIP	System cost	<€3,500/kW	€2,500/kW	Achieved
MAIP	System durability	over 5,000h	Durability: 15,000h warranty	Achieved – warranty guaranteed by supplier
MAIP	Market deployment	Roadmap for the establishment of a commercial HRI	Demonstration of 3 completely functioning HRIs	1 of the 3 HRI's is operational (Antwerp). The one for Aberdeen is in construction and will open in September 2014, the one for Sanremo will open February 2015
MAIP	Sustainability hydrogen production	10-20% of hydrogen demand should be produced carbon-free or carbon-lean	2/3 of hydrogen is produced with sustainable technology	Achieved when HRI's are operational.
AIP	2010 target – Aim at placing Europe at the forefront of fuel-cell and hydrogen technologies worldwide and enabling the market breakthrough of fuel-cell and hydrogen technologies, thereby allowing commercial market forces to drive the substantial potential public benefits	Not quantitative	Not quantitative	Once the technologies in the project are being demonstrated, the project results will be disseminated towards all stakeholders. That puts Europe at the forefront of fuel-cell technologies world wide.
AIP	2010 target - to speed up the development of hydrogen supply and fuel-cell technologies with up to 5 years to the point of commercial take-off for early market applications (e.g. handheld devices, portable generators); for stationary applications (domestic and commercial CHP); and for mass market roll-out of transport applications	Not quantitative	Not quantitative	The development and demonstration of a large fleet of FC buses stimulates development of hydrogen supply equipment and components as well as the roll-out of transport applications.

HYCARUS

HYdrogen Cells for AiRborne Usagex

CALL TOPIC	Fuel-cell systems for airborne application
START-DATE	1 May 2013
END-DATE	30 April 2016
TOTAL BUDGET	€10,057,617
FCH JU CONTRIBUTION	€5,219,265
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Günter Boomgaarden

Partners: Commissariat à l'énergie atomique et aux énergies alternatives, DASSAULT Aviation, Air Liquide, JRC-IET, Spanish National Institute for Aerospace Technology, ARTTIC, Zodiac Electrical Power Systems, Zodiac Galleys Europe.

PROJECT WEBSITE/URL

www.hycarus.eu

PROJECT CONTACT INFORMATION

Lothar Kerschgens, ZCC

lothar.kerschgens@zodiacaerospace.com

MAIN OBJECTIVES OF THE PROJECT

1) To design a generic fuel-cell system aiming to power non-essential aircraft applications such as galleys, lavatory or crew rest compartment in commercial aircraft, or to be used as a secondary power source on-board business jets.

2) To test the generic fuel-cell system in flight.

3) To assess and exploit the by-products in different airborne applications - galleys, lavatories, warmers, chillers or inerting functions such as fuel tank.

PROGRESS/RESULTS TO DATE

- Specification and sizing reported (D1.1 & D1.2)
- Draft GFCS architecture & scope of supply
- Integration prepared for galley integration
- Integration of GFCS for flight-test prepared

FUTURE STEPS

- Finalise the first HYCARUS amendment and submit to FCH JU
- Test plan due to RTD 160 G termination
- Final GFCS architecture & scope of supply
- All components prepared for integration
- GFCS integration for flight test

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- The HYCARUS project is one of the first fuel-cell system applications in aircraft use, covering all requirements in order to bring fuel-cell system into operation.
- HYCARUS has now started to select all relevant aircraft specifications, especially the use of hydrogen on the aircraft. This will also influence the supply-chain of fuel for fuel cells.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
	Fuel-cell system efficiency (LHV)	25% of rated power: 55%	25% of rated power: 55%	45%
	Durability with cycling hours	2,500h under flight representative load profiles	performing durability tests under flight representative load profiles	N/A (not finalised)
	Fuel-cell system power density (EOL) kW/L	0.40kW/L	0.40kW/L based on the fuel-cell stack value 1.7kW/L	0.40kW/L
	Fuel-cell system specific power (EOL) kW/kg	0.65kW/kg	0.65 kW/kg based on the fuel-cell stack value 1.2kW/kg	0.60kW/kg
	Demonstrator	TRL 6	Demonstration of a TRL 6 FC system under typical aircraft standard operating conditions	

HyCOMP

Enhanced design requirements and testing procedures of composite cylinders intended for the safe storage of hydrogen

CALL TOPIC	Pre-normative research on composite storage
START-DATE	1 January 2011
END-DATE	31 March 2014
TOTAL BUDGET	€3,802,542
FCH JU CONTRIBUTION	€1,380,728
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Air Liquide

Partners: Armines, BAM, WUT, Composites Aquitaine, Faber, Hexagon, JRC-IET, CEA, CCS, Alma Consulting Group.

PROJECT WEBSITE/URL

www.hycomp.eu

PROJECT CONTACT INFORMATION

Clémence Devilliers

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MAIN OBJECTIVES OF THE PROJECT

HyCOMP is a pre-normative research (PNR) project whose main objectives are to:

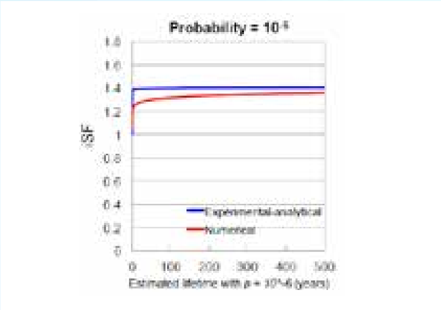
- Enhance design requirements for composite pressure vessels (CPV) for the storage or transport of compressed hydrogen, by redefining a safety factor (SF) value based on anticipated degradation in service;
- Improve the full set of requirements to ensure the structural integrity of the cylinders throughout their service life, for different type of testing:
  - Design type-approval
  - Manufacturing quality assurance
  - In-service inspection.

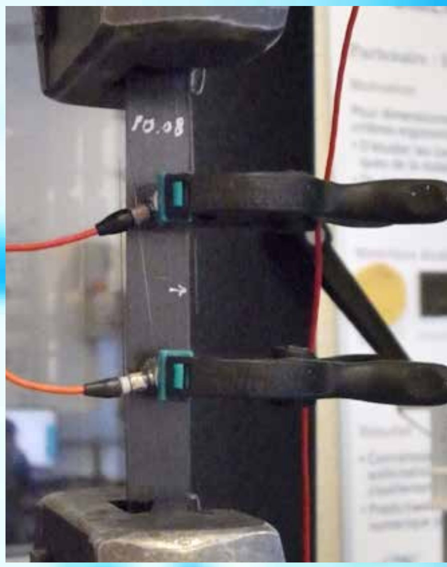
PROGRESS/RESULTS TO DATE

- Experimental and numerical approach developed to demonstrate the minimal safety factor required to cover intrinsic materials properties of CF composite materials (intrinsic variation of ultimate tensile strength).
- An SF value of 1.4 must be applied under a constant load to guarantee an infinite lifetime to the specimen (>500 years).
- Determination of the influence of manufacturing process parameters on the performances of cylinders (short-term and long-term performances).

FUTURE STEPS

- Continue exchanges with standardisation working group to present HyCOMP results and convince CPV experts.
- Implement HyCOMP recommendations into existing standards..





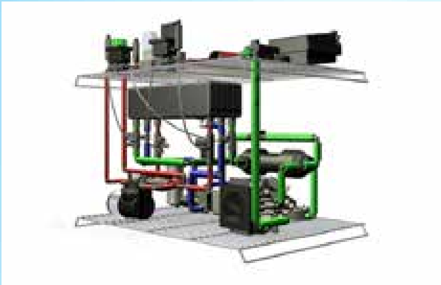
CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Proposals for several recommendations to standardisation working groups, covering design requirements, and testing procedures (type-approval and manufacturing quality assurance).
- Proposition to design CPV for a dedicated service (specific gases) instead of general service (all gases) involving a change of the design pressure (actually test pressure) to the maximum allowable working pressure (at the maximum temperature).
- Proposition to reduce the safety factor for transportable applications from 2 to a lower value to be defined.
- Strong influence of the curing step of cylinder on its performance proposition of requirements for the control of resin curing.
- Perspectives: interactions with standardisation working groups to propose a revision of existing standards based on HyCOMP recommendations..

HyCoRA

Hydrogen Contaminant Risk Assessment

CALL TOPIC	Fuel quality assurance for hydrogen refuelling stations
START-DATE	1 April 2014
END-DATE	31 March 2017
TOTAL BUDGET	€3,906,912
FCH JU CONTRIBUTION	€2,159,024
OTHER CONTRIBUTION(S)	



PARTNERSHIP/CONSORTIUM LIST

Coordinator: VTT Technical Research Centre of Finland

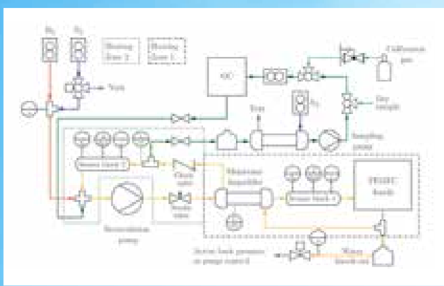
Partners: CEA, JRC, Protea ltd, SINTEF, Powercell Sweden AB.

PROJECT WEBSITE/URL

http://hycora.eu

PROJECT CONTACT INFORMATION

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



MAIN OBJECTIVES OF THE PROJECT

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

PROGRESS/RESULTS TO DATE

- A recirculation single-cell hardware has been developed, enabling anode gas humidification by recirculation and fuel utilisation of 99.5%.
- Acquisition of hydrogen pre-concentration device through collaboration with Argonne/Dept. of Energy.
- High-pressure sampling instrumentation approved and access to refuelling station measurement campaign scheduled for October 2014.

FUTURE STEPS

- The results from a single cell with recirculation and an automotive type PEMFC system are compared to define applicability of single-cell measurements for Task 1.3.
- Evaluation of analytical techniques with focus on challenging/cost driving analyses (ie. total sulphur and halogenates).
- Conduct analyses of hydrogen samples from first measurement campaign from hydrogen refuelling stations.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Hydrogen fuel contamination studies require high fuel utilisation and development of experimental techniques at both single-cell and PEMFC system level.
- A pre-concentration device may be necessary for reducing the analytical techniques in hydrogen quality assurance.

HYDROSOL-PLANT

Thermochemical HYDROgen production in SOLar monolithic reactor: construction and operation of a 750 kWth PLANT

CALL TOPIC	Thermo-electrical-chemical processes with solar heat sources
START-DATE	1 January 2014
END-DATE	31 December 2016
TOTAL BUDGET	€3,480,806
FCH JU CONTRIBUTION	€2,265,385
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: APTL/CPERI/CERTH, Greece

Partners: German Aerospace Center (DLR), CIEMAT, HyGear BV, HELPE.

PROJECT WEBSITE/URL

http://hydrosol-plant.certh.gr

PROJECT CONTACT INFORMATION

agk@cperi.certh.gr

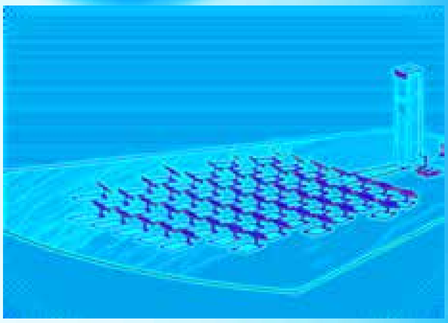
MAIN OBJECTIVES OF THE PROJECT

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

- Define all key components and aspects;
- Develop tailored heliostat field technology that enables accurate temperature control of the solar reactors;
- Construct a 750kWth solar hydrogen production demonstration plant to verify the developed technologies for solar H_2O-splitting;
- Operate the plant and demonstrate hydrogen production and storage on site;
- Techno-economic study for the commercial exploitation of the solar process.

PROGRESS/RESULTS TO DATE

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



FUTURE STEPS

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

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- N/A

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP				
AIP	Materials with performances suitable for economic operation, i.e. lifetimes in the range of more than 1,000 operational hours	1,000h	1,000h	N/A (test not finalised)
AIP	Solar hydrogen generator in a demonstration range @ 0.5-2MW scale for high-temperature water-splitting	0.5-2MW	0.75MW	N/A (construction not initiated)
AIP	Demonstration of hydrogen production and storage on site (>3kg/week)	3 kg H_2/week	3 kg H_2/week	N/A (operation not initiated)

HyFIVE

Hydrogen For Innovative Vehicles

CALL TOPIC	Large-scale demonstration of road vehicles and refuelling infrastructure VI
START-DATE	1 April 2014
END-DATE	30 September 2017
TOTAL BUDGET	€38,418,137
FCH JU CONTRIBUTION	€17,970,566
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Greater London Authority

Partners: BMW AG, Daimler AG, Honda Europe, Hyundai Motor Europe, Toyota Europe, Air Products, Copenhagen Hydrogen Network, ITM Power, Linde, Hydrogen Link Denmark, Istituto per Innovazioni Tecnologiche Bolzano, Element Energy, PE International, OMV.

PROJECT WEBSITE/URL

www.hyfive.eu

PROJECT CONTACT INFORMATION

Simona Webb

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MAIN OBJECTIVES OF THE PROJECT

- To deploy and monitor 110 next-generation FCEVs from leading OEMs (BMW, Daimler, Honda, Hyundai and Toyota) from summer 2014.
- To place vehicles with end-users representative of the likely earliest commercial adopters, study their behaviour and attitudes towards hydrogen transport to inform subsequent roll-out strategies for the technology.
- To create viable hydrogen refuelling station (HRS) networks in three regions by deploying six new 700 bar HRS and incorporating 12 existing HRS in the project.
- To spread a positive and accurate message about the status of FCEV and HRS technology and industry plans for commercialisation via a well-targeted dissemination strategy.

PROGRESS/RESULTS TO DATE

- Orders placed for 13 vehicles with five vehicles already deployed in the Southern Cluster.
- Sites being identified for three refuelling stations in London and discussions being finalised on two sites for Copenhagen.
- Site identified for the refuelling station in the Southern Cluster (Innsbruck) and work starting to deploy the station there.
- Work been done to link the HyFIVE project with other existing FCH-JU projects as well as national projects and initiatives like the CEP.
- Work being done on finalising consumer questionnaires which will gather information from end-users across the three clusters.

FUTURE STEPS

- Organising more test drives across the three clusters to identify end-users and place more FCEVs orders.
- Finalising discussions on the sites for London and Copenhagen and beginning the build of the stations.
- Launching the project website in summer 2014 and using this to engage members or the public, decision makers and potential early adopters.
- Using milestones in the project to disseminate information to local and national government, decision makers, potential early adopters and members of the public.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

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

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	~500 light-duty vehicles (mainly cars) at three additional sites with three new stations	~500	Ambition to deploy 110 new FC passenger cars and six new HRS in three clusters across Europe	Orders for the first 13 FCEVs placed, first five vehicles delivered to Bolzano
MAIP	Durability in car propulsion systems	Durability in car propulsion systems 5,000 hours	Vehicle operation lifetime (>2,000 hours initially, min. 3,000 hours as programme target)	Project started in April 2014. We expect to reach this target
MAIP	Roadmap for the establishment of a commercial European hydrogen refuelling infrastructure	Roadmap for the establishment of a commercial European hydrogen refuelling infrastructure	Deployment of six new HRS, linking with 12 existing stations and task forces to resolve all remaining pre-commercial hydrogen retailing issues	Project started in April 2014. We expect to reach this target
MAIP	Appropriate H_2 supply chain (including fuel purity) to match transport, stationary and early markets requirements. For 2015 10-20% of general H_2 demand should be produced via carbon-free/carbon-lean processes	Appropriate H_2 supply chain (including fuel purity) to match transport, stationary and early markets requirements. For 2015, 10-20% of general H_2 demand should be produced via carbon-free/carbon-lean processes	>50% of hydrogen to be sourced from renewables	Project started in April 2014. We expect to reach this target
MAIP	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) at start of project; identify conditions under which cost can fall to <€5/kg	Project started in April 2014. We expect to reach this target
AIP	Mean time between failures (>1,000 km)	>1,000 km	>1,000 km	We expect to reach this target
	Hydrogen cost at station	<€10/kg (ex. taxes) at start of project; identify conditions under which cost can fall to <€5/kg	<€10/kg on average for all stations, including electricity costs, delivered hydrogen cost (if any), unplanned maintenance and periodic servicing	We expect to reach this target

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

HYINDOOR

Hydrogen indoor use or in confined space

CALL TOPIC	Pre-normative research on the indoor use of hydrogen and fuel cells
START-DATE	1 January 2012
END-DATE	31 December 2014
TOTAL BUDGET	€3,657,760
FCH JU CONTRIBUTION	€1,528,974
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Air Liquide

Partners: Commissariat à l'energie atomique et aux energies alternatives (CEA), Karlsruhe Institute of technology, University of Ulster CCS global group, Joint Research Center (JRC), Hygear Fuel cell Systems, Health and Safety Laboratory (HSL), National Center for Scientific Research Demokritos (NCSRD), LGI consulting.

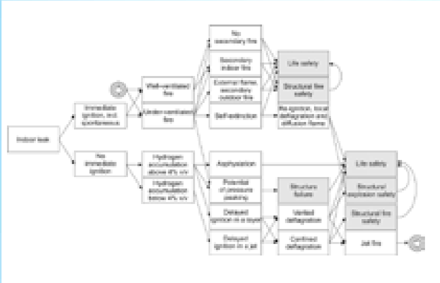
PROJECT WEBSITE/URL

http://hyindoor.eu

PROJECT CONTACT INFORMATION

Béatrice L'Hostis

Beatrice.lhostis@airliquide.com



MAIN OBJECTIVES OF THE PROJECT

Provide scientific and engineering knowledge for the specification of cost-effective means to control hazards specific to the use of hydrogen indoors or in confined space and developing state-of-the-art guidelines for European stakeholders.

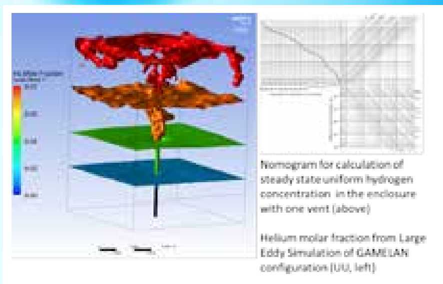
PROGRESS/RESULTS TO DATE

End of experimental, analytical and numerical works on:

- Ventilation of unignited releases
- Mitigation of hydrogen indoor deflagration
- Dealing with hydrogen jet fires
- Sensors for mitigation strategies

FUTURE STEPS

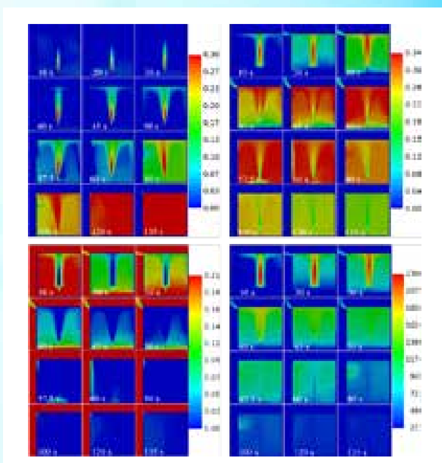
- Publish guidelines for the safe indoor installation and use of fuel-cell and hydrogen systems.
- Identify and define the RCS inputs to existing norms and standards or those being drafted.
- Organise final dissemination workshop in Paris on 11 December 2014.
- Consolidate and disseminate the final public report.



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

Detailed scientific reports and data from field experiments on:

- Passive and forced ventilation systems with one vent
- Pressure peaking phenomenon validation
- Vent sizing correlation for low strength
- Localised mixture deflagrations: inventory limit and mitigation
- Assessment of sensor performance and selectivity



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

Specific knowledge gaps need to be closed in the areas of indoor hydrogen accumulations, vented deflagrations, and under-ventilated jet fires in order to be able to optimally implement the most effective safety strategies. The project will in particular address:

- Improved criteria for allowing hydrogen and fuel-cell systems indoors to avoid hazardous accumulation, exceeding specified thermal dose and overpressure limit;
- Sizing of enclosure openings for natural ventilation and specification of forced ventilation systems in function of the hydrogen release parameters (position, flow-rate, leak diameter, direction, etc.);
- Sizing of the vent area for deflagration mitigation in relation to the accumulated inventory characteristics (hydrogen layer parameters, concentration gradient, layer's height, etc.), obstruction in the enclosure and leak parameters.

HyLIFT-DEMO

European demonstration of hydrogen-powered fuel cell materials-handling vehicles

CALL TOPIC	Demonstration of fuel cell-powered materials-handling vehicles including infrastructure
START-DATE	1 January 2011
END-DATE	30 June 2014
TOTAL BUDGET	€7,300,000
FCH JU CONTRIBUTION	€2,900,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Ludwig-Bölkow-Systemtechnik GmbH

Partners: H2 Logic A/S, DanTruck A/S (DANT - Sept 2011), Technical University of Denmark, Linde AG, JRC-IET, Stiftelsen SINTEF, European Regions and Municipalities Partnership for hydrogen and fuel cells and European Hydrogen Association (HyRaMP-EHA), TÜV SÜD Industrieservice GmbH.

PROJECT WEBSITE/URL

www.hylift-demo.eu

PROJECT CONTACT INFORMATION

Hubert Landinger

coordinator@hylift.eu

MAIN OBJECTIVES OF THE PROJECT

The project sought the demonstration of 11 units of hydrogen-powered fuel-cell forklifts and airport tow tractors as well as the demonstration of the appropriate hydrogen refuelling infrastructure at end-user sites throughout Europe for at least one year.

PROGRESS/RESULTS TO DATE

- HyLIFT-DEMO was a lead project in the field of hydrogen-powered fuel-cell materials- handling vehicles in Europe.
- 11 vehicles were in demonstration (10 forklifts; one airport tow tractor).
- Tests, trials and demo operations helped to overcome teething problems.
- Batch production of fuel-cell systems is in place, volume production is under preparation.
- Several vehicles clocked up to 2,400h of operation at real end-user sites and >3,500 refuelling procedures took place at corresponding hydrogen refuelling station.

FUTURE STEPS

- The next step is to raise the number of units involved into the hundreds as envisaged e.g. in the HyLIFT-EUROPE project (200 units).
- Authorities at all levels are asked to implement dedicated support mechanisms enabling a rapid market uptake in time.
- The project enabled key partners to establish contacts with potential end-users who were not ready to enter in a contract. These end-users will be approached in future steps.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Numerous lessons learned such as that test trials for potential customers are inevitable.
- A success of the project was that hydrogen-powered fuel-cell materials handling vehicles have clocked up to 2,400h of operation at a real end-user site in Europe while the number of hydrogen refuelling procedures at the corresponding refuelling station has exceeded 3,500.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	2015 target: number of industrial and off-highway vehicles	500	11 (previously 30)	11
AIP 2011	Number of materials-handling vehicles	10	11(previously 30)	11
AIP 2011	Total cost of fuel cell system (€/kW)	<€4,000	<€3,100 (price after public support when reaching stated volume)	<€3,100 (price after public support when reaching stated volume)
AIP 2011	System lifetime (with service/stack refurbishment) hours	>5,000h	>5,000h	>2,000h
AIP 2011	System efficiency (tank-to-wheel) (%)	>40%	>48% (@10kW)	49%
AIP 2011	Refuelling time (min)	<5	3-4	<3

HyLIFT-EUROPE

Large-scale demonstration of fuel cell-powered material-handling vehicles

CALL TOPIC	Demonstration of fuel cell-powered material-handling equipment vehicles including infrastructure
START-DATE	1 January 2013
END-DATE	31 December 2016
TOTAL BUDGET	€20,300,000
FCH JU CONTRIBUTION	€9,300,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Ludwig-Bölkow-Systemtechnik GmbH

Partners: STILL GmbH, MULAG Fahrzeugwerk Heinz Wössner GmbH, Air Products GmbH, Copenhagen Hydrogen Network A/S, Element Energy Ltd, Federazione delle Associazioni Scientifiche e Tecniche/European Hydrogen Association (FAST/EHA), JRC-IET, Heathrow Airport Ltd, H2 Logic A/S.

PROJECT WEBSITE/URL

www.hylift-europe.eu

PROJECT CONTACT INFORMATION

Hubert Landinger

coordinator@hylift.eu

MAIN OBJECTIVES OF THE PROJECT

- Demonstration of up to 200 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 support for the European industry.

PROGRESS/RESULTS TO DATE

- HyLIFT-EUROPE will become a leading European project
- Given initial problems, no vehicle demonstrations so far
- Several contacts to potential vehicle-users in place with discussions ongoing
- Tests, trials and demo operations are under preparation

FUTURE STEPS

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

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- In the US the number of hydrogen-powered fuel cell materials-handling vehicles has reached 5,400 units.
- American success factors are not easily transferred to Europe.
- Substantial financial support will be required until supply-chains are fully established and enable competitive cost structures compared to conventional technologies.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	2015 target: number of industrial and off-highway vehicles	500	200	0
AIP 2011	Number of FC systems	>50 units	Up to 200 units	0
AIP 2011	FC system lifetime (h)	>7,500h	10,000h	No vehicles in demo yet
AIP 2011	FC system efficiency (%)	>45%	45-50%	No vehicles in demo yet
AIP 2011	FC systems sales price	<€3,000/kW	<€2,300/kW	No agreements with vehicle-users signed yet
AIP 2011	Refuelling time	3 minutes	~3 minutes	No HRS installed yet
AIP 2011	HRS availability		98%	No HRS installed yet
AIP 2011	H_2 price at pump	<€10/kg	€8-12/kg (average <€10/kg)	No agreements for hydrogen supply signed yet

HyLIFT-EUROPE

Large-scale demonstration of fuel cell-powered materials-handling vehicles

CALL TOPIC	Demonstration of fuel cell-powered material-handling equipment vehicles including infrastructure
START-DATE	1 January 2013
END-DATE	31 December 2017
TOTAL BUDGET	€ 20,2 M
FCH JU CONTRIBUTION	€ 9,3 M
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Ludwig-Bölkow-Systemtechnik GmbH

Partners: STILL GmbH (STILL), MULAG Fahrzeugwerk Heinz Wössner GmbH (MULAG), Air Liquide Advanced Business S.A. (AL), Element Energy Ltd. (EE), Federazione delle Associazioni Scientifiche e Tecniche / European Hydrogen Association (FAST/EHA), European Commission, Directorate-General Joint Research Centre, Institute for Energy and Transport (JRC), Heathrow Airport Ltd. (HAL), H2 Logic A/S (H2L)

PROJECT WEBSITE/URL

www.hylift-europe.eu

PROJECT CONTACT INFORMATION

coordinator@hylift.eu

MAIN OBJECTIVES OF THE PROJECT

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SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
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AIP 2011	H2 price at pump	<€10/kg	€8-12/kg (average <€10/kg)	No agreements for hydrogen supply signed yet

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

HyPactor

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

CALL TOPIC	Pre-normative research on resistance to mechanical impact of pressure vessels in composite materials
START-DATE	1 April 2014
END-DATE	31 March 2017
TOTAL BUDGET	€4,049,293
FCH JU CONTRIBUTION	€2,143,665
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Commissariat à l'energie atomique et aux energies alternatives

Partners: Air Liquide,Hexagon Raufoss A/S,Institut de soudure, Politechnika Wroclawska,Norges Teknisk-Naturvitenskapelige Universitet, Alma Consulting Group SAS.

PROJECT WEBSITE/URL

Not available so far

(will most probably be: www.hypactor.eu)

PROJECT CONTACT INFORMATION

Fabien Nony

Fabien.nony@cea.fr

MAIN OBJECTIVES OF THE PROJECT

HYPACTOR aims at providing recommendations for regulation, codes and standards (RCS) regarding the qualification of composite overwrapped pressure vessels (COPV) and the procedures for periodic inspection in service of COPV subjected to mechanical impacts. It will:

- Build a database gathering data from literature and from experience (~100 cylinders to be tested) detailing damage characteristics as a function of impact conditions;
- Determine the consequences of the different kinds of impacts on vessels' properties and safety;
- Define criteria for standardisation organisms in order to optimise vessels' use and safety;
- Disseminate the results/make recommendations to the scientific and standardisation communities.

PROGRESS/RESULTS TO DATE

- Review of international impact-related incidents on pressure composite cylinders
- Investigation of industrial constraints for the use of NDT in industrial sites
- Definition of project impact test matrix
- Review of NDT techniques and protocols to characterise impact damage

FUTURE STEPS

- Technical report on impact testing with characterisation of induced tank damage
- Relationships between impact and induced damage
- Technical report on short/long-term residual performance of impacted tanks
- Definition of NDT protocols
- Modelling of impacted COPV

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

Considering the starting date, main perspectives are:

- Aggregate experimental database with impact parameters and characteristics of induced damage;
- Determine short- and long-term residual performance of impacted tanks;
- Develop understanding and numerical models of relationship between impact damage and residual performance of COPV;
- Define NDT technique and protocols with appropriate pass/fail criteria for vessel inspection and/or certification;
- Provide normative committees with scientific feedback.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
AIP	Identify types of alterations produced by mechanical impacts and develop an understanding of their consequences on short- and long-term structural integrity		• Determine damage characteristics induced by impacts • Identify impact conditions that produce short-term failure	Experimental activities not started
AIP	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		• Identify correlations between impact parameters and induced damage • Identify impact conditions that produce short-term failure • Determine residual burst performance after impact, and long-term influence of damage induced by impact • Develop numerical model to predict the influence of well-characterised damage induced by impact on tank performance and safety	Experimental activities not started
AIP	Apply the results of the above to assess the reliability of composite pressure vessels in the foreseen applications and potential needs of protection and/or opportunities of design optimisation.		• Identify most severe impact conditions • Assess reliability of COPV with respect to field/in-service experience	Experimental activities not started
AIP	Evaluate non-destructive examination methods, such as analysis of acoustic emissions, and associated pass/fail criteria for controlling pressure vessels in service with regards to potential damage from impact		• Assess non-destructive techniques and define protocols to assess composite damaged by impact • Define critical damage and pass/fail criteria	Experimental activities not started
AIP+MAIP	Recommendations to industry and for international standards development		• Dissemination of experimental results, revised methodology for qualification, inspection and testing to RCS committees	Not started
MAIP	International cooperation strategy/safety			Consortium contacted by DoE of the US for exchange

HYPER

Integrated hydrogen power packs for portable and other autonomous applications

CALL TOPIC	Research, development and demonstration of new portable fuel cell systems
START-DATE	3 September 2012
END-DATE	2 September 2015
TOTAL BUDGET	€3,900,000
FCH JU CONTRIBUTION	€2,200,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Orion Innovations (UK) Ltd

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

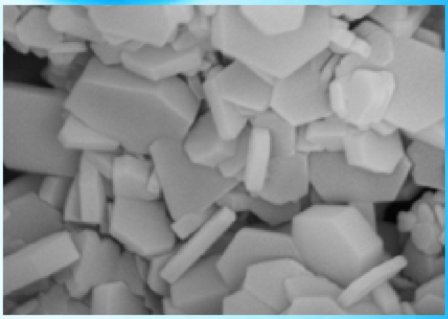
PROJECT WEBSITE/URL

www.hyperportablepower.com

PROJECT CONTACT INFORMATION

Dr Juliet Kauffmann

Juliet.kauffmann@orioninnovations.co.uk



MAIN OBJECTIVES OF THE PROJECT

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

PROGRESS/RESULTS TO DATE

- Re-design of FC to reduce weight and cost, and improve mechanical performance.
- Characterisation of novel solid-state composite material, including thermodynamic modelling.
- Material testing in bench-top tank and early design of prototype tank.
- Identification and purchase of suitable 700 bar and 300 bar lightweight gas cylinders.
- Preparation of UAV for system integration, including modification requirements and safety analyses.

FUTURE STEPS

- Finalisation of new FC design and scale up to $100W_e$ and $500W_e$ systems.
- Continued testing of solid-state storage materials and prototype tank development.
- Testing of gas cylinders, lightweight housing design and system integration.
- Field testing as remote power-pack and UAV range extender.
- Market validation with end-users.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- New fuel-cell design should enable significant cost reduction and performance improvement.
- Composite solid-state material could provide step-change in terms of onset temperature and gravimetric density, but requires more research before integration into final system.
- Gaseous cylinders offer secure route to field demonstration in the shorter term.
- Field testing with 100We power-pack to begin October 2014 at AGI and with independent industrial end user.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	To demonstrate technology readiness of specific applications	12,000-13,000 portable & micro FCs in the market by 2015	Field demonstration as $100W_e$ portable power-pack and $500W_e$ UAV range-extender	Field testing of 100We power-packs expected to begin in October 2014 Field testing of 500We UAV range-extender expected to begin April 2015
AIP	Develop application-specific prototypes ready to be used by specified end-users	Demonstration of complete systems		
AIP	Volume and weight	<35kg/kW and 50L/kW	$100W_e$ system: 65kg/kW and 60L/kW $500W_e$ system: 20kg/kW and 20L/kW	On track for $100W_e$ project targets (FC + gaseous storage); solid-state storage and $500W_e$ system volume and weight not yet finalised but expected to reach project targets
AIP	Final system cost	<€5,000/kW	<€5,000/kW	Precise costs not known, but project focus is on low-cost materials and design for low-cost manufacturing
AIP	System efficiency	>30%	FC efficiency >50%	FC efficiency of 50% achieved
AIP	Lifetime	1,000h, 100 start/stop cycles	1,000h, 100 start/stop cycles	Field testing expected to begin in October 2014 allowing >6 months testing
AIP	Operating temperature	-20°C to 60°C	-20°C to 60°C	On track: units will be tested at high altitude

HyTEC

Hydrogen Transport in European Cities

CALL TOPIC	Large-scale demonstration of road vehicles and refuelling infrastructure III
START-DATE	1 September 2011
END-DATE	30 August 2015
TOTAL BUDGET	€29,100,000
FCH JU CONTRIBUTION	€11,950,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Air Products

Partners: Element Energy, HyER, LTI ltd, Cenex, Greater London Authority, hySOLUTIONS, Matgas, LBST, Copenhagen Hydrogen Network, Kobenhaven Kommune, Foreningen Hydrogen Link, Intelligent Energy, Heathrow Airport Ltd, London Bus Services Ltd, Fraunhofer Gesellschaft.

PROJECT WEBSITE/URL

http://hy-tec.eu/

PROJECT CONTACT INFORMATION

Emma Guthrie

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MAIN OBJECTIVES OF THE PROJECT

HyTEC is creating two new hydrogen vehicle deployment centres in London and Copenhagen. Each city is adopting a different approach, trialling different vehicle types and approaches to refuelling infrastructure roll-out, allowing diverse concepts to be tested:

- In Copenhagen passenger cars are being trialled alongside a refuelling station dispensing green hydrogen;
- In London passenger cars and taxis are being deployed alongside a state-of-the-art refuelling station using innovative delivered hydrogen technology.

The experience acquired by the two cities is being spread to other cities and the project also aims to improve hydrogen awareness of the public.

PROGRESS/RESULTS TO DATE

London:

- Installation and operation of the UK's first publicly accessible hydrogen fuelling station at Heathrow airport.
- Vehicle test and shakedown, driver training and certification of five fuel-cell taxis and creation of their operations base in London.
- Tendering process for procurement of fuel-cell passenger cars completed, delivery underway.

Copenhagen:

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

FUTURE STEPS

- Continued operation and data collection from hydrogen vehicle fleets and associated infrastructure in Copenhagen and London.
- Delivery of further fuel-cell vehicles into London.
- Final design specification, installation and operation of the two remaining Copenhagen fuelling stations.
- Analyse the results of the project, considering the full well-to-wheels life-cycle impact of the vehicles and associated fuelling networks, demonstrating the technical performance of the vehicles and uncovering non-technical barriers to wider implementation.
- Finalise analysis on future commercialisation of the vehicles, as well as providing an approach for the roll-out of vehicles and infrastructure, building on the demonstration projects.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- HyTEC has contributed to implement stakeholder inclusive vehicle demonstration programmes that specifically address the challenge of transitioning hydrogen vehicles from running exemplars to fully-certified vehicles and moving along the pathway to providing competitive future products.
- HyTEC's work will lead to the creation of networks in each country for the ongoing coordination of the process leading to hydrogen vehicle roll-out in the UK and Denmark.
- These networks will outlive the project and will be used to coordinate policy, industrial and administrative action towards hydrogen vehicle roll-out. This work will be coordinated with the FCH JU to ensure the networks work within an overarching European vision for hydrogen vehicle deployment.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Light-duty vehicles deployment	~500	~20	15
MAIP	Additional sites and stations	Two additional sites with three new stations	Two additional sites with four new stations	Two additional sites with one station each
MAIP	Vehicle lifetime	>5,000h	>2,000h	This has already been achieved for passenger cars. For the taxis and scooter, this has been demonstrated in test stands in the laboratory, and taxis will achieve this target during the project.
MAIP	Establishment of a commercial European hydrogen refuelling infrastructure	Roadmap for establishing a commercial European hydrogen refuelling infrastructure	Roll-out strategies/partnerships developed in the UK and Denmark. Creation of links between demonstration sites	Roll-out strategies reports for Copenhagen and London Development of partnerships with key stakeholders
AIP	Vehicle reliability	Mean Time Between Failure (MTBF) >1,000 km	MTBF >1,000 km	N/A (Not tested as yet)
AIP	Vehicle availability	>95%	>95%	95-99% (average – depending on vehicle type and location)
AIP	Vehicle efficiency	Efficiency >40% (NEDC)	Efficiency >40% (NEDC)	70.3 km/kg H_2 - 74.3 km/kgH_2 (average – depending on vehicle type and location)
AIP	Refuelling capacity	Stations refuelling at 35 and 70 MPa, with refuelling capacity of 50 kg and potential for extension to 200 kg	Stations refuelling at 35 and 70 MPa, with refuelling capacity of 50 kg and potential for extension to 200 kg	35 and 70 MPa, with potential for extension to 200 kg
AIP	Station availability	98%	98%	83.3% - >99% (average – depending on site)
AIP	Station hydrogen production efficiency	Efficiency of 50-70%	Will be achieved at each station (>55% for onsite); the overall efficiency of the logistics based energy chains can exceed 70% (well to tank)	
AIP AIP	H_2 price at pump (€/kg)	€10/kg	€10/kg	€10/kg

HyTIME

Low temperature H2 production from 2nd generation biomass

CALL TOPIC	Low-temperature H_2 production processes
START-DATE	1 January 2012
END-DATE	31 December 2014
TOTAL BUDGET	€2,920,000
FCH JU CONTRIBUTION	€1,610,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Stichting Dienst Landbouwkundig Onderzoek- Food & Biobased Research

Partners: Awite, Environment Park, Heijmans, RWTH Aachen, TUWien, Wiedemann-Polska Projekt, HyGear and Veolia

PROJECT WEBSITE/URL

www.hy-time.eu

PROJECT CONTACT INFORMATION

Pieternel Claassen

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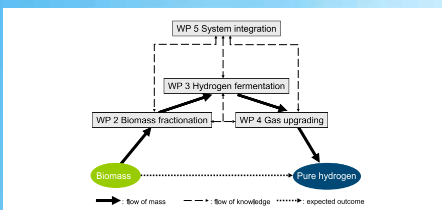

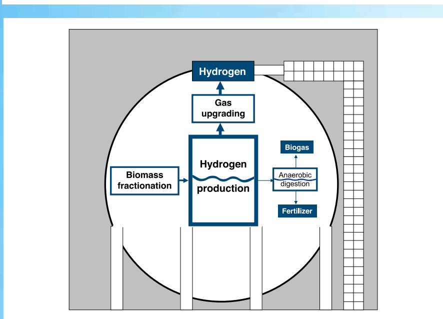

MAIN OBJECTIVES OF THE PROJECT

The objective of HyTIME is to construct a prototype process for delivering 1-10 kg H_2/day based on the unique strategy of a combination of extreme thermophilic dark fermentation with anaerobic digestion. HyTIME builds on previous results from FP5 (EU BIOHYDROGEN) and FP6 (HYVOLUTION). The acquired knowledge on biomass availability, logistics and pretreatment and on gas upgrading technology will be fully exploited to develop dedicated systems for an easy-to-handle biohydrogen production system.

PROGRESS/RESULTS TO DATE

- Fermentation feedstock prepared from straw and verge grass
- High hydrogen yield after fermentation of verge grass
- Full assembly of 50L dedicated hydrogen fermenter
- Efficient removal of CO_2 from fermenter off-gas
- Rapid anaerobic digestion of fermenter effluent

FUTURE STEPS

- Inoculation of 50L reactor with designed co-culture
- Combining gas purification system with 50L reactor for in-line gas upgrading
- Assembly and commissioning of 280L reactor for production of circa 1 kg H_2 per day
- Optimisation of anaerobic digestion
- Heat and energy integration

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Off-site production of enzymes for HyTIME seems the most realistic approach in feedstock preparation.
- From verge grass, H_2 production at lab-scale is 6.6 g/day from grass with 10% coming from grass juice.
- Efficient H_2 production from grass juice suffers from inhibition at higher concentrations.
- Fermentative hydrogen can be continuously operated for at least one month.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	No biological hydrogen production addressed in MAIP 2011 D708	>5,000	>10,000	N/A (test not finalised)
AIP 2010 SP1-JTI-FCH.2010.2.4	Development of digestion systems of 2nd generation biomass feedstock	Efficient and easy handling	75% efficiency in mobilisation of sugars from biomass	71% efficiency from straw 36% efficiency from grass <10% efficiency from kitchen waste
AIP 2010 SP1-JTI-FCH.2010.2.4	H_2 production from 2nd generation biomass	Demonstration in small-scale reactors	5L, 50L and 500L scale reactors in operation	5L reactor in operation, 50L reactor ready for wet tests, 300 L reactor purchased
AIP 2010 SP1-JTI-FCH.2010.2.4	Increase of H_2 productivity	1-10 kg H_2/day	1-10 kg H_2/day	6 g H_2/day from grass hydrolysate in 5L reactor with 0.6 g H_2/day from grass juice in 1L reactor
AIP 2010 SP1-JTI-FCH.2010.2.4	Continuous process prototype	1-10 kg H_2/day	1-10 kg H_2/day	Gas upgrading for 100% CO_2 removal method defined, anaerobic digestion of fermenter effluent successful with 96% SCOD removal in 1-2 days, monitoring unit for remote control of 50L reactor installed

HyTransfer

HyTransfer

Pre-Normative Research for Thermodynamic Optimisation of Fast Hydrogen Transfer

CALL TOPIC	Pre-normative research on gaseous hydrogen transfer
START-DATE	1 June 2013
END-DATE	30 November 2014
TOTAL BUDGET	€3,100,000
FCH JU CONTRIBUTION	€1,600,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Ludwig-Bölkow-Systemtechnik GmbH

Partners: Air Liquide SA, the CCS Global Group Limited, Raufoss Fuel Systems AS, Honda R&D Europe (Deutschland) GmbH, Joint Research Centre (JRC), Centre national de la recherche scientifique, Testnet Engineering GmbH.

PROJECT WEBSITE/URL

www.HyTransfer.eu

PROJECT CONTACT INFORMATION

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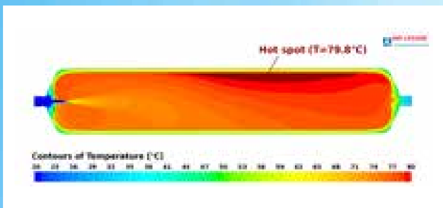
info@HyTransfer.eu



MAIN OBJECTIVES OF THE PROJECT

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

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

PROGRESS/RESULTS TO DATE

- CFD calculations for identifying the optimal spots for placing the thermocouples on the liner are concluded.
- Tanks including wrapped-in thermocouples are manufactured.
- Existing RCS and opportunities for improvements by the project are monitored.
- Detailed testing programme has been developed and is agreed and test facilities are preparing to start the test in the originally planned time slot.
- Simple modelling is in preparation.

FUTURE STEPS

- Carry out testing programme from September 2014
- CFD modelling of selected experiments in parallel for validation
- Development and validation of simple model sustaining energy-based fuelling process control criteria
- Techno-economical evaluation of results
- Prepare recommendations for RCS

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Optimised and more efficient refuelling protocol
- Guidance and simple models for optimised temperature control during hydrogen transfer
- Reduction of HRS OPEX and CAPEX
- Increased reliability and lifetime of technical HRS components
- Recommendations for international RCS

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
AIP	Identification of opportunities for optimisation	Not specified	Not specified	Optimisation by focusing on heat transfer
AIP	Identification of existing RCS and opportunities for improvement	Not specified	Not specified	Work in progress
AIP	Improved approaches for carrying out the transfer with less pre-cooling	Not specified	Not specified	Work in progress
AIP	Recommendations for implementation in international standards	Not specified	Not specified	This will be the final result of HyTransfer
AIP	Evaluate the influence of tank construction on the maximum allowable filling speed	Not specified	Not specified	Tanks of three different sizes from two different manufacturers with two different liner materials were purchased and will be evaluated in three different labs concerning their thermal behaviour under a variety of filling conditions

HyTransit

European Hydrogen Transit Buses in Scotland

CALL TOPIC	Large-scale demonstration of road vehicles and refuelling infrastructure IV
START-DATE	1 January 2013
END-DATE	30 June 2017
TOTAL BUDGET	€16,300,000
FCH JU CONTRIBUTION	€7,000,000
OTHER CONTRIBUTION(S)	Scottish Government, Scottish Enterprise, UK Technology Strategy Board

PARTNERSHIP/CONSORTIUM LIST

Coordinator: BOC

Partners: Van Hool, Aberdeen City Council, Stagecoach, HyER, PLANET, Dantherm, Element Energy.

PROJECT WEBSITE/URL

www.aberdeeninvestlivevisit.co.uk/hydrogen

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

HyTransit will trial a fleet of six hybrid fuel-cell buses in daily fleet services, together with one state-of-the-art hydrogen electrolyser and refuelling station in Aberdeen (Scotland) for three years. This project seeks to contribute to the commercialisation of hydrogen buses in Europe by:

- Bringing together an industrial consortium from across Europe to deliver the project, including buses from Van Hool (Belgium) and state-of-the-art refuelling technology from BOC (UK);
- Developing six A330 hybrid fuel-cell buses specifically modified for long suburban routes;
- Exposing the six buses to real-world operation with identical service requirements as diesel buses of 14 hours and 270 km per day;
- Constructing and operating a hydrogen refuelling station to serve the bus fleet. The station will be based on ionic compressors, configured to allow a refuelling speed of up to 120 grams per second. The station will be supplied with electrolytic hydrogen from an on-site electrolyser, whose operation will be controlled to demonstrate advantages to the local grid;
- A monitoring campaign to assess bus performance and demonstrate advances in reliability and fuel consumption compared with previous trials;
- Generating new intellectual property for Europe by developing the concept design for the world's first hybrid fuel-cell coach for long-route transit applications;
- Taking the first step for a large-scale roll-out of hydrogen buses in Scotland. The next logical step after this project is Scottish government support for the deployment of a minimum of 50 buses.

PROGRESS/RESULTS TO DATE

- Complex contracting process is complete, including contract between grid operator, station owner, and bus operator, which balances their different needs.
- All six new right-hand drive buses have been built by Van Hool in Belgium.
- Planning permission for the publicly accessible station has been obtained and construction of long-lead items has started.
- Designs to make an existing maintenance facility compatible with safe operation with hydrogen have been completed.
- Project public launch at the Al Energy show (May 2014).

FUTURE STEPS

- Refuelling station operational (autumn 2014)
- First passengers carried on the buses (autumn 2014)
- Monitoring campaign to demonstrate the reliability and low fuel consumption of the buses
- Complete the design for a fuel-cell inter-city coach
- Outreach to potential bus customers in Scotland and beyond

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Significant cost-reduction for fuel-cell buses compared to previous demonstrations has been achieved –with perhaps further potential to lower costs through increased demand and the technology improvements which are foreseen.
- Contractual commitments to improved reliability compared to current bus trials have been achieved – clearly this will need to be validated once the operational phase starts.
- The contracting process on this project has been challenging and led to delays. The problem was to satisfy the conflicting needs of grid operators (for flexibility of electrolyser generation) vs the needs of bus operators (for a highly reliable fuel supply). The contracts developed here could form the basis for standard contracts in the future.
- Clear interest from operators of local grids has been demonstrated, with the potential for significant "grid stabilisation" payments to operators of filling stations.
- The project has emphasised the importance of electricity tariffs in the cost of hydrogen fuel, and hence the total cost of ownership of hydrogen buses vs diesel ones. Further work to develop real tariffs for flexible electrolytic production of hydrogen would be very beneficial.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Number of buses deployed (MAIP 2015)	500 buses at 10 sites (of which seven are new)	Six buses in Aberdeen (+ four additional buses as part of sister High V. Lo City project)	All buses built
MAIP	Bus fuelling station capacity	400kg/day fuelling capacity at bus fuelling sites	Station capable of producing and dispensing over 400kg of hydrogen per day.	Components being manufactured, civil works underway
AIP	Bus stack life	>4,000 hour life initially, rising to 6,000 hours	15,000 hour warranty already achieved on FC stacks	Contractually secured warranty
AIP	Bus availability	>85%	85%	85% availability is included in supply contracts
AIP	Fuel consumption	<11-13 kgH_2/100 km	<10kg/100km	Design specification requires <10kg/100 km
AIP	Fuelling station availability	>98%	>98%	Multiply redundant station design. Contractual commitments are in place to achieve over 98%
AIP	Hydrogen purity	Consistent with SAE and ISO specifications	5 9's purity level specified	Purity level agreed with bus supplier
AIP	Hydrogen cost	<€10/kg with the conditions for <€5/kg identified	Cost below €10/kg on an opex basis	Contractually secured <€10/kg. TCO analysis demonstrating conditions under which <€5/kg can be delivered
AIP	Fuelling station efficiency (primary energy to nozzle)	50-70%	60% (HHV) from electricity to delivered hydrogen	Conservative estimate. Under construction

HyUnder

Assessment of the potential, the actors and relevant business cases for large-scale and seasonal storage of renewable electricity by hydrogen underground storage in Europe

CALL TOPIC	Assessment of benefits of H_2 for energy storage and integration in energy markets
START-DATE	18 June 2012
END-DATE	17 July 2014
TOTAL BUDGET	€1,766,516
FCH JU CONTRIBUTION	€1,193,273
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Foundation for Hydrogen in Aragon

Partners: Ludwig-Bölkow-Systemtechnik, Hinicio, KBB Underground Technologies, National Center for Hydrogen & Fuel Cells Romania, DEEP Underground Engineering, E.ON Gas Storage, Netherlands Energy Research Centre, Shell Global Solutions, Centre of Excellence for Low-Carbon and Fuel-Cell Technologies, Solvay Chemicals, Commissariat à l'énergie atomique et aux énergies alternatives.

PROJECT WEBSITE/URL

www.hyunder.eu

PROJECT CONTACT INFORMATION

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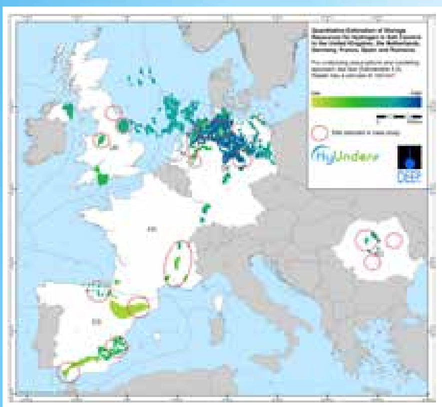

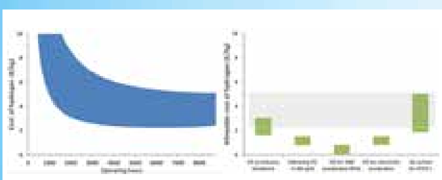

MAIN OBJECTIVES OF THE PROJECT

The objective of the HyUnder project is to establish a European initiative supporting the deployment of large-scale hydrogen energy storage in underground caverns, benchmark their storage potential in relation to the energy market and competing storage technologies, and to identify and assess application areas, stakeholders, safety, regulatory framework and public acceptance.

PROGRESS/RESULTS TO DATE

- Benchmarking of hydrogen storage with other large-scale energy/electricity storage concepts.
- Description of the relevant storage options for underground storage of hydrogen. Assess geological implications. Mapping of the better geological locations at European level.
- Evaluation of actual operating experience, also with respect to permitting and public acceptance. Documentation of the state-of-the-art of technology and operations in detail.
- Overview of the regional potential for hydrogen underground storage in Europe and identify/involve relevant players with a view to unlock synergies between energy sectors in different countries.
- Comparison of regional approaches to draw conclusions and provide recommendations to the FCH JU.

FUTURE STEPS

The project is near completion. Future steps focus on recommendations to the FCH JU related to the topic.

- Maintain focus on electrolysis as a key technology for low-CO_2 hydrogen production. Reach technology cost goals by R&D, and implement calls that aim at demonstrating and improving the performance of electrolysers for electricity storage and ancillary service applications across a number of countries with a high expected share of intermittent renewables.
- Perform a review of regulatory regimes for ancillary services like balancing power in all EU countries and the potential role for electrolysers, as a means to leverage additional revenue streams.
- Maintain a placeholder for an integrated electrolysis and underground hydrogen storage demonstration project in the Multi Annual Work Programme (MAWP) in order to gain operational experience, engage with public authorities on permitting requirements and test public acceptance.
- Further practical understanding of the technical challenges of storing large quantities of hydrogen in caverns is required.
- Explore business cases for hydrogen caverns other than for electricity storage, such as for hydrogen back-up supply for industry, as distribution hubs for mobility markets and to facilitate future import/export of hydrogen, possibly including building a strategic energy reserve.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Underground storage of hydrogen in salt caverns is technically feasible for large-scale storage of electricity, but requires suitable geology as well as public acceptance. There is geological potential for underground hydrogen storage in salt caverns in all countries scrutinised. These installations could help manage a high share of intermittent renewables which cover about 30-40% of the national electricity demand (could result in some TWhs of so-called surplus electricity that needs to be accommodated in the energy system. Higher shares of 60-80%, and more, could result in tens of TWhs of surplus electricity.
- The specific construction costs of salt caverns decrease significantly with size. Electrolysis dominates the total costs of an integrated production and underground hydrogen storage facility with over 80% (at some 50% utilisation), of which electricity costs take a major share. Although a cavern requires a significant upfront investment, it has a relatively small contribution to the total specific hydrogen costs of < € 0.5/kg.
- Besides electrolyser CAPEX and electricity purchase prices, the costs of hydrogen from electrolysis strongly depend on electrolyser utilisation. At less than about 2,000 hours the capital costs start to dominate the production costs, making hydrogen from electrolysis increasingly expensive.
- Hydrogen energy storage as a means to store renewable electricity via electrolysis and underground storage is economically very challenging. In the short term, under the assumptions made, the transport sector is the only market expected to allow a hydrogen sales price that may enable the commercial operation of an integrated hydrogen electrolysis and storage plant. No single industry sector alone will create a viable business case for underground hydrogen storage.
- Sensitivity analysis indicates that the most important factors for a potential business case are both low electrolyser CAPEX and significant periods of low electricity prices.

IMMEDIATE

Innovative autoMotive Mea Development – implementation of wIphe-genie Achievements Targeted at Excellence

CALL TOPIC	Next generation European MEAs for transportation applications
START-DATE	1 January 2013
END-DATE	31 December 2015
TOTAL BUDGET	€3,823,504
FCH JU CONTRIBUTION	€2,229,172
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: IRD

Partners: ICPH, CNRS, FUMA-TECH, Shanghai Jiao Tong University, Volvo Technology, SGL Carbon, Imerys Graphite & Carbon (former Timcal).

PROJECT CONTACT INFORMATION

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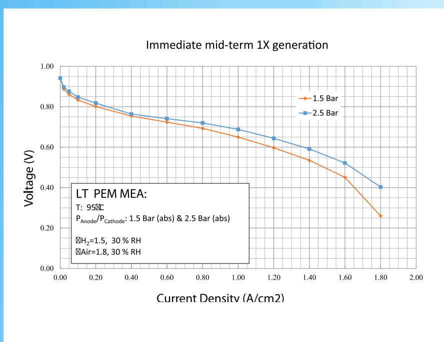


MAIN OBJECTIVES OF THE PROJECT

The objective of the IMMEDIATE project is to develop a medium-temperature PEM membrane electrode assembly (MEA) (80-130ºC) that will meet OEM requirements on cost, performance and durability and at the same time is a significant step towards the ultimate goal of having a PEM FC able to operate at >100°C at minimal RH, Pt-loadings <0.15 g/kW at >55% efficiency and >5,000h lifetime at dynamic operation

PROGRESS/RESULTS TO DATE

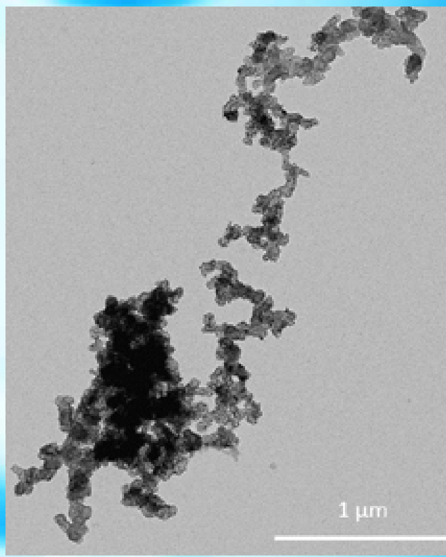
1. Membrane with proton conductivity of 90 mS/cm at 100 and 50% RH.
2. The first catalyst powders developed ready for stability screening and for incorporation in first generation MEA.
3. MEA with >0.55W @ El>55%, T>95ºC, RH<30%, P<1.5 bar.

FUTURE STEPS

1. Development of precursor materials
2. Fabrication and validation of the developed MEA's
3. Demonstrate MEA performance >1W/cm^2
4. Utilise and reduce Pt content: <0.15 g/kW

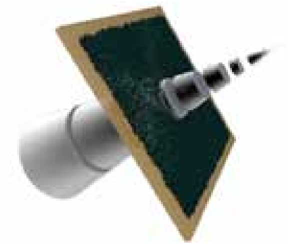
CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

The objectives and mid-term targets for the membrane and the first generation MEA performance have been achieved.



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Buses vehicle PEM-FC system	<€3,500/kW	MEA with Pt-loading of <0.15 g Pt/kW	N/A (test not finalised)
AIP	Next generation European MEAs for transportation applications	Membrane with proton conductivity 100mS/cm at 25% RH, 120ºC	Membrane with proton conductivity of at least 0.1S/cm at 120ºC & 25% RH Mid-term (18M) project target: 75 mS/cm^2 at 100 and 50% RH	90 mS/cm at 100 and 50% RH
AIP	Next generation European MEAs for transportation applications	MEA with BoL power density >1W/cm^2	MEA with BoL power density >1Wcm^2	N/A (test not finalised)
AIP	Next generation European MEAs for transportation applications	Lifetime >5000h	Lifetime >5000h	N/A (test not finalised)



IMPACT

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

CALL TOPIC	Investigation of degradation phenomena Next generation European MEAs for transportation applications
START-DATE	1 November 2012
END-DATE	30 April 2016
TOTAL BUDGET	€8,837,294
FCH JU CONTRIBUTION	€3,902,403
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

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

Partners: Commissariat à l'energie atomique et aux energies alternatives (CEA), JRC-IET, Consiglio Nazionale delle Ricerche, ITM Power, Johnson Matthey Fuel Cells, Zentrum für Sonnenenergie- und Wasserstoff-Forschung (ZSW), University of Applied Science Esslingen, TU Berlin, Institut National Polytechnique de Toulouse, Gwangju Institute of Science and Technology, Solvay Specialty Polymers Italy SpA.

PROJECT WEBSITE/URL

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

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

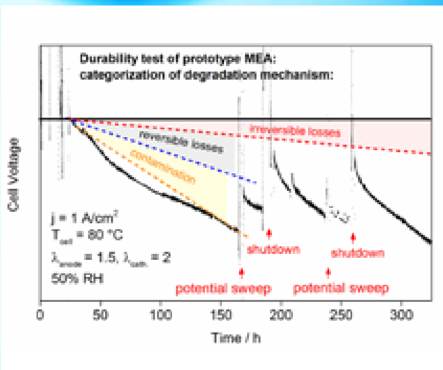
Identify the relevant degradation mechanisms of polymer electrolyte fuel cells at ultralow Pt content (<0.2 mgcm-2) and derive mitigation strategies to obtain a lifetime of 5,000 hours in dynamic operation, with a degradation rate below 10 µVh-1, by material development, structural design of cells and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

PROGRESS/RESULTS TO DATE

- In-situ and ex-situ investigation of reference MEA
- In-situ and ex-situ investigation of improved MEA
- Determination of reversible and permanent degradation
- Locally resolved analysis of cell performance

FUTURE STEPS

- Fabrication of 2nd generation improved MEA under different conditions
- Test of 2nd generation MEA in single cell and stack
- Further reduction of Pt loading



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Single-cell performance of 0.82W/cm^2 at 1.5 A/cm^2 reached for overall Pt loading of 0.4 mg/cm^2
- Degradation rates are still too high
- Target cell performance will probably be reached in 2016

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Demonstration of long-term stability under automotive fuel-cell conditions	Lifetime of 5,000 hours in dynamic operation, with a degradation rate below 10 µVh-1,	Lifetime of 5,000 hours in dynamic operation, with a degradation rate below 10 µVh-1,	Not yet started
AIP	Degradation	Irreversible and reversible degradation mechanism categorisation	Irreversible and reversible degradation mechanism categorisation	Analysis is in progress; degradation types can be distinguished
AIP	MEA development	Development of catalysts and electrode layers allowing for significant reduction in precious metal catalyst loadings	Pt loadings <0.2 mgPt/cm^2	Overall Pt loading of 0.4 mgPt/cm^2 (anode+cathode)
AIP	Development of durable ultra-low loaded MEAs for automotive applications	1W/cm^2 at 670mV (1.5 A/cm^2) single-cell performances	1W/cm^2 at 670mV (1.5 A/cm^2) single-cell performances	0.82W/cm^2 at 1.5 A/cm^2 single-cell performances

IMPALA

IMprove Pemfc with Advanced water management and gas diffusion Layers for Automotive application

CALL TOPIC	Next-generation European MEAs for transportation applications
START-DATE	1 December 2012
END-DATE	30 November 2015
TOTAL BUDGET	€5,081,868
FCH JU CONTRIBUTION	€2,640,535
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

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

Partners: German Aerospace Center (DLR), Paul Scherrer Institut JRC-IET, Institut national polytechnique de Toulouse, SGL Carbon GmbH, Nedstack Fuel Cell Technology BV.

PROJECT WEBSITE/URL

www.impala-project.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

The aim of IMPALA is to produce improved GDL to increase performance (up to $1W/cm^2$) of PEMFC by a twofold approach: a) modification of homogeneous GDL (MPL, wettability, additives); b) development of innovative non-uniform GDL. This technological work is supported by a deep-water management analysis combining the most advanced two-phase models (pore network modelling) and experimental diagnostics (X-ray liquid visualisation). This will help better understand the link between GDL properties and performance and propose design recommendations. The project is focused on automotive conditions but the improvements will be checked for different stack designs and back-up application.

PROGRESS/RESULTS TO DATE

- First two targets have been reached by modifying GDL: reference/MEA Level 0 ($0.75W/cm^2$) and MEA Level 1 ($0.90W/cm^2$).
- Pore network modelling of GDL has been improved: condensation effect, MPL; and experimental validation have been initiated.
- 3D images have been done on reference material: structure, liquid invasion.
- Different modifications of GDL have been done or have started: MPL, chemical grafting, structuration.
- Characterisation of GDL has started (of wettability and transfer properties).

FUTURE STEPS

- Compare modelling to 3D images (ex-situ liquid invasion and operating cell).
- Combine the different improvements of GDL to enhance performance even more.
- Finish coupling PNM of GDL backing and MPL; analyse the influence of materials on transfer properties and performance; compare liquid invasion to condensation.
- More work will be done on modelling transfer properties of GDL based on 3D images of the project.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Reference commercial GDL has been improved by modifying properties of the backing and/or of the MPL but final target ($1W/cm^2$) might be difficult to reach only by tuning the GDL properties.
- First analysis of 3D images of liquid pattern and two-phase 3D pore network modelling show a good consistency.
- Chemical grafting can improve performance.
- IMPALA gives the opportunity to better predict the transfer properties inside GDL based on real structure.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
AIP	Increase performance	Reach power density $>1W/cm^2$ at $1.5\ A/cm^2$ (BoL) and $>0.9W/cm^2$ at $1.4\ A/cm^2$ (EoL).	MEA Level 0: $0.75W/cm^2$ MEA Level 1: $0.9W/cm^2$ MEA Level 2: $1.0W/cm^2$ Operating conditions for automotive: H_2/air, gas hydration 50%, Stoe 1.2/2, 80°C, 1.5 bara	MEA Level 0 is reached MEA Level 1 is reached
AIP	Improvement of material	Improve performance of ref GDL (SGL 24BC) at RH 20% for automotive operating conditions (see below)	Improve performance at standard automotive conditions (MEA Level 0-2) and check improvement at other conditions	Performance has also been improved under RH 20%
		Conductivity >2 S/cm (in-plane) and >100 S/cm (through-plane)	Reduce through-plane resistance by 10%	Reached
AIP	Durability	Demonstration of long-term stability under automotive fuel-cell conditions.	Verify that degradation rate of MEA Level 1 and 2 is not lower than the one of MEA Level 0 (ref)	Ongoing for MEA Level 0
AIP	Industrialisation	Optimisation and demonstration of MEA processing at pilot-scale based on these innovative GDL	Analyse trade-off between increase of market thanks to improvement of performance, and new investments due to process modifications	Not started yet
	Modeling	Development and improvement of multi-scale and multi-phenomena modelling tools for increased understanding of performance and degradation phenomena	Pore network modelling (PNM): include condensation effect and MPL Performance modelling (PM) of MEA: improve predictability with better inputs (up-scaling of PNM, experiments) Cell modelling: improve predictability by up-scaling MEA PM	PNM: condensation is included and MPL is ongoing PM: ongoing First 3D images of liquid invasion have been obtained during capillary invasion and during operation – started
		Contribute to the development of European Industry solutions	Improve materials of SGL and PEMFC systems of NDSTK	SGL materials have already been improved. Tests are planned at NDSTK

IRMFC

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

CALL TOPIC	Demonstration of portable fuel-cell systems for various applications
START-DATE	1 May 2013
END-DATE	30 April 2016
TOTAL BUDGET	€3,266,389
FCH JU CONTRIBUTION	€1,586,038
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: FORTH/ICE-HT (Greece)

Partners: Advent, UMCS, Fraunhofer ICT-IMM, UPAT, ZBT, JRC-IET, Arpedon.

PROJECT WEBSITE/URL

irmfc.iceht.forth.gr

PROJECT CONTACT INFORMATION

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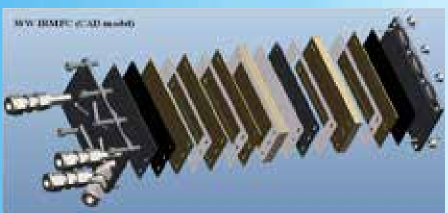

MAIN OBJECTIVES OF THE PROJECT

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

PROGRESS/RESULTS TO DATE

- Scale-up synthesis of ultra thin Cu-based methanol reformer ($5x10cm^2$, 500 μm thickness), highly active at 210°C, easily embedding in the cell;
- Polymer electrolyte membranes operating at 210-220°C with high stability (500h fuel-cell testing);
- New bipolar plates operating at 200-230°C;
- Single-cell testing of new materials resulted in 580 mV at 0.2 A/cm^2 at 210°C;
- Identification of critical engineering issues regarding BoP.

FUTURE STEPS

- Optimisation, construction and testing of anode/cathode flow fields
- Long-term testing of reformer and MEAs
- Single-cell and five-cell testing
- Stack and BoP design

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- The first 12 months results clearly demonstrate the IRMFC project progress, feasibility and future success.
- Crosslinking methodology adopted herein for the first time has demonstrated some excellent results leading to MEAs operating at 210-220°C.
- New-type methanol reformer (ultrathin and lightweight) and bipolar plates (operation at 200-230°C) have been successfully prepared.
- Promising results from single-cell testing raise prospects of achieving the objectives of the project.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	FC stack cost (€/kW)	<€5,000	<€5,000	N/A (components being scaled up and tested)
AIP	FC stack lifetime (h)	>1,000h	>1,000h	N/A (main components under testing/ optimisation)
AIP	FC system electrical efficiency (%)	>30%	>30%	N/A (Integration/testing of the final system will start at the end of 2015)

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

LASER-CELL

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

CALL TOPIC	Next generation cell and stack designs
START-DATE	1 December 2011
END-DATE	30 November 2014
TOTAL BUDGET	€2,877,089
FCH JU CONTRIBUTION	€1,421,757
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: AFC Energy plc

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

PROJECT WEBSITE/URL

http://www.laser-cell.eu/

PROJECT CONTACT INFORMATION

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Mark Boland : mboland@afcenergy.com

Holger Schiller : hschiller@afcenergy.com

MAIN OBJECTIVES OF THE PROJECT

1. Design a novel AFC based on laser-processed substrates that provide optimised technical and commercial characteristics.
2. Assess and adapt state-of-the-art laser manufacturing techniques; incorporating their benefits (while taking account of their restrictions) in the fuel-cell design.
3. Design an innovative fuel-cell stack to operate in industrial stationary settings, which delivers safety, mass manufacture, ease-of-assembly, recyclability, serviceability and optimal performance.
4. Establish cost-competitiveness of AFC technology in comparison with all competing technologies – confirming commercial viability of AFCs in large-scale stationary applications.

PROGRESS/RESULTS TO DATE

- Improved performance of alkaline-resistant polymers
- Rapid, precise drilling of substrates, with good thermal control and minimised part deflection
- Increased speed and quality of laser sintering
- Cost model for optimisation of parts and manufacturing process
- High-fidelity AFC models developed

FUTURE STEPS

- Drilled substrate stack testing
- Prototype development and testing
- Model validation
- Market analysis
- Publication of results and dissemination activities

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Further development of conductive polymers required before incorporation in substrate is commercially viable.
- Laser-drilling selected as manufacturing process for prototypes developed in phase II.
- Improved laser sintering performance; shows promise for future inclusion.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/QUANTITATIVE TARGETS CURRENT STATUS/ACHIEVEMENTS TO DATE
MAIP	Cost of system €/kW:	• mid-term 2015: €850/kW • long-term 2020: €600/kW	LASER-CELL will not contribute directly toward these targets, but achieving optimal design and materials for the mass manufacture of substrates will enable the coordinator to achieve conversion target price for project POWER-UP of GBP0.07/kWh in 2017
MAIP	Volume in the European market	• mid-term 2015: 2.5MW • long-term 2020: 20MW	No fuel cells will be deployed in project LASER-CELL. However, the substrate and design will be used in the systems deployed in project POWER-UP, in which a 500kWe alkaline fuel-cell system will be deployed in Germany by 2015
MAIP	Long-term durability	Reliability of 16,000h in 2015	No fuel cells will be deployed in project LASER-CELL. However, the substrate and design will be used in the systems deployed in project POWER-UP which will generate >15,000 hours by the end of the project in 2017

LIQUIDPOWER

LiquidPower fuel cell systems and hydrogen supply for early markets

CALL TOPIC	Research and development of 1-10kW fuel-cell systems and hydrogen supply for early market applications
START-DATE	1 October 2012
END-DATE	31 May 2015
TOTAL BUDGET	€3,680,000
FCH JU CONTRIBUTION	€1,990,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: H2 Logic A/S

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

PROJECT WEBSITE/URL

None

PROJECT CONTACT INFORMATION

info@h2logic.com

MAIN OBJECTIVES OF THE PROJECT

The LiquidPower project objectives are:

- R&D of a fuel-cell system for back-up-power and telecom applications (BT);
- R&D of a fuel-cell system for materials-handling vehicles (MH);
- R&D of a methanol reformer for onsite hydrogen supply, enabling low-cost hydrogen for the early markets of BT and MH.

PROGRESS/RESULTS TO DATE

- Methanol reformer design completed, including test and selection of catalyst
- Reformer PSA design completed
- Theoretical R&D of back-up power fuel-cell system conducted
- Theoretical R&D of materials-handling fuel-cell system conducted

FUTURE STEPS

- Construction and test of methanol reformer laboratory prototype
- Construction and test of back-up power fuel-cell laboratory prototype
- Continued R&D of materials-handling fuel cell and R&D efforts on cost reduction of hydrogen dispensed

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Public end-reports are expected by close of project

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Materials-handling fuel-cell system cost	€1,500/kW	€1,800/kW	€2,200/kW
MAIP	Back-up power fuel-cell system cost	€1,500/kW	€1,300/kW	€1,300/kW
MAIP	Materials-handling fuel-cell system efficiency	50%	52-55%	>52%
MAIP	Back-up power fuel-cell system efficiency	45%	45%	45%
AIP	Hydrogen cost at point of consumption	€7/kg	€7/kg	€9-11/kg

LOTUS

Low Temperature Solid Oxide Fuel Cells for micro-CHP applications

CALL TOPIC	Proof-of-concept fuel-cell systems
START-DATE	1 January 2011
END-DATE	30 June 2014
TOTAL BUDGET	€2,954,984
FCH JU CONTRIBUTION	€1,632,601
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: HyGear Fuel Cell Systems

Partners: SOFCPower, Fraunhofer-Institut für Keramische Technologien und Systeme, Domel d.d., University of Perugia, Joint Research Centre.

PROJECT WEBSITE/URL

LOTUS-project.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

The main objective of LOTUS is the development of a proof-of-concept 1kWe micro-CHP system based on SOFC technology operated at 650°C. The gas/air delivery system is targeted to be a low-cost, highly-efficient system based on field-proven components. The target electrical efficiency is 45% and the CHP efficiency is >80%. The system will be a direct replacement of conventional heating appliances using a modular concept and design practices from the heating appliances industry to reduce maintenance and repair downtime cost.

PROGRESS/RESULTS TO DATE

- Working static computer model of the CHP system
- Proven single-cell and stack technology for operation at 650°C
- Blower suitable for single blower strategy of system
- Successfully tested steam generator, reformer and combined start up/tail gas burner modules
- Successful testing of prototype

FUTURE STEPS

- Validation of dynamic system model
- Set up the follow-on projects

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- SOFC stack operation with partial internal reforming is feasible at 650°C.
- Successful operation of single blower system in exhaust stream is possible.
- Heat loss and pressure drop reduction are extremely important parameters in the design of small-scale high-temperature systems.
- Single burner system for both start-up on natural gas and Anode tail-gas combustion is successful.
- High efficiency due to successful combination of small-scale steam reforming with burner.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	System cost (2020) for micro CHP	€4,000-€5,000/kW	>€5,000	€4,745
AIP	Electrical efficiency (%)	>45%	>45%	43% (model)
AIP	Total system efficiency (%)	>80%	>80%	80% (model)

MAESTRO

MembrAnEs for STationary application with RObust mechanical properties

CALL TOPIC	Materials development for cells, stacks and balance of plant
START-DATE	1 January 2011
END-DATE	31 March 2014
TOTAL BUDGET	€2,264,765
FCH JU CONTRIBUTION	€1,040,049
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CNRS

Partners: Solvay Speciality Polymers, Johnson Matthey Fuel Cells, Università di Perugia, Pretexo.

PROJECT WEBSITE/URL

http://www.maestro-fuelcells.eu/

PROJECT CONTACT INFORMATION

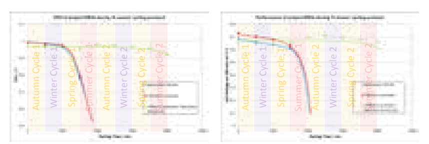
DeborahJones@univ-montp2.fr.

MAIN OBJECTIVES OF THE PROJECT

Improve the mechanical properties of the short-side chain (SSC) AquivionTM perfluorosulfonic acid (PFSA) ionomer to enable use of highly functionalised PFSA membranes at reduced thickness, for high conductivity and low area resistance, and with long lifetimes.

PROGRESS/RESULTS TO DATE

- Three routes for improved mechanical properties of low equivalent weight short-side-chain Aquivion membranes have been successfully developed in close collaboration among all technical partners – research institute/university and industrial.
- Elastic modulus of MAESTRO membranes based on low equivalent weight Aquivion improved by >300% and yield strength by >50% compared with the project benchmark state-of-the-art membrane.
- The improvement in mechanical properties allows use of a lower equivalent weight Aquivion ionomer, and the final membranes associate both improved mechanical properties and high conductivity/low electrical resistance.
- MEAs integrating MAESTRO membranes show greater durability (factor >2) in accelerated stress testing than those using the project benchmark, state-of-the-art low EW Aquivion membrane, and similar or improved performance, measured under the same conditions in a four-seasons testing protocol simulating micro-CHP operation conditions (voltage cycling, stop/start cycling) in a stack incorporating project and benchmark MEAs.
- Voltage loss (compared with start-of-life performance) of cells incorporating new membranes is <3% after 2,000 hours of operation including 500 hours of vigorous stop/startcycles.



Short stack durability test showing OCV (left) and Performance (right) throughout the project defined '4-season' durability protocol. Data for the project benchmark, 700EW crosslinked and 700EW crosslinked + nanofibre reinforcement plotted (in blue, red and green respectively). Trend lines added to guide the eye.

FUTURE STEPS

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

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- The approaches developed for mechanical stabilisation do not compromise conductivity.
- Non-optimised MEAs integrating MAESTRO membranes have significantly greater durability (lower performance loss) and longer lifetime than project benchmark MEAs.
- Excellent prospects for tuned, application-specific optimisation of mechanical/electrical properties.
- Clear prospects for future exploitation, including by the two industrial partners.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	e.g. FC system lifetime (h)	>5,000h	>10,000h	N/A (test not finalised)
AIP	e.g. Number of forklifts	10	20	7
AIP	e.g. FC system efficiency (%)	>40%	>40%	37% (last value obtained)
AIP	e.g. H_2 price at pump (€/kg)	<€13	<€12	€14.2 (average)

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

MATHRYCE

Material testing and recommendations for hydrogen components under fatigue

CALL TOPIC	Pre-normative research on design and testing requirements for metallic components exposed to H_2-enhanced fatigue
START-DATE	1 October 2012
END-DATE	30 September 2015
TOTAL BUDGET	€2,492,937
FCH JU CONTRIBUTION	€1,296,249
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA/Liten.

Partners: L'Air Liquide SA, Teknologian Tutkimuskeskus VTT, JRC-IET, The CCS Global Group Limited, Centro Sviluppo Materiali SPA, Dalmine SPA.

PROJECT WEBSITE/URL

www.mathryce.eu

PROJECT CONTACT INFORMATION

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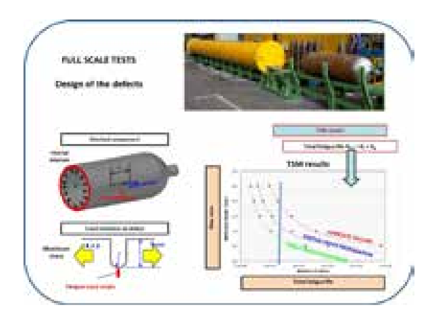


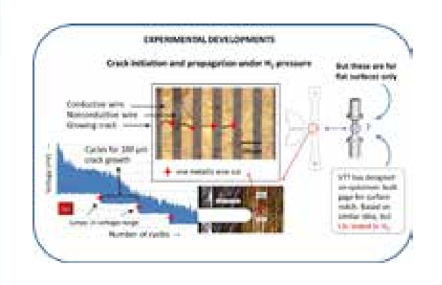
MAIN OBJECTIVES OF THE PROJECT

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

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

PROGRESS/RESULTS TO DATE

- Definition of the operational data of metallic pressure vessels used as buffers in hydrogen refuelling stations.
- Collecting and analysing the limits of the existing codes addressing the design of pressure vessels, considering hydrogen gas as well as cyclic pressure loading.
- Experimental development and definition of the first lab-scale and full-scale tests, including the design of the defects to be introduced through numerical simulations.
- Manufacturing and supply of the first pressure vessels.
- Thorough metallurgical analysis of the material and first mechanical tests under air and under hydrogen pressure.



FUTURE STEPS

- Finalising the experimental lab-scale programme on hydrogen-enhanced fatigue, including initiation and propagation. Hydrogen fatigue on a disc tests device will be performed as an alternative test closer to real cycling conditions.
- Hydraulic as well as hydrogen pressure tests on full-scale components.
- Development of a design methodology considering hydrogen-enhanced fatigue.
- Validation of the methodology from both lab-scale and full-scale tests.
- Dissemination through a workshop and in ISO-dedicated working groups of pre-normalisation recommendations.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Most relevant international design codes for design of H_2 pressure vessels were identified and analysed. Mathryce project will emphasise needed progress in terms of hydrogen-enhanced fatigue.
- A method to measure crack initiation and propagation under hydrogen pressure has been developed and validated. An influence of hydrogen pressure on both stages was demonstrated.
- We develop methodology to test hydrogen-enhanced fatigue using a single test and specimen characterising both crack initiation and propagation and based on known metal-hydrogen-fatigue interactions.
- Development of an ISO standard is tentatively considered possible within five years following the project.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP 2008-2013	RCS strategy	Development of RCS to avoid major barriers for the commercialisation of FCH products	Methodology for standardisation.	Mathryce is at M20. The project is on track with the planned objectives
AIP 2011	Design code for pressure equipment with metallic components in hydrogen service		Development of a design methodology taking into account hydrogen-enhanced fatigue	Thorough analysis of existing codes and standards. Identification of the main possible routes
AIP 2011	Metallic material characterisation for hydrogen service		Three types of tests are developed and applied to the metallic material AISI 4130	The experimental developments have been addressed and the first experimental results obtained
AIP 2011	Experimental implementation of design approach and design testing approach		Development of service-life assessment methodology based on lab-scale tests under hydrogen gas and taking into account fatigue	Test methods are being evaluated by experimental research

MCFC-CONTEX

MCFC catalyst and stack component degradation and lifetime: Fuel Gas CONTaminant effects and EXtraction strategies

CALL TOPIC	Degradation and lifetime fundamentals
START-DATE	1 January 2010
END-DATE	30 June 2014
TOTAL BUDGET	€4,429,336
FCH JU CONTRIBUTION	€1,841,929
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: ENEA (Italy)

Partners: MTU Onsite Energy, Ansaldo FC, TU Munich, Tubitak Marmara, Swedish Royal Institute of Technology, University Genoa, OVM Institute, University Perugia, CETaqua.

PROJECT WEBSITE/URL

http://mcfc-contex.enea.it/

PROJECT CONTACT INFORMATION

Stephen McPhail

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MAIN OBJECTIVES OF THE PROJECT

A systematic, application-oriented investigation of the tolerance levels of MCFC and reformer catalysts to specified sulphur-based pollutants downstream of clean-up or CO2 separation from power plant flue gas (CCS);

1. Evaluation of different cleaning technologies for implementation in a MCFC-driven, organic fuel-fed CHP system. Development of a pilot clean-up system specifically targeted to the requirements of a waste-water treatment plant;
2. Development of an accurate, real-time detection system for trace contaminant measurement and monitoring, combining advanced optical techniques;
3. Set-up of a predictive, numerical simulation model that replicates MCFC performance and supports the development of accelerated testing protocols.

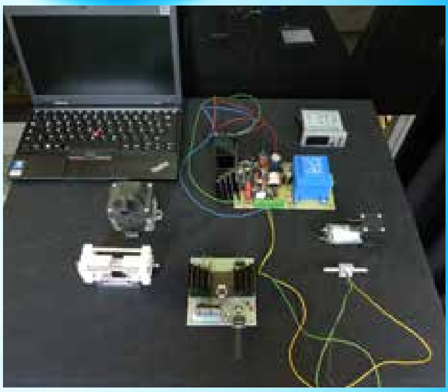
PROGRESS/RESULTS TO DATE

Tolerance levels to H2S at anode side mapped. Discovery of poisoning mechanism of SO2 in the cathode, that is transported to the anode side and is converted to H2S and concentrated.

4. In-depth characterisation of several adsorbents for H_2S and siloxane removal: materials have been selected and field-tested in a pilot system. Feasibility analysis of up-scaling carried out.
5. Detection for siloxanes proven to targeted requirements. Sulphur compound emission lines are masked in a biogas matrix: enriching techniques have improved resolution. Field-ready instrument completed.
6. Kinetic validation of numerical model successful, considering clean gas and contaminated gas.
7. Validation of accelerated testing protocols ongoing.

FUTURE STEPS

1. Further refinement of SO2 transport mechanisms and mapping MCFC operating conditions.
2. Implementation of clean-up characteristics in a calculation tool system design.
3. Field tests of gas analysis devices.
4. Extension of accelerated testing protocols to other degradation forms.



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

1. For CCS, a narrow band of feasible operation is likely, due to the low CO_2 concentrations and high utilizations rates required. This does not take into account cleaning of the flue-gas prior to entering the MCFC.
2. For biogas-fuelled systems, it is most feasible to focus on a fully effective clean-up system, ensuring totally clean fuel is fed to the MCFC stack, rather than attempt to make MCFC more resistant to contaminants.
3. This can be achieved cost-effectively with accurate selection of adsorbent materials. Careful engineering will minimise maintenance operations while maximising reliability.
4. Real-time detection of contaminants in the system is the key to enhance reliability: optical techniques are promising but prove to be difficult to calibrate due to the complex gas matrix and spectrum interference. Field tests are planned.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	FC system lifetime (h)	40,000h	Improve operating conditions to enhance lifetime	Mapping of operating conditions and effective cleaning methods established
AIP	Accelerated testing	To be improved	Protocols defined	Protocols defined and under elaboration
AIP	FC system efficiency (%)	>40%	>40%	47% reported

METPROCELL

Innovative fabrication routes and materials for METal and anode supported PROton conducting fuel CELLs

CALL TOPIC	Materials development for cells, stacks and balance of plant (BoP)
START-DATE	1 December 2011
END-DATE	30 November 2014
TOTAL BUDGET	€3,436,092
FCH JU CONTRIBUTION	€1,822,255
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Tecnalia.

Partners: EIFER, CNRS , Technical University of Denmark(DTU), Topsoe Fuel Cell (TOFC), Ceramic Power Technology,, Höganäs AB, Marion Technologies

PROJECT WEBSITE/URL

http://www.metprocell.eu/

PROJECT CONTACT INFORMATION

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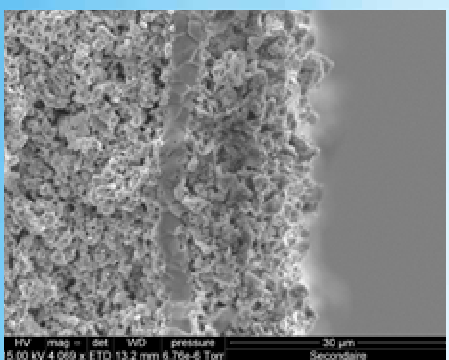
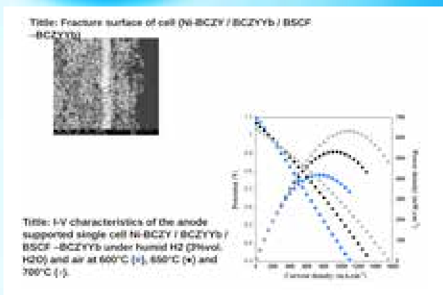


MAIN OBJECTIVES OF THE PROJECT

- Development of new electrolyte and electrode materials with enhanced properties for improved proton conducting fuel cells (PCFCs) dedicated to 500°C-600°C.
- Suppress the post-sintering steps using alternative manufacturing routes based on thermal spray technologies and plasma electrochemical vapour deposition (EVD).
- Assess the potential of both metal and anode-supported cell architectures to obtain the next generation of PCFCs.
- Bring the proof-of-concept of PCFCs by the set-up and validation of short stacks for APU and gas/micro-CHP (first complete PCFC stack units).
- Assess the PCFC technology as electrolyser.

PROGRESS/RESULTS TO DATE

- Well performing electrode/electrolyte materials dedicated to a service temperature range of 550°C-650°C have been developed:
- Electrodes: BSCF-BCYZ/BCY composite cathodes with an area-specific resistance (ASR) down to 0.44 ohm.cm^2; BCYZ-NiO anodes with ASR down to 0.07ohm.cm^2 and σ e >1000 S.cm^{-1};
- New electrolyte compositions based on solid solution of BCY and BCYZ with σ H+ of 14 mS.cm^{-1}.
- Anode supported button cells (Ni-BCZY/BCZYYb/BSCF–BCZYYb) with a max. power density of 420 and 532 mW.cm^{-2} at 600°C and 650°C respectively (using air as the oxidant gas and humid H_2 (3%vol. H_2O) as fuel gas - cell diameter: 30 mm).
- Low-cost ferritic stainless steel (iron chromium steels) supports with thermal expansion coefficients (TEC) close to that of the electrolytes (10•10^{-6} K^{-1}). Improved support post-treatment with a Y–base coating to guarantee high corrosion resistance under the target service conditions (i.e. humid H_2 (4% H_2O/H_2) at 600°C). Weight increase of 0.4% after oxidation tests for 1500h.
- NiO-BCYZ/BCY layers deposited by atmospheric plasma Spraying with thicknesses down to 40 m and ASR down to 0.45ohm.cm^2 at 600°C.



FUTURE STEPS

- Up-scaling of selected material compositions/anode-supported cell configurations to medium-sized cells (support diameter: 60 mm/active cathode area, Ø: 50 mm) and stack cells (foot-print: 120x120 mm) (in progress).
- Electrochemical performance validation of up-scaled cells (single-cell level).
- Short-stack assembly (based on stack design from TOFC) and testing in existing industrial systems.
- Promising results on cell components deposited using thermal spray methods on metal supports. Demonstration at single-cell level will follow at lab-scale only.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- New anode/electrolyte materials dedicated to PCFC technology with improved electrochemical performance at 550°C-650°C have been developed.
- Well-structured and good performing composite cathodes based on mixed ionic (O^{2-}) electronic conductors (MIEC) initially intended for SOFCs have been developed for application in PCFCs (550°C-650°C).
- The target for FC performance at single-cell level has been achieved on anode-supported cells: PCFCs with a max. power density at 600°C over the project target of 400 mW.cm^{-2}.
- Low-cost iron chromium stainless steel supports with TEC match to the developed anode/electrolyte materials and predicted good corrosion resistance under the target service conditions.
- The PCFC technology has been assessed for the first time in electrolysis mode, with promising results.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	e.g. FC system lifetime (h)	>5,000h	>10,000h	N/A (test not finalised)
AIP	e.g. Number of forklifts	10	20	7
AIP	e.g. FC system efficiency (%)	>40%	>40%	37% (last value obtained)
AIP	e.g. H_2 price at pump (€/kg)	<€13	<€12	€14.2 (average)

METSAPP

METSAPP

Metal Supported SOFC Technology for Stationary and Mobile Applications

CALL TOPIC	Materials development for cells, stacks, and balance of plant, in the stationary power generation & CHP part of the call for proposals.
START-DATE	1 November 2011
END-DATE	31 October 2014 (negotiation for extension ongoing)
TOTAL BUDGET	€7,965,367
FCH JU CONTRIBUTION	€3,396,469
OTHER CONTRIBUTION(S)	Energinet.dk via the ForskEL-programme (DK partners) €1,017,694

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Topsoe Fuel Cell A/S (DK)

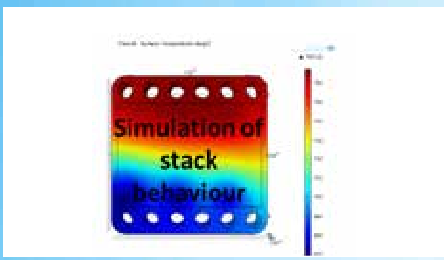
Partners: Sandvik Materials Technology, Technical University of Denmark, AVL List GmbH, Chalmers University of Technology, Karlsruhe Institute of Technology, University of St. Andrews, ICE Strömungsforschung GmbH, Joint Research Centre (JRC-IET).

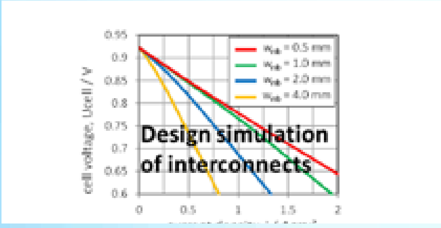
PROJECT WEBSITE/URL

www.metsapp.eu

PROJECT CONTACT INFORMATION

Niels Christiansen : nc@topsoe.dk





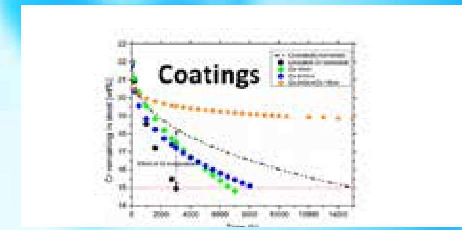
MAIN OBJECTIVES OF THE PROJECT

The aim of METSAPP is to develop novel cells and stacks based on a robust and reliable up-scalable metal-supported technology for stationary as well as mobile applications with the following primary objectives:

- Robust metal-supported cell design, ASR_{cell} <0.5Ωcm^2 at 650ºC;
- Cell optimised and up-scaled to >300 cm^2 footprint;
- Improved durability for stationary applications, degradation <0.25% /kh;
- Modular, upscaled stack design, stack ASR_{stack} <0.6 cm^2 at 650ºC;
- Robustness of 1-3kW stack verified;
- Cost-effectiveness, industrial relevance, up-scalability illustrated.

PROGRESS/RESULTS TO DATE

- Metal-supported cell fabrication shown possibilities for up-scaling footprint size of cell to >300 cm^2
- Novel anode materials and designs as well as nanostructured coatings for metal supports and interconnects have been developed.
- Development of novel stack concept for metal-supported cells in progress.
- Advanced multi-scale computational modelling tools including computational fluid dynamics (CFD) and finite element methods (FEM) have been developed from micro-level to stack level.
- Improved understanding of mechanical and thermo-mechanical behaviour of porous metals.



FUTURE STEPS

- Implement novel anode materials into the metal-supported cell design for improved durability.
- Proof-of-concept of novel stack concept for metal-supported cells.
- Demonstrate high performance and durability of the developed concepts in cells and stacks.
- Further improvements to computational modelling tools to support cell and stack development.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

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

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Improved durability for stationary applications, degradation	Address lifetime requirements for 40,000h	Stack degradation <0.25%/kh	N/A
MAIP	Robustness of 1-3kW stack verified for stationary applications	Address lifetime requirements for 40,000h	Stack with >1kW run with 70% fuel utilisation on reformed natural gas.	No full size stacks (25-50 cells) tested yet with new stack design
MAIP	Developing components as well as novel architectures for cell and stacks leading to step change improvements over existing technology. Cost effectiveness, industrial relevance, up-scalability illustrated	Cost of €4,000 - €5,000/kW for micro CHP	Show that ferritic stainless steel as support structure is a cost-efficient alternative for Ni/YSZ	Successfully shown that ferritic stainless steel is a promising alternative to Ni/YSZ. Lifetime and robustness need to be proven on full-sized stacks.
AIP	Development of materials to improve performance of single cells, stacks, and BoP components, in terms of longer lifetime and lower degradation.	Similar or better than state-of-the-art.	ASR_{cell} <0.5 Ωcm^2 at 650ºC	ASRcell <0.5Ωcm^2 at 650ºC on single cells. ASR_{cell} <0.6 Ωcm^2 at 650ºC in stacks.
AIP	Investigation on materials production techniques. Optimise materials and up-scaling	N/A	Cell footprint size >300 cm^2. IC coating up-scaled	Footprint of cell >300 cm^2 produced. Coating line at Sandvik.
AIP	Development of materials to improve performance of single cells, stacks, and BoP components, in terms of longer lifetime and lower degradation.	Similar or better than state-of-the-art.	ASR_{stack} <0.6 Ωcm^2 at 650ºC	ASR_{cell} <0.6 Ωcm^2 at 650ºC in stacks. Need to verify on larger stacks (25-50 cells) and on new stack design.

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

MMLCR=SOFC

Towards mass-manufactured, low-cost, and robust SOFC stacks

CALL TOPIC	Next generation cell and stack designs
START-DATE	1 January 2012
END-DATE	30 June 2015
TOTAL BUDGET	€4,468,929
FCH JU CONTRIBUTION	€2,067,975
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: University of Birmingham

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

PROJECT WEBSITE/URL

n/a

PROJECT CONTACT INFORMATION

Prof Robert Steinberger-Wilckens
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MAIN OBJECTIVES OF THE PROJECT

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

PROGRESS/RESULTS TO DATE

- D1.0 design updates implemented and first prototype stacks tested
- D2.0 accomplished and manufactured, testing initiated
- More power and better cycling capability implemented in D2.0
- D2.n improvements designed and ready for implementation
- Design of automated manufacturing line completed; one prototype assembly sub-station to be built

FUTURE STEPS

- Manufacturing of D2.0 stack
- Testing of D2.0 designcycling
  - cycling
  - long-term
- Implementation of D2.n improvements
- Validation testing of D2.n
- Long-term test of D2.0 or D2.n

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- D1.0 design performed well overall
- Better start-up and cycling capabilities expected with D2.0, though not yet tested

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP 2011	SOFC system cost	SOFC system cost <€4,000/kW	Low-cost manufacturing and materials saving design; stack cost 2kW €600	Ongoing
MAIP 2011	Start-up time	<1 hour	Rapid start-up: cold-start in 30 minutes	No D2.n testing yet; 45 minute startups on D1.0 design
MAIP 2011	Thermal cycling	Several 100 with 5% performance loss	500 with 10% performance loss	No D2.n testing yet; Juelich has performed 60 cycles on other design with no degradation
AIP cites MAIP in this topic				

Nano-CAT

Development of advanced catalysts for PEMFC automotive

CALL TOPIC	New catalyst structures and concepts for automotive PEMFCs
START-DATE	1 May 2013
END-DATE	30 April 2016
TOTAL BUDGET	€4,394,330
FCH JU CONTRIBUTION	€2,418,439
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA.

Partners: ARMINES, C-Tech Innovation Ltd, Nanocyl SA, JRC, German Aerospace Center (DLR), Volvo Technology AB, Fundacion Tecnalia.

PROJECT WEBSITE/URL

http://nanocat-project.eu/

PROJECT CONTACT INFORMATION

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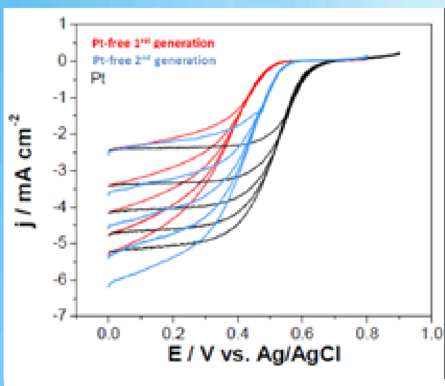
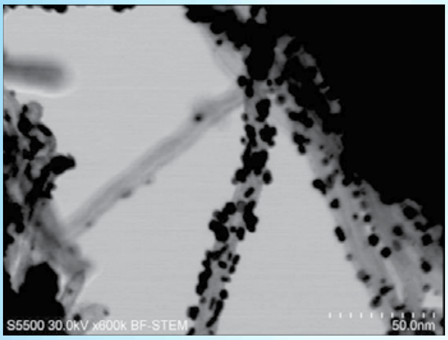


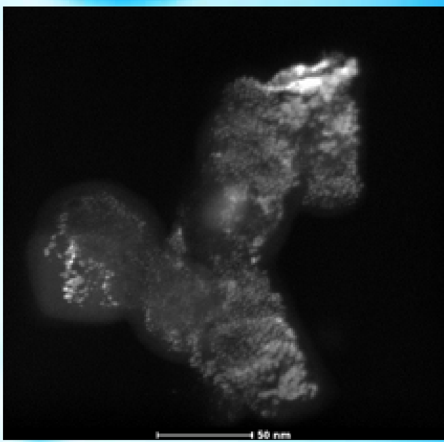


MAIN OBJECTIVES OF THE PROJECT

Nano-CAT aims at developing new catalysts to decrease the amount of Pt needed in PEMFC electrode. Two routes are followed. One is more fundamental dedicated to the synthesis of bio-inspired compound to produced Pt-free catalyst. A second, less risky, is based on the deposition of Pt alloys on resistant supports (carbon nanotube and doped metal oxide). The MEA integrating the project catalysts are tested under conditions required for bus application.

PROGRESS/RESULTS TO DATE

- 80 mV overvoltage for Pt catalyst for ORR (Vs Pt)
- 23 mA/mgPt @ 0.9 V/RHE with Pt3Co by physical vapour deposition
- Structuration of Pt alloy on carbon nanotubes
- Base line with reference material



FUTURE STEPS

- Integrate Pt-free catalyst in MEA and test in single cell
- Integrate catalyst supported on carbon nanotubes and test in single cell
- Test of best catalysts using protocol for bus application
- Upscale of catalyst production/MEA preparation to set up a short stack

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

Use of innovative catalyst and supports to reduce Pt loading and increase lifetime.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Reduce Pt cost in automotive PEMFC	<0.1 gPt/kw	<0.1 gPt/kW	0.67 gPt/kW with reference material
AIP	Increase specific power for automotive PEMFC	1W/cm^2 @ 1.5 A/cm^2	1W/cm^2 @ 1.5 A/cm^2	750 mW/cm^2 with reference material
AIP	Increase lifetime of automotive PEMFC	Lifetime: 5,000h	10% loss after 5,000h	1% loss after 10k cycles in AST (DoE for catalyst dissolution)

NELLHI

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

CALL TOPIC	Improved cell and stack design and manufacturability for application-specific requirements for stationary fuel-cell power and CHP systems
START-DATE	1 May 2014
END-DATE	30 April 2017
TOTAL BUDGET	€2,858,447
FCH JU CONTRIBUTION	€1,633,895
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: ENEA (Italy)

Partners: Elcogen AS, Elcogen Oy, VTT, Flexitallic, Borit, Sandvik Materials Technology, Cutec-Institut GmbH.

PROJECT WEBSITE/URL

http://www.nellhi.eu/ (under development)

PROJECT CONTACT INFORMATION

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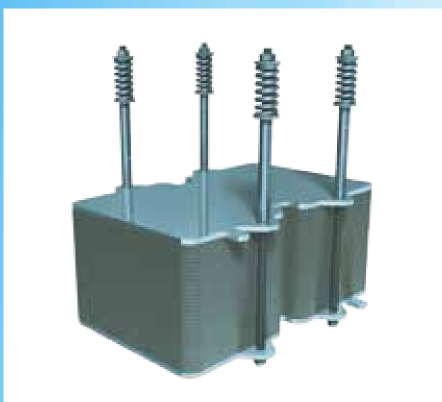


MAIN OBJECTIVES OF THE PROJECT

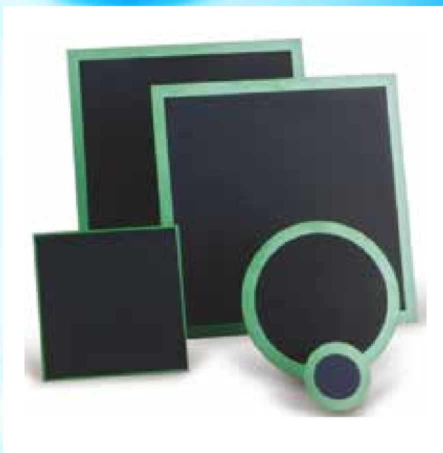
NELLHI combines European know-how in single cells, coatings, sealing, stack design and manufacturing technology to produce an innovative and modular 1kW SOFC stack, together with the proof-of-concept of a 10kWe SOFC stack module. Improvements over the state-of-the-art in cost, performance, efficiency, and reliability will be proven, as a combined result of high-performance cells and manufacturability designed for mass production at high yield. The project target is an off-the-shelf, modular stack assembly that can be integrated in stationary CHP applications of various sizes fed by natural gas – from single kilowatt to multi-megawatt scale.

PROGRESS/RESULTS TO DATE

- Project kick-off has taken place and detailed work-plan defined
- Testing specifications and materials are being circulated
- Test rigs are being adapted
- Website under development

FUTURE STEPS

- Input to stack boundary conditions from industrial advisory group
- All components delivered for 1st generation stack assembly
- Cell testing and validation for 2nd generation stack
- Component development for 2nd generation stack



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- All partners are in contact and preparing facilities and hardware for complementary development
- Next meeting at end-September 2014 at Elcogen facilities

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
AIP	Increase robustness and lifetime	Not specified	Less than 0.2% voltage loss in 1,000 hours and 0.5% after 10 thermal cycles (enables >25,000h lifetime)	N/A yet
AIP	Increase performance, power density, and efficiency	Not specified	Cell voltage 900 mV @ 0.4 A/cm^2 current density	N/A yet
AIP	Reduce materials and manufacturing cost	Not specified	Cell manufacturing process up-scaled and validated for production of 12x12 cm^2 cells, reducing scrap rates and increase yield to >95%. Cost target for cells less than €300/kWe. Target for ready interconnect in annual production volume of 100,000 pcs is ~ €200/kW. The price target for the final sealing materials in mass manufacturing is €30/kWe	N/A yet

NEMESIS2+

New Method for Superior Integrated Hydrogen Generation System 2+

CALL TOPIC	Development of fuel processing catalysts, modules and systems
START-DATE	1 January 2012
END-DATE	31 December 2014
TOTAL BUDGET	€3,393,062
FCH JU CONTRIBUTION	€1,614,944
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

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

Partners: HyGear BV, Johnson Matthey PLC, Abengoa Hidrógeno SA, Abengoa Bioenergía San Roque SA, Centre for Research and Technology Hellas, Instituto Superior Técnico.

PROJECT WEBSITE/URL

www.nemesis-project.eu

PROJECT CONTACT INFORMATION

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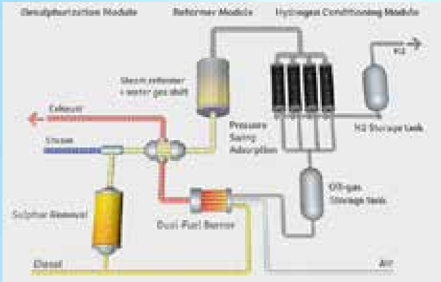

MAIN OBJECTIVES OF THE PROJECT

Within the three-year project NEMESIS2+ a small-scale hydrogen generator capable of producing 50 m^3h^{-1} hydrogen (purity: 5.0) from biodiesel and diesel will be developed. With the envisaged process concept, a system efficiency (based on the lower heating value of hydrogen related to the lower heating value of liquid fuel) >65% is targeted. The hydrogen production cost is expected to be lower than €4/kg.

PROGRESS/RESULTS TO DATE

- Stable steam reforming of diesel and biodiesel shown on lab-scale (100 hours).
- Stable water/gas shift performance in the presence of 1 ppm H_2S and 100 ppm hydrocarbons (100 hours).
- Successful testing of dual-fuel burner based on air-assisted atomisation.
- Liquid desulphurisation (<2 ppm S) achieved in an adsorption bed of activated carbon.
- Improved catalyst formulations (reformer, water/gas shift) developed.

FUTURE STEPS

- Build-up of prototype system (50 Nm^3/h)
- Final test campaign in the second half of 2014

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Coking and sintering have been identified as main causes of catalyst deactivation.
- By using a noble metal catalyst and properly choosing the operating conditions (in particular temperature and feed mass flow per open area of catalyst), coking can be minimised, thus avoiding initiation of catalyst deactivation.
- Stable steam reforming of diesel and biodiesel is possible.
- Experimental results indicate that desulphurisation of diesel is beneficial for long-term operation.
- Upon successful transfer of the laboratory results on prototype level a pre-commercial product will be available.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Supply of 50% of the anticipated hydrogen energy demand (expected to come mainly from transport and early market applications) from renewable energy sources by 2020	NEMESIS2+ will contribute to reach this target by using biodiesel as an environment-friendly resource with high energy density.	Stable and cheap hydrogen production from biodiesel	Successful and stable reforming of biodiesel has been shown on lab-scale
AIP	System efficiency (higher heating value H_2/ higher heating value fuel)	80	70	N/A
AIP	Catalyst durability	Stable long-term operation	>1,000h	100h (on laboratory- scale)
AIP	H2 production costs (€/kg)	<€5	<€4	N/A

NOVEL

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

CALL TOPIC	Innovative materials and components for PEM electrolysers
START-DATE	1 July 2012
END-DATE	30 June 2016
TOTAL BUDGET	€5,743,445
FCH JU CONTRIBUTION	€2,663,357
OTHER CONTRIBUTION(S)	Research Council of Norway €310,683

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Stiftelsen SINTEF.

Partners: Fraunhofer Gesellschaft zur Förderung der angewandten Forschung, Commissariat a l´ energie atomique et aux energies alternatives, Helion SAS, Johnson Matthey Fuel Cells Ltd, Teer Coatings Limited, Beneq OY, Paul Scherrer Institute.

PROJECT WEBSITE/URL

www.novelhydrogen.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

The main objective of NOVEL is to develop and demonstrate an efficient and durable PEM water electrolyser utilising the new, beyond the state-of-the-art materials developed within the project. The electrolyser will demonstrate a capability to produce hydrogen with an efficiency of at least 75% (LHV) at rated capacity with a stack cost below €2,500/Nm^3h^{-1} and a target lifetime in excess of 40,000 hours (<15 μVh^{-1} voltage increase at constant load).

PROGRESS/RESULTS TO DATE

- Identified degradation mechanisms in PEM electrolysers
- Developed membranes with lower H_2 crossover
- Supported electro-catalysts with higher activity developed
- Evaluation of several bipolar plate coatings ongoing
- AREVA electrolyser stack tested more than 6000h

FUTURE STEPS

- Integration of catalysts and membranes to new MEAs
- Upscaling process optimisation of bipolar plate coating process
- Lifetime evaluation of PEM electrolysers

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- A new generation of polyaromatic membranes for PEM electrolysers with significant enhancement in membrane lifetime and cost;
- New oxygen evolution catalysts with significant improvement in catalytic activity and potential for noble metal thrifting;
- Increased understanding of degradation issues in PEM electrolysers and parameters affecting overall lifetime which can contribute to increasing the lifetime of these units;
- Novel stack design, reducing construction material costs and easing assembly.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
AIP	More efficient catalysts for the oxygen evolution reaction presenting lower activation overpotential as well as new catalyst structures or metal alloys resulting in lower noble metal loadings	N/A	Improved catalysts with 200% mass activity vs. state-of-the-art demonstrated. Fibrous catalyst supports and the use of alternatives to Pt for hydrogen evolution is being evaluated	Catalysts with 300% mass activity vs. state-of-the-art demonstrated ex situ. Fibrous catalyst supports and the use of alternatives to Pt for hydrogen evolution have been evaluated
AIP	Polymer membranes with improved conductivity, low gas crossover and high mechanical stability at operating conditions such as hydrocarbon membranes or other novel membrane concepts, including composite structures	N/A	• Thinner, more conductive and reinforced PFSA membranes; • Radiation-grafted membranes; • More advanced concepts, such as structured radiation grafted membranes and hybrid membranes. membranes to new MEAs	Membranes with a higher ratio of conductivity vs hydrogen crossover have been developed and tested for hydrogen crossover and conductivity ex-situ. First tests of electrolyser MEAs are ongoing
	Development and experimental validation of testing procedures and test protocols applicable to PEM electrolyser to determine performance (e.g. power output, efficiency) and endurance. An effort to develop AST protocols for electrolysers should have high priority.	N/A	Evaluation of lifetime of PEM electrolysers under dynamic operation. Post mortem analysis of components to identify degradation mechanisms. Development of AST protocols for electrolyser components and fuel cells.	An international seminar with more than 100 participants on degradation issues in PEM electrolysers has been held Developed AST protocols for catalysts and bipolar plates. AST protocols for electrolyser cells are under development

ONSITE

Operation of a Novel Sofc-battery Integrated hybrid for Telecommunication Energy systems

CALL TOPIC	System-level proof of concept for stationary power and CHP fuel-cell systems at a representative scale
START-DATE	1 July 2013
END-DATE	30 June 2016
TOTAL BUDGET	€5,525,440
FCH JU CONTRIBUTION	€3,012,038
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

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

Partners: efceco, Ericsson Telecomunicazioni, FIAMM ESS, HTCeramix, Bonfiglioli Vectron GmbH, Instytut Energetyki, Haute ecole specialisee de Suisse occidentale.

PROJECT WEBSITE/URL

www.onsite-project.eu

PROJECT CONTACT INFORMATION

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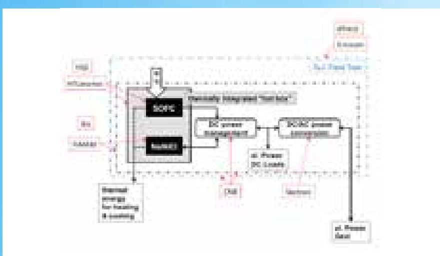

MAIN OBJECTIVES OF THE PROJECT

The overall objective of ONSITE is the construction and operation of a containerised system, based on SOFC/NaNiCl battery hybridisation, that generates more than 20kW at high efficiency and economically competitive costs. The demonstration of the system shall take place at a site of an existing telecoms station. Starting from previous SOFC research results, commercially available power electronics and NaNiCl batteries will improve next-generation SOFC systems and adapt them to the requirements for telecoms stations.

PROGRESS/RESULTS TO DATE

- Preliminary system design and subsystem specifications
- SOFC subsystem based on improved cells is being developed
- Thermal and electrical SOFC-batteries integration is also under development
- A preliminary market assessment completed
- Agreement with a telecoms operator is being finalised

FUTURE STEPS

- Definition of the electrical integration
- Development of the control electronics. The focus is to adapt the control to the higher switching frequency and to the selected converter topology
- Definition of the thermal integration
- Selection of site for final field test
- Test on SOFC subsystem

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Preliminary tests shown SOFC stack electrical efficiency (H_2/N2) >60%; electrical efficiency >55% target achievable.
- Hybridizations (SOFC + NaNiCl batteries) allows final system costs reduction (in terms of €/kW).
- The final system should enable telecoms energy station integration into future smart grids/smart buildings scenarios.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

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

PECDEMO

Photoelectrochemical Demonstrator Device for Solar Hydrogen Generation

CALL TOPIC	Validation of photoelectrochemical hydrogen production
START-DATE	1 April 2014
END-DATE	31 March 2017
TOTAL BUDGET	€3,394,010
FCH JU CONTRIBUTION	€1,830,644
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Helmholtz-Zentrum für Materialien und Energie (HZB)

Partners: Ecole Polytechnique Federale de Lausanne, Technion – Israel Institute of Technology, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Universidade do Porto, Evonik Industries AG, Solaronix SA.

PROJECT WEBSITE/URL

www.PECDEMO.eu
(expected to be active by September 2014)

PROJECT CONTACT INFORMATION

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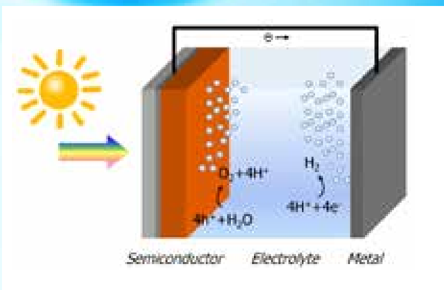
luise.richter@helmholtz-berlin.de

MAIN OBJECTIVES OF THE PROJECT

To address the challenges of solar energy capture and storage in the form of a chemical fuel, we will develop a hybrid photoelectrochemical-photovoltaic tandem device for light-driven water-splitting with an active area of ≤50 cm^2 and a solar-to-hydrogen efficiency of 8-10% that is stable for more than 1000h. In parallel, our partners from industry and research institutions will work together on an extensive techno-economic and life-cycle analysis based on actual performance characteristics. This will give a reliable evaluation of the application potential of photoelectrochemical hydrogen production, and further strengthen Europe's leading position in this growing field.

PROGRESS/RESULTS TO DATE

- Kick-off meeting took place on 5 May 2014 in Berlin
- First successful deposition of photoactive $BiVO_4$ films with reactive magnetron sputtering
- First PhD students and postdocs have started their activities



FUTURE STEPS

- Finalise hiring of project personnel
- Completion of first models to describe performance limitations
- Further optimisation of magnetron sputtering process

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Successful start of the PECDEMO project
- First experiments and modelling efforts are underway

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP		Development and testing of new hydrogen production pathways (the MAIP does not specify quantitative targets for these pathways)	Development of a hybrid photoelectrochemical-photovoltaic tandem device for light-driven water-splitting with an active area of at least 50 cm^2 and a solar-to-hydrogen efficiency of 8% that is stable for more than 1,000h	Concept has been demonstrated by applicants, the best efficiency achieved so far is 5.2% for a <1 cm^2 device
AIP		Estimate feasibility to meet EU target cost of €5/kg H_2	Cost estimate for photoelectrochemically produced hydrogen through economic analysis (Task 5.4)	Task will start in M10
AIP		Demonstrate prototypes that allow easy integration in small and medium-scale applications ranging from 100W to 100kW	Demonstration of a prototype module of four devices, each larger than 50 cm^2 having an efficiency of 8%	Construction of prototype module is scheduled to start in M28
AIP		Design innovative device architectures that combine efficient sunlight harvesting	Development of effective light management strategies for tandem devices based on wavelength-selective mirrors and filters	First experiments with dichroic mirrors are in progress
AIP		Develop diagnostic methods to identify the energy loss and material degradation mechanisms limiting performance	Modelling of optical and electrical coupling of PEC-PV tandem devices and development of diagnostic methods to identify and quantify losses	First model to define an effective energy conversion efficiency for a single photoelectrode is under development
AIP		To develop technologies that enable controlled, reproducible and potentially large-scale production of large-area (>50 cm^2) stable solar hydrogen production devices	To evaluate and develop the deposition technology that is needed for fabricating large-area hybrid PEC-PV devices.	First photoactive BiVO4 photoanodes have been successfully deposited with reactive magnetron sputtering, a technique that can be easily scaled-up to m^2 sizes.
AIP		Laboratory and field tests of 1,000h duration.	Performance and stability test 1,000h.	Tests will start in M28.

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

PEMBeyond

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

CALL TOPIC	Development of 1-30kW fuel-cell systems and hydrogen supply for early market applications
START-DATE	1 May 2014
END-DATE	30 April 2017
TOTAL BUDGET	€4,586,324
FCH JU CONTRIBUTION	€2,315,539
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: VTT Technical Research Centre of Finland

Partners: PowerCell Sweden AB, Genport srl, Fraunhofer ICT-IMM, University of Porto.

PROJECT WEBSITE/URL

http://pembeyond.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

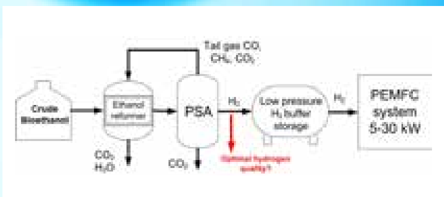
In the PEMBeyond project a cost-competitive, energy-efficient and durable integrated PEMFC-based power system operating on low-grade (crude) bioethanol will be developed for back-up and off-grid power generation. The system will be:

- Using crude (80-90%) bioethanol as primary fuel;
- Cost-competitive (complete system <€2,500/kW @ 500 units);
- Energy-efficient (>30% overall system efficiency, >45% PEMFC system efficiency);
- Durable (>20,000 hours system lifetime).

Extensive techno-economic and environmental analyses will be carried out throughout the project to ensure attractiveness of the concept. A roadmap to volume production will be a main project deliverable.

PROGRESS/RESULTS TO DATE

- Defining of system specifications work started
- Market analysis for telecoms back-up systems started
- Component/subsystem development work (PEMFC stack & system, bioethanol reformer) has started
- Analysis of crude bioethanol samples completed (gives input to bioethanol reformer development)
- Updating test benches for component/subsystems testing (PEMFC stack & system, bioethanol reformer, PSA) has begun



FUTURE STEPS

- System specifications and used H_2 quality-level frozen
- Completion of component/subsystem (PEMFC stack & system, bioethanol reformer) development
- Functional testing of components/subsystems separately
- Complete system integration, testing and field-trial
- Completing techno-economic & environmental analyses

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Very high interest from potential end-user companies (telecoms) in the project and system to be developed.
- Both local and EU-level regulation will affect significantly the telecoms back-up market and system requirements.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Number of new UPS/back-up power units in the EU market	1,000 units	One new back-up power unit installed during the project	Setting the system specifications and system design work started
MAIP	Cost of industrial/commercial units	€1,500–€2,500/kW	<€3,300/kW (@ >500 units & 5kW) <€2,500/kW (@ >500 units & 25kW)	€9,000/kW, estimated with current existing subsystem and component designs
AIP	Fuel cell and hydrogen system cost (including H_2 generator)	€2,500/kW (@ >500 units)	<€3,300kW (@ >500 units & 5kW) <€2,500 €/kW (@ >500 units & 25kW)	€9,000/kW, estimated with current existing subsystem and component designs
AIP	Fuel cell system (FCS) efficiency	45%	>45%	N/A, no data or calculations available for this system design
AIP	System lifetime	20,000 hours (fuel-cell stack 20,000 hours)	>20,000 hours	N/A, stacks still in development phase
AIP	System efficiency when working with an integrated hydrogen generator	>30%	>30%	N/A, no data or calculations available for this system design

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

PEMICAN

PEM with Innovative low-cost Core for Automotive application

CALL TOPIC	Development and optimisation of PEMFC electrodes and GDLs
START-DATE	1 April 2011
END-DATE	31 March 2014
TOTAL BUDGET	€3,960,000
FCH JU CONTRIBUTION	€1,860,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

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

Partners: Opel, Solvay (Italy), Tecnalia, Imerys, Imperial College London.

PROJECT WEBSITE/URL

http://www.pemican.eu/

PROJECT CONTACT INFORMATION

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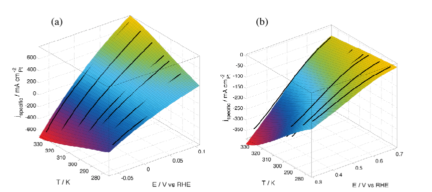
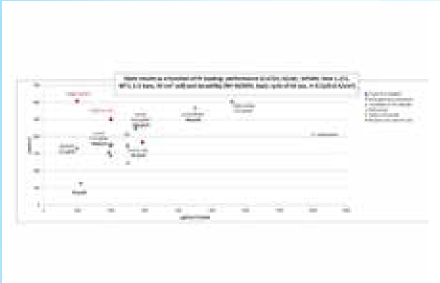


Potential-temperature-current data for HOR (a) and ORR (b) measured on ultra low loaded electrode (<0.5 μg/cm²)

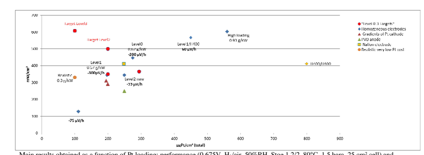


MAIN OBJECTIVES OF THE PROJECT

PEMICAN aims at reducing the Pt cost of PEMFC for automotive application by a twofold approach: i) increase Pt efficiency by improving transport properties of active layers (specific Aquivion ionomer and carbon black); ii) reduce Pt loading (thin layers and gradients). This technological approach is supported by a scientific one: i) numerical modelling to analyse performance and propose design recommendations; ii) fundamental characterisations (structure, electrochemistry, gas diffusion) to improve existing models and analyse MEA performance limitations. Performance and durability tests under automotive conditions have been performed and analysed.

PROGRESS/RESULTS TO DATE

- New raw materials (Aquivion ionomer and carbon) have been developed and characterised.
- Electrodes have been manufactured (total Pt loading ~100-400 µg/cm²) and sensitivity of different grades of raw materials has been tested on performance and durability.
- The feasibility to produce electrodes by alternative techniques (gradients of Pt, direct electro deposition, physical vapour deposition) has been demonstrated and their performance tested.
- Innovative characterisation tools of active layers have been set-up and used (fundamental electrochemistry, gas diffusion, proton resistance).
- Innovative pore network model (PNM) has been developed for electrodes taking into account more realistic structure and transfers while performance models have become more predictive by introducing more reliable inputs from characterisation and PNM models.



Main results obtained as a function of Pt loading: performance (0.675V, H_2/air, 50%RH, Stoe 1.2/2, 80°C, 1.5 bara, 25 cm² cell) and durability (RH 40/60%, basic cycle of 60 sec, i= 0.12/0.6 A/cm²)

FUTURE STEPS

- Select three most promising raw materials and optimise manufacturing processes to produce more performing and durable electrodes with total Pt loading around 300-400 µg/cm².
- Perform deep characterisation of these electrodes and try to link their performance to material properties with modelling.
- Perform complementary experiments to validate further the models to be used as "design tools".

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Aquivion ionomer can lead to higher performance than Nafion at low gas hydration and specific grades can improve durability.
- Carbons of the project can be used to produce efficient micro-porous layer and to tune Pt size by electrodeposition
- Performance and durability decrease as Pt loading decreases; durability has improved but power density seems to be the key issue.
- Modifications of classical models for electrochemistry and gas-diffusion have been proposed to better fit experimental results obtained in the project.
- Improved modelling combined with fundamental characterisation shows that limitation of performance is mainly due to proton resistance of the membrane (Pt loadings around 100 µg/cm²) and also gas-diffusion in the AL (higher loadings).

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
AIP	Reduce Pt cost of PEMFC from 1 to ideally 0.15	0.15	MEA Level 0 (Aquivion): ~ 0.82 gPt/kW	MEA Level 0: reached ~ 0.6 gPt/kW
			MEA Level 1: ~ 0.57 gPt/kW	MEA Level 1: reached ~ 0.48 gPt/kW
			MEA Level 2: ~ 0.40 gPt/kW	MEA Level 2 (modified to focus on durability): reached ~ 0.61 gPt/kW
			MEA Level 3: ~ 0.15 gPt/kW	MEA Level 3: not reached but 0.3 gPt/kW seems feasible

PHAEDRUS

High Pressure Hydrogen All Electrochemical Decentralised RefUeling Station

CALL TOPIC	Research & development of 700 bar refuelling concepts & technologies
START-DATE	1 November 2012
END-DATE	31 October 2015
TOTAL BUDGET	€6,309,832
FCH JU CONTRIBUTION	€3,566,343
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Hydrogen Efficiency Technologies (Netherlands).

Partners: ITM power Limited, H2 Logic, Raufoss Fuel Systems, Daimler, Shell Global Solutions), Bundesanstalt für Materialforschung und Prüfung, Association pour la recherche et le développement des méthodes et processus industriels – ARMINES, Hochschule Esslingen, Uniresearch.

PROJECT WEBSITE/URL

www.phaedrus-project.eu/

PROJECT CONTACT INFORMATION

Project management:
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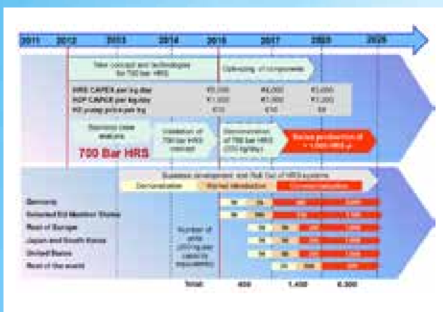
Technical coordinator:
Peter Bouwman <peter.bouwman@hyet.nl>



MAIN OBJECTIVES OF THE PROJECT

The objective of the project is to develop and validate a new concept for 70 MPa hydrogen refuelling retail stations enabling self-sustained infrastructure roll-out for early vehicle deployment volumes. It will also show the applicability of the novel electrochemical hydrogen compression technology in combination with a PEM electrolyser, storage units and dispensing system. A step-change is expected in both efficiency and cost of ownership of an integrated hydrogen refuelling system. The applicability will be demonstrated in a fuelling system producing 5 kg hydrogen per day, while a design is made for a fuelling system capable of producing 200 kg hydrogen per day.

PROGRESS/RESULTS TO DATE

- Construction of electrolysis unit delivering 8MPa
- Construction electrochemical compression unit achieving 100MPa
- Storage tank configuration selected at medium (50MPa) and high pressure (100MPa)
- A dispensing system equipped with a pre-cooling unit, with a capacity of 5 kg/3 min

FUTURE STEPS

- Design 200 kg/day HRS based on new technology
- Integrate new technology into 5kg/day system
- Validate technology and cost-efficiency improvement

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- New catalyst materials appear promising
- Model shows advantages of new system design
- Measurement data being accumulated

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	HRS CAPEX (design 200kg/day)	2015 target: <€1m	Optimal system configuration with new technology	Model ready, accumulating data/ awaiting system integration
MAIP	H2P CAPEX	2015: €3,500 per Nm3/hr	Cost reduction and scalable design	Modular compression unit system, low membrane costs and catalyst loadings
AIP	Optimisation of compression & storage systems with respect to cost, efficiency and capacity.	CAPEX and OPEX costs enabling self-sustained roll-out	Balance between component specifications in final system configuration	Components are being tested separately & data generated.
AIP	Compliance	SAE J2601, SAE J2 799 and ISO 20100	Standardised compliance verification involving BAM evaluation	New SAE J2601refuelling control system under development
AIP	Hydrogen price	2015 target €10-€15/kg	Meeting target of €10/kg	OPEX production/compression: €5.6/kg. Including depreciation and interest a price close to €10/kg

POWER-UP

Demonstration of 500kWe alkaline fuel-cell system with heat capture

CALL TOPIC	Field demonstration of large-scale stationary power and CHP fuel-cell systems
START-DATE	1 April 2013
END-DATE	30 June 2017
TOTAL BUDGET	€11,552,448
FCH JU CONTRIBUTION	€6,137,565
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: AFC Energy plc

Partners: Air Products plc, Innomech Limited, Zentrum für Brennstoffzellentechnik GmbH, Paul Scherrer Institut, European Hydrogen Association.

PROJECT WEBSITE/URL

http://project-power-up.eu/

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

POWER-UP will demonstrate a 500kWe alkaline fuel-cell (AFC) system at an industrial gas plant in Germany. It will be the world's first large-scale AFC demonstration system. POWER-UP will:

- Deliver an AFC system that converts hydrogen into electricity and heat at competitive prices;
- Achieve scaled-up manufacture of ISO-standard compliant components;
- Demonstrate automated fuel-cell stack component assembly processes;
- Reduce installation and commissioning times (and costs) by developing a modular, containerised balance of plant;
- Recycle/recondition substrate plates, catalyst materials and stack components;
- Quantify environmental burdens and socio-economic factors;
- Meet end-user reliability requirements.

PROGRESS/RESULTS TO DATE

- Scaled-up system design finished; PNID and HAZOP independently completed, and assembly of first system commenced
- Automated stack-assembly system constructed
- Fuel-cell production underway
- Site preparations in Stade (Germany) underway

FUTURE STEPS

- Fuel-cell systems will be installed and commissioned in 2015
- Continuous operation of fuel-cell systems to start in 2015
- Automated stack disassembly system will be built in 2015
- Streamlined recycling and reconditioning of components to be completed by 2016

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Design of scaled-up system independently validated
- First high-volume fuel-cell manufacturing processes proven
- Feasibility of European supply-chain established for majority of FC components
- Commercial interest in AFC systems from chlor-alkali companies

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Volume of FC systems in the European market	- 2.5MW (mid-term 2015) - 20MW (long-term 2020)	0.5MW by 2017	Not applicable; first system under construction.
MAIP	System efficiency	58% (mid-term 2015); 58% (long-term 2020)	58-59% (2017)	52-53% (2013)
MAIP	AFC system durability/ reliability	16,000h (mid-term 2015)	15,000h (2017)	Not applicable; first system under construction
AIP	Capacity	Install complete integrated systems/applications with significant power generation capacity (>100kWe) per system	Two systems will be operated and maintained, eventually generating 500kWe	First system under construction

PREMIUM ACT

PREdictive Modelling for Innovative Unit Management and ACcelerated Testing procedures of PEFC

CALL TOPIC	Fundamentals of fuel-cell degradation for stationary power application
START-DATE	1 March 2011
END-DATE	28 February 2014
TOTAL BUDGET	€5,370,190
FCH JU CONTRIBUTION	€2,513,251
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA

Partners: IRD Fuel Cells, POLIMI, German Space Center (DLR), ICI Caldaie, JRC, Soprano.

PROJECT WEBSITE/URL

http://www.mrtfuelcell.polimi.it/premiumact.html

PROJECT CONTACT INFORMATION

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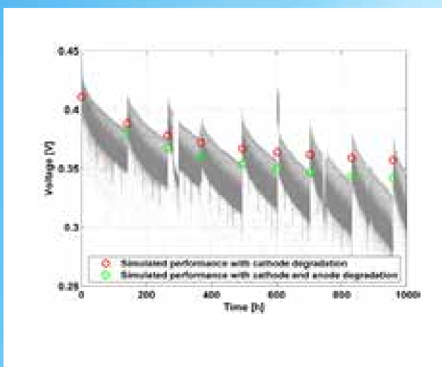

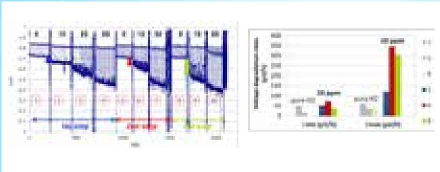

MAIN OBJECTIVES OF THE PROJECT

- Contributing to better stationary fuel-cell systems durability (target required 40,000h)
- Investigating specific degradation of PEFC operating with methanol (DMFC) and reformate
- Conducting fuel-cell tests (at system, stack and cell levels) in nominal and critical conditions
- Analysing microstructure and properties before and after ageing
- Modelling of the degradation mechanisms
- Identifying parameters enhancing or reducing degradation
- Development of specific accelerated stress tests
- Proposed operating strategies and lifetime prediction methodology

PROGRESS/RESULTS TO DATE

- In-situ tests and ex-situ analyses allowed the determination of major degradation mechanisms leading to non-reversible performance losses for both technologies (Pt and PtRu catalysts degradation related to local conditions).
- Sensitivity studies and performance modelling allowed the definition of main accelerating or mitigating parameters related to operating conditions, fuel composition and load profiles.
- Operating strategies or parameters enabling the stabilisation of performance during ageing tests have been proposed and validated at cell or stack level.
- Accelerated stress tests able to enhance main specific mechanisms and to increase the voltage losses by a factor of around five have been designed and validated.

FUTURE STEPS

Combination with other projects results to conduct further understanding investigations, including the application of the validated protocols, in order to propose improvements of PEFC stationary systems' durability.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- For DMFC: new AST, based on OCV and air break periods: it facilitates an accelerated cathode ECSA loss by a factor of five; and a performance decay acceleration factor, generally about 6-7.
- For reformate PEMFC: combined AccST including higher CO content and more dynamic and higher load cycles increasing involved mechanisms, such as ruthenium dissolution as the specific one for reformate case, leads to a voltage decay acceleration factor of around five.
- It has been shown that the accelerating degradation effect of a protocol depends on the MEAs' initial properties and performance.
- For DMFC, refresh cycles including OCV and air break of various durations have been validated as operating strategies, which avoid voltage temporary losses due to anode or cathode.
- For PEMFC, stops of the load, air bleeding and increase of temperature (limited to 80°C) have been validated as parameters which decrease the voltage degradation rates during load cycles.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Stationary FC system lifetime	Degradation and lifetime fundamentals related to materials and typical operation environments for all power ranges.	Better understanding of cell and stack degradation for reformate PEMFC and DMFC Specific degradation of PEFC operating in nominal and critical conditions; studies of the microstructure and properties before and after ageing; modelling of the degradation mechanisms	Specific degradation mechanisms causing reversible and non-reversible performance degradation have been identified and analysed. AccST protocols have been developed, tested and analysed in single cells and stacks in systems for DMFC and PEMFC operating under reformate. A lifetime prediction methodology has been proposed: systematic experimental characterisation of the MEA in different operating conditions; testing of the MEA in reference condition for a short period, performing complete diagnostics at meaningful time periods; AST is performed for a short period equivalent to a long-term testing; detailed models of degradation mechanisms are calibrated on both AST and reference condition testing results. Simple correlations are tuned to the simulations and integrated in MEA models; MEA models are used to predict the decay of performance and MEA lifetime.
AIP	FC stacks degradation understanding Lifetime prediction methodology	Basic research to better understand degradation/failure mechanisms for different fuels and levels of power. Critical parameters and operating conditions Methodologies as well as tools for modelling, operational controls and diagnostics.	Identification of main parameters enhancing or reducing degradation Development of accelerated tests Proposal of operating strategies and of lifetime prediction methodology	Operating strategies addressing temporary (or reversible) degradation (methods enabling stabilisation of performance, or reduction of cell voltage losses during ageing tests) have been proposed and validated for DMFC and PEMFC operating under reformate.

PROSOFC

Production and Reliability oriented SOFC Cell and Stack Design

CALL TOPIC	Improved cell and stack design and manufacturability for application-specific requirements
START-DATE	1 May 2013
END-DATE	30 April 2016
TOTAL BUDGET	€7,359,054
FCH JU CONTRIBUTION	€3,011,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: AVL List GmbH

Partners: Topsoe Fuel Cell A/S, Dynardo GmbH, Technical University of Denmark, Forschungszentrum Jülich, Karlsruhe Institute of Technology, Imperial College London, JRC-IET.

PROJECT WEBSITE/URL

www.prosofc-project.eu

PROJECT CONTACT INFORMATION

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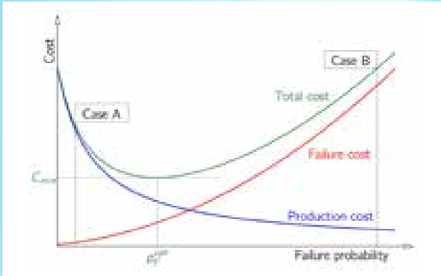

MAIN OBJECTIVES OF THE PROJECT

The PROSOFC project aims at improving the robustness, manufacturability, efficiency and cost of 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 optimisation.

PROGRESS/RESULTS TO DATE

- Probabilistic design approach and random field models for materials and loads established
- 2D model on cell cracks set up for COPRD optimisation and model homogenisation methodology established
- Cell yield improvements in TOFC's production
- Electrochemical characterisation of SoA cells performed and mechanical characterisation ongoing
- Design of close-to-reality cell test equipment carried out

FUTURE STEPS

- Further development of stack simulation model towards 3D temperature and stress distribution
- COPRD optimisation gives input to further cell improvements in TOFC's production
- Testing of mechanical material behaviour in relation to production and microstructure
- Long-term stack testing for reliability validation
- Calibrate close-to-reality cell-test equipment for simulation validation

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- SOFC exhibits complex multi-physics compared to other areas where COPRD has been applied
- Failure-mode description is big challenge needing further studies
- Cell improvements have big impact on production costs
- Electrochemical tests show very good cell performance and durability

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
AIP	Improved electrical efficiency	N/A	ASR (area-specific resistance) =600mOhm*cm^2	650 mOhm cm^2
AIP	Greater robustness, better lifetime, improved manufacturing methods	N/A	Identify major failure modes and link them to stack design and production using a statistical simulation approach	• Major failure modes identified • Statistical simulation model linked with stack model • Ongoing stack tests
AIP	Cost reduction	N/A	Index 75 (M36)	Index 33
AIP	Improved manufacturing methods	Stack scrap rate: 5% by 2017		Stack scrap rate 15%
AIP	Higher power density			No improvements yet, awaiting improved robustness through COPRD optimisation
MAIP	Electrical efficiency (SOFC system)	55%+ (SOFC)	Indirectly targeted	Decrease of ASR will lead to higher electrical efficiency. However, main target is robustness of stacks
MAIP	Lifetime/durability (SOFC System)	20,000h	Indirectly targeted	Within the project stack long-term tests are performed to validate durability. An improved stack lifetime will contribute to the whole durability of the SOFC system.
MAIP	Cost (SOFC system)	<€4,000/kW	Indirectly targeted	All AIP targets will contribute to significantly lower stack costs and thus lead to lower system costs. However, only stack costs can be considered in this project.

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

PUMA MIND

Physical Bottom-up Multiscale Modelling for Automotive PEMFC Innovative Performance and Durability Optimisation

CALL TOPIC	Innovative materials and components for PEM electrolysers
START-DATE	17 December 2012
END-DATE	17 December 2015
TOTAL BUDGET	€4,100,000
FCH JU CONTRIBUTION	€2,300,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA (France)

Partners: German Aerospace Center (DLR), Universita degli Studi di Salerno, AECSIC (Spain), Hochschule Offenburg, Ecole Normale Superieure de Lyon, JRC, Simon Fraser University, Vodera Ltd, Idiada Automotive Technology SA.

PROJECT WEBSITE/URL

www.pumamind.eu

PROJECT CONTACT INFORMATION

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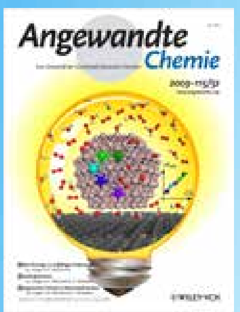


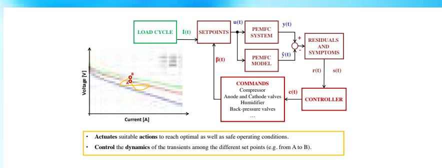
MAIN OBJECTIVES OF THE PROJECT

Puma Mind aims at establishing a predictive multi-scale modelling tool for PEMFC performance and durability as function of its components and operating conditions (automotive applications) as follows:

- a detailed model of the electrochemical phenomena;
- a detailed model of the transport processes;
- a 1D cell-level multi-scale model describing the competitive mechanisms and calculating their relative influence on the macroscopic performance and durability under current cycled conditions;
- a 2D cell-level multi-physics CFD model to predict instantaneous efficiency;
- an innovative diagnostic and control-oriented physical model for online PEMFC diagnosis and real-time optimisation of operating conditions.

PROGRESS/RESULTS TO DATE

- Adsorption energies (WP2): linear relationship to estimate adsorption energies as a function of a simple geometric descriptor, the generalised coordination number. Easy to calculate and to integrate in the micro-scale models (WP3, WP4).
- Multi-scale coupling between the electrochemical double layer model including a kinetic Monte Carlo description of the adsorbed species and the meso-scale/micro-scale transport model (MS-LIBERT code, WP3).
- Integration of the electrochemical and transport data in a 1D multi-scale model (EDMOND, WP4).
- Macro-scale model linked to system models ready for the integration of degradation models to address performance and durability at system level (WP5).
- Development of on-board monitoring tools to quantify the major losses of the fuel cell, and to enable building comprehensive strategies to reach optimal and safe conditions (WP6).



FUTURE STEPS

Next year will be dedicated to:

- Further atomistic calculations and their integration at the meso-scale;
- Comparison between the kinetic Monte Carlo and the mean field approach for the integration of the electrochemical data;
- Sensitivity study at the 1D multiscale model level to demonstrate the relative impact of the mechanisms involved, and enable further reduction of the electrochemical and transport modules for their integration in the macro-models;
- Integration of degradation (Pt dissolution and chemical degradation of the membrane) in the models;
- Improvements in the development of on-board diagnostic tools and control strategies to ensure both performance and durability.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Modules are under development at each scale and their integration is on-going thanks to strong interaction between the partners.
- Performance models are set up and degradation will be implemented next year.
- System-level models are ready for incorporation of the reduced models from the lower scale.
- Comprehensive strategies for performance and durability optimisation are under development.
- The first workshop on multi-scale modeling for PEMFC was held at CEA Grenoble, France, on 12-13 June 2014.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Development of modelling tools for PEMFC performance and durability	DFT calculation of adsorption energies on a Pt_{201} nanoparticule (nanoscale)	Linear relationships for the estimation of the adsorption energies. Suitable for taking into account the degradation of the catalyst
		Kinetic Monte Carlo for the description of the adsorbed species in the electrochemical double layer (meso-scale). Calculation of the surface potential according to a calculated electric permittivity and a given distribution of the size of the nanoparticles. On-going development.	Coupling of kinetic Monte Carlo and transport model. Ready for comparison between kinetic Monte Carlo and the mean field approaches for the modelling of the electrochemical double layer
		Integration of the modules at the meso-scale Study of the interplay (sensitivity study) Methodology for the reduction of the micro-model	Integration of the electrochemical module and the transport module in the micro-scale model
		Bridge between the micro-model and the system-level models	Performance model at the system level is ready for the incorporation of the reduced models from the lower scales, and ready for the incorporation of the degradation mechanisms
		Design of on-board experiments to quantify the major losses in the FC depending on the operating conditions. Design of comprehensive control command strategies to promote performance and durability	Methodology for the model reduction at the system level is well established On-board quantification of the major losses is developed Control command strategies are under development for improving performance and durability
		Ex-situ post-mortem GDL computed tomography for structure reconstruction and effective properties calculation	CT scans performed on the fresh and aged GDL. Results are under analysis
		In-situ investigations: SAXS (ESRF, Grenoble) for PEM water content	Neutron experiments were carried out to validate the water management models

PURE

Development of Auxiliary Power Unit for recreational yachts

CALL TOPIC	Research, development and demonstration of new portable fuel-cell systems
START-DATE	1 January 2013
END-DATE	31 December 2015
TOTAL BUDGET	€2,884,875
FCH JU CONTRIBUTION	€1,641,194
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Hygear Fuel Cell Systems

Partners: Danmarks Tekniske Universitet, Centre for Research and Technology Hellas, Joint Research Centre, Damen Shipyards Gorinchem.

PROJECT WEBSITE/URL

www.PURE-project.eu

PROJECT CONTACT INFORMATION

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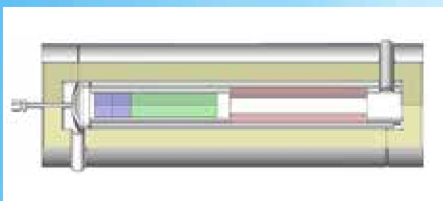


MAIN OBJECTIVES OF THE PROJECT

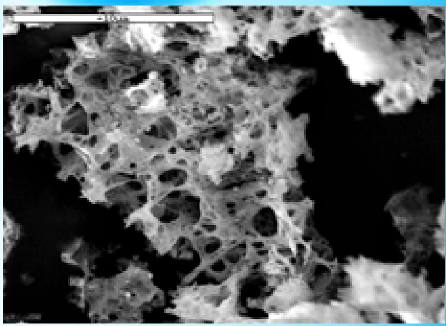
The main objectives of the PURE project are the development, construction and testing of a fuel-cell system based on high-temperature MEA technology running on LPG as primary fuel. The system has a target to produce 500We, fit in a box of 25 litres and weigh 17.5 kg. The precious metal-reduced MEAs will be built into a stack which will be combined with a small autothermal steam reforming-based fuel processor. High-capacity desulphurisation materials are developed for sulphur management.

PROGRESS/RESULTS TO DATE

- Precious metal-reduced MEAs developed
- Process design finalised
- Small ATR/HX reactor constructed
- Sulphur-tolerant ATR catalyst developed
- Stack type identified

FUTURE STEPS

- Develop controls for systems
- Build prototypes
- Test prototypes



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- H_2/CO ratio is more important to HTPEM than CO concentration only.
- ATR with steam condensation downstream is optimal fuel processor technology for these small systems.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Assessment of fuelling supply options	Propane	Propane/LPG	Propane/LPG fuelled
AIP	Dimensions of FC APU (500We)	25L	25L	30L (model)
AIP	Weight of FC APU (500We)	17.5 kg	17.5 kg	20 kg (detailed design)
AIP	System efficiency (%)	<30%	30%	28% (model)

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

RAMSES

Robust Advanced Materials for metal SupportEd SOFC

CALL TOPIC	Materials development for cells, stacks and BoP
START-DATE	1 January 2011
END-DATE	31 May 2014 (3 years + five-month extension)
TOTAL BUDGET	€4,696,343
FCH JU CONTRIBUTION	€2,140,334
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA (France)

Partners: SOFCpower Spa, CNRS-BX, Höganäs AB, Baikowski, AEA Srl, SINTEF, Ikerlan S. Coop, Copreci S. Coop, NRC.

PROJECT WEBSITE/URL

www.ramses-project.org

PROJECT CONTACT INFORMATION

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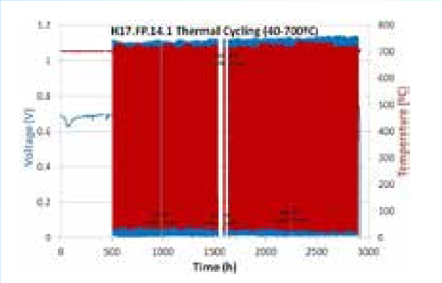

MAIN OBJECTIVES OF THE PROJECT

The main technical objective is to develop a SOFC cell with an improved lifetime due to the low operating temperature (700°C), while achieving high performances by applying advanced low-temperature electrodes and electrolyte materials. To achieve this purpose, the cell architecture considered is a metal-supported cell (MSC). The scientific objective is understanding the performance and degradation of MSCs in order to allow a further optimisation of such cells. In particular the robustness of the cell towards cycling is investigated, as well as the resistance of the cathode to chromium poisoning.

PROGRESS/RESULTS TO DATE

- Development of advanced materials (metal support, electrolyte, cathode) tailored for processes used in MSC manufacturing.
- Improved performances of tubular MSC including RAMSES materials compared to reference MSC cell; first planar cells using the challenging co-sintering option produced and tested.
- Durability proven over 3,000h, including 500 thermal cycles on tubular cells; quick and versatile inspection technique for in-line electrolyte gas-tightness measurement developed and patented.
- Cell cost reduction achieved: -14% for planar cell, -37% for tubular cell, thanks to better performances.

FUTURE STEPS

- Follow-up activities since project terminated.
- Improved durability in general, and oxidation resistance of porous substrate in particular: coating required through post-sintering process, to be further developed/validated for long-term operation.
- Optimisation of cell conventional manufacturing process needed to overcome difficulties with classical processes (sintering at low T-low pO_2, corrosion of the support, mechanical deformation during process, reduce Ni coarsening and associated drop in cell performance): additive materials, sintering aid, barrier layer or interlayer to promote adhesion, composite/graded layers.
- Elaboration of dense and gas-tight electrolytes remains a concern.
- Push alternative techniques: infiltration/low T processes (thermal spraying, PVD), Investigate alternative materials (LST), alternative concepts: proton conducting electrolytes.
- Check scalability: technical and economic feasibility.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Development of advanced materials (metal support, electrolyte, cathode) tailored for processes used in MSC manufacturing.
- Performance and durability including thermal cycling proven for tubular cells, more work remaining for planar cell and the challenging manufacturing option targeted (co-sintering).
- Quick and versatile inspection technique for in-line electrolyte defects detection developed and patented.
- Cell cost-reduction achieved: -14% for planar cell, -37% for tubular cell, thanks to better performances.
- Further optimisation still required (anode, coating of the metal support).

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	SOFC competitivity	Achievement of principal technical and economic specifications for stationary FC competitiveness/other technologies	Increase SOFC durability: low-temperature operation and more robust MSC architecture Cost reduction: low-temperature MSC concept with less expensive ceramic materials	Durability showed over 3,000h including 500 thermal cycles on tubular cells RAMSES tubular cell 37% cheaper than reference tubular cell thanks to improved performance; planar cell 14% cheaper than reference anode supported cell
MAIP	Fuel versatility	Use of multiple fuels	Targets to be reached in the project have been fixed both for H_2 and Internal Steam Reforming (ISR)	Tests in pure hydrogen
MAIP	Durability	Lifetime increase to 40,000h	Low-temperature operation and more robust MSC architecture Degradation target in agreement with such lifetime target	Degradation rate low enough to reach this objective
MAIP	Innovation in design	Novel architecture for cell and stacks improved performance, endurance, robustness, durability and cost	Innovative MSC architecture developed in the RAMSES project to achieve these goals	Improved performance, endurance, robustness, durability and cost for tubular cell achieved

ReforCELL

Advanced multi-fuel Reformer for CHP-fuel CELL systems

CALL TOPIC	Component improvement for stationary power applications
START-DATE	1 February 2012
END-DATE	31 January 2015
TOTAL BUDGET	€5,590,762
FCH JU CONTRIBUTION	€2,857,211
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Fundación Tecnalia Research & Innovation

Partners: Eindhoven University of Technology, Commissariat à l'energie atomique et aux energies alternatives, Politecnico di Milano, SINTEF, ICI caldaie SPA, HyGear BV, Soprano Industry, Hybrid Catalysis BV, Quantis Sàrl, JRC.

PROJECT WEBSITE/URL

www.reforcell.eu

PROJECT CONTACT INFORMATION

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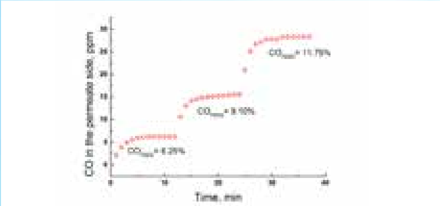
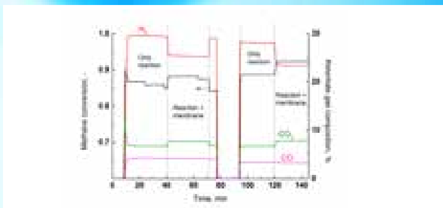


MAIN OBJECTIVES OF THE PROJECT

ReforCELL aims at developing a high efficiency PEM fuel-cell micro-CHP 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 optimised design of the subcomponent for the BoP. The target will be pursued with the integration of reforming and purification in one single unit using catalytic membrane reactors (CMR).

PROGRESS/RESULTS TO DATE

- A lab-scale fluidised bed membrane reactor was demonstrated operating for two weeks when using the new catalyst developed in ReforCELL and commercial membranes.
- The new ceramic-supported membranes developed in ReforCELL were demonstrated operating under fluidisation conditions up to 600°C without loss of permeation/stability under non-reactive conditions.
- Reactor prototype has been designed. PEM FC has been characterised and stack for the m-CHP selected.
- A preliminary LCA analysis for environmental impact assessment has been delivered.



FUTURE STEPS

- Integration of membrane in the reactor (sealing)
- Finalising the lab-scale testing of the CMR
- Pilot-scale CMR reformer development & testing
- Integration and testing of the new m-CHP system
- Complete life cycle and safety analyses

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

The incorporation of catalytic membrane reactors in the PEM fuel-cell micro-CHP systems could improve efficiency while reducing the cost due to the integration of the reforming and purification in one single unit (working at lower temperature) and the optimised design of the subcomponent for the BoP.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Overall efficiency CHP units	>80%	>90%	According to the simulation techno-economic optimisation of the lay-out for the ReforCELL system (D7.3) the target could be achieved. However, measuring it as real m-CHP is delayed.
MAIP	Micro-CHP (residential), natural gas based Cost per system (1kWe + household heat).	2015 target: Cost €10,000 per system (1kWe + household heat). 2020 target: €5,000 per system (1kWe + household heat).	€5,000 (1kWe + house heat)	Cost could be achieved for mass production. However this is not the actual situation for some components. An estimated cost will be calculated when final components and their costs are known at the end of the project
AIP	Electrical efficiency (%) >42%	>42%	>42%	According to the simulation techno-economic optimisation of the lay-out for the ReforCELL system the target could be achieved. However, measuring it as real m-CHP is delayed.
AIP	Recyclability	LCA and safety study	LCA and safety study	A preliminary LCA analysis for environmental impact assessment has been delivered

RESelyser

Hydrogen from RES: Pressurised alkaline electrolyser with high efficiency and wide operating range

CALL TOPIC	Efficient alkaline electrolysers
START-DATE	1 November 2011
END-DATE	31 October 2014
TOTAL BUDGET	€2,890,000
FCH JU CONTRIBUTION	€1,480,000
OTHER CONTRIBUTION(S)	Energinet.dk/ForskEl programme €80,000

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Deutsches Zentrum fuer Luft- und Raumfahrt (DLR)

Partners: Vlaamse Instelling voor Technologisch Onderzoek (VITO), Hydrogenics Europe NV, Danmarks Tekniske Universitet (DTU).

PROJECT WEBSITE/URL

www.reselyser.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

The project RESelyser develops high-pressure, highly efficient, low-cost alkaline electrolysers that can be integrated with renewable energy power sources using an advanced membrane concept, highly efficient electrodes and a new cell concept. Quantitative objectives: efficiency >80%, 1,000 on/off switching cycles; €3,000/(Nm^3/h) plant capacity.

PROGRESS/RESULTS TO DATE

- Novel diaphragms with internal electrolyte bypass and properties for maximum benefit of the cell developed and produced in technical size.
- Cell and 10kW stack concept to integrate this membrane realised and in test.
- Electrode coatings with low-cost material developed with 373 mV overpotential reduction versus uncoated electrodes.
- Gas impurity reduction at low current density to 25% of value for conventional cell.

FUTURE STEPS

- Long-term test of 10kW stack
- Design, construction and tests of high-pressure stack
- System concept

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Key steps towards a next-generation alkaline water electrolyser for higher pressure and highly fluctuating power supply were achieved: separators, electrodes, stack construction.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
AIP 2010	Power level stack	Exceeding 5kW	30kW	10kW stack first tests
AIP 2010	Efficiency @current density 0.75 A/cm^2	>80% on HHV basis	σ >80% on HHV basis 300 cm^2 electrodes, low-cost materials	σ =70%, on HHV basis at 0.75 A/cm^2
AIP 2010	Electrolyser system operation at high pressure	15MPa=150 bar with compression or 3 MPa=30 bar without compression	100-150 bar concept, 25 bar realisation	Tests now up to 5 bar
AIP 2010	Retention of ...% of initial efficiency over at least 1,000 on/off switching cycles	>90%	>90% demonstrated with 10kW electrolyser	Tests at a too early stage
AIP2010	Modular system cost	€1,000 per Nm^3/h plant capacity for the stack and €3,000 per Nm3/h plant for a complete system	System costs €3,000 per Nm^3/h plant capacity for the complete system	N/A (technique not yet finalised)

SAFARI

Sofc Apu For Auxiliary Road-truck Installations

CALL TOPIC	R&D on fuel supply concepts for micro fuel-cell systems Demonstration of portable fuel-cell systems for various applications
START-DATE	1 January 2014
END-DATE	31 December 2016
TOTAL BUDGET	€2,442,396
FCH JU CONTRIBUTION	€1,536,475
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Adelan Ltd

Partners: T. Baden Hardstaff Ltd, Almus AG, University of Birmingham, Fundacio Institut de Recerca de L'Energia de Catalunya, Zachodniopomorski Uniwersytet Technologiczny w Szczecinie.

PROJECT WEBSITE/URL

http://safari-project.eu

PROJECT CONTACT INFORMATION

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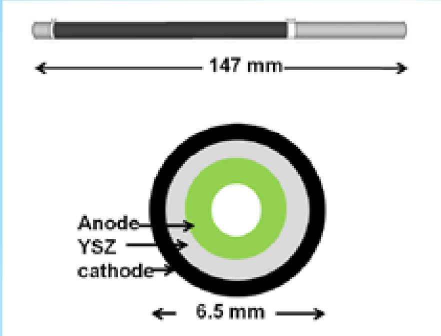

MAIN OBJECTIVES OF THE PROJECT

The objective is to design, optimise and build five 100W solid oxide fuel cells (SOFC) and to integrate into truck cab power systems, comprising both rapid heating planar SOFC from ALM and microtubular SOFC from ADE. Liquefied methane is chosen as fuel due to its wide and growing availability in trucks. The complete fuel-cell power unit will first be tested in the lab and, after further optimisation, in the truck platform built by HAR. The design of the system will be primarily driven by high efficiency, low cost and long-term durability. It will open opportunities for exploitation in other sustainable portable low-carbon applications.

PROGRESS/RESULTS TO DATE

- Technical requirements and performance defined

FUTURE STEPS

- Establish performance on LNG
- Install prototype in truck
- Complete field trials
- Demonstrate consumer/environmental performance and acceptability.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Good cell and substack performance has been achieved
- Initial CPOX experiments with methane were successful

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Development of miniaturised BoP for specific devices		As the fuel-cell generator including fuelling has to fit into a confined truck space, the BoP components have to be miniaturised	
MAIP	Assessment of fuelling supply options		On-board fueling with LNG	
MAIP	Supportive actions for SME		T. Baden Hardstaff Ltd Almus AG and Adelan are SME contributors to SAFARI	

SAPIENS

Solid Oxide Fuel Cell Auxiliary Power In Energy/Noise Solutions

CALL TOPIC	Research, development and demonstration of new portable fuel-cell systems
START-DATE	1.November 2012
END-DATE	31.October 2015
TOTAL BUDGET	€2,369,507
FCH JU CONTRIBUTION	€1,591,590
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Adelan Ltd

Partners: Auto-Sleepers Group Ltd, Center for Abrasives and Refractories Research and Development, Clausthaler Umwelttechnik Institut GMBH, Joint Research Centre, Fundacio Institut de Recerca de L'Energia de Catalunya, Zachodniopomorski Uniwersytet Technologiczny w Szczecinie.

PROJECT WEBSITE/URL

http://sapiens-project.eu

PROJECT CONTACT INFORMATION

Jill Newton

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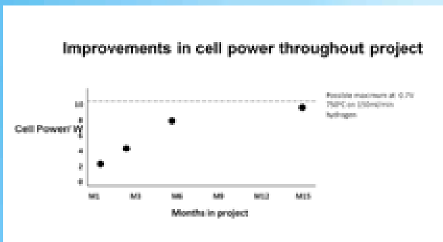

MAIN OBJECTIVES OF THE PROJECT

SAPIENS aims to design, optimise and build 100W micro-tubular solid oxide fuel-cell (mSOFC) stacks, and to integrate them into hybrid power systems. These will form auxiliary power units to provide power for appliances found in recreational vehicles (RVs).

- Test the liquid petroleum gas (LPG) fuel
- Improve the mSOFC in terms of materials, lifetime, performance, noise reduction, emissions and costs
- Disseminate by getting users to apply the new device and report results across Europe. Three special conferences will be organised to disseminate information, ten refereed publications will be submitted and patents will be published.

PROGRESS/RESULTS TO DATE

- Cells tested
- Stack built
- Balance of plant complete

FUTURE STEPS

- Establish performance on LPG
- Install prototype in RV
- Complete field trials
- Demonstration of consumer/environmental performance and acceptability.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Good cell and substack performance has been achieved
- Initial CPOX experiments with propane were successful

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Development of miniaturised BoP for specific devices		As the fuel-cell generator including fueling has to fit into a confined RV space, the BoP components have to be miniaturised eded	
MAIP	Assessment of fueling supply options		On-board fueling with LPG for mission extension	
MAIP	Supportive actions for SME		Auto-Sleepers is customer and contributor in SAPIENS SME, producer of RV products, Adelan Ltd is developer of the core modules	
MAIP	Pre-normative research on safety, emissions etc		As the fuel-cell generator including fueling has to fit into a confined RV space, the BoP components have to be miniaturised	
AIP	Stack power max. 100We net.			
AIP	On-board fuel storage			
AIP	Fuel processing			
AIP	Balance of plant			
AIP	Power electronics and controls			
AIP	Proof-of-concept unit			
AIP	System validation through testing			
AIP	Life-cycle assessment			

SAPPHIRE

System Automation of PEMFCs with Prognostics and Health management for Improved Reliability and Economy

CALL TOPIC	Robust, reliable and cost-effective diagnostic and control systems design for stationary power and CHP fuel-cell systems
START-DATE	1 May 2013
END-DATE	30 April 2016
TOTAL BUDGET	€3,226,420
FCH JU CONTRIBUTION	€1,745,140
OTHER CONTRIBUTION(S)	Norwegian Research Council €240,000

PARTNERSHIP/CONSORTIUM LIST

Coordinator: SINTEF Foundation (Norway)

Partners: European Institute for Energy Research, CLAB Research Federation, University of Split, Centre for Solar and Hydrogen Energy Research, Dantherm Power A/S.

PROJECT WEBSITE/URL

www.sapphire-project.eu

PROJECT CONTACT INFORMATION

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MAIN OBJECTIVES OF THE PROJECT

To develop an integrated prognostics and health management (PHM) system, including a health-adaptive controller to extend the lifetime and increase the reliability of low-temperature PEM fuel-cell stacks in µCHP systems. This is achieved by developing degradation and health assessment methods that can be applied online with existing or inexpensive additional sensors, prognostic algorithms to estimate the residual useful life (RUL) of the stack given its current state and predicted usage, and a control system to maximise the RUL by manipulating the operating conditions of the system.

PROGRESS/RESULTS TO DATE

- Specified test protocols
- Started experiments on purpose-built short stacks
- Built test µCHP-system
- Classified relevant degradation mechanisms
- Analysed controllability of µCHP system

FUTURE STEPS

- Specification and implementation of controller
- Prognostic algorithms
- Diagnostic algorithms
- Validation of PHM controller

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Multiple relevant degradation mechanisms
- Some degradation mechanisms are not measurable directly
- Controller must operate with as little information on the stack as possible (sensor cost)

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	FC system lifetime (h)	>40,000h	20,000h (without new technology)	N/A (test not finalised)
AIP	Cost target for control system	<5% of total	<€100/kW	N/A (architecture not finalised)

SCORED 2:0

Steel Coatings For Reducing Degradation

CALL TOPIC	Component and sub-system cost and reliability improvement for critical path items in stationary power and CHP fuel-cell systems
START-DATE	1 July 2013
END-DATE	30 June 2016
TOTAL BUDGET	€3,656,757
FCH JU CONTRIBUTION	€2,183,023
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: University of Birmingham

Partners: Teknologian Tutkimuskeskus (VTT), Ecole polytechnique federale de Lausanne, ENEA, Teer Coatings Ltd, TurboCoating, SOFCpower.

PROJECT WEBSITE/URL

n/a

PROJECT CONTACT INFORMATION

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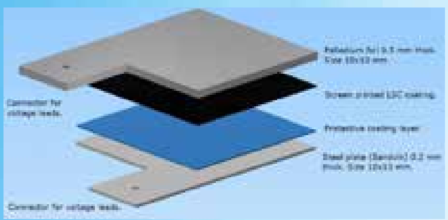


MAIN OBJECTIVES OF THE PROJECT

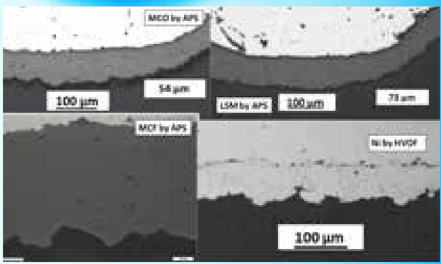
The project looks into coated steel components for SOFC with markedly improved properties with regard to chromium release, contact resistance and scale growth. Optimised combinations of protective layer materials with different steel qualities (including low-cost options) will be chosen for testing and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

PROGRESS/RESULTS TO DATE

- Sample choice & preparation
- First test coatings
- Test matrix established
- First systematic coating application, generation 1
- Systematic testing & analysis

FUTURE STEPS

- Continuation of systematic analysis
- Preparation of subsequent coating generations
- Validation tests with single SOFC cells
- Validation tests in stacks



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

Project has not yet been running long enough to have conclusions

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP 2011	SOFC system lifetime (h)	>20,000h	>40,000h (>10,000h proven within project)	N/A (test not finalised)
MAIP 2011	System cost (€/kW)	<€4,000/kW	contribution to low-cost interconnects (IC); IC are only one cost element of many	N/A (cost modelling follows later)

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

SCOTAS-SOFC

Sulphur, Carbon, and re-Oxidation Tolerant Anodes and Anode Supports for Solid Oxide Fuel Cells

CALL TOPIC	Materials development for cells, stacks and balance of plant
START-DATE	1 October 2010
END-DATE	31 December 2013
TOTAL BUDGET	€4,368,579
FCH JU CONTRIBUTION	€1,701,770
OTHER CONTRIBUTION(S)	DK, ForskEL programme, top-up funding €735,215

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Technical University of Denmark

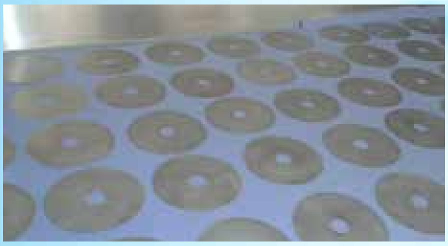
Partners: Forschungszentrum Jülich, Hexis AG, Topsøe Fuel Cell A/S, University of St Andrews.

PROJECT WEBSITE/URL

www.scotas-sofc.eu

PROJECT CONTACT INFORMATION

peho@dtu.dk



MAIN OBJECTIVES OF THE PROJECT

The project addresses the development of a new full ceramic solid oxide fuel cell (SOFC) with superior robustness as regards sulphur tolerance, carbon deposition (coking) and re-oxidation (redox resistance). Such a cell can mitigate three major failure mechanisms which today have to be addressed at system level. Having a more robust cell will thus enable the system to be simplified, something of particular importance for small fuel-cell systems, such as CHP supply.

PROGRESS/RESULTS TO DATE

- Three different strontium titanate materials have been prepared and integrated into anode- and electrolyte-supported cells of sizes up to 100 cm^2 which have been infiltrated with small amounts of Ni or Ru as electro-catalysts.
- Stable power outputs of more than 0.5W/cm^2 have been achieved for 25 cm^2-sized electrolyte-supported cells at 850°C.
- Anode-supported cells reached 0.95W/cm^2 on button cells in hydrogen.
- Five cell stacks using electrolyte-supported cells have been tested for more than 1,500 hrs by using partial oxidation reformed natural gas with and without desulphuriser and simulating fuel cut-offs (Redox) combined with thermo cycles.
- A 1 kilowatt stack could be assembled reaching 21% electrical efficiency at 60% fuel utilisation.

FUTURE STEPS

- As the project is over, follow-on activities will be part of new projects to demonstrate the potential of full ceramic cells
- Development of a supply chain for strontium titanate material
- Up-scaling the infiltration process and control of resulting nano-structured electrode
- Adaptation of stack design to electrical and thermal properties of full ceramic cells

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Strontium titanate ceramics have proven to be a stable and redox-tolerant electrode backbone material which can be activated to high electrochemical activity upon infiltration with electro-catalysts such as nickel and ruthenium.
- Mechanical properties of strontium titanates have been assessed for dense and porous structures making the electrolyte-supported cell design the favoured application.
- The electrode concept shows promise as regards sulphur tolerance and the concept can be tailored further by using other electro-catalysts.
- Based on the present results a use of this anode type for commercial use seems to be feasible in the mid-term.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	CHP efficiency	>80% total efficiency	Not specified	21% electrical efficiency (non-optimised stack design) total efficiency >95% (estimated), potential for electrolyte-supported cells
AIP	Lifetime	Solutions to specific identified failure mechanisms	Improve redox stability, sulphur and coking tolerance through the development of an alternative anode material	Increase redox tolerance and thermo redox cycling capability has been achieved by using strontium titanate based cells Sulphur tolerance comparable to SoA Ni-cermet cells. However, potential for further improvements
AIP	Performance	Proof of improved performance for existing design of cells, stacks and BoP	Integration of the ceramic anodes based on strontium titanates into electrolyte and anode supported cells Investigate stability of nano-structured electro-catalysts	Mechanical and thermal aspects evaluated, and found suitable for electrolyte-supported cells Stable infiltrated electrodes achieved
AIP	Manufacturing	New material production techniques and new inspection techniques	Infiltration of electro-catalysts into a ceramic backbone as a new step in the cell fabrication and the fabrication of a large number (100) cells to build the stack	Infiltration has shown to be reproducible and viable route for the anode fabrication The process is not state-of-the-art and needs up-scaling The anode fabrication could be transferred from a university lab to the Hexis automated screen-printing line
AIP	Environmental aspects	Recommendations for use of materials in specific stack or BoP components	Replace carcinogenic Ni by using a strontium titanate ceramic	The improvements are clearly attributed to the new materials used Strontium titanates and particularly La-Sr-Ca Titanate can be recommended for electrolyte-supported cells

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

SECOND ACT

Simulation, Statistics and Experiments Coupled to develop Optimized aNd Durable µCHP systems using ACcelerated Tests

CALL TOPIC	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 May 2014
END-DATE	30 April 2017
TOTAL BUDGET	€4,643,707
FCH JU CONTRIBUTION	€2,523,254
OTHER CONTRIBUTION(S)	Research Council of Norway €137,000

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CEA

Partners: IRD Fuel Cells, NEDSTACK, ICI Caldaie, Politecnico di Milano, DLR, JRC, SINTEF, TU-Graz.

PROJECT WEBSITE/URL

Under construction

PROJECT CONTACT INFORMATION

Sylvie Escribano

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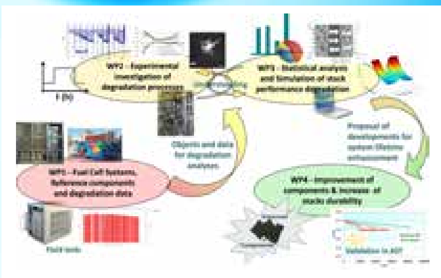
MAIN OBJECTIVES OF THE PROJECT

To improve understanding of stack degradation and propose durability improvements for µCHP systems using PEMFC or DMFC:

- Analysing long-term lifetime tests data from systems to identify main causes of failure;
- Testing to investigate degradation in single cells and stacks;
- Developing, applying and validating AST (accelerated stress tests) and specific harsh tests for failures;
- Developing and applying in-situ and ex-situ analyses for better identification and local resolution of mechanisms;
- Developing statistical approach and models, including stochastic/deterministic, reversible/permanent degradations and heterogeneities;
- Demonstrating improvements on tolerance to applications' relevant modes with modified components (materials, design, processes for pure H_2 or reformate PEMFC and DMFC).

PROGRESS/RESULTS TO DATE

- Definition of reference components, test objects, ageing conditions and existing ageing data to be investigated by experimental, statistical and modelling tools.
- Collection of ageing data for statistical analyses from systems, stacks and single cells ageing tests of past projects related to the three fuel-cell technologies considered.
- Definition of test methods and protocols to be conducted by each partner.
- Initial identification of operating behaviours and mechanisms to be implemented in the models for the simulation of cells and stacks performance degradation.



FUTURE STEPS

- Statistical analyses of ageing data to identify failure modes
- First delivery of reference components
- Starting of ageing tests with reference components
- Failures, mechanisms and corresponding AST and harsh specific tests to be defined for each technology
- More detailed description of phenomena and mechanisms to be simulated

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

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

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Stationary FC system lifetime	Degradation and lifetime fundamentals related to materials and typical operation environments for all power ranges Proposal of new or improved materials General aim of 40,000h	1-Better understanding of cell and stack degradation for Pure H_2 or Reformate PEMFC and DMFC 2-Demonstrating lifetime improvements thanks to stack core component modifications (enabling >20,000h for H2 syst. case)	NA
AIP	Systems degradation causes	Identify, quantify and document relevant degradation and failure mechanisms over the long-term (i.e. >20,000h	Collection, production and statistical analysis of ageing data from cells, stacks and systems related to the three technologies of industry partners	In progress: collection of ageing data from past projects and existing field test systems
AIP	Systems lifetime improvement	Identify improvements, and verify these in existing cell and stack design	Integration and testing of improved core components (materials, electrodes design or process) for demonstrating measurable lifetime improvement at stack level and potential lifetime enhancement at system level	NA
AIP	Applications-relevant investigations (degradation and improvement)	Quantification of mechanisms and verification of improvements by accelerated testing and/or by durability testing under harsh conditions, compared to application-relevant conditions.	For quantification: iterative loops of testing and numerical simulation coupled with advanced in-situ or ex-situ analyses For verification: measurement of improvements based on comparison of degradation slopes or % of voltage losses at selected operating points when applying AST or harsh specific tests representative of major degradation cause or failure mechanism for each FC technology considered Target of the project is to aim for >20,000 hours (maximum duration currently reached by stacks integrated in H2-fed systems considered)	

SMARTCat

Systematic, Material-oriented Approach using Rational design to develop break-Through Catalysts for automotive PEMFC

CALL TOPIC	New catalyst structures and concepts for automotive PEMFCs
START-DATE	1 June 2013
END-DATE	31 May 2017
TOTAL BUDGET	€4,768,172
FCH JU CONTRIBUTION	€2,501,998
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CNRS

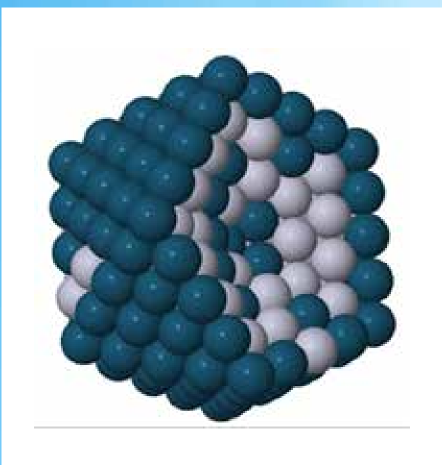
Partners: SINTEF, DTU, CEA, mxpolymers

PROJECT WEBSITE/URL

smartcat.cnrs.fr

PROJECT CONTACT INFORMATION

Pascal Brault, Pascal.Brault@univ-orleans.fr



MAIN OBJECTIVES OF THE PROJECT

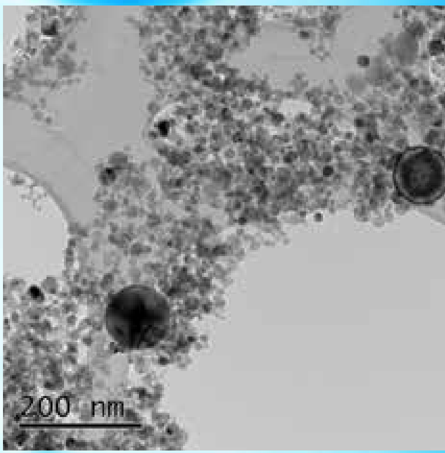
- New and innovative electrodes using tri-metallic low Pt-content (0.01 mg^{-2}, 0.05g/kW) based catalyst nanoparticles and nanostructured layers (CL) combined with new and corrosion-resistant metal-doped oxide-based materials (CL-conductivity σ =1-10 S/cm).
- Up-scaling HT membranes proton conductivity >60 mS/cm @ 40°C; >200 mS/cm @ 180°C.
- Enable to optimise and automate the production of MEAs (60/day).
- Prove the viability of the new concept for automotive applications (220 cm-2, 5,000h durability).

PROGRESS/RESULTS TO DATE

- Project roadmap
- Website (http://smartcat.cnrs.fr) and private platform
- DFT simulations of tri-metallic catalyst systems.
- Chemical and plasma sputtering synthesis of efficient bimetallic catalyst
- Computational modelling; synthesis and doping of oxide-based materials as support

FUTURE STEPS

- Identify optimal tri-metallic system, alloys and core shell with highest ORR activity
- Metal oxide catalysed support with improved conductivity
- 1kg-scale polymer synthesis with proton conductivity
- First complete MEA based on novel GDE and PFSA membrane



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Ongoing project is on time
- DFT simulations are promising for predicting tri-metallic system
- Computational modelling of doped oxide properties in good agreement with support characterisation findings
- First MEA with new support and catalyst planned for month 24

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	New electrodes materials for fuel-cell car	Not defined	25 cm^2 single-cell performance of 1Wcm-2	N/A (test not finalised)
	Lowering cost with targeted performances		100 cm-2 single-cell performance of 0.9 Wcm-2 at EoL	
	Developing process fabrication of low-cost catalyst, support materials and automated high rate MEA fabrication at the pilot scale		220 cm-2 short stack >WL-1	
AIP	Pt loading	0.1 g/kW	0.1 g/kW	0.08 g/kW
AIP	Support + catalyst conductivity	n/a	>1 S/cm	0.6 S/cm without catalyst

SOCTESQA

Solid Oxide Cell and Stack Testing, Safety and Quality Assurance

CALL TOPIC	Development of industry-wide uniform performance test schemes for SOFC/SOEC cells & stacks
START-DATE	1 May 2014
END-DATE	30 April 2017
TOTAL BUDGET	€3,212,186
FCH JU CONTRIBUTION	€1,626,373
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

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

Partners: Commissariat à l énergie atomique et aux énergies alternatives (CEA), Danmarks Tekniske Universitet (DTU), Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile, (JRC), Europäisches Institut für Energieforschung (EIFER), Nanyang Technological University.

PROJECT WEBSITE/URL

Not yet established

PROJECT CONTACT INFORMATION

Michael Lang
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MAIN OBJECTIVES OF THE PROJECT

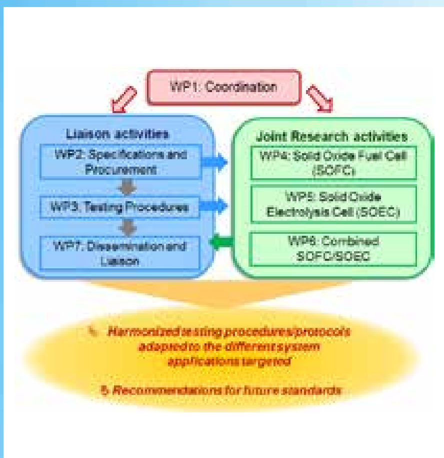
The main objective is to develop uniform and industry-wide test procedures for solid oxide cell/stack assembly units. The project will address three different operation modes: solid oxide fuel cell (SOFC), solid oxide electrolysis cell (SOEC) and combined SOFC/SOEC operations. Both stationary and mobile applications will be covered. Moreover, advanced characterisation techniques, e.g. electrochemical impedance spectroscopy, will be integrated in the test programmes. The test modules will be experimentally validated on solid oxide short stacks. Moreover, the project will address safety aspects, liaise with standards developing organisations and establish contact with industrial practice.

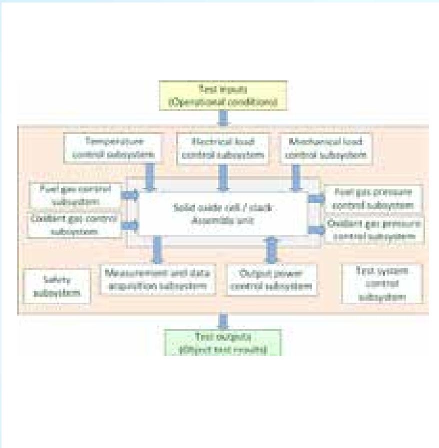
PROGRESS/RESULTS TO DATE

- Industrial advisory board (IAB) established
- Contacts to standards developing organisations (SDO) intensified
- Test matrix and master document in progress
- Specification list of test facilities in progress

FUTURE STEPS

- Definition of the solid oxide cell/stack specifications
- Survey of existing solid oxide cell/stack test procedures
- Procurement of testing samples
- Test matrix and master document finalised
- Specification list of test facilities finalised





SOFC-Life

Solid Oxide Fuel Cells – Integrating Degradation Effects into Lifetime Prediction Models

CALL TOPIC	Degradation and lifetime fundamentals of the call FCH-JU-2009-1 in the application area 'Stationary power production and CHP'
START-DATE	1 January 2011
END-DATE	31 December 2013
TOTAL BUDGET	€5,700,000
FCH JU CONTRIBUTION	€2,400,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Forschungszentrum Jülich

Partners: Hexis AG, HTceramix, Topsøe Fuel Cell A/S, Commissariat à l´énergie atomique, DTU-EC, Eidgenössische Materialprüfungs- und Forschungsanstalt, Institute of High Temperature Electrochemistry, Valtion Teknologian Tutkimuskeskus (VTT), Ecole Polytechnique Fédérale Lausanne, Imperial College, Electricité de France, Zürcher Hochschule für angewandte Wissenschaften.

PROJECT WEBSITE/URL

www.sofc-life.eu

PROJECT CONTACT INFORMATION

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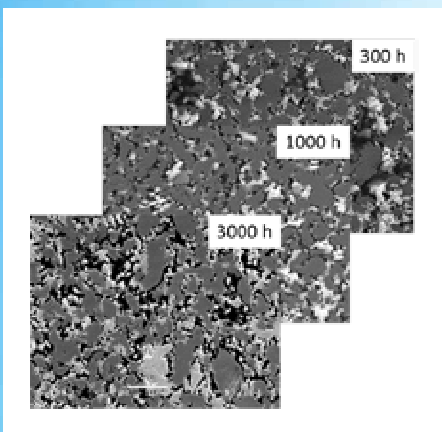


MAIN OBJECTIVES OF THE PROJECT

The objectives addressed in the SOFC-Life project were:

- Understand the details of the major SOFC continuous degradation effects;
- Develop models that predict single degradation phenomena;
- Transfer the physical-chemical models to electrochemical models;
- Re-assemble the single-effect models to a full SRU lifetime prediction model.

The themes (degradation mechanisms) addressed were:

- Morphological change in the anode cermet (impacting on anode activity and electrical continuity);
- Nickel-steel corrosion (impacting on electrical continuity and conductivity);
- The stability (chemical, kinetic and morphological) of state-of-the-art cathode materials (impacting the cathode activity);
- Processes at the cathode-interconnect interface (impacting electrical continuity and chemical composition of components, thus their electrochemical performance).

PROGRESS/RESULTS TO DATE

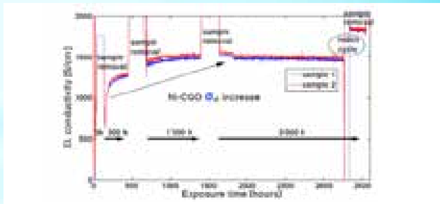
- The conductivity of Ni/YSZ and Ni/CGO anodes shows only marginal degradation or even improvement over time. This can be considered as not a major contribution to the overall degradation observed in SRUs and stacks.
- Description of the conductivity and microstructural changes in LSM-YSZ and LSCF cathodes from several 3,000h continuous conductivity measurements and 2D and 3D microstructural analysis. Only a slight degradation was found, which can be considered as not a major contribution to the overall degradation observed in SRUs and stacks.
- The interconnect steel with and without coating in air shows an increase of resistivity with time, which can be considered to be a major contribution to the overall degradation observed in SRUs and stacks.
- Microstructural parameters as function of operating conditions and time for cathodes and anodes have been extracted for use in the respective sub-models. A micro-model of SOFC electrodes has been developed for LSM-YSZ material. The model validation has been performed by implementing microstructural and electrochemical data from 3D reconstruction available on fresh LSM-YSZ.
- Cellular automaton model developed to predict 3D microstructure evolution, and corresponding degradation of polarisation resistance, of Ni/YSZ anodes.

FUTURE STEPS

N/A: project ended on 31 December 2013 (100% of project duration passed)

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- From the selected four themes (degradation mechanisms), all contributing to the overall ohmic part of the SRU impedance, three could be identified as having only minor or even no influence on the degradation behaviour observed in SOFC stacks. Only the contact resistance between the metal interconnect and the cathode (contact layer) showed substantial increases over time and can be considered to be a major contribution to the overall degradation observed in SRUs and stacks.
- Continuum composite electrode models were developed. Three semi-empirical degradation laws as obtained from the materials exposure tests could be implemented.
- The electrode models including degradation were then implemented in stack models for lifetime prediction under practical operating conditions.
- Implementation of the results from the model development was performed within the scope of the model validation with real stack testing. Due to the participation of major European SOFC manufacturers this process resulted in direct industrial implementation of results.



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP AIP	SOFC-Life addresses basic research activities directed to degradation and lifetime fundamentals of SOFC technology, particularly focusing on SOFC materials available and in industrial application today. The SOFC-Life project aimed at a better understanding of the degradation phenomena as a tool for mitigating these effects and as a first step towards developing accelerated testing methods.	No quantitative targets for basic research in either MAIP and/or AIP		

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

SOFCOM

SOFC CCHP with poly-fuel: operation and management

CALL TOPIC	Proof-of-concept and validation of integrated fuel-cell systems
START-DATE	1 November 2011
END-DATE	31 October 2014
TOTAL BUDGET	€6,261,367
FCH JU CONTRIBUTION	€2,937,753
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Politecnico di Torino (Italy)

Partners: Teknologian Tutkimuskeskus VTT, Topsoe Fuel Cells A/S, Società Metropolitana Acque Torino spa, Matgas 2000 AIE, Consiglio Nazionale delle Ricerche, Instytut Energetyki, Ecole Polytechnique Fédérale de Lausanne, Technische Universität München,
Università di Torino.

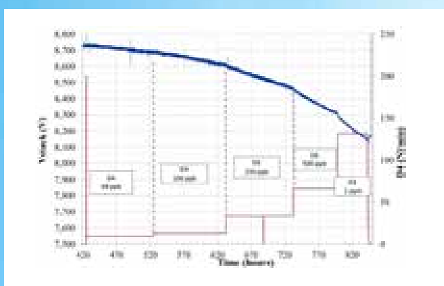
PROJECT WEBSITE/URL

www.sofcom.eu
(http://areeweb.polito.it/ricerca/sofcom/en/)

PROJECT CONTACT INFORMATION

Massimo Santarelli

Massimo.santarelli@polito.it



MAIN OBJECTIVES OF THE PROJECT

SOFCOM is devoted to demonstrate the technical feasibility, efficiency and environmental advantages of CHP systems based on SOFC fed by biogenous primary fuels (biogas and bio-syngas) integrated by a process for CO_2 separation and carbon reutilisation. The demonstration is implemented in the context of two axes:

Lab-scale: fuel production section; fuel cleaning section; fuel processing section; SOFC CHP section; carbon capturing module (oxy-combustion, CO_2 separation, C-fixing in algae).

System analysis: energy, economic, environmental analysis of the option of SOFC-based CHP plants as distributed systems using local biogenous energy sources; development of guidelines for the scale-up; development of pre-normative results; LCA analysis.

PROGRESS/RESULTS TO DATE

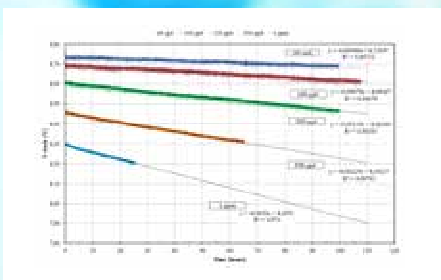
- Analysis of biogas contaminant effects on SOFC anodes: halogens, siloxanes, sulphur
- Experimental analysis of CO_2 recovery from anode exhaust using micro-algae
- DEMO of SOFC stack fed with lean fuel (syngas from biomass gasification)
- Process engineering of DEMO of complete biogas-cleaning-SOFC-CO_2 recovery from anode exhaust

FUTURE STEPS

- Analysis of biogas contaminant effects on SOFC anodes
- DEMO of complete biogas-cleaning-SOFC-CO_2 recovery from anode exhaust
- Biogas-SOFC-CO_2 recovery plants: scale-up and exploitation analysis

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- SOFCOM demonstrates (through in-field DEMO) the high interest of electrochemical systems based on high-temperature fuel cells to operate as the core of future energy systems with renewable fuels and multi-product configuration, with particular care on CO_2 management through C re-utilisation in different processes (electrochemical, chemical, or biological as in SOFCOM).
- Deep analysis of biogas contaminant effects on SOFC anodes: combined and synergetic effects.
- Scale-up of the biogas-SOFC plant (size of around 250kW). SMAT and POLITO have already worked on the feasibility analysis (technical and economic) of the scale-up based on a SOFC system of 250kW, fully fed by biogas from WWTP.
- Activities on SOFC fed by lean syngas and strong interest in going on with the activities on the contaminants effect on cells and elements of the stack.
- CO_2 recovery from SOFC anode exhausts.



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Field demonstration activities are split into small-scale (residential and commercial applications) and large-scale (distributed generation or other industrial or commercial applications)	DEMO 1 in Turin is a small-scale demonstration activity but performed in a real industrial application scale The DEMO 2 in Helsinki is a small scale demonstration activity but with emphasis on future scale-up (biomass gasification fuel).	DEMO 2 Helsinki: done. DEMO 1 Turin: under in-house testing, in-field activity from July 2014	90%
AIP	Validation activities, performed in a real system environment or with real equipment in a simulated system environment	The proof-of-concept validation of the tested systems on the demonstration sites is one of the main results of the project		90%
AIP	Identification of technical and economic requirements in order to be competitive in the marketplace	Under analysis, following the real experience performed in the demonstration activity, with a scale-up analysis of the integrated SOFC systems studied	Analysis under development, to be used especially for next scale-up projects in the area of biogas-fed FCs	100%

SOFT-PACT

SOFT-PACT

Solid Oxide Fuel Cell micro-CHP Field Trials

CALL TOPIC	Field demonstration of stationary fuel-cell systems
START-DATE	8 July 2011
END-DATE	8 October 2015
TOTAL BUDGET	€10,300,000
FCH JU CONTRIBUTION	€3,900,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: E.ON New Build & Technology Limited

Partners: Ceramic Fuel Cells GmbH, Ideal Boilers Ltd, Homa Software BV.

PROJECT WEBSITE/URL

www.soft-pact.eu

PROJECT CONTACT INFORMATION

Andrew Thomas

andrew.thomas@eon.com

MAIN OBJECTIVES OF THE PROJECT

SOFT-PACT has been established to undertake a large-scale field demonstration of SOFC generators that can be utilised in residential applications. The objectives being to:

- Design, develop and deploy integrated fuel-cell mCHP systems;
- Long-term reliability and life data from the systems;
- Remote control and diagnostics of all the systems from a central point in real time;
- Training and re-skilling of installation and maintenance engineers;
- Identification and quantification of benefits to the homeowner.

Key outputs: EU market study, data from two field trials, increasing installation capability and completing development of an optimised integrated FC system.

PROGRESS/RESULTS TO DATE

- EU FC market opportunities study report
- Deployment of Pathfinder BlueGen systems in DE & UK
- Specification for integrated fuel-cell appliance
- Cost reduction and component optimisation of BlueGen
- Design, test, build and deployment of integrated fuel-cell appliance

FUTURE STEPS

- Finish deployment of remaining integrated fuel-cell appliances
- Monitoring data analysis
- Plan and schedule removal of field trial units (Mid 2015)
- Final reports

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Large opportunities for fuel-cell deployment with EU @ right price
- Policy and incentive support must be maintained to aid volume production cost reductions
- Range of systems required to meet all EU markets (gas types and local regulations)
- Deployment of systems by local companies requires hybrid installation engineer training to reduce costs

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	FC system lifetime (h)	>5,000h	>10,000h	Ongoing (test not finalised)
AIP	Deployment of fuel cells with trial	10	Up to 100	39 BlueGen systems 24 integrated fuel-cell appliance 63 fuel-cell systems total (ongoing)
AIP	FC system electrical efficiency (%) (HHV)	>40%	>40%	56%->42% over lifetime
AIP	Cost reduction (€/kWe)	€5,000/kWe	25% reduction on BlueGen	Achieved via re-engineering & supply chain enhancements

SOL2HY2

Solar To Hydrogen Hybrid Cycles

CALL TOPIC	Thermo-electrical-chemical processes with solar heat sources
START-DATE	1 June 2013
END-DATE	31 May 2016
TOTAL BUDGET	€3,701,300
FCH JU CONTRIBUTION	€1,991,115
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: EnginSoft SpA

Partners: Aalto-korkeakoulusäätiö, Deutsches Zentrum für Luft- und Raumfahrt, Agenzia per le Nuove Tecnologie l'Energia e lo Sviluppo Economico Sostenibile, Outotec (Finland) Oy, Erbicol SA, Oy Woikoski AB.

PROJECT WEBSITE/URL

sol2hy2.eucoord.com

PROJECT CONTACT INFORMATION

Prof. Stefano Odorizzi

stefano.odorizzi@enginsoft.it

MAIN OBJECTIVES OF THE PROJECT

1. Development of the key components, especially sulphur-depolarised electrolyser, solar-powered H_2SO_4 cracker and heat storage.
2. Modelling, multi-objective design and optimisation and testing of improved critical materials solutions and processes, leading to a virtual plant model.
3. Designing and running field tests of key blocks of the hybrid cycles, their performance analysis and feedback for the solutions validation.
4. Technical-economic evaluation of the new process concept and development of the technology implementation on the market.
5. Development of the flexible centralised H_2 production plant options using interfaces to running industrial process as the starting point for renewable H_2 by-production.

PROGRESS/RESULTS TO DATE

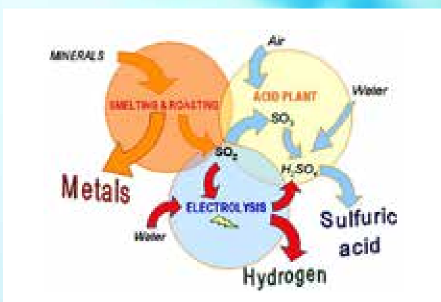
- A multi-cell stack sulphur oxide depolarised electrolyser (SDE) was selected for hydrogen production. The cost-effective option for bipolar plates was chosen as gold-plating of steel.
- A model of the acid decomposition chamber was developed and verified with experimental data available from on-sun tests.
- Three solar-to-heat (STH) and solar-to-electricity (STE) concepts have been chosen for further analysis, where heat is recovered by means of molten salts in downstream heat exchangers.
- Based on an updated, detailed process flow-sheet, the most critical BoP units have been reconsidered; flow-sheets of the main process blocks have been built using Aspen Plus and HSC software.

FUTURE STEPS

- Extended tests of SDE in different conditions relevant to the hybrid (semi-closed) cycle design.
- Development of the efficient catalysts for SDE and solar sulphuric acid cracking.
- Multi-objective simulation of the plant flow-sheets and its combination with the design of the key components.
- Preparations for demonstration activities at the solar tower.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Realistic thermodynamics of the SO_2-H_2SO_4-H_2O system was assessed, water transport model developed and validated in the lab-scale electrolyser operating at ambient conditions.
- Two-part solar cracker was designed: a cavity absorber for rapid heat up and an adjacent catalytic reaction chamber for adiabatic decomposition.
- Several plant concepts have been analysed and their bottlenecks identified: sulphuric acid concentrator/cracker, solar input splitting (high- and medium-temperature) with its connections with SDE and BoP. The twin-power (1000/500°C) solar input model and three main cracker/concentrator designs were selected for further analysis.



CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
AIP	Catalysts with activities	+30% vs. state-of-the-art	>100% vs. known Pt/Pd loads	Tests is progress
AIP	Redox materials with conversion rate	+100% vs. state-of-the-art	Redox materials not used	N/A
AIP	Development of key components with enhanced efficiency in relevant scale	0.5-2.0MW	>0.5MW at daily solar input 20MWh	Design according to the programme objective

SOPHIA

Solar integrated pressurised high temperature electrolysis

CALL TOPIC	New generation of high-temperature electrolyser
START-DATE	1 April 2014
END-DATE	31 March 2017
TOTAL BUDGET	€6,080,105
FCH JU CONTRIBUTION	€3,325,751
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: HyGear BV

Partners: HTceramix SA, Commisariat à l'energie atomique et aux energies alternatives, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Ecole polytechnique federale de Lausanne, Teknologian Tutkimuskeskus VTT, GdF Suez, SOFCpower spa.

PROJECT WEBSITE/URL

Under construction

PROJECT CONTACT INFORMATION

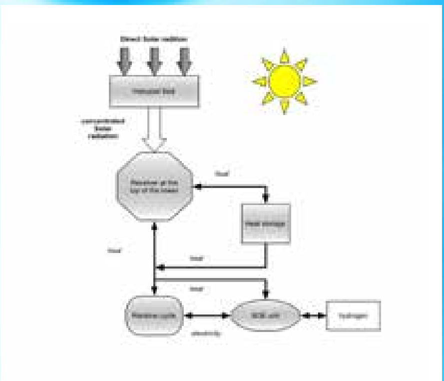
Dr. Ellart de Wit

Ellart.de.wit@hygear.nl

MAIN OBJECTIVES OF THE PROJECT

Design, fabrication, and operation on-sun of a 3 kWe-size pressurised 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 pressurised.

Development and manufacturing of optimised large-area cells for HTE operation targeting high performance, and improved durability. Design of a stack for pressurised operation.



PROGRESS/RESULTS TO DATE

New project

FUTURE STEPS

- Concept development
- Start modelling activities

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

New project

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Carbon-free/carbon-lean H_2 production	10%–20%	HT SOE system at kW size	N/A
AIP	Low degradation rate	<0.5% per 1000h		
AIP	Pressurised electrolysis	>1	15	

SSH2S

Fuel Cell Coupled Solid State Hydrogen Storage Tank

CALL TOPIC	Improved solid-state hydrogen storage systems
START-DATE	1 February 2011
END-DATE	31 July 2014
TOTAL BUDGET	€3,500,000
FCH JU CONTRIBUTION	€1,600,000
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Università di Torino

Partners: Institute for Energy Technology, Karlsruhe Institute of Technology, Deutsches Zentrum für Luft- und Raumfahrt (DLR), Tecnodelta s.r.l., Serenergy A/S, Centro Ricerche Fiat, JRC.

PROJECT WEBSITE/URL

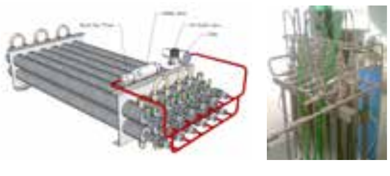
www.ssh2s.eu

PROJECT CONTACT INFORMATION

Marcello Baricco

marcello.baricco@unito.it

Electric Iveco Daily with installed SSH2S APU.



SSH2S solid state hydrogen tank

MAIN OBJECTIVES OF THE PROJECT

The main objective of SSH2S is to develop a solid-state hydrogen storage tank fully integrated with a fuel cell and to demonstrate its application on a real system. A well-assessed hydrogen storage material (a mixed lithium amide/magnesium hydride system) has been considered as the active material for the tank. The application of the hydrogen tank on a real system will be experimentally investigated with a 1kW prototype on high-temperature polymer electrolyte membrane (HTPEM) fuel cells.

If suitable performance is obtained, a scale-up of the tank will be applied to a 5kW APU.

PROGRESS/RESULTS TO DATE

- Design and the synthesis, as well as the physico-chemical characterisation, of existing and novel materials for solid-state hydrogen storage have been undertaken. Ab-initio and thermodynamic/kinetic calculations helped to determine the choice of materials. The synthesis of materials was performed by ball-milling, firstly at laboratory scale and then scaled-up. The characterisation has been performed by a combination of structural and spectroscopic experimental techniques.
- A new two-material concept has been developed for the tank, combining hydrogen sorption properties of complex hydrides and metal hydrides. In particular, thanks to a careful control of thermal exchanges, synergic effects have been obtained, promoting fast hydrogen sorption reactions.
- Fluido-dynamic modelling of different tank concepts, as well as the experimental validation of the models in a lab-scale tank, drove the design of a prototype tank, optimised for use with the selected materials. The project and the development of the prototype tank have been undertaken by industrial partners.
- The results have been used to integrate the materials/tank systems with a HT-PEM fuel cell (1kWel) to be used as APU in a light vehicle.
- The decision about possible scale-up has been taken after a critical techno-economic evaluation.

FUTURE STEPS

- The project is close to the end and final testing on the developed APU system will be finalised.
- LCA and techno-economic evaluation will be concluded by the end of the project.

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- A material for a solid-state hydrogen tank with capacities of up to 4.5 H2 wt%, fully reversible at 160°C-180°C and with high stability on cycling has never been developed in previous European projects. New concepts on the design and the coupling of solid-state hydrogen tank with HT-PEM fuel cells represent a significant achievement of the project.
- The development of an APU prototype 1kW integrated system is a real advance in the field of solid-state hydrogen storage.
- The results of the project may be of significant economic impact for large industries, as well as for SMEs' industrial partners. The possibility of coupling the HTPEM with a compact and safe hydrogen storage system will possibly increase business opportunities for SER and TD partners.
- The availability of safe hydrogen tanks at low pressures is expected to contribute to the social acceptance of hydrogen technologies.
- On the basis of a techno-economical evaluation at the end of the project, the possible commercial impact of the developed APU system will be evaluated.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/ TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Hydrogen storage materials	Storage materials with capacities ≥6 wt.%, ≥60 kg H2/m3 reversibly releasing hydrogen at operating temperatures compatible e.g. with PEM FC, HT PEM FC or SOFC/MCFC	Same as MAIP	Storage materials with capacities up to 4.5 wt% H2. Reversibility at 180°C. Single reaction step. Stability on cycling. Stop for mixed borohydrides
MAIP	Improved system density for H2 storage	Not defined	4 wt% of H2. 4 kg H2/100L. Close to room temperature and pressure	Gravimetric density lower than goal. Volumetric density likely OK

Stack-Test

Development of PEM Fuel Cell Stack Reference Test Procedures for Industry

CALL TOPIC	Development of EU-wide uniform performance test schemes for PEM fuel-cell stacks
START-DATE	1 September 2012
END-DATE	31 August 2015
TOTAL BUDGET	€5,637,780
FCH JU CONTRIBUTION	€2,909,898
OTHER CONTRIBUTION(S)	Polish Ministry of Science and Higher Education covers ICRI's cost which are not covered by FCH-JU grant

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Zentrum für Sonnenenergie- und Wasserstoff-forschung,

Partners: CEA, Danmarks Tekniske Universitet, DLR, ICRI, Aalborg Universitet, NEXT-E, Fundacion Cidetec, Fraunhofer ISE, JRC-IET, Symbio FCell

PROJECT WEBSITE/URL

http://stacktest.zsw-bw.de

PROJECT CONTACT INFORMATION

Ludwig Jörissen
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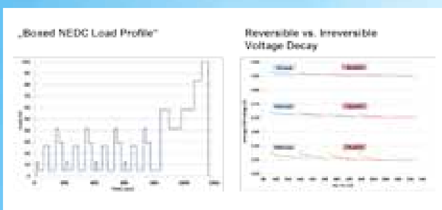


MAIN OBJECTIVES OF THE PROJECT

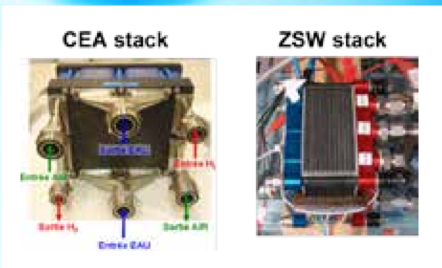
Propose and validate harmonised, and industrially relevant test procedures for PEM fuel-cell stacks in form of generic test modules and application-specific test programmes. Dress functional performance, endurance, and safety testing, interact with industry.

PROGRESS/RESULTS TO DATE

- Generic test modules, and application-specific test programmes for performance, endurance and safety testing drafted
- Initial experimental validation completed
- Two stakeholder workshops held
- Review of documents in progress

FUTURE STEPS

- Completion of test module and test programme review
- Experimental validation
- Preparation of final release versions
- Further stakeholder workshops



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

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 programmes have been defined and initially validated. Two different sets of stack test samples were supplied to participants for validation purpose.

Consistent results in performance testing were achieved using static and dynamic load. Understanding of degradation testing needs to be refined.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Provide a coherent framework to monitor progress		Provide a methodology of performance, endurance, and safety/environmental testing on a PEM-FC stack level	Generic test modules and application-oriented test programmes for performance, endurance and safety testing are available in draft
MAIP	Maintain, consolidate and disseminate results of RCS and PNR activities		Provide annually updated review of RCS relevant for PEM fuel-cell stack testing	Initial assessment and first annual update compiled and submitted as deliverable for public dissemination
AIP	Development of harmonised testing protocols for PEM stacks, in order to achieve a set of testing procedures that provide a uniform look at their characteristics		Provide experimentally validated test procedures for performance, endurance and safety/environmental testing	Generic test modules and application-oriented test programmes for performance, endurance and safety testing are available in draft. First series of validation experiments finished. Revision in progress

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

STAGE-SOFC

Staged SOFC Stack Connection for Efficient Power and Heat Generation

CALL TOPIC	Proof of concept and validation of whole fuel-cell systems for stationary power and CHP applications at a representative scale
START-DATE	1 April 2014
END-DATE	31 March 2017
TOTAL BUDGET	€3,970,268
FCH JU CONTRIBUTION	€2,165,724
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: VTT Technical Research Centre of Finland

Partners: Sunfire GmbH, ICI Caldaie SpA, Lappeenranta University of Technology, West Pomeranian University of Technology.

PROJECT WEBSITE/URL

http://www.stage-sofc-project.eu/

PROJECT CONTACT INFORMATION

Matti Reinikainen

matti.reinikainen@vtt.fi

MAIN OBJECTIVES OF THE PROJECT

The project aims to develop a 5kWel proof-of-concept prototype of a new SOFC concept that achieves an electrical efficiency of ≥45% and a thermal efficiency of >85% with a serial connection of stacks. The system combines the benefits of the simple and robust catalytic partial oxidation layout with the high efficiencies obtained by the steam reforming process. A staged cathode air supply allows an individual control of stack temperatures and saving of costly heat exchanger area. The system will be designed for small-scale CHP and off-grid applications in the power range of 5 to 50kW.

PROGRESS/RESULTS TO DATE

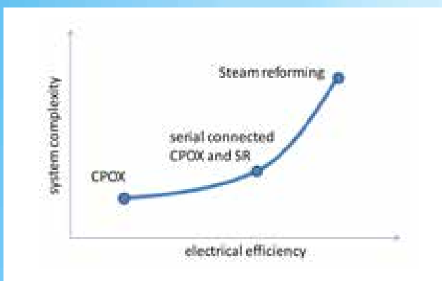
- Two deliverables
- Website launched
- Conference presentation

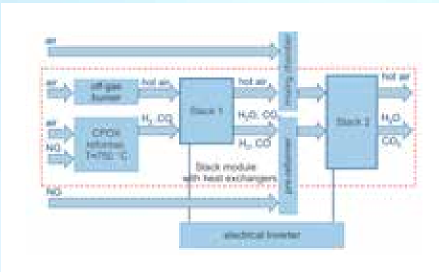
FUTURE STEPS

- Conceptual design and system specification
- First prototype testing
- Hotbox components development
- Safety system and certification

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- N/A





CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	FC system electrical efficiency (%)	>45%	>45%	N/A (test not finalised)
MAIP	FC lifetime	>40,000h	>40,0000h	N/A (test not finalised)
AIP	PoC prototype system with advanced components	PoC tested	5kWel prototype built and tested	N/A (test not finalised)
AIP	Successful duration of run times for whole fuel-cell systems	several hundreds of hours	≥3,000h	N/A (test not finalised)

STAMPEM

STAble and low-cost Manufactured bipolar plates for PEM fuel cells

CALL TOPIC	Research & development on bipolar plates
START-DATE	1 July 2012
END-DATE	30 June 2015
TOTAL BUDGET	€5,223,807
FCH JU CONTRIBUTION	€2,576,505
OTHER CONTRIBUTION(S)	Research Council of Norway €400,000

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Stiftelsen SINTEF

Partners: Teer Coatings Ltd, Miba Coatings Group, ElringKlinger AG, Fraunhofer Gesellschaft zur Förderung der angewandten Forschung, University of Birmingham, Fronius International GmbH.

PROJECT WEBSITE/URL

www.stampem.eu

PROJECT CONTACT INFORMATION

Anders Ødegård
anders.odegard@sintef.no

MAIN OBJECTIVES OF THE PROJECT

The main objective of STAMPEM is to develop durable coating materials for metal-based bipolar plates (BPP) that can be mass produced for less than €2.5/kW of rated stack power at mass production volumes of 500,000 pieces annually. Properties after extrapolated 10,000 hours from accelerated stress test (AST) single-cell testing shall still be within the AIP specifications. The main parameters are interfacial contact resistance (ICR, <25 mohm cm^2) and corrosion resistance (<10 μA/ cm^2).

PROGRESS/RESULTS TO DATE

- All three coating concepts (physical vapour deposition (PVD), polymer- and carbon composite-based) show promising performance in ex-situ tests
- Best PVD-based coatings retain low ICR after in-situ AST
- PVD-based coatings potentially withstand stamping process
- Full-size segmented test cell in operation
- Promising results from plasma cleaning process for in-line cleaning of BPP substrates

FUTURE STEPS

- Investigations on effect and tolerance of different contaminants on MEA/membrane degradation
- In-situ AST of polymer and carbon composite coatings
- Long-term operation of most promising coatings in full-size stacks
- Degradation experiments of metal BPP stack in system

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Existing test protocols not fully representative for BPP degradation
- Gap in information/knowledge on MEA ion tolerance
- Possibility to apply low(er) cost alternatives to gold coating

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	2015 target lifetime for vehicles	>5,000	Properties after extrapolated 10,000 hours from AST single-cell testing shall still be within the AIP specifications	N/A (test not finalised)
AIP	BPP interfacial contact resistance	<25 mohm cm^2	<25 mohm cm^2 after 10,000 hours extrapolated from AST	<10 mohm cm^2 after small-scale in-situ AST
AIP	BPP/coating corrosion resistance	<10 μA/cm^2	<10 μA/cm^2 after 10,000 hours extrapolated from AST	<10 μA/cm^2 in ex-situ tests (Beginning of Life (BoL), 1 mM H_2SO4 at 0.8 V_{SHE} and 80°C at BoL

STAYERS

STAtionary PEM fuel cells with lifetimes beyond five YEaRS

CALL TOPIC	Materials development for cells, stacks, and balance of plant (BoP) Fundamentals of fuel-cell degradation for stationary power applications
START-DATE	1 January 2011
END-DATE	30 June 2014
TOTAL BUDGET	€4,100,000
FCH JU CONTRIBUTION	€1,900,000
OTHER CONTRIBUTION(S)	Research Council of Norway €265,000

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Nedstack Fuel Cell Technology BV

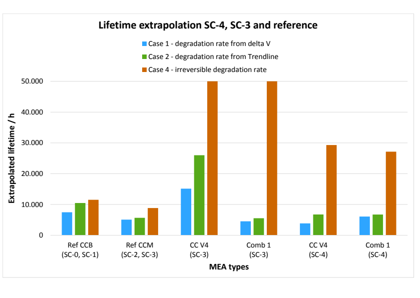
Partners: Solvicore GmbH & Co KG, Solvay Speciality Polymers Italy SpA, Stiftelsen SINTEF, JRC-IET.

PROJECT WEBSITE/URL

www.stayers.eu

PROJECT CONTACT INFORMATION

Jorg Coolegem, jorg.coolegem@nedstack.com



MAIN OBJECTIVES OF THE PROJECT

The main objective of the project is to carry out materials research in order to produce PEM fuel-cell stacks with a guaranteed lifetime of 40,000 hours for stationary applications where longevity and reliability are essential. These applications are power generators on by-product hydrogen for the chlor-alkali and chlorate industry, power generators for telecommunication, and heavy duty transport.

PROGRESS/RESULTS TO DATE

- Several improved membranes have been developed as well as a novel process route, resulting in AST lifetime indications well over 40,000 hours for the latest scavenger-containing membrane variation.
- 4 iterations of MEA's (50 types in total) have been produced and evaluated by ASTs, lab testing and industrial field tests.
- 25,000 operational hours in an industrial test facility have been achieved within the project; dedicated software has contributed in selecting the most promising MEA and stack compositions.
- Improved stack hardware components have been developed and have been evaluated in field tests and ASTs, indicating lifetimes beyond 40,000 hours.
- AST tests have been developed that successfully mimic the observed irreversible and reversible decay.
- Using CFD a 3D two-phase model has been developed and validated with experimental BOL and EOL results. A sensitivity study has contributed in identifying the most relevant contributions for voltage decay.

FUTURE STEPS

- Not applicable

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

The predominant degradation mechanisms in stationary operation have been determined to be:

  - Cathode ECSA loss, partially reversible by poisoning through contaminant traces
  - Cathode increase of proton resistance
  - To a lesser extent reversible anode ECSA loss by contamination.
- The excellent AST results for the membrane and the low decay rates (0.6 to 1.5 μV/h) based on irreversible decay obtained in the first 6,000 to 9,000 hours give a promising perspective on obtaining the 40,000 hours lifetime target for two MEA variations from the final iterations (CC V4 and Comb 1).
- Evaluation of stack hardware components after 20,000 hours of operation as well as by ASTs indicate lifetimes beyond 40,000 hours for the final stack iteration; system lifetime beyond 40,000 hours has been demonstrated.
- An AST has been developed and validated for the most dominant, irreversible decay mechanism. An acceleration factor of 5-10 has been achieved.
- A parametric study using the CFD model confirmed ECSA loss as the most significant contribution to voltage decay.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP 2008-2013	Stack lifetime (h)	20,000h	40,000h	40,000h extrapolated lifetime reached

SUAV

Microtubular Solid Oxide Fuel Cell Power System development and integration into a Mini-UAV

S ofc
U nmanned
A erial
V ehicle

CALL TOPIC	RTD on new portable and micro fuel-cell solutions
START-DATE	1 December 2011
END-DATE	30 November 2014
TOTAL BUDGET	€3,873,401
FCH JU CONTRIBUTION	€2,109,514
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: HyGear Fuel Cell Systems BV

Partners: Adelan Ltd, Catator AB, CNR-ITAE, Airbus Group Innovations UK and Germany, efceco, University of Birmingham, West Pomeranian University of Technology Szczecin, SURVEY Copter SAS.

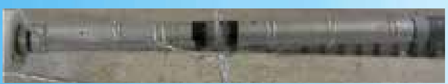
PROJECT WEBSITE/URL

www.suav-project.eu

PROJECT CONTACT INFORMATION

Dr. Ellart de Wit - ellart.de.wit@hygear.nl (coordinator contact)

Dr. Erich Erdle – efceco@efceco.com (technical contact)

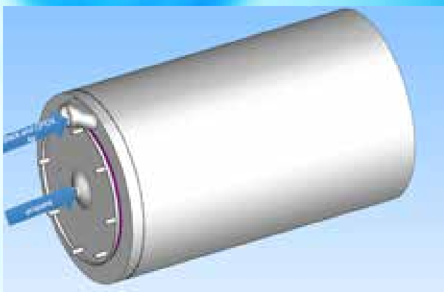


MAIN OBJECTIVES OF THE PROJECT

The objective of the project is to design, optimise and build a fuel-cell power generator for small unmanned aerial vehicles (mini-UAV). The stack to be developed will be integrated together with the required fuel processor and mechanical as well as electrical balance of plant components. The fuel-cell generator will be packaged and placed into a mini-UAV. The advanced mini-UAV will be tested in a flight mission with the goal of achieving three-times longer flight endurance compared to batteries.

PROGRESS/RESULTS TO DATE

- Top-level requirements for fuel-cell system in UAV defined including battery size
- Improved tubular cell power from 1W to 7W (hydrogen flow)
- Design of tubular SOFC stack (micro-SOFC)
- Stress calculation and modelling of micro-SOFC-stack
- Development of highly integrated fuel-cell power system design to implement fuel-cell power system in UAV



FUTURE STEPS

- Manufacture fuel-cell power system
- Integrate fuel-cell power system and UAV
- Perform flight mission with FC-equipped UAV

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Cell power improvement difficult to achieve
- Sealing big challenge for tubular SOFC
- Weight/volume constraints hard to tackle
- Perspective to achieve European technology with higher energy densities compared to other technologies (e.g. batteries)

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Portable & micro FCs on EU market in 2012	400	Project started in 2011, targeted to mini-UAV	
MAIP	Portable & micro FCs on EU market in 2015	12,000–13,000	Not on market, SUAV will end in November 2014, targeted to a mini-UAV prototype	
MAIP	Development of miniaturised BoP for specific devices		As the fuel-cell generator including fueling has to fit into a mini-UAV the BoP components have to be miniaturised	Stack and BoP miniaturised, development of special lightweight air valve (50 g in total)
MAIP	Assessment of fueling supply options		On-board fueling with propane for long range missions	Propane is the fuel to fly with
MAIP	Supportive actions for SME		SURVEY Copter is customer and contributor in SUAV SME, producer of mini-UAV and part of Airbus HyGear Fuel Cell Systems B.V., ADELAN Ltd. and CATATOR SA as developer and manufacturer of the core modules with efceco as technical consultant	
MAIP	Pre-normative research on safety, emissions etc.		Is part of the top level requirements task related to civil aviation	
AIP	Stack power	$200W_e$ net	$250W_e$	Potentially $300W_e$
AIP	On-board fuel storage		Propane on-board storage	
AIP	Fuel processing		Pre-reformer development	Highly integrated CPOX fuel-cell system, to be manufactured
AIP	Stack		Sack development	Not yet complete
AIP	Balance of plant		Mechanical and electrical balance of plant	Highly integrated fuel-cell power system designed
AIP	Power electronics and controls		Controls development	Development on-going with delay
AIP	Proof-of-concept unit		Assembly of lab test and UAV unit	Manufacturing not started yet
AIP	System validation through testing		Lab testing and flight mission of UAV version	Delayed: to be performed at later stage of the project

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

SUSANA

SUpport to Safety ANAlysis of Hydrogen and Fuel Cell Technologies

CALL TOPIC	Computational fluid dynamics (CFD) model evaluation protocol for safety analysis of hydrogen and fuel-cell technologies
START-DATE	1 September 2013
END-DATE	31 August 2016
TOTAL BUDGET	€2,119,669
FCH JU CONTRIBUTION	€1,159,124
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: Karlsruhe Institute of Technology

Partners: University of Ulster, National Centre for Scientific Research "Demokritos", JRC-IET, Health and Safety Laboratory, element energy, AREVA.

PROJECT WEBSITE/URL

www.susana.eu

www.support-cfd.eu

PROJECT CONTACT INFORMATION

Olaf Jedicke

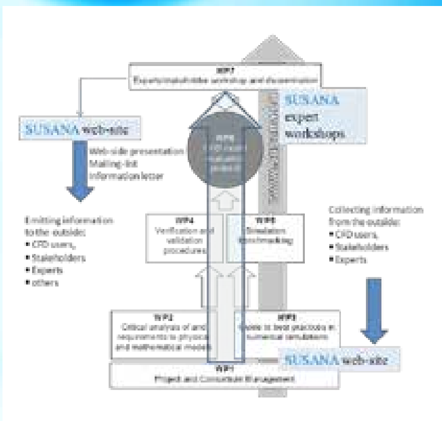
Olaf.Jedicke@kit.edu

MAIN OBJECTIVES OF THE PROJECT

The project builds on the complementarities of expertise of leading European experts in 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. SUSANA aims to support all stakeholders using CFD for safety engineering design and assessment of FCH systems and infrastructure, especially those with no specialised knowledge in hydrogen safety and associated CFD modelling/simulations practice, through the development of the CFD model evaluation protocol, specialised databases, etc.

PROGRESS/RESULTS TO DATE

- List of experiments for CFD benchmarking
- Best practice in numerical simulation – interim report
- International experts' list on modelling and simulation
- State-of-the-art review of FCH technologies
- SUSANA website, share point and access provisions to database



FUTURE STEPS

- International expert workshop September 2014
- CFD benchmarking according: release and distribution, ignition and fire, deflagration, DDT, detonation
- Database is nascent

SWARM

Demonstration of Small 4-Wheel fuel cell passenger vehicle Applications in Regional and Municipal transport

CALL TOPIC	Large-scale demonstration of road vehicles and refuelling infrastructure IV
START-DATE	1 October 2012
END-DATE	30 September 2016
TOTAL BUDGET	€17,603,942
FCH JU CONTRIBUTION	€6,978,277
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: PLANET Planungsgruppe Energie & Technik GbR

Partners: Riversimple, H_2O e-mobile GmbH, GESPA, Air Liquide Advanced Technologies, University of Birmingham, Coventry University Enterprises Limited, Birmingham City Council, Université Libre de Bruxelles, Université de Liège, Jahde-Hochschule Wilhelmshaven/Oldenburg/Elsfleth, EWE-Forschungszentrum für Energietechnologie, Universität Bremen, TÜV Süd Product Service, Wallonia Regional Government, Element Energy Limited, Deutsches Forschungszentrum für künstliche Intelligenz.

PROJECT WEBSITE/URL

www.swarm-project.eu

PROJECT CONTACT INFORMATION

Robert Steinberger-Wilckens
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MAIN OBJECTIVES OF THE PROJECT

Delivery and operation of a critical mass of passenger and delivery vehicles (close to 100 vehicles) and infrastructure (three new H_2 refuelling stations), development of commercialisation and market entry strategies, enlargement and extension of existing hydrogen infrastructure, extensive performance monitoring.

PROGRESS/RESULTS TO DATE

- Identification of users
- Identification of sites for HRS
- Initiation of research, first results
- Roll-out of first vehicles

FUTURE STEPS

- Delivery of vehicles to users
- Opening of HRS at all three sites
- Research on fuel cells to improve driving experience
- Research on user acceptance

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Sourcing of reliable and reasonable-cost fuel-cell systems still a problem
- Siting of HRS is an involved process
- Cost of HRS still far too high
- Pre-financing of SMEs remains a major issue.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Number of hydrogen vehicles	500 (?)	92	3
MAIP	Number of new HRS	3 (?)	3	3 from end of 2014
AIP	Energy efficiency tank-to-wheel	40%	>40%	tbc
AIP	H_2 price at pump (€/kg)	<€13	€10	€10

T-CELL

Innovative SOFC Architecture based on Triode Operation

CALL TOPIC	Next generation stack and cell design
START-DATE	1 September 2012
END-DATE	31 August 2015
TOTAL BUDGET	€3,424,167
FCH JU CONTRIBUTION	€1,796,267
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

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

Partners: Centre national de la recherche scientifique (CNRS), Ecole Polytechnique Federale de Lausanne, Instituto de Ciencia de Materiales de Sevilla, Mantis Deposition Ltd, Prototech AS, SOFCpower.

PROJECT WEBSITE/URL

www.tcellproject.eu

PROJECT CONTACT INFORMATION

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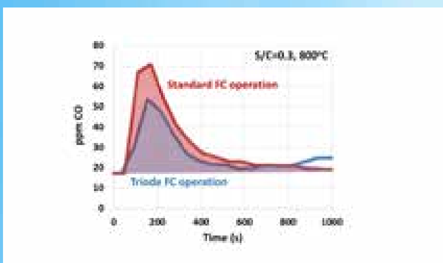


MAIN OBJECTIVES OF THE PROJECT

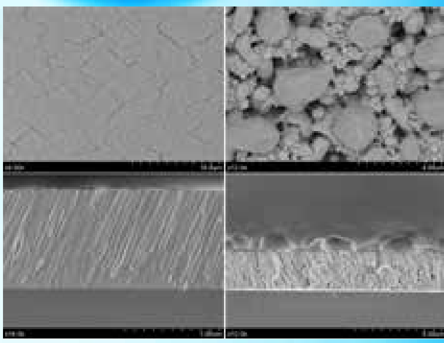
The project objective is the investigation of the synergetic effect of advanced Ni-based cermet anodes modified via doping with a second or a third metal in conjunction with triode operation, in order to control the rate of carbon deposition and sulphur poisoning. A detailed mathematical model will be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

PROGRESS/RESULTS TO DATE

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

FUTURE STEPS

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



CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- The synergy between Au-Mo-Ni regarding electrocatalytic stability under CH4 steam reforming has been proven.
- The addition of Au and Au-Mo doped materials modifies the reducibility of both Ni/YSZ and Ni/GDC catalysts.
- Magnetron sputtered Ni-YSZ films exhibit good electrical conductivity and can form buffer layer between anode and electrolyte.
- Triode operation results in 40-50% lower carbon deposition on commercial anodes.
- Minimising resistance between the cathode and auxiliary electrode is crucial for triode performance.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

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

TriSOFC

Durable Solid Oxide Fuel Cell Tri-generation System for Low Carbon Buildings

CALL TOPIC	Proof-of-concept fuel-cell systems
START-DATE	1 August 2012
END-DATE	31 July 2015
TOTAL BUDGET	€2,735,560
FCH JU CONTRIBUTION	€1,481,391
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: University of Nottingham

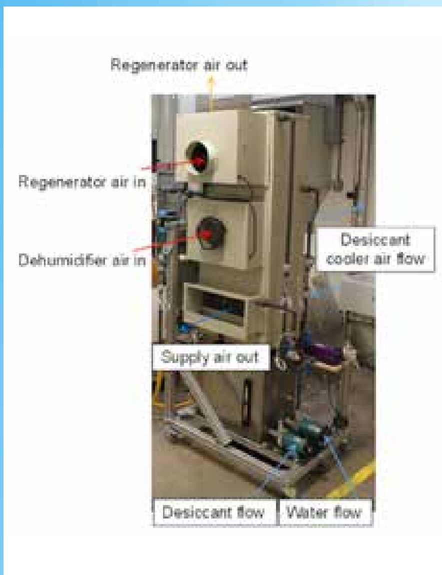
Partners: Swedish Royal Institute of Technology, University of Birmingham, IDMEC–Polo FEUP, GETT Fuel Cells International AB, Vestel Savunma Sanayi A.S.Turkey, Complex Ltd, Swerea IVF.

PROJECT WEBSITE/URL

www.trisofc.com

PROJECT CONTACT INFORMATION

Saffa.riffat@nottingham.ac.uk



MAIN OBJECTIVES OF THE PROJECT

TriSOFC aims to design, optimise and build a 1.5kW 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 utilised 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, in real-life conditions on the Creative Energy Homes platform built at the University of Nottingham.

PROGRESS/RESULTS TO DATE

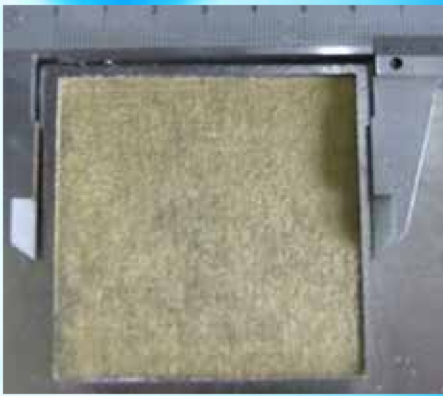
- Desiccant unit simulation complete
- Potassium formate selected as working fluid
- Desiccant unit designed, built and tested
- 3-in-1 single component fuel cell developed and tested
- 1100W/cm^2 achieved - 12W power output from two-cell stack

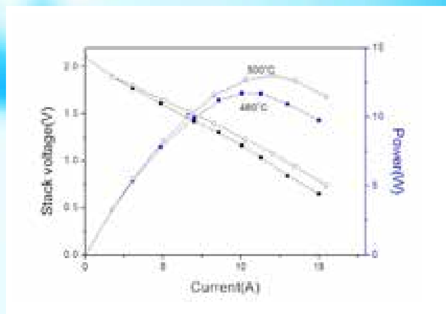
FUTURE STEPS

- Develop LT-SOFC stack
- Develop LT-SOFC reformer
- Develop prototype tri-generation system
- Develop field trial system

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- Potassium formate was found to be the most suitable desiccant for the system.
- A novel combined dehumidifier/cooler/regenerator has been developed and will provide a basis for compact, light-weight and low-cost tri-generation for the fuel cell.
- Single component fuel cells working at low temperatures (500°C-600°C) will enable cost reductions in BoP and improvement in performance.





CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	Power range	1-5kWe	200-1,500We	N/A (test not finalised)
AIP	Efficiency	35% to 45% (elec) 75% to 85% total	Expect 40-45% (elec) 85%-95% total	Estimates from modelling: actual performance will be determined during prototype testing
AIP	Durability	30,000h	40,000h	100h
AIP	Costs	€2,000/kW	<12	Costs dependent on stack and BoP.

UNIfHY

UNIQUE gasifier for hydrogen production

CALL TOPIC	BTH - Biomass-to-hydrogen (thermal conversion process)
START-DATE	1 September 2012
END-DATE	31 August 2015
TOTAL BUDGET	€3,555,652
FCH JU CONTRIBUTION	€2,203,599
OTHER CONTRIBUTION(S)	

PARTNERSHIP/CONSORTIUM LIST

Coordinator: CIRPS - Interuniversity Research Centre for Sustainable Development - Italy

Partners: Pall Filtersystems Gmbh, National Agency for New Technologies, Energy and Sustainable Economic Development (Italy), HYGEAR, Université de Strasbourg, Engineering Procurement & Construction, Air Liquide.

PROJECT WEBSITE/URL

www.unifhy.eu

PROJECT CONTACT INFORMATION

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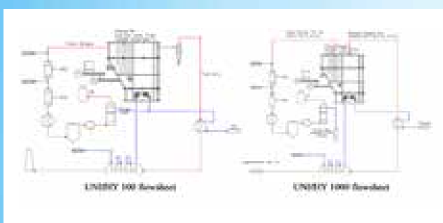

MAIN OBJECTIVES OF THE PROJECT

By exploiting the results obtained in past EU R&D projects on hot gas catalytic conditioning, UNIfHY aims to develop a continuous process for pure hydrogen production from biomass, for fuelling vehicles in a low-cost and effective way, by the integration of: (i) biomass gasification with catalytic hot syngas cleaning and conditioning integrated in the gasifier vessel (UNIQUE gasification concept); (ii) water-gas shift (WGS) performed with catalysts impregnated on ceramic foams; (iii) pressure swing adsorption (PSA) for hydrogen separation from syngas; (iv) high thermal integration and efficiency, by using the H_2-depleted syngas within the conversion process.

PROGRESS/RESULTS TO DATE

- Iron and copper WGS catalysts supported on ceramic alumina foams have been developed and characterised, showing good lifetime, low pressure drop and resistance to sintering.
- Gasification bench-scale tests allowed evaluating the performance of new types of catalytic candle filters.
- Extensive gasification test campaigns were started in order to evaluate the performance of the two prototype gasifiers, without and with the candle filters, using nut shells as biomass feedstock.
- Portable purification system (PPS) modelling and design together with the experimental validation based on the gasification process allowed to evaluate the optimal PSA working conditions.
- An analysis of the economical requirements and the hydrogen target cost (5€/kg) for UNIfHY-based hydrogen production has been done.

FUTURE STEPS

- Conclusion of characterisation and testing of catalysts filters and sorbents at bench-scale
- New results on modelling at different scales
- PPS realisation (PSA, WGS and complementary components) and integration with gasifier systems
- Long-term tests with the prototype reactor
- LCA analysis and ultimate exploitation plan

CONCLUSIONS, MAJOR FINDINGS AND OUTLOOK

- The tests of fluidised bed steam biomass gasifiers integrating the hot gas cleaning system in the freeboard will verify the realisation of compact, high-efficiency and cost-effective gasification systems.
- New materials, as Fe-Cu/Foams, will facilitate highly efficient WGS also at atmospheric pressure that is a constraint for more sustainable small plant sizes, and modified PSA permits to obtain continuous hydrogen production at PEMFC grade even with reduced (>34%) hydrogen content in the feed flow.
- By the analysis of economic requirements and the operative plant scenarios, according to preliminary evaluations UNIfHY is a profitable solution to match the hydrogen target cost of 5€/kg.
- The integrated system is able to produce hydrogen from various biomass feedstocks in the forecourt size range for a hydrogen filling station (from 100 to 500 kg/day) with: (i) energy and cost savings; (ii) reduction of space and components up to 50%; (iii) overall hydrogen efficiency greater than 50% in comparison to standard systems (70% vs 45%).
- Due to the variety and complexity of problems, expertise and know-how, scientific and/or technological, which are necessary to implement the UNIfHY technology, the project combines the efforts and capabilities available in Europe in order to maintain competitiveness on the global market.

CONTRIBUTION TO THE PROGRAMME OBJECTIVES

SOURCE OF OBJECTIVE/TARGET (MAIP, AIP)	ASPECT ADDRESSED	PROGRAMME OBJECTIVE/ QUANTITATIVE TARGET	PROJECT OBJECTIVES/ QUANTITATIVE TARGETS	CURRENT STATUS/ ACHIEVEMENTS TO DATE
MAIP	H2 price at pump (€/kg)	<€5/kg	<€5/kg	Feasible, according to the preliminary exploitation analysis, with a plant utilisation index ≥6000h/year
AIP	Heating value of the gas, including purification, related to heating value of the feedstock	>66%	70%	Feasible, according to the preliminary model evaluation
AIP	LCA analysis	To be conducted	To be conducted	In progress

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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