3EMOTION
Environmentally Friendly, Efficient Electric Motion

Panel 1 — Technology validation in transport applications

Acronym:	**3EMOTION**
Project ID:	303485
Title:	Environmentally Friendly, Efficient Electric Motion
Call Topic:	SP1-JTI-FCH.2013.1.1 (2)
Project total costs (€):	€ 41,891,579
FCH JU maximum contribution (€):	€ 14,999,983
Project start/end:	01 Jan 2015 - 31 Dec 2019
Coordinator:	Van Hool, Belgium
Beneficiaries:	Acetilene & Gastecnici di Bagnoli Maria & C., Air Liquide Advanced Technol., Azienda per la Mobilita del Comune di Roma, Centro Interuniversitario Ricerca Sviluppo Sostenibile, Fit Consulting, Aalborg Kommune, Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile, Rotterdamse Elektrische Tram, Services Automobiles de La Vallee de Chevreuse, Uni. Roma La Sapienza, Commissariat à l'Energie Atomique et aux Energies Alternatives CEA, Communaute Urbaine de Cherbourg, Waterstofnet, Commune de Cherbourg-en-Cotentin, Compagnia Trasporti Laziali, Dantherm Power, London Bus Services Ltd, Provincie Zuid-Holland, Regione Lazio, North Denmark Region, Vlaamse Vervoersmaatschappij de Lijn
Website:	http://www.3emotion.eu/

Project and objectives

The irreversible deployment of fuel cell buses as an alternative to fossil fuel driven public transport is hampered by high costs. By achieving significant reductions on Total Cost of Ownership (TCO) for fuel cell bus operators, 3Emotion seeks to bridge the gap between current demonstration projects towards larger scale deployment as foreseen by the Bus Commercialisation study. With demonstration activities in several key EU bus markets (London, Rotterdam, Pau, Rome, Versailles and Aalborg), the project aims to demonstrate across Europe the potential value of this technology for different types of bus fleets.

Major project achievements

- 4 new buses have been put in operation during the summer of 2017: 2 in London and 2 in Rotterdam. Hence, 12 buses are operational at the moment

Future steps

- Publication of tenders for FC buses for Rome and Aalborg, foreseen for october 2018
- Start of operations in Rotterdam (PZH), foreseen for mid 2018
- Procurement of FC buses for Versailles (foreseen october 2017) and, Aalborg and Rome, foreseen mid 2018
- Integration of Pau and Connexxion as a new partner (to be completed before end 2017): demonstration of 8 articulated "tram look" FC buses
- First evaluation of ongoing demonstrations

Non-quantitative objectives and status

- Development of a transferability plan: appropriate bus business concepts will be developed for interested stakeholders to identify opportunities for FC bus operations in daily business
- Consolidation and enhancement of Hydrogen Bus Centre of Excellence: Practical information for future users is a key requirement in the deployment of fuel cell bus technology. This information will be made available

Relevant to FCH JU overarching objectives

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

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
MAIP 2008-2013	FC Bus purchase cost	EUR	1,120,000	850,000	850,000	<850,000	Delayed	Procurement of post-prototpye phase FC buses
MAIP 2008-2013	FC Bus fuel consumption	kg/100km	11	8.51			Delayed	Realisation through accurate monitoring during demonstrations
MAIP 2008-2013	FC System Lifetime	hours	15,000	15,000			Due later	Demonstrations not started, lifetime based on suppliers warranty.
MAIP 2008-2013	Vehicle availability	%	83	90			Due later	Vehicles not yet or not yet long enough in operations for evaluation.
AWP 2013	Number of bus fleets deployed	fleets	6	6	2		Due later	Buses in Rotterdam and London are operational.
AWP 2013	Number of higher capacity refuelling stations deployed	HRIs	3	3			Due later	Sites with new HRS's are Pau, Aalborg and Versailles. They will be operational at a later phase.

PROGRAMME REVIEW DAYS 2017

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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CHIC
Clean Hydrogen in European Cities

Panel 1 — Technology validation in transport applications

Acronym:	**CHIC**
Project ID:	256848
Title:	Clean Hydrogen in European Cities
Call Topic:	SP1-JTI-FCH.2009.1.1
Project total costs (€):	€ 81,956,227
FCH JU maximum contribution (€):	€ 25,878,334
Project start/end:	01 Apr 2010 - 31 Dec 2016
Coordinator:	Evobus, Germany
Beneficiaries:	Suedtiroler Transportstrukturen, Air Products, Hysolutions, Infraserv & Co. Hochst Kg, Air Liquide Hydrogen Energy, Azienda Trasporti Milanesi, Berliner Verkehrsbetriebe, British Columbia Transit, Centro Ricerche Fiat, Ruter, Element Energy Ltd, Spilett New Technol., Euro Keys, Total Deutschland, Uni. Stuttgart, Vattenfall Europe Innovation, Hycologne - Wasserstoff Region Rheinland, Hydrogen, Fuel Cells and Electro-mobility in European Regions HYER, Linde, London Bus Services Ltd, Pe International, Planet Planungsgruppe Energie und Technik, Postauto Schweiz, Shell Downstream Services International, Wrightbus Ltd
Website:	http://chic-project.eu/
Twitter:	@CHICproject

Project and objectives

CHIC was the crucial next step for the full commercialisation of hydrogen powered fuel cell buses. Project targets were set for fuel cell (FC) lifetime, fuel consumption, availability, running distance and hours of operation. CHIC has met and in many instances significantly exceeded expectations. It has provided further necessary evidence for the functionality of hydrogen FCl buses and the refuelling infrastructure, and the practicality of their commercialisation in the near term. The project was completed in December 2016. The public project report can be found on the CHIC website.

Major project achievements

- Greatly increased FC bus efficiency, halving the fuel consumption of previous bus generations
- Greatly increased FC lifetime exceeding targets of the project and AIP and far in excess of any previous transport FCs
- Refueller availability comparable to diesel and other conventional refuelling infrastructure

Future steps

- Project completed 2016

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
AIP 2009	HRS capacity (upgradeable)	kg		200	200		achieved	upgradable to >= 400kg/day
AIP 2009	HRS availability	%		98	98		achieved	All >94%, 3 sites >98%
AIP 2009	HRS OPEX	€/kg H_2		5	12		Not achieved	12-28 €/kg: Electricity price is dominant factor
AIP 2009	Production efficiency	%		50	54		achieved	All sites >54%
AIP 2009	Diesel replacement	million l		0.50	4.3		achieved	> 1.5 across Phase 1 sites, > 4.3 across all sites
AIP 2009	FC stack lifetime	h		4000	6000		achieved	6820h average
AIP 2009	Bus availability	%		85	69		achieved	Target likely achieved if Oslo oil leak incident is disregarded
AIP 2009	Bus fuel consumption	kg/100 km		13,0	12,1		achieved	12,1 overall 9,9 phase 1 cities
AIP 2009	Distance driven	million km		2.75	9,6		achieved	9,6 overall 4,0 phase 1 cities
AIP 2009	hours of operation	kh		160	519		achieved	519 overall project 269,4 phase 1 cities

Non-quantitative objectives and status

- Reporting of accidents during project 2010-2016
- Global Warming Potential
- 85% savings for fully green H_2 fuel in FC buses
- Individuals interviewed on buses & hydrogen powered transport
- Project Environment: 185
- Critics and Sceptics: 63
- Dissemination and Exploitation
- Local sites general: 50-80 special events in each of 6 cities; Website (>30,000 unique visitors/yr)
- Phase 2 cities identified: 5 Clusters established

Relevant to FCH JU overarching objectives

- Reduce the production cost of fuel cell systems to be used in transport applications, while increasing their lifetime to levels which can compete with conventional technologies
- Increase the energy efficiency of production of hydrogen mainly from water electrolysis and renewable sources while reducing operating and capital costs, so that the combined system of the hydrogen production and the conversion using the fuel cell system can compete with the alternatives for electricity production available on the market

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H2ME
Hydrogen Mobility Europe

Panel 1 — Technology validation in transport applications

Acronym:	**H2ME**
Project ID:	671438
Title:	Hydrogen Mobility Europe
Call Topic:	FCH-01.7-2014
Project total costs (€):	€ 72,0 million
FCH JU maximum contribution (€):	€ 32,0 million
Project start/end:	01 Jun 2015 - 31 May 2020
Coordinator:	Element Energy Ltd, United Kingdom
Beneficiaries:	Linde Gas, H2 Mobility Deutschland, Communaute d'Agglomeration Sarreguemines Confluences, Falkenberg Energi, Hyop, Danish Hydrogen Fuel, Omv Refining & Marketing, Honda R&D Europe (Deutschland), AGA, Hyundai Motor Europe, Symbiofcell, Air Liquide Advanced Technol., Cenex - Centre of Excellence for Low Carbon and Fuel Cell Technol., Mcphy Energy, Nucellsys, BOC Ltd, Areva H2Gen, Intelligent Energy Ltd, Renault, ITM Power (Trading), Waterstofnet, Nissan Motor Manufacturing (Uk) Ltd, Air Liquide Advanced Business, H2 Logic, Icelandic New Energy Ltd, Eifer Europaisches Inst. fur Energieforschung, Linde, Bayerische Motoren Werke, Daimler
Website:	http://chic-project.eu/

Project and objectives

Hydrogen Mobility Europe (H2ME) brings together Europe's four most ambitious national initiatives on hydrogen mobility (from Germany, Scandinavia, France and the UK). The project will expand their developing networks of Hydrogen Refuelling Stations (HRS) - 29 new stations will be deployed - and the fleets of FCEVs operating on Europe's roads (325 vehicles) creating both a physical and a strategic link between these four regions and three 'observer countries' (Austria, Belgium and the Netherlands), who will use the learnings produced by this project to develop their own strategies.

Major project achievements

- Fruitful first two years with 3 HRSs commissioned and 100 vehicles in operation (40 B-CLASS F-CELL Daimler cars and 60 Symbio vans)
- Technical data set delivered and analysed with emerging conclusions for project drafted
- Successful launch of follow-up project, H2ME-2, and collaboration with an extra 1100 vehicles and 20 HRS planned for the next 6 years

Future steps

- Commissioning of the rest of the HRS network
- Deployment of more vehicles, including the first next generation Daimler GLC F-CELL
- A least one major dissemination event
- Solid and growing basis of operational data from vehicles and petrol stations and further fact-based analysis on vehicles and HRS performances

Relevant to FCH JU overarching objectives

- Reduce the production cost of fuel cell systems to be used in transport applications, while increasing their lifetime to levels which can compete with conventional technologies
- Increase the energy efficiency of production of hydrogen mainly from water electrolysis and renewable sources while reducing operating and capital costs, so that the combined system of the hydrogen production and the conversion using the fuel cell system can compete with the alternatives for electricity production available on the market

Non-quantitative objectives

- Minimum of 100 FCEVs and 23 HRS
  100 vehicles and 3 HRS deployed to date - 325 FCEVs and 29 HRS planned in total by the end of the project
- Further activities for deployment of HRS and FCEVs after project
- H2ME-2 and CEF project applications submitted
- HRS to be accessible for private users and integrated in petrol courts
- All of the 700bar HRS will be accessible for private drivers. The 20 x 700bar HRS in Germany will be integrated in petrol forecourts.
- Ensure cross-fertilisation of knowledge acquired in the project
- Dedicated work package and dissemination and exploitation plan to achieve this; 3 observer countries are included in the coalition

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
AIP 2013	Min. FCEV operation during project	mths		12	12	48	achieved	All vehicles to be operated for min. 1 year or 10,000 km. Some vehicles to be operated for 3 years and >30,000km
AIP 2013	Vehicle availability	%	95	98	95	98	Due later	95-98%. measured in available operation time.
AIP 2013	Tank-to-wheel TTW) efficiency	%	40	53	52	53	Due later	40-53% - to be validated in New European Driving Cycle (NEDC) test
MAWP 2014-2020	HRS availability	%	97	97	99	98	Due later	Min. 97% (measured in usable operation)
MAWP 2014-2020	Minimum HRS operation	mths	0	24	12	24	Due later	First HRSs deployed will operate for > 3 years. Last HRS will operate for just under 2 years

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H2ME 2
Hydrogen Mobility Europe 2

Panel 1 — Technology validation in transport applications

Acronym:	**H2ME 2**
Project ID:	700350
Title:	Hydrogen Mobility Europe 2
Call Topic:	FCH-03.1-2015
Project total costs (€):	€ 102,2 million
FCH JU maximum contribution (€):	€ 35,0 million
Project start/end:	01 May 2016 - 30 Jun 2022
Coordinator:	Element Energy Ltd, United Kingdom
Beneficiaries:	Linde Gas, H2 Mobility Deutschland, Hyop, Honda R&D Europe (Deutschland), Gnvert, AGA, Air Liquide Advanced Technol., Islenska Vetnisfelagid Ehf, Communaute Urbaine du Grand Nancy, Stedin Diensten, Societe du Taxi Electrique Parisien, Partnerskab for Brint Og Braendsels Celler, Cenex - Centre of Excellence for Low Carbon and Fuel Cell Technol., Compagnie Nationale du Rhone, Hysolutions, Hydrogene de France, Nucellsys, Symbiofcell, Areva H2Gen, Renault Trucks, Societe d'Economie Mixte des Transports en Commun de l'Agglomeration Nantaise (Semitan), Ministerie van Infrastructuur en Milieu, Intelligent Energy Ltd, Manufacture Francaise des Pneumatiques Michelin, Renault, ITM Power (Trading), Kobenhavns Kommune, McPhy Energy, Nissan Motor Manufacturing (Uk) Ltd, Uni. Manchester, Air Liquide Advanced Business, H2 Logic, Icelandic New Energy Ltd, Eifer Europaisches Inst. fur Energieforschung, Bayerische Motoren Werke, Audi, Open Energi Ltd, Daimler
Website:	www.h2me.eu

Project and objectives

H2ME 2 brings together actions in 8 countries in a 6-year collaboration to deploy over 1,100 fuel cell (FC) vehicles and 20 new hydrogen refuelling stations (HRS). The project will perform a large-scale market test of a large fleet of FC electric vehicles operated in real-world customer applications across multiple European regions. In parallel, it will demonstrate that the hydrogen mobility sector can support the wider European energy system via electrolytic hydrogen production.

Major project achievements

- Fruitful first year with first HRS commissioned (Mariestad, SE) and vehicles procured (STEP Paris, City of Copenhagen)
- Technical data set delivered and analysed with emerging conclusions for project drafted
- Successful collaboration in place with H2ME project

Future steps

- > 50% of the HRS network to be commissioned
- Over 200 vehicles to be deployed including the first next generation Daimler GLC F-CELL
- A least one major dissemination event
- Further fact-based analysis on vehicles and HRS performance

Non-quantitative objectives and status

- Project target: 1,114 fuel cell vehicles and 20 HRS
- Demonstration of electrolyser integrated HRS operating in grid balance
- H2ME 2 has a dedicated work package to assess the way in which electrolytic H_2 production in the mobility sector can link to the wider energy system.
- Vehicles supplied from multiple OEMs, including cars and utility vehicle H2ME 2 will deploy cars, light duty vans and trucks from OEMs including Daimler, Honda and Symbio FCell as well procure Hyundai and Toyota cars.
- Ensure cross-fertilisation of knowledge acquired in the project
- Dedicated WP and dissemination and exploitation plan to achieve this.
- 3 observer countries are included in the coalition

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
AIP 2015	Minimum vehicle operation during project	months		36	na	36	delayed	Target 36 months or 45,000 km or 12 months and 10,000km
AIP 2015	Vehicle availability	%	95	98	na	98	delayed	no vehicle in operation
AIP 2015	Tank to wheel (TTW) efficiency	%	40	42	42	53	delayed	To be validated in New European Driving Cycle (NEDC) test.
MAWP 2014-2020	HRS availability	%	95	98	98	98	delayed	To be measured in usable operation @ end of project
MAWP 2014-2020	Hydrogen purity	%	99.99	99.99	99.99	99.99	Due later	All 700bar HRS to be comply with the SAE J2601 and SAE J2799 H_2 dispensed to have a purity >= 99.999%
MAWP 2014-2020	Minimum HRS operation (per station)	months		36	3	36	Due later	measured at end of project

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HAWL

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

Panel 1 — Technology validation in transport applications

Acronym:	**HAWL**
Project ID:	325381
Title:	Large scale demonstration of substitution of battery electric forklifts by hydrogen fuel cell forklifts in logistics warehouses
Call Topic:	SP1-JTI-FCH.2012.4.1
Project total costs (€):	€ 9,0 million
FCH JU maximum contribution (€):	€ 4,3 million
Project start/end:	01 Sep 2013 - 31 Aug 2017
Coordinator:	Air Liquide Advanced Business, France
Beneficiaries: Air Liquide Advanced Technol., BT Products, Cesab Carrelli Elevatori, Crown Gabelstapler, Fm France, Hypulsion, Toyota Material Handling Europe, Diagma, FM Logistic Corporate, FM Polska	
Website:	https://hawlproject.eu/en

Project and objectives

The project aims at accelerating market penetration of fuel cell technologies (i.e. fuel cell forklifts) in European warehouses.

8 different fuel cells were developed and certified for use in Europe.

Following a successful trial, 46 forklifts are now running at FM warehouse in Neuville-aux-Bois (France). Productivity is confirmed for a specific application.

The H_2 solution brings flexibility for the operations, reduces risk and is preferred by former users of the battery alternative.

A French regulation for warehouse H_2 operations was published: this will reduce time for future deployment of H_2 forklifts.

Major project achievements

- Deployment of 46 forklifts: HAWL deployment is one of the main hydrogen warehouses in Europe
- Technical maturity of the solution (station + fuel cells) confirmed: it clearly meets the logistician needs
- Publication of a French regulation for warehouse H_2 applications – reducing permitting time and bringing confidence to the logistic industry

Future steps

- Analysis of the return of experience of the 46 forklifts demonstration
- Preparation of the public conclusions
- Publication / dissemination of the public deliverables

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
MAIP 2008-2013	Cost of fuel cell systems	€/kW		3500	<3000	3000	achieved	Cost at early volume production for FC > 3kW
AIP 2012	System lifetime	hours		10000	8300	10000	Due later	Deployment too short to reach target. NB target forsees service/stack refurbishment)
AIP 2012	FC system efficiency	%		45	45	45	achieved	
AIP 2012	Refueling time	seconds		180	128	128	achieved	

Non-quantitative objectives and status

- Accelerate the market introduction of the technology
  Project allowed to create a strong reference for the European logistic industry strongly helped to convince other customers (see project Hylift-Europe)
- Develop & certify European ranges of FC products and FC-ready forklifts
  8 types of fuel cells certified.
- Solve the safety and acceptance issues
  Project was instrumental in creating French regulation: it will ease future deployments by reducing permitting time
- Assess and demonstrate the productivity given by the technology
  Productivity confirmed for a specific application

Relevant to FCH JU overarching objectives

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

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HIGH V.LO-CITY
Cities speeding up the integration of hydrogen buses in public fleets

Panel 1 — Technology validation in transport applications

Acronym:	**HIGH V.LO-CITY**
Project ID:	278192
Title:	Cities speeding up the integration of hydrogen buses in public fleets
Call Topic:	SP1-JTI-FCH.2010.1.1
Project total costs (€):	€ 29,243,442
FCH JU maximum contribution (€):	€ 13,491,724
Project start/end:	01 Jan 2012 - 31 Dec 2018
Coordinator:	Van Hool, Belgium
Beneficiaries:	Ballast Nedam International Product Management, Cng Net, Dantherm Power, Fit Consulting, Riviera Trasporti, Solvay, Uni. Genova, Waterstofnet, Aberdeen City Council*, Hydrogen, Fuel Cells and Electro-mobility in European Regions HYER, Regione Liguria, Vlaamse Vervoersmaatschappij de Lijn
Website:	http://highvlocity.eu/ and www.fuelcellbuses.eu
Twitter:	@HighVLOCity

Project and objectives

The overall objective of High V.LO-City is to facilitate rapid deployment of FC Buses in public transport operations, by addressing the key environmental and operational concerns that transport authorities are facing today.

This is realised by demonstrating 14 FC Buses and their refuelling equipment in 4 sites throughout Europe (Antwerp, Sanremo, Aberdeen and Groningen). Currently the vehicles in Aberdeen and Antwerp are operational, while those in Groningen and Sanremo will start operations from end 2017.

Major project achievements

- High V.LO City contributes in the largest European FC Bus site in Europe in Aberdeen
- With the demonstration in the High V.LO City project, several other key projects in the deployment of FC Buses could be initiated
- One website collects and presents all required information for partners that want to be informed about FC Bus technology: www.fuelcellbuses.eu

Future steps

- Launch of FC Bus services in Sanremo. We wait for the refuelling equipment to become available
- Start of real service of FC Buses in Groningen. We wait for the refuelling equipment to become available

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
MAIP 2008-2013	Number of operational vehicles			14	9	14	Delayed	The vehicles in Antwerp and Aberdeen are operational. Those for Groningen and Sanremo will come soon.
MAIP 2008-2013	Number of operational FC bus sites			4	2	4	Delayed	The sites of Aberdeen and Antwerp are in operation. Groningen and Sanremo will come soon.
MAIP 2008-2013	Number of operational refuelling stations			4	2	4	Delayed	Refuelling stations in Aberdeen and Antwerp are operational. Groningen and Sanremo are being put in place.
MAIP 2008-2013	FC System cost	€/kW		3,500	2,500		Achieved	
AIP 2010	Set up Centres of Excellence to communicate about FC buses			4	1	1	Achieved	A virtual Centre of Excellence is set up that replaces the original foreseen physical centres. This is the FC Bus website: www.fuelcellbuses.eu

Non-quantitative objectives and status

- Evaluate the entire life cycle costs of buses: currently inputs from the buses are collected: bus performance, maintenance data, costs
- Contribute to the commercialization of H_2 Hybrid buses in Europe: with the demonstration in the High V.LO City project, several other key projects in the deployment of FC Buses could be initiated

Relevant to FCH JU overarching objectives

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

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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HYCARUS
Hydrogen cells for airborne usage

Panel 1 — Technology validation in transport applications

Acronym:	**HYCARUS**
Project ID:	325342
Title:	Hydrogen cells for airborne usage
Call Topic:	SP1-JTI-FCH.2012.1.6
Project total costs (€):	€ 12,0 million
FCH JU maximum contribution (€):	€ 5,2 million
Project start/end:	01 May 2013 - 30 Apr 2018
Coordinator:	Zodiac Aerotechnics, France
Beneficiaries:	Air Liquide Advanced Technol., Dassault Aviation, Zodiac Cabin Controls, Arttic, Commissariat à l'Energie Atomique et aux Energies Alternatives CEA, Driessen Aerospace, Inst. Nacional de Tecnica Aeroespacial, JRC -Joint Research Centre, European Commission, Zodiac ECE
Website:	http://hycarus.eu/

Project and objectives

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

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

Major project achievements

- Completion of the verification tests of the whole GFCS
- Completion of the design and the tests of the different components and sub-systems of the GFCS
- Completion of the functional Hazard Assessment & Preliminary System Safety Assessment

Future steps

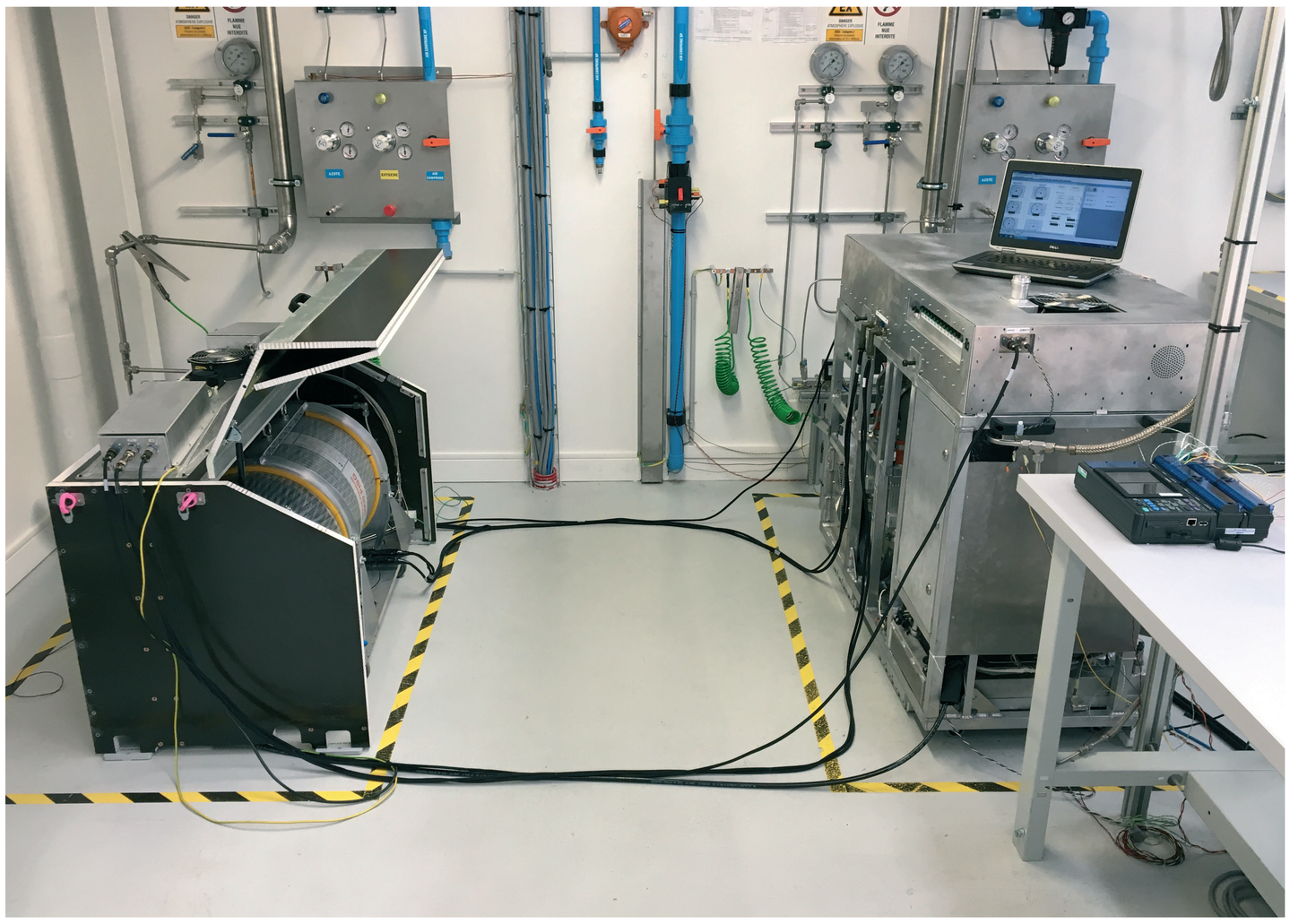
- Completion of the verification tests of the whole GFCS
- System Safety Assessment completion
- Flight Readiness Process completion
- Environmental tests of the GFCS for the flight test configuration

Non-quantitative objectives and status

- Proof of concept of H_2 storage and supply on-board an aircraft
- Gaseous 350 bars H_2 storage and supply system developed. H_2 leakage and safety management strategy approved. Demonstration planned for 2017
- Demonstrate operational capacity for such systems in aircrafts
- Fuel Cell system specification and qualification plan completed. Environmental and Flight tests planned for 2017

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
AIP 2011	Demonstrator TRL	TRL	3	6	4	6	Due later	FC sub-systems tested, Functional FC system tests ongoing for flight tests configuration
AIP 2011	Power range	kW		20.00	12.5	20.00	Due later	FC sub-systems tested, Functional fc system tests for flight tests configuration ongoing (galley configuration tests are planned late on.
AIP 2011	Durability	Hrs		2500	2000	2000	Achieved	Only FC stack durability tests performed (2000 hrs, under flight representative load profiles)
AIP 2011	FC system efficiency (LHV) @ 25% of rated power	%		55	45	45	Not achieved	based on simulation results, tests to be performed in 2018
AIP 2011	FC system power density (End of life – EoL)	kW/L		0.40	0.02	0.02	Not achieved	H_2 storage excluded. Initial target very ambitious in the timeframe of the project, for an aerospace 20kWe FC system.
AIP 2011	FC system specific power (EoL)	kW/kg		0.65	0.10	0.10	Not achieved	H_2 storage excluded. Initial target very ambitious in the timeframe of the project, for an aerospace 20kWe FC system.



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HYFIVE
Hydrogen for innovative vehicles

Panel 1 — Technology validation in transport applications

Acronym:	**HYFIVE**
Project ID:	621219
Title:	Hydrogen for innovative vehicles
Call Topic:	SP1-JTI-FCH.2013.1.1
Project total costs (€):	€ 39,0 million
FCH JU maximum contribution (€):	€ 18,0 million
Project start/end:	01 Apr 2014 - 30 Sep 2017
Coordinator:	Greater London Authority, United Kingdom
Beneficiaries:	Daimler, Linde, Thinkstep, Air Products, Copenhagen Hydrogen Network, Danish Hydrogen Fuel, Honda R&D Europe (Deutschland), Hyundai Motor Europe, Bayerische Motoren Werke, Element Energy Ltd, Foreningen Hydrogen Link Danmark, Omv Refining & Marketing, Istituto per Innovazioni Tecnologiche Bolzano, ITM Power (Trading), Partnerskab For Brint Og Braendsels Celler, Toyota Motor Europe
Website:	http://www.hyfive.eu/

Project and objectives

HyFIVE is an ambitious European project including 15 partners for the deployment of 185 fuel cell electric vehicles (FCEVs) from the five global automotive companies who are leading in their commercialisation (BMW, Daimler, Honda, Hyundai and Toyota).

Refuelling stations configured in viable networks will be developed in three distinct clusters by deploying 6 new stations linked with 12 existing stations supplied by Air Products, Copenhagen Hydrogen Network, Linde, Danish Hydrogen Fuel, ITM Power and OMV.

Major project achievements

- Deployment of 185 vehicles supporting development of hydrogen technologies in 3 EU regions
- Deploying 6 new stations and utilising 12 existing stations to ensure utilisation and future planning
- Increasing consumer awareness as well as existing consumer support

Future steps

- Finalising data submission and data reports
- Finalising consumer attitudes reports
- Organise a final conference for the project in September 2017
- Environmental tests of the GFCS for the flight test configuration

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
MAIP 2008-2013	Nr vehicles deployed			185	185	185	Achieved	
MAIP 2008-2013	Nr HRSs deployed			6	6	6	Achieved	
MAIP 2008-2013	Hydrogen cost	€		10			Not achieved	We expect to achieve this in one or two of the clusters
MAIP 2008-2013	Vehicle operation	km		10,000	10,000		Achieved	Target is 12 months or 10,000 km
MAIP 2008-2013	Vehicle availability	%		95	95	95	Achieved	
MAIP 2008-2013	Station availabilty	%		98	98	98	Achieved	

Non-quantitative objectives and status

- Training and education
  Supporting FCEVs in the field and existing infrastructure: training dealers and first responders; training technicians and sales staff. Training documents
- Safety, regulations, codes and standards
  Refuelling sites are being identified according to safety considerations alongside safety risks for plans to be implemented to manage each of the risk
- Public awareness
  The project aims to raise public awareness and inform public about the technology and the benefits it brings. We do this through twitter, blogs, news

Relevant to FCH JU overarching objectives

- Reduce the production cost of fuel cell systems to be used in transport applications, while increasing their lifetime to levels which can compete with conventional technologies
- Increase the energy efficiency of production of hydrogen mainly from water electrolysis and renewable sources while reducing operating and capital costs, so that the combined system of the hydrogen production and the conversion using the fuel cell system can compete with the alternatives for electricity production available on the market

EG-04-17-700-EN-P

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

Panel 1 — Technology validation in transport applications

Acronym:	**HYLIFT-EUROPE**
Project ID:	303451
Title:	Large scale demonstration of fuel cell powered material handling vehicles
Call Topic:	SP1-JTI-FCH.2011.4.1
Project total costs (€):	€ 22,0 million
FCH JU maximum contribution (€):	€ 9,3 million
Project start/end:	01 Jan 2013 - 31 Dec 2017
Coordinator:	Ludwig-Boelkow-Systemtechnik, Germany

Beneficiaries:
Air Products, Copenhagen Hydrogen Network, Dantherm Power, Fast - Federazione delle Associazioni Scientifiche e Tecniche, Air Liquide Advanced Business, Element Energy Ltd, H2 Logic, Mulag Fahrzeugwerk Heinz Wössner, Heathrow Airport Ltd, Still, JRC -Joint Research Centre, European Commission, Prelocentre

Website: http://www.hylift-europe.eu/

Project and objectives

The aim of HyLIFT-EUROPE is to demonstrate more than 200 fuel cell (FC) material handling vehicles and associated refuelling infrastructure at more than 2 sites across Europe (the initial plan foresaw 5-20 sites), making it the largest European trial of hydrogen fuel cell material handling vehicles to date. This continues efforts of the previous FCH JU supported project HyLIFT-DEMO. In the HyLIFT-EUROPE project, the partners demonstrate FC systems in material handling vehicles from the partner STILL and from non-participating OEMs.

Major project achievements

- Demonstration in real-world operation of 49 materials handling vehicles at the Prelocentre site
- Demonstration in real-world operation of an indoor hydrogen refuelling station including hydrogen supply at the Prelocente site
- Identification of a further customer to install also a fleet of FC forklifts enabling the project to achieve the 200 vehicles target

Future steps

- Extension of the project beyond current end date to demonstrate the new forklifts
- Start-up of second demonstration fleet at second site (137 FC materials handling vehicles in total)
- Large opening ceremony foreseen in second half of 2017

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
MAIP 2008-2013	Nr vehicles	[-]	11	200	49	201	Due later	11 vehicles ex HyLIFT-DEMO, 49 at Prelocentre. Contracts signed for achieving target
AIP 2011	Nr FC systems	[-]	11	200	49	201	Due later	
AIP 2011	FC system efficiency	[%]	45	45-50	>45	>45	Achieved	Target already reached with past generation FC systems
AIP 2011	Refuelling time	[min]	n.a.	~3	2.5	2.5	Achieved	Application of most advanced refuelling technology
AIP 2011	HRS availability	[%]	98	>98	>99	>99	Achieved	Application of most advanced refuelling technology
Project's own	Nr HRS	[-]	0	⩾ 2	2	2	Achieved	

Non-quantitative objectives and status

- Validation of Total Cost of Ownership (TCO) & path towards commercial target
  Validation of TCO and development of the path towards commercial targets are taking place
- Plan and ensure initiation of supported market deployment beyond 2018
  The project and demonstration volume in itself provide first step towards commercialisation by selling the vehicles at commercially competitive prices
- Best practice guide for hydrogen refuelling station installation
  A best practice guide documents in detail the lessons learned from obtaining safety approval for an airport HRS
- European dissemination and supporting of the European industry
  The European dissemination and supporting of the European industry is a still ongoing task to be finished only at the end of the project

Relevant to FCH JU overarching objectives

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

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HYTRANSIT
European Hydrogen Transit Buses in Scotland

Panel 1 — Technology validation in transport applications

Acronym:	**HYTRANSIT**
Project ID:	303467
Title:	European Hydrogen Transit Buses in Scotland
Call Topic:	SP1-JTI-FCH.2011.1.1
Project total costs (€):	€ 17,8 million
FCH JU maximum contribution (€):	€ 7,0 million
Project start/end:	01 Jan 2013 - 31 Dec 2018
Coordinator:	BOC Ltd, United Kingdom
Beneficiaries:	Dantherm Power, Aberdeen City Council*, Element Energy Ltd, Hydrogen, Fuel Cells and Electro-mobility in European Regions HYER, Planet Planungsgruppe Energie und Technik, Stagecoach Bus Holdings Ltd, Van Hool
Website:	http://aberdeeninvestlivevisit.co.uk/Invest/Aberdeens-Economy/City-Projects/H2-Aberdeen/Hydrogen-Bus/Hydrogen-Bus-Project.aspx

Project and objectives

The overall project objective is to prove that the hybrid fuel cell bus is capable of meeting the operational performance of an equivalent diesel bus in long route operation whilst offering significant benefits in terms of OPEX and environmental performance.

The project will also address bus capital cost, the main commercial barrier to the technology, by deploying state- of-the-art components, to reduce the unit cost of buses below €1.1 million for the first time (excluding non-recurring engineering costs).

Major project achievements

- Europe's largest fuel cell bus fleet has been operated for over two years in Aberdeen
- UK's largest HRS (300 kg/day) installed and commissioned by BOC in March 2015, has operated with very high availability (>99%) for over two years
- HRS has dispensed over 70 tonnes of hydrogen in over 2,300 refuelling

Future steps

- Evaluate the HRS and FC bus performance with life-cycle and technical assessments
- Evaluate economic and environmental impact compared to operating regular diesel buses
- Develop a strategy for continuing FC bus and HRS operation beyond the project

Relevant to FCH JU overarching objectives

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

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Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
AIP 2011	FC lifetime	h	4000	6000	5184	8775	Due later	> 4,000h lifetime initially, > 6,000h as program target
AIP 2011	Bus Availability	%	85	90	75	90	Achieved	+ target of maintenance as for conventional buses
AIP 2011	Fuel Consumption	kg/100km	11-13	10	10.3	10.3	Due later	
AIP 2011	Refuelling capacity	kg/day	50	200	360	360	Achieved	Peak fuelling currently 360 kg/day. Regularly refuelling ~200kg/day
AIP 2011	Nr back-to-back refuellings	#/hour	1-2	6	6	6	Achieved	Each bus fuelling takes <10 minutes, system can manage 6 buses back to back.
AIP 2011	Potential for modular exapnsion of HRS	vehicles/d	100.00	250.00	250.00	250.00	Achieved	Mudular design exceeds the AIP targets
AIP 2011	HRS Availability	%	98	98	99.2	99.5	Due later	Excellent availability to date
AIP 2011	Hydrogen cost	€/kg	10	10			Due later	Cost of H_2 delivered to the buses + H_2 production costs basis is 6 euros/kg, assuming 200kg/day

PROGRAMME REVIEW DAYS 2017

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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NewBusFuel
European Hydrogen Transit Buses in Scotland

Panel 1 — Technology validation in transport applications

Acronym:	**NewBusFuel**
Project ID:	671426
Title:	New Bus ReFuelling for European Hydrogen Bus Depots
Call Topic:	FCH-01.6-2014
Project total costs (€):	€ 2,5 million
FCH JU maximum contribution (€):	€ 2,4 million
Project start/end:	01 Jun 2015 - 31 Mar 2017
Coordinator:	Element Energy, United Kingdom
Beneficiaries:	Ffg Fahrzeugwerkstatten Falkenried, Linde Gas, Wsw Mobil, Mcphy Energy Deutschland, Rigas Satiksme Sia, Hydrogenics, Hyop, Ingenieurteam Bergmeister, Vip Verkehr sbetrieb Potsdam, Air Products, Vattenfall Europe Innovation, Empresa Municipal de Transportes de Madrid, Stuttgarter Strassenbahnen, Akershus Fylkeskommune, Kunnskapsbyen Lillestrom Forening, Abengoa Innovacion, Evobus, Thinkstep, ITM Power (Trading), Aberdeen City Council*, Air Products, Suedtiroler Transportstrukturen, Istituto per Innovazioni Tecnologiche Bolzano, London Bus Services Ltd, Hamburger Hochbahn, H2 Logic, Linde, Vlaamse Vervoersmaatschappij de Lijn, Birmingham City Council, Siemens
Website:	www.newbusfuel.eu

Project and objectives

Produce 13 engineering studies to define optimal designs, H_2 supply routes, commercial arrangements and practicalities involved in refuelling high volumes of H_2 at busy bus depots across Europe.

Conclude on the cost and practical issues associated with hydrogen refuelling at a very large scale by analysing results across all studies

Prepare a range of publically accessible design guideline reports based on the analysis

Disseminate results to a wider audience to ensure the challenge of H_2 fuelling for buses is not seen as a credible reason to delay engagement with the technology.

Major project achievements

- Proved the technical feasibility of H2 bus operation at a large scale meeting local specifications and regulatory conditions
- Demonstrated the ability to provide hydrogen at high reliability for affordable prices (depending on local energy circumstances)
- Developed clear guideline documents which will allow future bus operators to easily and quickly deploy an appropriate HRS solutions for their buses

Future steps

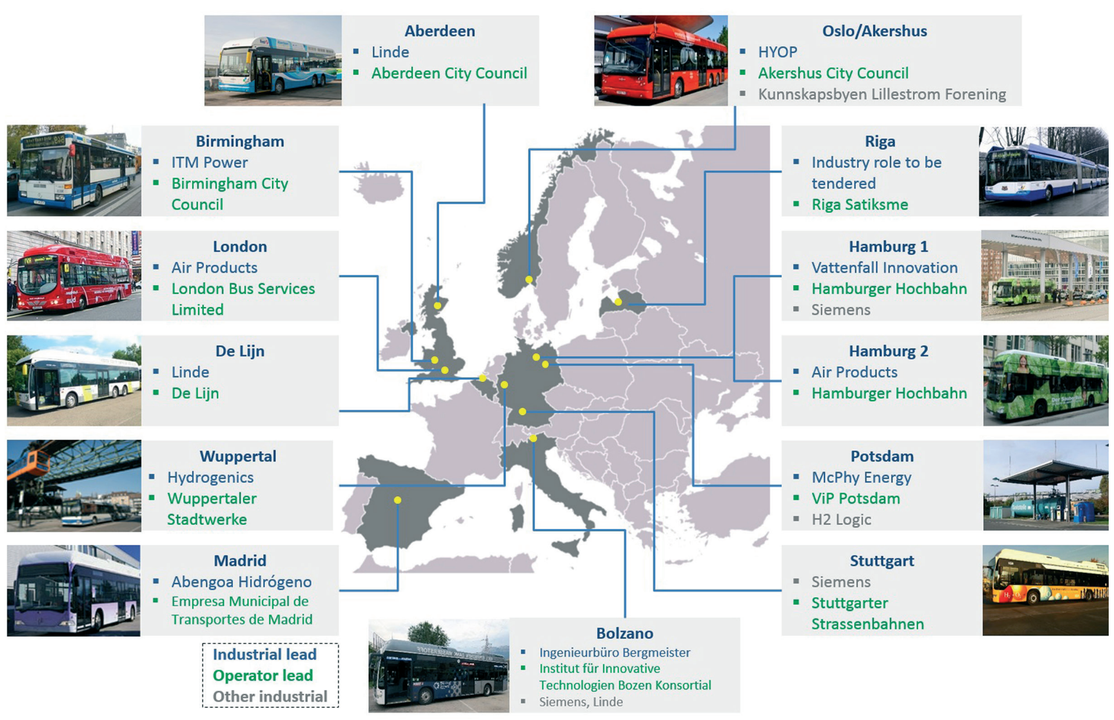
- Project finished

Non-quantitative objectives and status

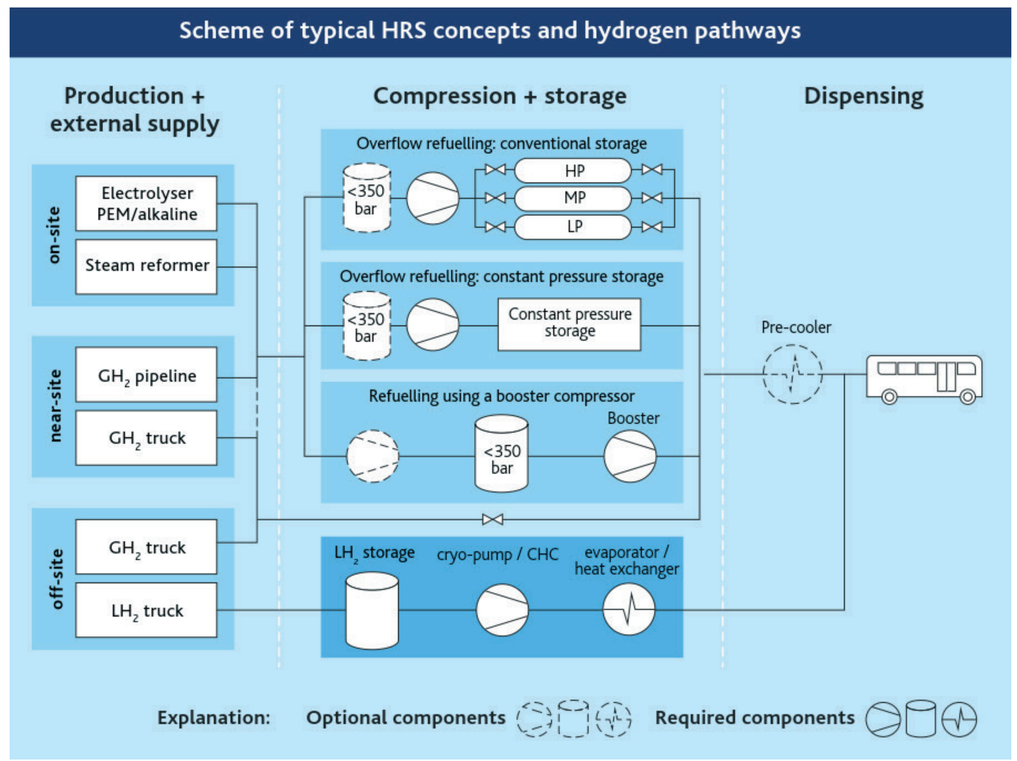
- Consider fuelling station requirements for at least 75-150 buses
  All designs completed and outputs for public dissemination finalised
- Assess H_2 supply options: on-site (WE and SMR), and delivered
  NewBusFuel considered the full range of supply options and demonstrated the conditions required to acquire affordable hydrogen from each option
- Designs should focus on affordable reliable hydrogen supply
  The project has demonstrated that affordable hydrogen (cost range € 5-10/kg) can be delivered at a large bus scale with appropriate reliability
- Opportunities for standardising should be assessed
  Six cross cutting working groups were established to debate cross-industry issues. Outputs finalised in reports for each group

Relevant to FCH JU overarching objectives

- Increase the energy efficiency of production of hydrogen mainly from water electrolysis and renewable sources while reducing operating and capital costs, so that the combined system of the hydrogen production and the conversion using the fuel cell system can compete with the alternatives for electricity production available on the market
- Demonstrate on a large scale the feasibility of using hydrogen to support integration of renewable energy sources into the energy systems, including through its use as a competitive energy storage medium for electricity produced from renewable energy sources



Inter-study partners: Element Energy, thinkstep



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PROGRAMME REVIEW DAYS 2017

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

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PURE
Development of auxiliary power unit for recreational yachts

Panel 1 — Technology validation in transport applications

Acronym:	**PURE**
Project ID:	303457
Title:	Development of auxiliary power unit for recreational yachts
Call Topic:	SP1-JTI-FCH.2011.4.4
Project total costs (€):	€ 2,9 million
FCH JU maximum contribution (€):	€ 1,6 million
Project start/end:	01 Jan 2013 - 30 Jun 2016
Coordinator:	Hygear Fuel Cell Systems, The Netherlands
Beneficiaries:	Danmarks Tek. Uni., Centre for Research and Technology Hellas, Scheepswerf Damen Gorinchem, JRC -Joint Research Centre, European Commission
Website:	http://pure-project.eu/

Project and objectives

In the PURE project an auxiliary power unit (APU) for use on-board of recreational yachts has been designed, built and tested. The objectives were to test a high temperature PEM fuel cell based system running on LPG. The size and weight targets of the 500 W system were 35kg/kW and 50 liters/kW. In the project, improved Membrane-Electrode Assemblies (MEAs) have been developed and new high temperature desulfurisation and sulphur-tolerant auto-thermal reforming (ATR) catalyst materials have been tested. Two prototypes have been constructed and tested in the laboratory. The project has been finalised by a test of a prototype on board of a yacht.

Major project achievements

- Preparation of ATR catalysts for LPG which are sulphur-tolerant
- Development of a new route for MEA preparation with less waste and reduced precious metal content
- Demonstration of a LPG fuelled HT PEM fuel cell system on-board of a recreational yacht

Future steps

- Project finished

Non-quantitative objectives and status

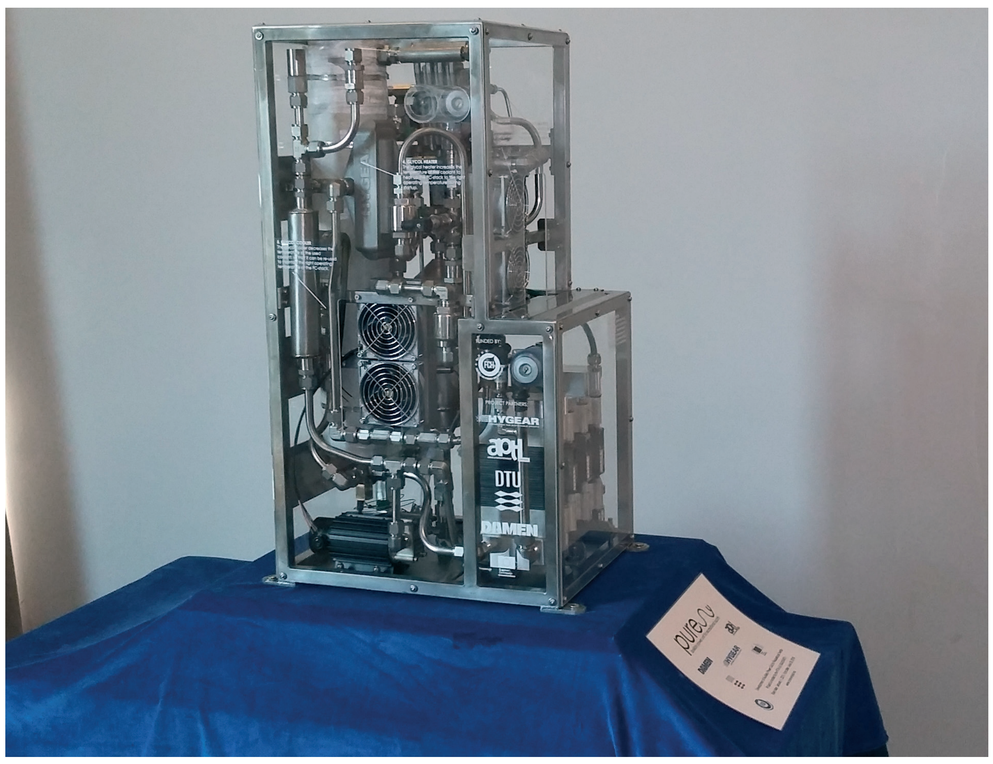
- LPG fuelled system
  The PURE system was demonstrated on board running on LPG
- Sulfur-tolerant ATR catalyst
  catalyst developed which is tolerant to 33 ppm sulfur
- Use 3D metal printed heat exchangers
  3D metal printed heat exchangers developed and successfully tested

Relevant to FCH JU overarching objectives

- Increase the electrical efficiency and the durability of the different fuel cells used for power production to levels which can compete with conventional technologies, while reducing costs
- Increase the energy efficiency of production of hydrogen mainly from water electrolysis and renewable sources while reducing operating and capital costs, so that the combined system of the hydrogen production and the conversion using the fuel cell system can compete with the alternatives for electricity production available on the market
- Reduce the use of the EU defined 'Critical raw materials', for instance through low-platinum or platinum-free resources and through recycling or reducing or avoiding the use of rare earth elements

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
MAIP 2008-2013	Development of miniaturized BoP for specific devices 1	l/kW	380	50	180	180	Not achieved	Compact design, 3D printed metal heat exchangers, with multiple functionality
MAIP 2008-2013	Development of miniaturized BoP for specific devices 2	kg/kW	160	35	100	100	Not achieved	Compact design, 3D printed metal heat exchangers, with multiple functionality
AIP 2011	Stack power	W	500.00	500	500	500	Achieved	Use enough MEA's in the stack
AIP 2011	System electrical efficiency	%	11	30	25	25	Not achieved	High conversion in fuel processor modules
AIP 2011	System cost (mass produced)	€	50000	2500	2317	2317	Achieved	Reduce parts, mass production of stack materials



FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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SWARM

Demonstration of Small 4-Wheel fuel cell passenger vehicle Applications in Regional and Municipal transport

Panel 1 — Technology validation in transport applications

Acronym:	**SWARM**
Project ID:	303485
Title:	Demonstration of Small 4-Wheel fuel cell passenger vehicle Applications in Regional and Municipal transport
Call Topic:	SP1-JTI-FCH.2011.1.1
Project total costs (€):	€ 15,7 million
FCH JU maximum contribution (€):	€ 6,8 million
Project start/end:	01 Oct 2012 - 31 Dec 2017
Coordinator:	Element Energy, United Kingdom
Beneficiaries:	Tuv Sud, Air Liquide Advanced Technol., Coventry Uni. Enterprises Ltd, Deutsches Forschungszentrum fuer Kuenstliche Intelligenz, Birmingham City Council, Ewe-Forschungszentrum für EnergieTechnol., Gespa, H2O E-Mobile, Jade Hochschule Wilhelmshaven/Oldenburg/Elsfleth, Planet Planungsgruppe Energie und Technik, Riversimple Engineering Ltd, Riversimple, Riversimple Movement Ltd, Uni. Birmingham, Service Public de Wallonie, Tuv Sud Product Service, Uni. Bremen, Uni. Liege, Uni. Libre Bruxelles
Website:	http://www.swarm-project.eu/

Project and objectives

SWARM is a demonstration project concerning a fleet of small passenger vehicles that builds on and expands existing hydrogen refuelling infrastructure in the UK, Belgium, and Germany. The vehicles are low-cost, high fuel-efficiency, hybridised, light-weight passenger cars specifically designed for city and regional transport. New hydrogen refuelling sites are to be deployed in each country to close the gaps in a continuous 'hydrogen highway' that leads from Wales and the Midlands to London, connecting to Brussels and Hamburg/Scandinavia/Berlin/ Bremen via Cologne*.

Major project achievements

- 1st full year of operation achieved for vehicles demo and further optimisation have been implemented following collaboration with universities
- 1st full year of operation achieved for HRS demo with additional sites to be rolled out
- Commercial discussions with investors with positive outcomes and preparation for post demo activities strategically for two vehicles OEMs

Future steps

- All demonstration activities at all sites to be fully started or close to
- Further vehicles optimisation and development of next generation models
- Analysis tasks to deliver first project's analysis

Non-quantitative objectives and status

- Fleet of critical mass in small vehicle segment
  Two prototypes developed for two fleets, including gen 3 prototypes ready for next step commercialisation trial
- New regional hydrogen network and increased density of EU network
  First HRS deployed in Brussels (Zaventem), densification of network in the Midlands and Wales, key node for German network linking Germany to Belgium
- Demonstrate a complementary approach to hydrogen vehicle drive trains
  Two prototypes (incl. various gen) developed with novel approach for H_2 vehicles with built-in battery dominant hybrid mode
- Strong engagement and collaboration of EU SMEs and research institutes
  Project dominated by SMEs and research partners and proposed collaboration on improvement work for vehicle development

Relevant to FCH JU overarching objectives

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

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
MAIP 2008-2013	Vehicle energy consumption	Kg/100 km	1	1	1	1	Achieved	Only 5 vehicles (2 suppliers) in operation; Both suppliers have achieved the target
AIP 2011	HRS availability	%	90	95	95	95	Achieved	>95% achieved in Zaventem (2016); 2 more HRS will be commissioned
AIP 2011	Hydrogen price dispensed at pump	€/kg	15	10	10	10	Achieved	Achieved in Zaventem (2016); 2 more HRS will be commissioned
AIP 2011	Lifetime	h	2000	3000			Due later	
AIP 2011	Driving distance	km			25900	200000	Due later	

* Subject to amendment

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