3EMOTION

ENVIRONMENTALLY FRIENDLY, EFFICIENT ELECTRIC MOTION

Project ID	633174
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	SP1-JTI-FCH.2013.1.1: Large-scale demonstration of road vehicles and refuelling infrastructure VI
Project total costs	EUR 38 181 930.72
Clean H_2 max. contribution	EUR 14 999 983
Project period	1/1/2015 – 31/12/2022
Coordinator	Van Hool NV, Belgium
Beneficiaries	Aalborg Kommune, Acetilene & Gastecnici di Bagnoli Maria & C. SAS, Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile, Air Liquide Advanced Business, Air Liquide Advanced Technologies SA, Autocars Dominique, Azienda per la mobilità del Comune di Roma SpA, B.E. green, Centro Interuniversitario di Ricerca per lo Sviluppo Sostenibile, Commissariat à l'énergie atomique et aux énergies alternatives, Communauté urbaine de Cherbourg, Commune de Cherbourg-en-Cotentin, Compagnia Trasporti Laziali, Connexxion Openbaar Vervoer NV, Connexxion Vloot BV, Dantherm Power AS, Fit Consulting SRL, London Bus Services Limited, Provincie Zuid-Holland, Regione Lazio, Region Nordjylland (North Denmark Region), Rotterdamse Elektrische Tram NV, Services automobiles de la vallée de Chevreuse SAS, Syndicat mixte des transports urbains de Pau Porte des Pyrénées, Università degli Studi di Roma 'La Sapienza, Vlaamse Vervoersmaatschappij De Lijn, WaterstofNet VZW

http://www.3emotion.eu/

PROJECT AND OBJECTIVES

The 3Emotion project aims to operate 29 fuel cell buses (FCBs) in five leading European cities – London, Pau, Versailles, Rotterdam (with intercity links throughout the province of South Holland) and Aalborg – and develop three new hydrogen-refuelling stations (HRSs).

Objectives:

- lower H_2 consumption to < 9 kg/100 km;
- integrate the latest drivetrain, fuel cell and battery technology to lower the total cost of ownership and increase FCBs' lifetimes;
- ensure FCB availability of > 90 %;
- increase warranties (> 15 000 hours and improved delivery times of the key components);
- reduce bus investment costs to 850 000 k€ for a 13 m bus.

PROGRESS AND MAIN ACHIEVEMENTS

- All 29 FCBs and all three HRSs are in operation.
- The project has implemented three bus original equipment manufacturers with two different fuel cells at the 'set' bus price of the initial call, operating in different EU sites.
- The buses are largely meeting their targets on H_2 consumption, average consumption and availability.

FUTURE STEPS AND PLANS

- The project will be finalised by 30 December 2022, with the aim of all buses operating at all locations.
- 3Emotion will meet the expectation of having higher capacities at the HRSs. After COVID-19, in the final year of the project, the operation of the buses will be resumed, and full operation of HRSs can be achieved.
- The project will perform the data monitoring and gathering of operational and performance indicators for the FCBs and the HRSs.

QUANTITATIVE TARGETS AND STATUS

Target Source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
Project's own objectives	Lower H_2 consumption for FCBs to < 9 kg/100 km	kg/100 km	9	Average of 8 kg/100 km	✓
	Ensure FCB availability of > 90 %	%	90	≤ 80 %	⚙
	Increase warranties (> 15 000 hours)	hours	15 000	15 000	✓
	Investment cost of <850 000K € for a 13 m bus	€	850 000	850 000	✓

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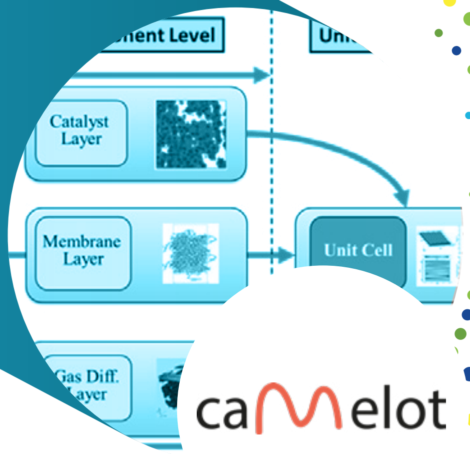


CAMELOT

UNDERSTANDING CHARGE, MASS AND HEAT TRANSFER IN FUEL CELLS FOR TRANSPORT APPLICATIONS

Project ID	875155
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-4-2019: Towards a better understanding of charge, mass and heat transports in new generation PEMFC MEA for automotive applications
Project total costs	EUR 2 295 783.50
Clean H_2 max. contribution	EUR 2 295 783.50
Project period	1/1/2020 – 31/12/2022
Coordinator	Sintef AS, Norway
Beneficiaries	Fuel Cell Powertrain GmbH, Johnson Matthey Fuel Cells Limited, Pretexo, Bayerische Motoren Werke Aktiengesellschaft, Albert-Ludwigs-Universität Freiburg, Technische Universität Chemnitz, Johnson Matthey plc

https://camelot-fuelcell.eu

PROJECT AND OBJECTIVES

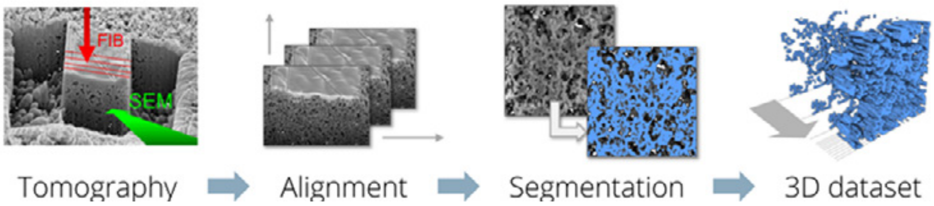
CAMELOT brings together highly experienced research institutes, universities, fuel cell membrane electrode assembly suppliers and transport original equipment manufacturers to improve understanding of the limitations of fuel cell electrodes. This will enable the partners to provide guidance on the next generation of membrane electrode assemblies required to achieve the 2024 performance targets.

PROGRESS AND MAIN ACHIEVEMENTS

The project has successfully validated the updated model for water transport.

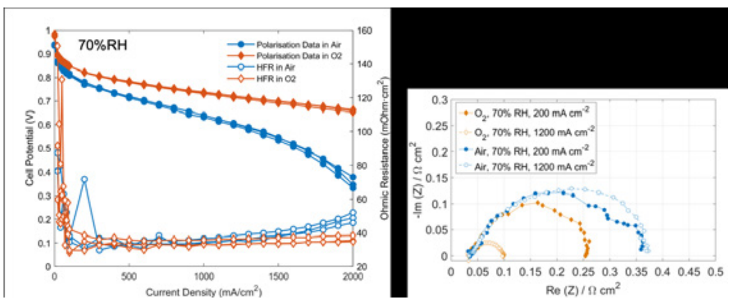
FUTURE STEPS AND PLANS

- The project was on hold for 10 months in 2021 and restarted on 1 January 2022.
- The project timeline was extended by 12 months.



QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	Membrane thickness	µm	< 10	



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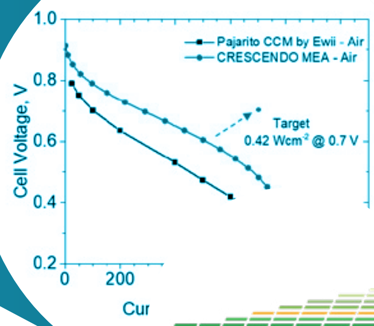
CRESCENDO

CRITICAL RAW MATERIAL ELECTROCATALYSTS REPLACEMENT ENABLING DESIGNED POST-2020 PEMFC



Project ID	779366
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-2-2017: Towards next generation of PEMFC: Non-PGM catalysts
Project total costs	EUR 2 739 602.5
Clean H_2 max. contribution	EUR 2 739 602.5
Project period	1/1/2018 – 30/6/2021
Coordinator	Centre national de la recherche scientifique, France
Beneficiaries	Université de Montpellier, Johnson Matthey Fuel Cells Limited, Pretexo, Bayerische Motoren Werke Aktiengesellschaft, Johnson Matthey plc, Technische Universität Berlin, Commissariat à l'énergie atomique et aux énergies alternatives, Imperial College of Science Technology and Medicine, Università degli Studi di Padova

http://www.crescendo-fuelcell.eu/

PROJECT AND OBJECTIVES

CRESCENDO reached the power density target of 0.42 W/cm² with an air feed with a platinum-group-metal (PGM)-free cathode at 0.6 V, in small-area hardware in optimised operation conditions, in the final weeks of the project. This major achievement is on a par with the highest-performing PGM-free catalysts internationally. The project has identified the gaps between the capabilities of current materials and catalyst layers, and industry needs, and ways to close that gap, comprising increased site density and active-site accessibility, and design features for improved mass transport.

PROGRESS AND MAIN ACHIEVEMENTS

- The power density target was achieved.
- CRESCENDO was strongly affected by COVID-19 owing to university laboratory closures and limitations to on-site working. This meant that the power density target was achieved significantly later than planned, and that activities for scale-up and industrial validation had to be carried out on catalysts that had inferior activity compared with the final project material.

FUTURE STEPS AND PLANS

- The project finished in 2021.
- Innovation Radar analysed and uploaded the results to enable further exploitation; see the web page 'Novel stabilizers and stabilization techniques for non-PGM catalysts for PEMFCs' (https://www.innoradar.eu/innovation/37272).

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SoA result achieved to date (by others)	Year of SoA target
AWP 2018	Power density	W/cm²	0.42 (at 0.7 V)	0.42 (at 0.6 V)	✓	0.45 (at 0.6 V)	2020
	Durability at 1.5 A/cm²	hours	1 000	Not achieved	⚙	No durability data available at 1.5 A/cm²	N/A
	Current density at 0.9 V (iR-free)	mA/cm²	44	41.3	⚙	28.5	2020

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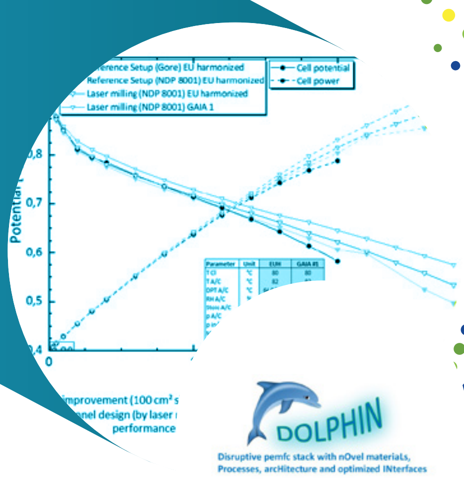
DOLPHIN

DISRUPTIVE PEMFC STACK WITH NOVEL MATERIALS, PROCESSES, ARCHITECTURE AND OPTIMIZED INTERFACES



Project ID	826204
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-6-2018: Game changer fuel cell stack for automotive applications
Project total costs	EUR 2 962 681.25
Clean H_2 max. contribution	EUR 2 962 681.25
Project period	1/1/2019 – 31/12/2022
Coordinator	Commissariat à l'énergie atomique et aux énergies alternatives, France
Beneficiaries	Chemours France SAS, Chemours Belgium, Chemours International Operations SARL, Hexcel Composites GmbH & Co KG, DMG MORI Additive GmbH, Symbio, Faurecia Systemes D'echappement SAS, Hexel Reinforcements SAS, Hexcel Composites Ltd, Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg, University of Manchester

http://www.dolphin-fc.eu/

PROJECT AND OBJECTIVES

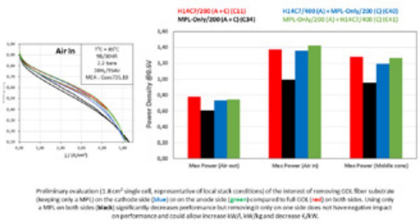
The overall aim of the project is to validate disruptive technologies for 100 kW lightweight and compact fuel cell stack designs, reaching outstanding (specific and volumic) power density, while simultaneously featuring enhanced durability (under automotive application conditions) compared with state-of-the-art (SoA) stacks, and being compatible with large-scale/mass production of full-power stacks. Validation of the DOLPHIN technologies will be supported by the design and fabrication of an automotive stack of 5 kW, representative of 100 kW power stacks.

PROGRESS AND MAIN ACHIEVEMENTS

- Owing to the reduction in rib-channel dimensions, an increase in performance has been achieved.
- Manufacturing methods (printing, laser milling, additive manufacturing, etc.) have been developed to produce flow fields with thin dimensions on metallic and composite thin sheets.

FUTURE STEPS AND PLANS

- The selection of the most promising components/technologies for short stacks and 5 kW stacks is ongoing (2022–2023). Some materials have already been selected.
- The project will undertake performance and durability tests of the 5 kW stack (or 2–3 kW if necessary) (2023). Relevant test protocols have been defined.
- The experimental validation of the different routes of the project to increase performance and durability is ongoing. The life cycle analysis (LCA) will also be one of the parameters to take into account.



QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Target achieved?	SoA result achieved to date (by others)	Year of SoA target
AWP 2018	Weight-specific power density	kW/kg	4		3.4	2017 (by Auto-Stack CORE)
	Volume-specific power density	kW/l	5		4.1	
	Surface power density	W/cm²	2		1.13	
	Durability	hours	6 000		3 500	
	Stack cost	€/kW	20		36.8	

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FCH_2RAIL

FUEL CELL HYBRID POWERPACK FOR RAIL APPLICATIONS

Project ID	826204
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-7-2020: Extending the use cases for FC trains through innovative designs and streamlined administrative framework
Project total costs	EUR 13 341 609.93
Clean H_2 max. contribution	EUR 9 999 999.12
Project period	1/1/2021 – 31/12/2024
Coordinator	Deutsches Zentrum für Luft- und Raumfahrt EV, Germany
Beneficiaries	CAF Digital & Design Solutions SA, Faiveley Transport Leipzig GmbH & Co. KG, Renfe Viajeros SA, Centro de Ensayos y Analisis Cetest SL, CAF Turnkey & Engineering SL, CAF Power & Automation SL, Centro Nacional de Experimentación de Tecnologias de Hidrógeno y Pilas de Combustible Consorcio, Stemmann-Technik GmbH, Renfe Operadora, Toyota Motor Europe NV, Construcciones y Auxiliar de Ferrocarriles Investigacion y Desarrollo SL, Infraestruturas de Portugal SA, Construcciones y Auxiliar de Ferrocarriles SA, Administrador de Infraestructuras Ferroviarias

http://www.fch2rail.eu/

PROJECT AND OBJECTIVES

The project consortium is developing and testing a new train prototype. At the heart of the project is a hybrid, bimodal drive system that combines the advantages of an electrical power supply from the overhead line with a hybrid power pack consisting of fuel cells and batteries. This system allows for more sustainable and energy-efficient rail transport. The project will show that this type of bimodal power pack is a competitive and environmentally friendly alternative to diesel power.

NON-QUANTITATIVE OBJECTIVES

An expert network with external stakeholders has been created to support analysis of gaps in the normative framework.

PROGRESS AND MAIN ACHIEVEMENTS

The project is ongoing. The focus is on case data analysis and developing the methodology.

FUTURE STEPS AND PLANS

- Testing of the fuel cell hybrid power pack (FCHPP) traction system components on the test bench started in 2022 and is expected to end in late autumn 2022. During testing, the system characteristics and the controls will be optimised.
- The integration of the FCHPP traction system into the demonstrator train has started with the integration concept, schematics and drawings. The physical integration of FCHPP components in the demonstrator train will be performed soon.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	System lifetime/ durability	N/A	N/A	
	Hydrogen and electricity consumption	To be configured	To be configured	

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FLAGSHIPS

CLEAN WATERBORNE TRANSPORT IN EUROPE

Project ID	826215
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-2-2018: Demonstration of fuel cell applications for midsize passenger ships or inland freight
Project total costs	EUR 6 766 811.83
Clean H_2 max. contribution	EUR 4 999 978.75
Project period	1/1/2019 – 31/3/2025
Coordinator	Teknologian tutkimuskeskus VTT Oy, Finland
Beneficiaries	Sogestran, Sogestion, Future Proof Shipping BV, LMG Marin France, LMG Marin AS, Norled AS, Seam AS, Maritime Cleantech, Persee, Compagnie Fluviale de Transport, Ballard Power Systems Europe AS, ABB Oy, Kongsberg Maritime AS

http://www.flagships.eu/

PROJECT AND OBJECTIVES

Two commercially operated hydrogen fuel cell vessels will be demonstrated, one in France (Paris) and one in the Netherlands (Rotterdam). The Paris demonstrator is a self-propelled barge operating as a goods transport vessel in the city centre; the Rotterdam demonstrator is a container vessel transporting goods between Rotterdam and Duisburg. The Paris demonstrator vessel is built and is en route to France where H_2 fuel cell systems will be installed. The Rotterdam demonstrator entered the project at the end of 2021, and the design work for that vessel has begun.

NON-QUANTITATIVE OBJECTIVES

- The project aims to develop and demonstrate bunkering technologies based on swapping gaseous hydrogen fuel containers.
- Procedures for hydrogen bunkering are being developed and will be demonstrated in 2022.

PROGRESS AND MAIN ACHIEVEMENTS

- The FCwave fuel cell module that was designed is ready and the type approval process has started.
- The Zulu vessel (Paris demonstrator) design is ready and has been built at the site.

FUTURE STEPS AND PLANS

- The process of gaining approval for the Zulu vessel is ongoing, involving Bureau Veritas and local authorities. Approval is expected to be granted in 2022.
- The project will demonstrate the Zulu vessel in commercial operation. Operations are expected to begin in September 2022.
- FLAGSHIPS will finalise the design and retrofitting of the FPS WAAL vessel. Work started at the beginning of 2022 after an amendment was accepted. It is expected to be finalised in 2022–2023.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	PEMFC system availability	%	95	✓
Project's own objectives	Complete fuel cell and H_2 system cost	€/kW	4 000	
MAWP (2014–2020)	PEMFC system lifetime	hours	25 000	

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FLHYSAFE

FUEL CELL HYDROGEN SYSTEM FOR AIRCRAFT EMERGENCY OPERATION

Project ID	779576
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-1-2017: Development of fuel cell system technologies for achieving competitive solutions for aeronautical applications
Project total costs	EUR 7 296 552.51
Clean H_2 max. contribution	EUR 5 063 023
Project period	1/1/2018 – 30/9/2022
Coordinator	Safran Power Units, France
Beneficiaries	Safran Aerotechnics, Instituto Nacional De Técnica Aeroespacial 'Esteban Terradas', ARTTIC, Universität Ulm, Deutsches Zentrum für Luft- und Raumfahrt EV, Commissariat à l'énergie atomique et aux énergies alternatives

http://www.flhysafe.eu/

PROJECT AND OBJECTIVES

In the shift towards 'More Electric Aircraft" (MEA), fuel cell systems are considered one of the best options for efficient power generation. The main objective of FLHYSAFE is to demonstrate that a cost-efficient modular fuel cell system can replace the most critical safety systems and be used as an emergency power unit aboard a commercial aeroplane, providing enhanced safety functionalities. In addition, the project has the ambition of virtually demonstrating that the system can be integrated, respecting both installation volumes and maintenance constraints, using current aircraft designs.

NON-QUANTITATIVE OBJECTIVES

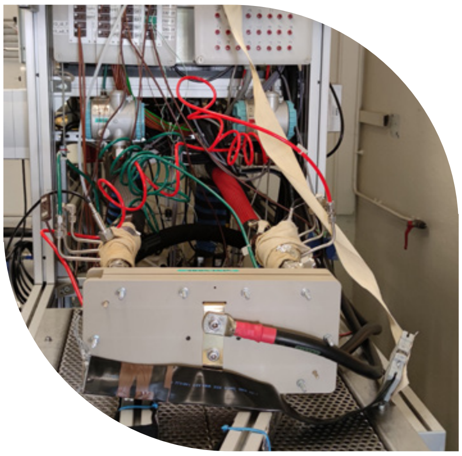
The project aims to prepare a plan of the environmental tests to achieve the airworthiness qualification. Instituto Nacional de Téchnica Aerospacial has initiated the regulations study, and the test plan is in progress.

PROGRESS AND MAIN ACHIEVEMENTS

- The short stack was validated by H_2/O_2 tests.
- A critical design review of the low-temperature module for the fuel cell system was performed.
- A demonstrator critical design review (for major subsystems) was performed.

FUTURE STEPS AND PLANS

- The assembly and testing of the low-temperature fuel cell module are ongoing.
- The assembly and testing of the FLHYSAFE demonstrator are ongoing.
- The total cost of ownership study is ongoing
- The virtual reality study is ongoing.



QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
Project's own objectives	EPU weight (taking into account thermal management, electrical and power management, but excluding hydrogen storage)	kg	150	220	⚙
	System power density	W/kg	100	78	✓
	Nominal continuous electrical power	kW	18.1	18.1	✓

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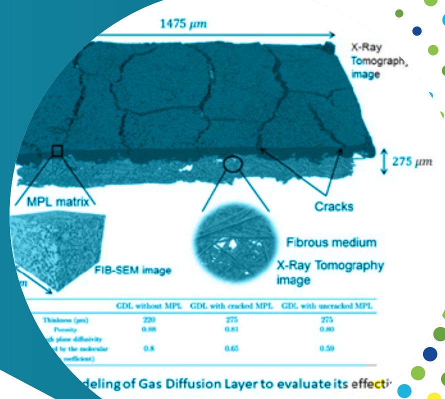

FURTHER-FC

FURTHER UNDERSTANDING RELATED TO TRANSPORT LIMITATIONS AT HIGH CURRENT DENSITY TOWARDS FUTURE ELECTRODES FOR FUEL CELLS

Project ID	875025
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-4-2019: Towards a better understanding of charge, mass and heat transports in new generation PEMFC MEA for automotive applications
Project total costs	EUR 2 735 031.25
Clean H_2 max. contribution	EUR 2 199 567.35
Project period	1/1/2020 – 29/2/2024
Coordinator	Commissariat à l'énergie atomique et aux énergies alternatives, France
Beneficiaries	Chemours France SAS, The Chemours Company FC, LLC, Université De Montpellier, Hochschule Esslingen, Toyota Motor Europe NV, École nationale supérieure de chimie de Montpellier, University of Calgary, Institut national polytechnique de Toulouse, Deutsches Zentrum für Luft- und Raumfahrt EV, Imperial College of Science Technology and Medicine, Paul Scherrer Institut, Centre national de la recherche scientifique (CNRS)

https://further-fc.eu/

PROJECT AND OBJECTIVES

FURTHER-FC proposes complete experimental and modelling coupled platforms to better understand the performance limitations of the cathode catalyst layers (CCLs) of low-Pt-loaded proton-exchange membrane fuel cells. Based on this, CCL improvements will be discussed and tested. Up-to-date references and some customised membrane electrode assemblies (different ionomer-to-carbon ratio, thickness, etc.) have been produced, models of the CCLs are progressing based on their structural characterisation, and the first effective properties have been derived.

PROGRESS AND MAIN ACHIEVEMENTS

- Progress has been made on the characterisation of the CCLs (atomic force microscopy, Raman, three-dimensional focused ion beam scanning electron microscopy, etc.).
- Progress has been made on the modelling of the CCLs.
- The definition and validation of test protocols allows for reliable comparison between the partners.

FUTURE STEPS AND PLANS

- The finalisation of the characterisations of reference and customised membrane electrode assemblies is ongoing.
- The finalisation of the modelling of the CCLs at different scales is ongoing.
- The definition of the most performance-limiting mechanisms is ongoing.
- The upscaling of the models as necessary has not started yet.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Target achieved?	SoA result achieved to date (by others)	Year of SoA target
MAWP (2014–2020)	Volumetric power density	kW/l	9.3		4.1	2017 (by Auto-Stack Core)
	Weight power density	kW/kg	4		3.4	
	Surface power density	W/cm²	1.8		1.13	
	Cost	€/kW	20		36.8	
	Durability	hours	6 000		3 500	
	Total Pt loading	mg/cm²	0.144		0.4	
	Total Pt loading	g/kW	0.08		0.35	
	Pt efficiency	A/mg	15		4.5	

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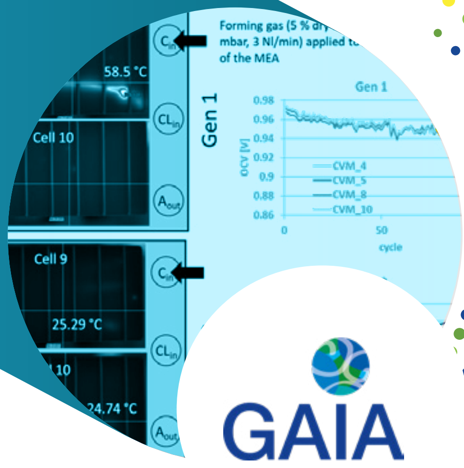
GAIA

NEXT GENERATION AUTOMOTIVE MEMBRANE ELECTRODE ASSEMBLIES



Project ID	826097
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-5-2018: Next generation automotive MEA development
Project total costs	EUR 4 493 025
Clean H_2 max. contribution	EUR 4 493 025
Project period	1/1/2019 – 30/6/2022
Coordinator	Centre national de la recherche scientifique, France
Beneficiaries	Dyneon GmbH, Université de Montpellier, Johnson Matthey Fuel Cells Limited, Pretexo, Freudenberg Performance Materials SE & Co KG, 3M Deutschland GmbH, Elmarco SRO, Bayerische Motoren Werke Aktiengesellschaft, Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg, Johnson Matthey plc, Technische Universität München, Technische Universität Berlin

http://www.gaia-fuelcell.eu/

PROJECT AND OBJECTIVES

GAIA aims to develop high-performance automotive membrane electrode assemblies (MEAs) capable of achieving a 6 000-hour lifetime. By month 38, GAIA had validated its stack hardware and optimised its testing protocols, and developed new carbon support, catalyst, ionomer, membrane, reinforcement, gas diffusion and microporous layer components. The project has reached its first five milestones, which include achieving a leading power density of 1.8 W/cm² at 0.6 V in full-size cell short stacks. Techno-economic evaluation will assess how the GAIA MEA cost is positioned with respect to the very ambitious 6 €/kW MEA cost target.

NON-QUANTITATIVE OBJECTIVES

- The project aimed to perform outreach through videos on catalyst preparation and characterisation by rotating disk electrode and catalyst integration into MEAs and testing/diagnostics, prepared by Technische Universität Berlin and Technische Universität München.
- It aimed to disseminate the results through articles in international journals; four articles have been published and one article has been accepted for publication.
- It also aimed to communicate results through the publication of three newsletters on its website.

PROGRESS AND MAIN ACHIEVEMENTS

- The project developed MEAs that provide 1.8 W/cm² at 0.6 V.

FUTURE STEPS AND PLANS

- GAIA will complete the performance and durability testing with the Gen4 short stack. Testing commenced in 2022.
- The project will complete the techno-economic analysis, which will provide a €/kW metric for the GAIA MEAs.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SoA result achieved to date (by others)	Year of SoA target
AWP 2019	Power density at 0.6 V	W/cm²	1.8	1.8	✓	No public data at 3 A/cm² under call conditions	N/A
	Durability (voltage decay rate)	%	< 10 % after 6 000 hours of operation	Test is running		10 % after 500 hours of automotive drive cycle testing	2019
	MEA cost	€/kW	6	N/A		13 (estimated)	2017

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H2HAUL

HYDROGEN FUEL CELL TRUCKS FOR HEAVY-DUTY, ZERO EMISSION LOGISTICS

Project ID	**826236**
PRD 2022 Panel	**3 – H2 end uses: Transport**
Call topic	**FCH-01-1-2018: Large scale demonstration of H2 fuelled HD trucks with high capacity hydrogen refuelling stations (HRS)**
Project total costs	**EUR 28 137 376.80**
Clean H_2 max. contribution	**EUR 12 000 000**
Project period	**1/2/2019 – 31/1/2024**
Coordinator	**Element Energy Limited, United Kingdom**
Beneficiaries	DATS 24, Plastic Omnium New Energies Wels GmbH, Element Energy, H2 Energy AG, Air Liquide France Industrie, VDL Enabling Transport Solutions BV, VDL Special Vehicles BV, Eoly, FPT Motorenforschung AG, Hydrogenics GmbH, IRU Projects ASBL, FPT Industrial SpA, Air Liquide Advanced Technologies SA, Sphera Solutions GmbH, IVECO SpA, ElringKlinger AG, Etablissementen Franz Colruyt NV, WaterstofNet VZW, Air Liquide Advanced Business, PowerCell Sweden AB, Union Internationale des Transports Routiers, Bayerische Motoren Werke Aktiengesellschaft, Robert Bosch GmbH, Hydrogen Europe

https://www.h2haul.eu

PROJECT AND OBJECTIVES

H2Haul brings together two major European truck OEMs (IVECO and VDL) and three fuel cell stack/system suppliers (Plastic Omnium, Bosch and PowerCell) to develop and demonstrate fleets of heavy-duty trucks in day-to-day commercial operations in four sites across four countries. The overall objective of H2Haul is to prove that hydrogen trucks can be a zero-emission and zero-carbon solution for Europe's trucking needs and, pave the way for the commercialisation of fuel cell trucks in Europe. The project is currently at the end of the planning and pre-deployment phase.

NON-QUANTITATIVE OBJECTIVES

H2Haul aims to:

- Develop long-haul heavy-duty (26 t and 44 t) fuel cell trucks that meet customers' requirements in a range of operating environments.
- Homologate three fuel cell truck types to certify that they are safe to use on Europe's roads. Truck OEMs are working closely with hydrogen safety experts and the relevant certification bodies.
- Develop the business case for the further roll-out of heavy-duty fuel cell trucks, providing a valuable database of real-world performance information and insights into the next steps required for the commercialization of this sector. Analysis will be carried out to highlight the economics of more ambitious deployments of many tens of vehicles or more.
- Prepare the European market for the further roll-out of fuel cell trucks through communication and the dissemination of results to a wide audience of relevant stakeholders.

PROGRESS AND MAIN ACHIEVEMENTS

- The fuel cell truck technical specifications were finalised. Data were gathered on the technical specifications of the fuel cell trucks and hydrogen-refuelling stations (HRSs).
- The first project HRS was deployed.
- The second observer group meeting took place.

FUTURE STEPS AND PLANS

- H2Haul will deploy the VDL and IVECO trucks. The first batches of trucks will be deployed by the end of 2022. The first VDL truck will be delivered to Colruyt in spring 2022 to start commercial operation. The remaining VDL trucks will be deployed by autumn 2022. The IVECO Beta trucks are currently being assembled with fuel cells from Bosch and will be deployed in the fourth quarter of 2022. The remaining four Gamma trucks will be deployed by IVECO in the fourth quarter of 2023.
- The project will commission and start the operation of all remaining project HRSs. Currently, one HRS is in operation in Switzerland; end of 2022.
- H2Haul will continue high-profile dissemination and lobbying work through key conferences and events. It will continue work on observer group and other stakeholder engagement.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target
Project's own objectives and MAWP Addendum (2018–2020)	Truck operational period	Months	Start of operation including ramp-up phase: minimum of 24 months
	Truck distance travelled	km	Min. 30 000 km per truck per year, on average, per site
	Truck availability	%	> 90 % on a fleet basis after an initial ramp-up phase of a max. 6 months
	Truck-specific fuel consumption	kg/100 km	< 7.5 kg/100 km, rigid, at 30–50 % load, inner-city delivery (< 25 km/h on average); < 8.5 kg/100 km, tractor with semi-trailer @30–50 % load, long-haul delivery (> 65 km/h on average)
	Availability of station (by project end)	%	99
	Mean distance between failures	km	Fuel cell MDBF of > 2 500 km
	Well-to-wheel CO_2 emissions of < 50 % of those of diesel trucks	kg of CO_2/km	kg of CO_2/vehicle-km (per vehicle type, average across fleet) of < 50 % compared with diesel trucks
	Speed of hydrogen dispensing	kg/min	> 2.5 kg/min
	Cost of hydrogen dispensed to HRSs	€/kg	≤7.5 €/kg dispensed (excluding taxes) at end of project – in practice, lower values are expected
	Amount of hydrogen dispensed to project trucks	kg/year	> 2 500 kg per truck per year

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H2ME 2

HYDROGEN MOBILITY EUROPE 2

Project ID	700350
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-03.1-2015: Large scale demonstration of hydrogen refuelling stations and FCEV road vehicles – including buses and on-site electrolysis
Project total costs	EUR 100 015 655.40
Clean H_2 max. contribution	EUR 34 999 548.50
Project period	1/5/2016 – 30/6/2022
Coordinator	Element Energy Limited, United Kingdom
Beneficiaries	R-Hynoca, HysetCo, Réseau GDS, Toyota Norge AS, Toyota Danmark AS, Mercedes-Benz AG, McPhy Energy Italia SRL, Element Energy, Stichting Cenex Nederland, B. Kerkhof & Zn BV, Tech Transports Compagnie, Air Liquide France Industrie, Alphabet Fuhrparkmanagement GmbH, Linde Gas GmbH, Íslenska Vetnisfélagið EHF, Communauté Urbaine du Grand Nancy, Stedin Diensten BV, Société du Taxi Electrique Parisien, H2 MOBILITY Deutschland GmbH & Co KG, HYOP AS, Brintbranchen, New NEL Hydrogen AS, Compagnie Nationale Du Rhône SA, Hydrogène de France, Honda R&D Europe (Deutschland) GmbH, GNVert SAS, AGA AB, Symbio, Air Liquide Advanced Technologies SA, Elogen, Société d'économie mixte des transports en commun de l'agglomération nantaise, Ministerie van Infrastructuur en Waterstaat, Intelligent Energy Limited, Manufacture Francaise des Pneumatiques Michelin, ITM Power (Trading) Limited, Centre of Excellence for Low Carbon and Fuel Cell Technologies, Københavns Kommune, hySOLUTIONS GmbH, McPhy Energy, Mercedes-Benz Fuel Cell GmbH, WaterstofNet VZW, Nissan Motor Manufacturing (UK) Limited, Air Liquide Advanced Business, Renault Trucks SAS, Element Energy Limited, Nel Hydrogen AS, Icelandic New Energy Ltd, Europäisches Institut für Energieforschung EDF-KIT EWIV, Stedin Netbeheer BV, Renault SAS, Bayerische Motoren Werke Aktiengesellschaft, Audi Aktiengesellschaft, Open Energi Limited, Daimler AG, University of Manchester

http://www.h2me.eu/

PROJECT AND OBJECTIVES

H2ME 2 brings together actions in eight countries in a 7-year collaboration to deploy 20 hydrogen-refuelling stations (HRSs) and around 1 000 vehicles. The project will perform a large-scale market test of a large fleet of fuel cell 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. The H2ME initiative is the largest European deployment to date for hydrogen mobility, with 897 vehicles and 40 HRSs deployed.

NON-QUANTITATIVE OBJECTIVES

- A minimum of 1 200 fuel cell vehicles and 20 HRSs were planned by the end of the project.
- The project aims to demonstrate the electrolyser-integrated HRS operating in grid balancing. H2ME 2 has a dedicated work package to assess the way in which electrolytic hydrogen production in the mobility sector can link to the wider energy system.
- H2ME 2 aims to deploy cars, light-duty vans and trucks from OEMs including Mercedes, Honda, Symbio, Hyundai and Toyota.
- H2ME 2 aims to ensure the cross-fertilisation of knowledge acquired in the project. A dedicated work plan and a dissemination and exploitation plan are being used to achieve this.

PROGRESS AND MAIN ACHIEVEMENTS

- There were 500 vehicles and 12 HRSs in operation as of February 2022 (in the H2ME 2 project alone).
- Demonstration is under way for more than 800 vehicles from five OEMs (Mercedes, Honda, Hyundai, Symbio and Toyota) and 50 HRSs from five suppliers across six countries (Denmark, France, Iceland, the Netherlands, Sweden and the United Kingdom) – jointly with H2ME.
- The demonstration of positive business cases under H2ME 2 has led to further commitments from partners to expand fleets in Denmark, Germany and France.
- The project is building a rich dataset for Europe, jointly with H2ME. Since 2016, 19.2 million km have been driven and 243 t of H_2 distributed in 104 000 events (figures from November 2021).

FUTURE STEPS AND PLANS

- All 20 HRSs planned for the project are expected to have been commissioned and be in operation by the end of 2022. Almost all the HRSs to be commissioned have the permits required.
- The last vehicles planned for the project are expected to be deployed in the next 6 months.
- The project will build a solid and growing base of operational data from vehicles and HRSs, and undertake further fact-based analysis of vehicles' and HRSs' performances.
- H2ME and H2ME 2, more than 50 reports have been prepared to date. The projects have prepared a summary report for the end of phase 1 of the initiative.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SoA result achieved to date (by others)	Year of SoA target
HRSs							
Project's own objectives, MAWP Addendum (2018–2020) and AWP 2015	HRS availability	%	98	96	⚙	98	2017
	Min. HRS operation	months	36	58	✓	32	
	Hydrogen purity	%	99.99	99.999	✓	99.99	
Fuel cell vehicles							
Project's own objectives, MAWP Addendum (2018–2020) and AWP 2015	Min. vehicle operation during the project	months	36	60	✓	12	2017
	Vehicle availability	%	98	> 99	✓	98	

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H2PORTS

IMPLEMENTING FUEL CELLS AND HYDROGEN TECHNOLOGIES IN PORTS

Project ID	826339
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-03-1-2018: Developing fuel cell applications for port/harbour ecosystems
Project total costs	EUR 4 117 197.50
Clean H_2 max. contribution	EUR 3 999 947.50
Project period	1/1/2019 – 31/12/2022
Coordinator	Fundación de la Comunidad Valenciana para la Investigación, Promoción y Estudios Comerciales de Valenciaport, Spain
Beneficiaries	Valencia Terminal Europa SA Cantieri Del Mediterraneo SpA, Hyster-Yale Nederland BV, Atena scarl – Distretto Alta Tecnologia Energia Ambiente, Mediterranean Shipping Company Terminal Valencia SA, Centro Nacional de Experimentación de Tecnologías de Hidrógeno y Pilas de Combustible Consorcio, Grimaldi Euromed SpA, Ballard Power Systems Europe AS, Autoridad Portuaria de Valencia, Enagás SA, Università degli Studi di Napoli Parthenope, Università degli Studi di Salerno, Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

https://h2ports.eu/

PROJECT AND OBJECTIVES

The H2Ports project will demonstrate and validate two innovative solutions based on fuel cell technologies. A reach stacker and a terminal tractor will be tested on a daily basis during 2 years of real operational activities at the port of Valencia, and a mobile hydrogen-refuelling station (HRS) designed and built during the project will provide the required hydrogen. All three elements are currently in advanced stages of building, and the piloting period is planned to start in summer 2022.

NON-QUANTITATIVE OBJECTIVES

- The project aims to disseminate H_2 technologies to the port maritime sector. This goal has been accomplished through the organisation of the stakeholder advisory group.
- H2Ports will gather information on the use of H_2 in port environments.
- It will gather information on the use of H_2 as fuel for vessels.

PROGRESS AND MAIN ACHIEVEMENTS

- H2Ports has designed a mobile HRS.
- The project has completed the design and component selection for a fuel cell reach stacker.
- It has completed the design and component selection for a terminal tractor.

FUTURE STEPS AND PLANS

It is planned that the two applications (reach stacker and 4 × 4 terminal tractor) will undergo 2 years of piloting under normal operative conditions. The piloting period is expected to start in summer 2022.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	HRS daily capacity	kg/day	60	
	Reach stacker's vehicle power	kW	90	✓
	Vehicle power	kW	75	✓

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HEAVEN

HIGH POWER DENSITY FC SYSTEM FOR AERIAL PASSENGER VEHICLE FUELED BY LIQUID HYDROGEN

Project ID	826247
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-4-2018: Fuel cell systems for the propulsion of aerial passenger vehicle
Project total costs	EUR 4 600 881.68
Clean H_2 max. contribution	EUR 3 995 305
Project period	1/1/2019 – 31/12/2022
Coordinator	Fundación Ayesa, Spain
Beneficiaries	Pipistrel Vertical Solutions DOO podjetje za napredne letalske rešitve, H2FLY GmbH, Air Liquide Advanced Technologies SA, ElringKlinger AG, L'Air Liquide SA, Deutsches Zentrum für Luft- und Raumfahrt EV

https://heaven-fch-project.eu/

PROJECT AND OBJECTIVES

The overall objective of this project is to address the gap between the research and product stages of a zero-emission fuel-cell-based propulsion technology to achieve emission- and noise-reduction scenarios, and meet the 2050 environmental goals for aviation. To that end, a high-efficiency, high-power-density, fuel-cell-based serial hybrid-electric propulsion architecture will be combined with the high energy density of cryogenic hydrogen storage. It will be advanced up to TRL 6.

NON-QUANTITATIVE OBJECTIVES

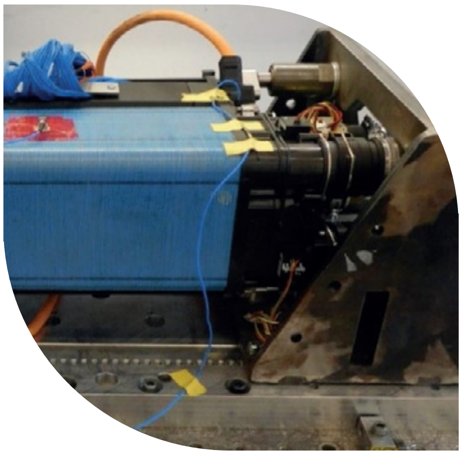
- HEAVEN aims to increase the credibility of the solution for the propulsion of passenger aircraft and UAVs.
- The project aims to advance towards zero-emission hydrogen-powered regional commuter airliners.

PROGRESS AND MAIN ACHIEVEMENTS

- The conceptual design of the overall powertrain is complete.
- The full stack test system has been fully integrated into the test bench.
- Aircraft safety studies are ongoing.

FUTURE STEPS AND PLANS

- HEAVEN will finish manufacturing and testing the liquid hydrogen tank system, which is expected to be done in July 2022.
- The project will couple the powertrain system with the liquid hydrogen system (expected to be in progress until October 2022).
- The overall system will be tested (until February 2023).



QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
Project's own objectives and AWP 2018	FC stack power density in weight	kW/kg	2 kW/kg	2.7 kW/kg (stack including end plates)	
	FC power density in volume	kW/l	3.5 kW/l	4.1 kW/l (stack including end plates)	
	Air subsystem	%	> 50 %	Preliminary results are in compliance with this value but not achieved yet	
	Power converter	kW/kg	8 kW/kg	Preliminary results are in compliance with this value but not achieved yet	
	System lifetime	hours	500 (stack)	N/A	

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HYSHIP

DEMONSTRATING LIQUID HYDROGEN FOR THE MARITIME SECTOR

Project ID	101007205
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-6-2020: Demonstration of liquid hydrogen as a fuel for segments of the waterborne sector
Project total costs	EUR 10 796 560
Clean H_2 max. contribution	EUR 7 993 942
Project period	1/1/2021 – 31/12/2025
Coordinator	Wilh. Wilhelmsen Holding ASA, Norway
Beneficiaries	NorSea Group AS, Diana Shipping Services SA, Wilhelmsen Ship Management (Norway) AS, Air Liquide Norway AS, Stolt Tankers BV, Massterly AS, LMG Marin France, LMG Marin AS, Norled AS, Maritime Cleantech, Persee, DNV GL SE, Equinor Energy AS, Kongsberg Maritime AS, DNV AS, University of Strathclyde, National Centre of Scientific Research 'Demokritos', Eidgenössische Technische Hochschule Zürich

https://hyship.eu/

PROJECT AND OBJECTIVES

HyShip is building two vessels that will run on liquid hydrogen (LH_2). The vessels will transport goods from port to port along the west coast of Norway, and transport LH_2 for bunkering stations for other vessels/trucks running on hydrogen. The project aims to replace trucks on the roads between the ports, demonstrate the use of LH_2 on a vessel and distribute LH_2 to ports to facilitate a LH_2 supply chain. The main key performance indicator of the project is to demonstrate 3 000 hours of operation of 3 MW fuel cells. The design of the vessel is ongoing, and the vessel has not been ordered yet.

NON-QUANTITATIVE OBJECTIVES

- HyShip aims to conceptually design a full range of vessel and hydrogen systems.
- The project aims to develop and describe a business ecosystem with a timeline for cost-efficient operation.
- HyShip aims to integrate the demonstrator into a larger socio-technical system – with business models, policy models and LH_2 supply – that will help move towards use of LH_2.
- The project aims to use further RHODA ship design methods, lowering the cost of estimating complex projects with novel fuel and infrastructure, allowing real-time data collection on the effects of the use of novel fuels (no real-time data provided yet).
- It aims to develop input to the International Maritime Organization, which will help the systems transition to its rules instead of following the alternative design approach.

PROGRESS AND MAIN ACHIEVEMENTS

The preliminary design of vessel and liquid hydrogen propulsion systems is complete.

FUTURE STEPS AND PLANS

- The ship building contract will be signed.
- The vessels will be delivered.
- Vessel operations will begin.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	Fuel cell power output	MW	3.0	
	Hours of operation of LH_2-powered propulsion	hours	3 000	
	Develop an intelligent energy management system that reduces the CAPEX of the energy system by > 5 %	%	5	
	Reduction of > 40 % of cost of design and ship integration cost related to the hydrogen/fuel cell systems themselves	%	40	

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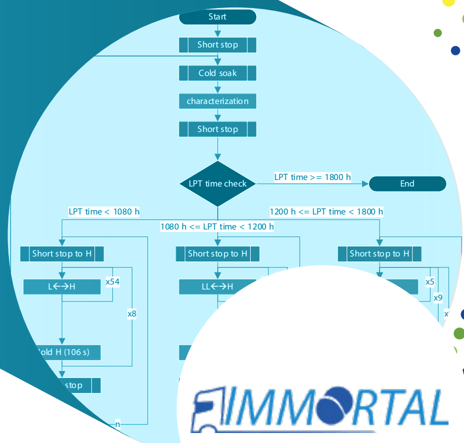
IMMORTAL

IMPROVED LIFETIME STACKS FOR HEAVY DUTY TRUCKS THROUGH ULTRA-DURABLE COMPONENTS



Project ID	101006641
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-2-2020: Durability-lifetime of stacks for heavy duty trucks
Project total costs	EUR 3 825 927.50
Clean H_2 max. contribution	EUR 3 825 927.50
Project period	1/1/2021 – 31/12/2023
Coordinator	Centre national de la recherche scientifique, France
Beneficiaries	FPT Motorenforschung AG, Université de Montpellier, FPT Industrial SpA, Johnson Matthey Fuel Cells Limited, Pretexo, Albert-Ludwigs-Universität Freiburg, Robert Bosch GmbH, Johnson Matthey plc, AVL List GmbH

https://immortal-fuelcell.eu/

PROJECT AND OBJECTIVES

IMMORTAL aims to develop high-performance and high-durability membrane electrode assemblies (MEAs), and their components, specifically designed for heavy-duty truck application. By month 14, an initial set of accelerated and load profile cell and stack tests had been developed and applied to baseline MEAs. Selected actual truck missions were simulated to produce load profiles that will be used to produce load-profile testing procedures. Materials (support, catalyst, membrane) were developed that will be integrated into an initial heavy-duty MEA for single-cell and short-stack testing.

NON-QUANTITATIVE OBJECTIVES

IMMORTAL aims to contribute to activities on Mission Innovation's hydrogen innovation challenge through cooperation with the US Department of Energy's Million Mile Fuel Cell Truck Consortium. Several workshops have been held with the consortium, and with Japan's fuel cell platform, which included discussions on, inter alia, heavy-duty stressors, the second-generation Toyota Mirai and advanced characterisation techniques.

PROGRESS AND MAIN ACHIEVEMENTS

- IMMORTAL has developed catalysts with improved retention of mass activity compared with reference Pt/C catalysts.
- The project has simulated actual heavy-duty truck missions, leading to load profiles that inform cell and stack test protocol development.

FUTURE STEPS AND PLANS

- IMMORTAL will deliver materials for initial heavy-duty specific-catalyst-coated membranes (expected to take place in 2022).
- It will deliver initial heavy-duty specific-catalyst-coated membranes for single-cell, stack-accelerated and load-profile testing as part of work package 2 (expected in 2022).

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SoA result achieved to date (by others)	Year of SoA target
AWP 2020	Cell voltage at 1.77 A/cm^2	V	0.675	0.607		0.675	2021
	Durability	hours	30 000 hours with < 10 % degradation	Durability testing is planned in RP2; MEAs have been developed for heavy-duty trucks		8 500 hours with < 10 % degradation	2020
Project's own objectives	Catalyst surface area and mass activity	cm^2/g of Pt and A/mg of Pt	Exceeding values of reference Pt and better retention after accelerated degradation cycles than reference Pt/C	Two catalyst designs achieve this objective	✓	N/A	N/A

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JIVE

JOINT INITIATIVE FOR HYDROGEN VEHICLES ACROSS EUROPE

Project ID	735582
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-9-2016: Large scale validation of fuel cell bus fleets
Project total costs	EUR 102 467 226.91
Clean H_2 max. contribution	EUR 32 000 000
Project period	1/1/2017 – 31/12/2022
Coordinator	Element Energy Limited, United Kingdom
Beneficiaries	RebelGroup Advisory BV, In-der-City-Bus GmbH, ESWE Verkehrsgesellschaft mbH, Mainzer Verkehrsgesellschaft mbH, Verkehrs-Verbund Mainz-Wiesbaden Gesellschaft mit beschränkter Haftung, Regionalverkehr Köln GmbH, EUE ApS, Dundee City Council, West Midlands Travel Limited, Società autobus servizi d'area SpA AG, Herning kommune, WSW mobil GmbH, Rīgas Satiksme SIA, Trentino Trasporti SpA, EE Energy Engineers GmbH, Gelderland, Sphera Solutions GmbH, hySOLUTIONS GmbH, Aberdeen City Council, Südtiroler Transportstrukturen AG, HyCologne Wasserstoff Region Rheinland EV, London Bus Services Limited, Planungsgruppe Energie und Technik GbR, Birmingham City Council, Fondazione Bruno Kessler, Union Internationale des Transports Publics, Hydrogen Europe

http://www.fuelcellbuses.eu/projects/jive

PROJECT AND OBJECTIVES

The JIVE project exists to assist the commercialisation of fuel cell buses (FCBs) as a zero-emission public transport option across Europe. The project aims to address the current high ownership cost of FCBs relative to conventionally powered buses and the lack of hydrogen-refuelling infrastructure across Europe by supporting the deployment of 142 FCBs in eight locations. This will more than double the number of FCBs currently operating in Europe.

NON-QUANTITATIVE OBJECTIVES

- JIVE aims to demonstrate the suitability and provide experience of FCBs for wider roll-out. Through the publication of project deliverables such as a best practice and commercialisation report, information flows to interested observer parties have been established.
- The project aims to raise awareness of the readiness of fuel cell technology for wider roll-out – with a focus on bus purchasers and regulators. A strong observer group within the JIVE consortium has been established. This group monitors discussions and best practices emerging from the project. This will ensure that the momentum for FCB uptake in Europe continues beyond the project.
- JIVE aims to deliver positive environmental impacts by operating FCBs for extended periods. As per the project objective, all buses deployed thus far in the project are replacing diesel technology. This means that the buses will lead to CO_2 abatement and will not simply operate as a 'visible extra'.

PROGRESS AND MAIN ACHIEVEMENTS

- To date, all 142 buses have been ordered from four bus manufacturers.
- In total, 121 of these buses are currently in operation (85 %).

FUTURE STEPS AND PLANS

- By the end of 2022, all buses are expected to be operational.
- To date, two cities do not yet have operational buses (one of the cities has faced unexpected events that have led to considerable delays, and the other city is expected to have operational buses by summer 2022).

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives and AWP 2016	Vehicle operational lifetime	years	8	
	Distance travelled	km/year	≥ 44 000	
	Operating hours per fuel cell system	hours	> 20 000	
	Availability	%	> 90	⚙
	MDBF	km	> 2 500	
	Specific fuel consumption	kg/100 km	> 9	
	Efficiency	%	> 42	
	Vehicle OPEX	euro	Max. 100 % more than diesel bus OPEX	
	Vehicle CAPEX	euro	< 650 000	✓

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JIVE 2

JOINT INITIATIVE FOR HYDROGEN VEHICLES ACROSS EUROPE 2

Project ID	779563
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-5-2017: Large scale demonstration in preparation for a wider roll-out of fuel cell bus fleets (FCB) including new cities – Phase two
Project total costs	EUR 105 520 120.12
Clean H_2 max. contribution	EUR 25 000 000
Project period	1/1/2018 – 31/12/2023
Coordinator	Element Energy Limited, United Kingdom
Beneficiaries	Transdev Occitanie Ouest, HYPORT, Občina Šoštanj, Element Energy, Engie Energie Services, Communauté d'Agglomération de L'Auxerrois, Connexxion Vloot BV, Rheinsche Bahngesellschaft Aktiengesellschaft, Société publique locale d'exploitation des transports publics et des services à la mobilité de l'agglomération paloise, Stræto bs, Twynstra Gudde Mobiliteit & Infrastructuur BV, Openbaar Lichaam OV-Bureau Groningen en Drenthe, Pau Béarn Pyrénées Mobilités, Landstinget Gävleborg, RebelGroup Advisory BV, Regionalverkehr Köln GmbH, Dundee City Council, Connexxion Openbaar Vervoer NV, WSW Mobil GmbH, Rigas Satīksme SIA, Mestna občina Velenje, Kolding kommune, Transports de Barcelona SA, Sphera Solutions GmbH, Brighton & Hove Bus and Coach Company Limited, Ruter AS, Provincie Zuid-Holland, Petroleos De Portugal – Petrogal SA, Vätgas Sverige Ideell Förening, Noord-Brabant Provincie, Union internationale des transports publics, Hydrogen Europe

http://www.fuelcellbuses.eu/projects/jive-2

PROJECT AND OBJECTIVES

The JIVE 2 project aims to deploy 152 fuel cell buses (FCBs). Combined, the JIVE projects will deploy nearly 300 FCBs in 18 cities across Europe by the early 2020s – the largest deployment in Europe to date.

NON-QUANTITATIVE OBJECTIVES

- JIVE 2 aims to demonstrate the suitability and provide experience of FCBs for wider roll-out. Through the publication of project deliverables such as a best practice and commercialisation report, information flows to interested observer parties have been established.
- The project aims to raise awareness of the readiness of fuel cell technology for wider roll-out – with a focus on bus purchasers and regulators. A strong observer group within the JIVE consortium has been established. This group monitors discussions and best practices emerging from the project. This will ensure that the momentum for the FCB uptake in Europe continues beyond the project.
- JIVE 2 aims to deliver positive environmental impacts by operating FCBs for extended periods. As per the project objective, all buses deployed thus far in the project are replacing diesel technology. This means that the buses will lead to CO_2 abatement and will not simply operate as a 'visible extra'.

PROGRESS AND MAIN ACHIEVEMENTS

- To date, all 156 buses have been ordered.
- To date, 86 buses are operational, which represents 55 % of all the buses.

FUTURE STEPS AND PLANS

- By the end of 2022, all buses are expected to be operational.
- To date, four cities do not yet have operational buses as they are still waiting for their buses to be delivered. The last buses are expected to be delivered in November 2022.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives and AWP 2017	Vehicle operational lifetime	years	8	
	Distance travelled	km/bus	≥ 44 000	
	Operating hours per fuel cell system	hours	> 20 000	
	Availability	%	> 90	
	MDBF	km	> 2 500	
	Specific fuel consumption	kg/100 km	> 9	
	Efficiency	%	> 42	
	Vehicle OPEX	euro	Max. 100 % more than diesel bus OPEX	
	Vehicle CAPEX	euro	< 650 000	✓

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MARANDA

MARINE APPLICATION OF A NEW FUEL CELL POWERTRAIN VALIDATED IN DEMANDING ARCTIC CONDITIONS

Project ID	735717
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-5-2016 – Develop new complementary technologies for achieving competitive solutions for marine applications at an economic scale of implementation
Project total costs	EUR 3 704 757.50
Clean H_2 max. contribution	EUR 2 939 457.50
Project period	1/3/2017 – 28/2/2021
Coordinator	Teknologian tutkimuskeskus VTT Oy, Finland
Beneficiaries	Swiss Hydrogen SA, Persee, OMB Saleri SpA, PowerCell Sweden AB ABB Oy, Suomen Ympäristökeskus

http://projectsites.vtt.fi/sites/maranda

PROJECT AND OBJECTIVES

In the MARANDA project, an emission-free hydrogen-fuelled proton-exchange-membrane-fuel-cell-based hybrid powertrain system (3 × 82.5 kW AC) was developed for marine applications and was validated in test benches and at a durability test site, as approval for testing the systems in the Aranda vessel was not granted. The project increased the market potential of hydrogen fuel cells in the marine sector. General business cases for different marine and harbour actors or fuel cell business actors were created.

NON-QUANTITATIVE OBJECTIVES

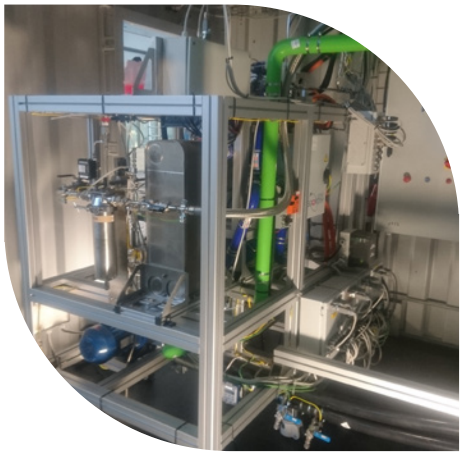
- The MARANDA project has already had a significant impact on the development of regulations, codes and standards.
- The fuel cell systems should be able to withstand the shocks, vibrations, saline environment and ship motions commonly encountered on the water, and other marine-application-relevant requirements. Fuel cell systems and hydrogen storage are designed to withstand these conditions.
- MARANDA aimed to evaluate the economic and environmental impacts for a prospective customer. A report on the business analysis of hydrogen fuel cells for marine applications has been prepared.
- The project aimed to formulate an initial go-to-market strategy. The report on the business analysis includes this strategy.
- MARANDA aimed to map opportunities for future demonstration actions. This is included in a report on the business analysis of hydrogen fuel cells for marine applications.

PROGRESS AND MAIN ACHIEVEMENTS

- Three fuel cell systems from Swiss Hydrogen were assembled, delivered to VTT, integrated in containers, and tested at VTT and at the durability test site.
- A significant improvement in stack durability has been shown by PowerCell Sweden.
- Containers and equipment for the integration of fuel cell systems were designed, manufactured and tested, including all safety systems.

FUTURE STEPS AND PLANS

The final test runs were carried out in March–May 2022; 80 % of the test runs had been completed by 28 February 2022.



QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
AWP 2016	Fuel cell system power	kW	75	75	✓
	Stack durability	mV/1 000 h	4.6	1.7	✓
	Fuel-to-electricity efficiency (alternating current)	%	48	42	✓

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MORELIFE

MATERIAL, OPERATING STRATEGY AND RELIABILITY OPTIMISATION FOR LIFETIME IMPROVEMENTS IN HEAVY DUTY TRUCKS

Project ID	101007170
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-2-2020: Durability-lifetime of stacks for heavy duty trucks
Project total costs	EUR 3 499 913.75
Clean H_2 max. contribution	EUR 3 499 913.75
Project period	1/9/2019 – 31/8/2024
Coordinator	AVL List GmbH, Austria
Beneficiaries	EKPO Fuel Cell Technologies GmbH, Mebius, Raziskovalno razvojna dejavnost, zastopanje in trgovina, DOO, Nedstack Fuel Cell Technology BV, Univerza v Ljubljani, Technische Universiteit Eindhoven, Technische Universität München

https://morelife-info.eu/

PROJECT AND OBJECTIVES

The MORELife project is addressing the need for highly efficient material utilisation, maximised durability and optimised matching of the operation conditions for a proton-exchange membrane fuel cell in heavy-duty applications. The objectives are to:

- perform accelerated stress tests for the shortened test duration for lifetime verification;
- make improvements at material and operation strategy levels;
- create advanced degradation models;
- find the optimised and validated operating conditions based on the improved materials;
- achieve a fuel cell predicted lifetime of 30 000 hours.

PROGRESS AND MAIN ACHIEVEMENTS

The project is currently in an early phase.

FUTURE STEPS AND PLANS

- MORElife will establish in situ and ex situ tests and accelerated stress testing protocols. For material analyses, these will target the mechanistic understanding relevant to heavy-duty application.
- Catalyst-coated membrane preparation on two selected membranes will be carried out. Issue-specific material improvements will be made.
- Membrane electrode assemblies based on innovative materials will be made for assessment in single cells, five-cell small-active-area stacks and the industry-relevant 10-cell short stack.

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PEGASUS

PEMFC BASED ON PLATINUM GROUP METAL FREE STRUCTURED CATHODES

Project ID	779550
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-2-2017: Towards next generation of PEMFC: Non-PGM catalysts
Project total costs	EUR 2 829 016.88
Clean H_2 max. contribution	EUR 2 829 016.88
Project period	1/2/2018 – 31/6/2021
Coordinator	Commissariat à l'énergie atomique et aux énergies alternatives, France
Beneficiaries	Heraeus Amloy Technologies GmbH, Toyota Motor Europe NV, IRD Fuel Cells A/S, École nationale supérieure des mines de Paris, Technische Universität München, Association pour la recherche et le développement des méthodes et processus industriels, Deutsches Zentrum für Luft- und Raumfahrt EV, Agencia Estatal Consejo Superior de Investigaciones Cientificas

http://www.pegasus-pemfc.eu/

PROJECT AND OBJECTIVES

PEGASUS is exploring a promising route towards the removal of Pt and other critical raw materials (CRM) from proton-exchange membrane fuel cells (PEMFCs), and their replacement by non-critical elements and structures enabling efficient and stable electrocatalysis.

NON-QUANTITATIVE OBJECTIVES

- PEGASUS aims to implement new techniques to characterise platinum-group-metal (PGM)-free catalysts for oxygen reduction reaction (ORR) in PEMFCs. Atomic force microscopy (AFM) was combined with scanning electrochemical microscopy (SECM) to quantify the ORR activity of the PGM catalyst at agglomerate level.
- The project aims to perform diagnosis to quantify the O_2, H^+ and e^- transport achieved in PGM-free cathodes.
- PEGASUS aims to achieve benchmark PGM catalysts integrating catalysts from other research groups (US Department of Energy, New Energy and Industrial Technology Development Organization).
- The project delivered a workshop to share the results.

PROGRESS AND MAIN ACHIEVEMENTS

- PEGASUS achieved synthesis of PGM-free catalysts.
- It diagnosed and characterised the PGM-free cathodes for PEMFCs.
- Life cycle analysis was performed on the PGM-free catalysts.

FUTURE STEPS AND PLANS

The project has finished.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SoA result achieved to date (by others)
AWP 2017	Catalyst activity (i geo @ 0.9 V under air)	mA/cm²	44	6.5	⚙	N/A
	Catalyst activity (i geo @ 0.7 V under air)	mA/cm²	600	280		
	Catalyst activity @ 0.9 V (iR-free under O_2)	mA/cm²	75	17.5		
	Diagnosis and in situ characterisation of PGM-free cathode's H^+ resistance and O_2 diffusion	N/A	N/A	N/A		200
Project's own objectives	Implementation of SECM	N/A	N/A	N/A	✓	N/A
	Multigram production of catalyst for one batch	g	5	5		N/A
	LCA/Techno-economic assessment	N/A	N/A	N/A		

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REVIVE

REFUSE VEHICLE INNOVATION AND VALIDATION IN EUROPE

Project ID	779589
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-7-2017: Validation of fuel cell trucks for the collect of urban wastes
Project total costs	EUR 9 278 697.55
Clean H_2 max. contribution	EUR 4 993 851
Project period	1/1/2018 – 31/12/2024
Coordinator	Tractebel Engineering, Belgium
Beneficiaries	Gemeente Noordenveld, Tractebel Impact Belgium SA, Gemeente Groningen, Saver NV, PreZero Nederland Holding BV, Azienda Servizi Municipalizzati di Merano SpA, Servizi Energia Ambiente Bolzano SpA, Swiss Hydrogen SA, Renova Aktiebolag, E-Trucks Europe, Gemeente Breda, Symbio, Stad Antwerpen, WaterstofNet VZW, PowerCell Sweden AB, Element Energy Limited, Proton Motor Fuel Cell GmbH, Gemeente Amsterdam, Commissariat à l'énergie atomique et aux énergies alternatives

https://h2revive.eu/

PROJECT AND OBJECTIVES

REVIVE will significantly advance the state of development of fuel cell refuse trucks by integrating fuel cell powertrains into 14 vehicles and deploying them at eight sites across Europe. The project will deliver substantial technical progress by integrating fuel cell systems from four major suppliers and by developing effective hardware and control strategies to meet highly demanding refuse truck duty cycles. Today, three trucks are in operation, and the remaining trucks will be deployed in the coming months.

NON-QUANTITATIVE OBJECTIVES

- The project aims to involve four fuel cell suppliers. Currently, two EU fuel cell suppliers are involved in the project: Proton Motor and PowerCell Sweden.
- The project aims to demonstrate a route to high utilisation of hydrogen-refuelling stations to support roll-out of H_2 mobility for light vehicles. Even with limited running hours, the three trucks deployed in the project have already consumed 1 t of H_2 during the project.

PROGRESS AND MAIN ACHIEVEMENTS

- All trucks are in the building phase.
- The first Proton Motor fuel cell system has been delivered and successfully integrated.
- The first REVIVE trucks have been deployed.

FUTURE STEPS AND PLANS

- **Deployment preparation.** At project consortium level, sharing of experience and relevant documentation is taking place to fully prepare for truck deployment.
- **Increased dissemination activities.** To catch up following the delays experienced in 2020, a plan for dissemination will be developed.
- **Decrease of teething issues.** The trucks are being tested thoroughly before delivery.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
AWP 2017	Number of FCs deployed in the project	–	15	14	
	Tank-to-wheel efficiency	%	50	N/A	
	Lifetime	hours	25 000	N/A	
	Availability	%	90	N/A	
	Driving Distance Between Failures (MDBF)	km	3 500	N/A	
	Fuel cell power	kW	> 40	45	✓

PRD 2022 PANEL
H2 End Uses - Transport

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SH2APED

STORAGE OF HYDROGEN: ALTERNATIVE PRESSURE ENCLOSURE DEVELOPMENT

Project ID	101007182
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-1-2020: Development of hydrogen tanks for electric vehicle architectures
Project total costs	EUR 1 993 550
Clean H_2 max. contribution	EUR 1 993 550
Project period	1/1/2021 – 31/12/2023
Coordinator	Plastic Omnium Advanced Innovation and Research, Belgium
Beneficiaries	MISAL SRL, Optimum CPV, OMB Saleri SpA, Bundesanstalt Für Materialforschung und -Prüfung, University of Ulster

http://sh2aped.eu/

PROJECT AND OBJECTIVES

The goal of the SH2APED project is to develop and test at technology readiness level 4 a conformable and cost-effective hydrogen 70 MPa storage system with increased efficiency and unprecedented safety performance.

NON-QUANTITATIVE OBJECTIVES

Regarding certification procedures, the project aims to contribute to the revision of regulations.

PROGRESS AND MAIN ACHIEVEMENTS

- The first assembly design has been finalised (several types are available). The vessel design has also been completed and made available.
- Vessel prototypes are available.
- SH2APED has designed pressure container elements (liner–boss reinforcement).
- System testing of the model's reaction to fire is in progress.

FUTURE STEPS AND PLANS

The frame design is ongoing.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SoA result achieved to date (by others)	Year of SoA target
Project's own objectives	H_2 storage volume for estimated design space	%	> 45	43	⚙	41	2021
	Low-cost process for liner	euro	1 million	1 million	✓	3 million	2021
	Burst pressure (R134)	MPa	> 157.5	170	⚙	157.5	2021

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SHIPFC

PILOTING MULTI MW AMMONIA SHIP FUEL CELLS

Project ID	875156
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-2-2019: Scaling up and demonstration of a multi-MW fuel cell system for shipping
Project total costs	EUR 13 179 056.25
Clean H_2 max. contribution	EUR 9 975 477.50
Project period	1/1/2020 – 31/12/2025
Coordinator	Maritime Cleantech, Norway
Beneficiaries	Eidesvik Shipping AS, Wärtsilä Gas Solutions Norway AS, Sustainable Energy AS, North Sea Shipping AS, Star Bulk Shipmanagement Co (Cyprus) Ltd, Wärtsilä Norway AS, Capital-Executive Ship Management Corp, Persee, Prototech AS, Equinor Energy AS, Yara International ASA, University of Strathclyde, National Centre of Scientific Research 'Demokritos', Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung EV

https://shipfc.eu/

PROJECT AND OBJECTIVES

ShipFC's main mission is to prove and show the case for large-scale zero-emission shipping through developing, piloting and replicating a modular 2 MW fuel cell technology using ammonia as fuel. The project will also prove the case for large-scale, zero-emission fuel infrastructure through a realistic business model. Currently, the fuel cells are being scaled up and going through laboratory testing. The onboard fuel system design is in progress, together with integration design for the fuel cell power system. ShipFC is building the knowledge base for the development of a global green ammonia fuel infrastructure.

NON-QUANTITATIVE OBJECTIVES

- ShipFC aims to integrate ammonia fuel cell and fuel systems into ship power systems. The integrated ship design is under development. Initial discussions with actors from the industry are complete and follow-up actions have been identified. The detailed design will contribute to updated knowledge in the industry, as this is the first vessel with MW-scale ammonia-powered solid oxide fuel cells (SOFCs) onboard.
- The project aims to demonstrate wider use of the system and scale-up of the system to + 20 MW. The first iteration design for the 5 000 TEU container ship has been established. As the detailed designs of all systems for Viking Energy progress, the container ship design will be modified through several iterations.

PROGRESS AND MAIN ACHIEVEMENTS

- The project has signed an agreement for the delivery of green ammonia fuel for the duration of the project.
- Conceptual designs for the fuel system have been developed.
- The preliminary SOFC module and integrated system designs are complete.

FUTURE STEPS AND PLANS

- ShipFC will scale up and test the SOFC.
- The SOFC is currently undergoing laboratory-scale testing, in preparation for large-scale tests. By November 2023, the full-sized 2 MW SOFC will have been tested.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Target achieved?
Project 's own objectives	Greenhouse gas reduction by using ammonia fuel	%	70	
	Ammonia SOFC system power	MW	2	
	MW-scale SOFC operational experience	hours	3 000	

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STASHH

STANDARD-SIZED HEAVY-DUTY HYDROGEN

Project ID	101005934
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-4-2020: Standard sized FC module for heavy duty applications
Project total costs	EUR 14 514 575.80
Clean H_2 max. contribution	EUR 7 500 000
Project period	1/1/2021 – 30/6/2024
Coordinator	Sintef AS, Norway
Beneficiaries	Damen Global Support BV, FEV Software and Testing Solutions GmbH, VDL Energy Systems, Plastic Omnium New Energies Wels GmbH, Future Proof Shipping BV, Hyster-Yale Italia SpA, FCP Fuel Cell Powertrain GmbH, VDL Enabling Transport Solutions BV, Hydrogenics GmbH, Freudenberg FST GmbH, Aktiebolaget Volvo Penta, Symbio, Scheepswerf Damen Gorinchem BV, Intelligent Energy Limited, Volvo Construction Equipment AB, WaterstofNet Vzw, Ballard Power Systems Europe AS, Solaris Bus & Coach Spolka Z Ograniczona Odpowiedzialnoscia, Proton Motor Fuel Cell GmbH, Toyota Motor Europe NV, Cetena SpA – Centro per gli Studi di Tecnica Navale, Nedstack Fuel Cell Technology BV, FEV Europe GmbH, Alstom Transport SA, AVL LIST Gmbh, Volvo Technology AB, Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek (TNO), Commissariat à l'énergie atomique et aux énergies alternatives

https://stashh.eu/

PROJECT AND OBJECTIVES

StasHH's objectives are to agree to a standard for fuel cell modules across the heavy-duty sector (trucks, buses, ships, generators, trains, etc.), to build prototypes in accordance with this standard and to test them in accordance with agreed-upon methods. The project has produced three documents for standards – covering sizes, interfaces and communication – and several partners are already developing prototypes.

NON-QUANTITATIVE OBJECTIVES

- The project aims to disseminate the standard. This has recently started, as the standard was only recently fixed.
- StasHH plans to update the standard based on experience in 2023.

PROGRESS AND MAIN ACHIEVEMENTS

- A standard definition has been agreed.
- StasHH has created a regulations, codes and standards overview.

FUTURE STEPS AND PLANS

- The fuel cell module prototypes will be constructed (expected to be completed in 2022). Some partners are ahead of schedule and some are behind owing to difficulties in aligning with internal schedules.
- Prototype testing will take place at FEV and TNO premises (planned for 2023).

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
AWP 2020	Number of sizes	–	≤ 3	3	✓
	Number of fuel cell module partners	–	7	11	
	Fuel cell module power rating	kW	30–100	30–200	

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TAHYA

TANK HYDROGEN AUTOMOTIVE

Project ID	779644
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-3-2017: Improvement of compressed storage systems in the perspective of high volume automotive application
Project total costs	EUR 3 996 943.75
Clean H_2 max. contribution	EUR 3 996 943.75
Project period	1/1/2018 – 30/6/2021
Coordinator	Optimum CPV, Belgium
Beneficiaries	AbsisKey, Polarixpartner GmbH, Anleg GmbH, Raigi SAS, Bundesanstalt für Materialforschung und prüfung, Technische Universität Chemnitz, Volkswagen Aktiengesellschaft

htpp://tahya.eu/

PROJECT AND OBJECTIVES

The TAHYA project, mainly led by industrial partners already involved in producing and manufacturing hydrogen solutions for the automotive and aviation industries, focused on the development of a complete, competitive and innovative European H_2 storage system (a cylinder with a mounted on tank valve with all integrated functionalities) for automotive applications outperforming the current Asian and US models.

NON-QUANTITATIVE OBJECTIVES

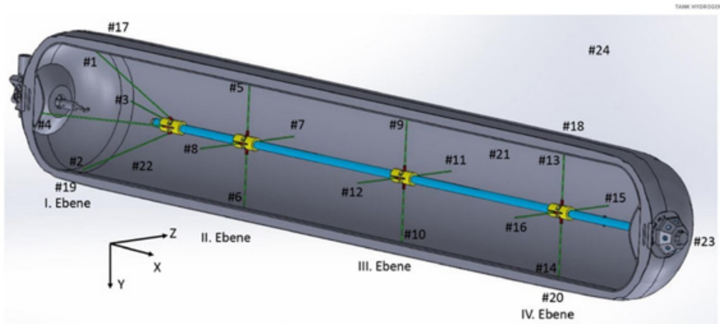
The orbital winding process can be used for the production of tubular component structures.

PROGRESS AND MAIN ACHIEVEMENTS

- TAHYA has created a compatible H_2 storage system that is high performing, safe and environmentally responsible.
- The project has created a cost-competitive H_2 storage system for mass production.
- Regulations, codes and standards activities proposed updates to international safety standard GRT13.

FUTURE STEPS AND PLANS

The project finished in June 2021. All objectives were achieved.



To carry out the experimental filling test, a measuring system to determine pressure and temperature inside TAHYA's 127-litre type IV cylindrical pressure vessel was produced and assembled at Technische Universität Chemnitz.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SoA result achieved to date (by others)	Year of SoA target
MAWP Addendum (2018–2020)	Gravimetric efficiency of the storage system	%	5.3 %	6.5 %		5.9 %	2021
	Storage cost per kg of hydrogen	€/kg	500	450	✓	N/A	N/A
Project's own objectives	Industrialisation scenario	systems/year	20 000	20 000		30 000	2020

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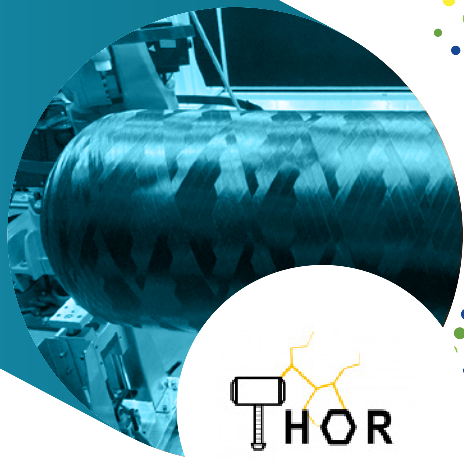
THOR

THERMOPLASTIC HYDROGEN TANKS OPTIMISED AND RECYCLABLE



Project ID	826262
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-3-2018: Strengthening of the European supply chain for compressed storage systems for transport applications
Project total costs	EUR 2 884 330.29
Clean H_2 max. contribution	EUR 2 853 958.75
Project period	1/1/2019 – 30/9/2022
Coordinator	Faurecia Systemes d'Echappement SAS, France
Beneficiaries	ETIM, Covess NV, Cetim Grand Est, École Nationale Supérieure de Mécanique et d'Aérotechnique, Sirris het collectief centrum van de technologische industrie, Rina Consulting – Centro Sviluppo Materiali SpA, Centre technique des industries mécaniques, Université de Poitiers, L'Air Liquide SA, Norges Teknisk-Naturvitenskapelige Universitet, Centre national de la recherche scientifique

https://thor-fch2.eu/

PROJECT AND OBJECTIVES

The project aims to validate the technology and its associated process for a recyclable thermoplastic composite tank for the storage of high-pressure gaseous hydrogen for mobility.

NON-QUANTITATIVE OBJECTIVES

- THOR will conduct health monitoring using optical fibres, for temperature control and fire detection. Tests were scheduled to take place in July 2022.
- The project aims to create a recycled panel of thermoplastic reinforced with carbon fibres. Recycling activities are scheduled to take place at the end of the project. The performance of the panels will be tested to define their best use.
- Recyclability of the tanks.
- The project is working on the reuse of the end-of-life tank with a recycling process for producing carbon-fibre composite sheets (preparation of the material and process for the manufacturing of the reused sheets).

PROGRESS AND MAIN ACHIEVEMENTS

- The tanks have been prepared.
- Recycling has been carried out.

FUTURE STEPS AND PLANS

- THOR will finalise the tanks preparation to test the new winding pattern link to the new matrix. This will involve testing the tanks (at ambient, cycling and extreme temperatures).
- The project will perform burst tests, a cycling test at ambient and critical temperatures, and bonfire tests.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
MAWP (2014–2020)	Gravimetric efficiency	%	> 6 %	–	
	Burst pressure	bars	1 575	1 460	
	Cost of tanks	€/kg of H_2	400	N/A	

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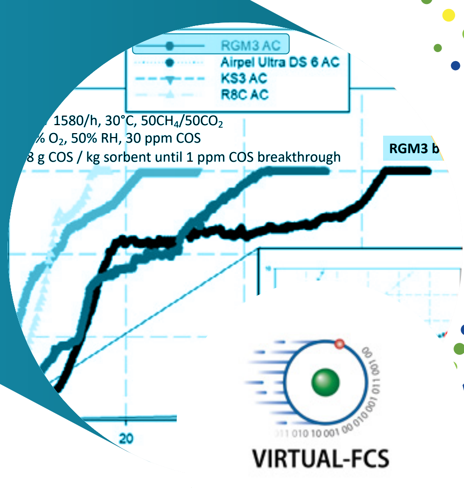
VIRTUAL-FCS

VIRTUAL & PHYSICAL PLATFORM FOR FUEL CELL SYSTEM DEVELOPMENT



Project ID	875087
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-3-2019: Cyber-physical platform for hybrid fuel cell systems
Project total costs	EUR 1 897 806.25
Clean H_2 max. contribution	EUR 1 897 806.25
Project period	1/1/2020 – 31/12/2022
Coordinator	Sintef AS, Norway
Beneficiaries	Banke Aps, Vivarail Ltd, Communauté d'universités et d'établissements université Bourgogne Franche-Comté, Seam AS, Ballard Power Systems Europe AS, École nationale supérieure de mécanique et des microtechniques, Solaris Bus & Coach Spolka Z Ograniczona Odpowiedzialnoscia, Université de technologie de Belfort-Montbéliard, Université De Franche-Comté

http://www.sintef.no/projectweb/virtual-fcs/

PROJECT AND OBJECTIVES

The overall objective of the VIRTUAL-FCS project is to make the design process of hybrid fuel cell and battery systems easier, cheaper and quicker. VIRTUAL-FCS will produce a toolkit combining software and hardware parts for designing and optimising hybrid systems of proton-exchange membrane fuel cells and batteries. The platform will be entirely open source, allowing everyone in both industry and research to benefit from and contribute to the future development of the framework. The software tools are being developed in close collaboration with end users and system integrators, securing widespread accessibility.

NON-QUANTITATIVE OBJECTIVES

- VIRTUAL-FCS aims for a significant reduction of development times for new fuel cell and battery hybrid systems. The advanced modelling, simulation and emulation tools developed in VIRTUAL-FCS will enable end users with limited experience of fuel cell systems to design and implement new systems more quickly.
- The project aims to create a development platform for hybrid fuel cell systems with integration capabilities and corresponding simulation models. The real-time software platform combined with a full range of emulated components will enable end users to seamlessly integrate real, simulated and emulated components together in a mixed software–hardware system.
- It aims to create analytical tools and instrumentation to validate the different systems and energy management methodologies developed. VIRTUAL-FCS will validate different energy management systems on the mixed software–hardware system. The characterisation of the systems will be carried out using the standard techniques to validate system performance.
- VIRTUAL-FCS aims to create high-performance, real-time emulators of the dynamic behaviour of real components and subsystems. VIRTUAL-FCS will develop new and improved balance-of-plant and stack models capable of accurate real-time emulation of components' dynamic performance, along with their degradation.
- The project aims to enable the establishment of an EU-based supply industry for hybrid fuel cell system simulation and the experimental tool environment (XiL platform) to boost the competitiveness of the EU fuel cell industry. The system simulation tools and methods for making and using the experimental platform will be available to the entire European industry free of charge to boost competitiveness.

PROGRESS AND MAIN ACHIEVEMENTS

- VIRTUAL-FCS has demonstrated cyber-physical hardware integration.
- The project has demonstrated fuel cell electric vehicle simulations.
- It has also demonstrated real-time system simulation.

FUTURE STEPS AND PLANS

- The project will demonstrate real-time system emulation. The project will demonstrate this capability by emulating a full multistack system with an energy management strategy that can take real-time input from a physical sensor, use this feedback for real-time control of a standard fuel cell stack test bench and simulate real load cycles on the physical stack.
- The project will integrate components from the physical hybrid system into the system simulated in the software tools and those emulated on a controller.
- The effect of the energy management strategy on system degradation will be investigated. To validate the mixed software hardware development approach, new energy management systems will be explored. Using the software tools developed in the project, simulations of systems will take place using different control strategies and will examine how this affects the system's lifetime.
- VIRTUAL-FCS will perform balance-of-plant prognostics model validation. The project will develop a reduced-order model that can describe proton-exchange membrane fuel cell stack performance and degradation.
- The project will produce explanatory webinars and blog posts to accompany every release of new code. It will also organise a workshop, the focus of which will be practical training in the use of the developed platform.

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Clean Hydrogen Partnership

Co-funded by the European Union

ZEFER

ZERO EMISSION FLEET VEHICLES FOR EUROPEAN ROLL-OUT

Project ID	779538
PRD 2022 Panel	3 – H2 end uses: Transport
Call topic	FCH-01-6-2017: Large scale demonstration of hydrogen refuelling stations and fuel cell electric vehicle (FCEV) road vehicles operated in fleet(s)
Project total costs	EUR 17 508 573.08
Clean H_2 max. contribution	EUR 4 998 843
Project period	1/9/2017 – 31/8/2022
Coordinator	Element Energy Limited, United Kingdom
Beneficiaries	Air Liquide Advanced Technologies GmbH, Linde GmbH, Element Energy, Green Tomato Cars Limited, Breath, Air Liquide France Industrie, L'Air Liquide Belge, Societe du Taxi Electrique Parisien, Air Liquide Advanced Technologies SA, ITM Power (Trading) Limited, Centre of Excellence for Low Carbon and Fuel Cell Technologies, Air Liquide Advanced Business, Ville de Paris, Linde AG, Bayerische Motoren Werke Aktiengesellschaft

https://zefer.eu/

PROJECT AND OBJECTIVES

ZEFER aims to demonstrate viable business cases for fuel cell electric vehicles (FCEVs) in high-mileage fleet applications. The project aims to deploy 180 FCEVs into taxi, private-hire and emergency-service operations in three major European cities in which their operational benefits and zero-emission credentials can be monetised. The vehicles will use existing hydrogen-refuelling station (HRS) networks to increase local utilisation levels and improve the business case for HRS operators.

NON-QUANTITATIVE OBJECTIVES

ZEFER aims to:

- Develop comprehensive lessons from the deployment on topics such as customer acceptance, the business case for FCEVs and the technical performance of HRSs and FCEVs under high utilisation.
- Increase the confidence of investors and policymakers in FCEV and HRS roll-out. ZEFER has proven that FCEVs and HRSs can meet the demands of high-mileage fleet operations.
- Maintain or even increase the participation of SMEs in Clean Hydrogen JU projects. Currently, 50 % of ZEFER partners are SMEs, and 84 % of the project funding targets SMEs.
- Reduce the production cost of FC systems in transport applications. The bulk procurement of FCEVs is expected to reduce FCEVs' costs to their lowest level.
- Demonstrate, at utilisation levels, a significantly longer lifetime of fuel cells in FCEVs than that of those currently deployed, to compete with conventional technologies.
- Increase the energy efficiency of hydrogen production while reducing operating and capital costs. ZEFER aims to reduce the hydrogen cost at the pump to < 10 €/kg.

The project also aims to trigger further cost reductions by encouraging investment in the low-cost green production systems.

PROGRESS AND MAIN ACHIEVEMENTS

- All 180 FCEVs have been deployed into everyday operation in Paris, London and Copenhagen (60 in each).
- Most of the HRS upgrades have been completed, leading to improvements in the technical performance and customer experience of HRSs.
- All deployment partners in the project have plans to scale up their FCEV fleets as a result of the ZEFER project.

FUTURE STEPS AND PLANS

- ZEFER will complete the HRS upgrades required in Paris. The initial plan for the upgrade has been delayed due to permit procedures taking longer than anticipated. As a mitigation plan, Air Liquide will perform different upgrades at other Parisian HRSs (Porte de la Chapelle and Roissy-en-France).
- The project will continue collecting data on the FCEVs and HRSs to better understand how performance is affected by long-term high utilisation levels.
- ZEFER will undertake higher-visibility dissemination work to ensure that the fleet operation use case is expandable across other European regions. Round tables with policymakers and taxi operators will be hosted by the project to increase awareness of the business case for FCEVs in fleet applications.
- Project reports analysing the business case for FCEVs in high-mileage applications will be produced.
- New iterations of the business case and customer acceptance reports are expected.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SoA result achieved to date (by others)	Year of SoA target
				FCEVs			
Project's own objectives	Min. distance for vehicles	km/vehicle	90 000	~ 45 500 km per year pre-COVID-19 for certain fleets	⚙	FCEVs operated as taxis in H2ME drive an average of ~ 45 000 km per year	2020
	Vehicle availability	%	> 98	> 99	✓	> 99	2021
	Range	km	500	650	✓	756	2020
				HRSs			
Project's own objectives	HRS availability	%	> 98	> 98	✓	98	2016
	Hydrogen purity	%	99.99	99.99	✓	99.99	2020
	Level of back-to-back vehicle refuelling	refuelling events/h	6	6	✓	6	2020
	Cost of hydrogen	€/kg	≤10	10	✓	10	

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