ALKAMMONIA

AMMONIA-FUELLED ALKALINE FUEL CELLS FOR REMOTE POWER APPLICATIONS

Project ID:	**325343**
Call topic:	**SP1-JTI-FCH.2012.3.5** - SP1-JTI-FCH.2012.3.5 - System level proof of concept for stationary power and CHP fuel cell systems at a representative scale
Project total costs:	**€ 2,884,512.59**
FCH JU max. Contribution:	**€ 1,962,548.00**
Project start - end:	01/05/2013- 30/06/2018
Coordinator:	**AFC ENERGY PLC, UK**
Website:	**www.alkammonia.eu**

BENEFICIARIES: ACTA SPA, FAST - FEDERAZIONE DELLE ASSOCIAZIONI SCIENTIFICHE E TECNICHE, FUEL CELL SYSTEMS LTD, PAUL SCHERRER INSTITUT, UNIVERSITAET DUISBURG-ESSEN, UPS SYSTEMS PLC, ZENTRUM FUR BRENNSTOFFZELLEN-TECHNIK GMBH

PROJECT AND OBJECTIVES

In project ALKAMMONIA a proof-of-concept system designed to provide power in remote areas has been developed and is being tested, focusing on diesel generator displacement opportunities. The project integrates three innovative and proven technologies: a highly efficient and low-cost alkaline fuel cell system, plus a novel ammonia fuel system which consists of a fuel delivery system and a cracker system for generation of a hydrogen rich gas. The integrated system is being rigorously tested and the results will be shared with potential end-users.

NON QUANTITATIVE OBJECTIVES

- Achieve CE certification for cracker
- Assessment of system impacts

PROGRESS & MAIN ACHIEVEMENTS

- Successful short-term testing of the alkaline fuel cell Balance of Plant and stack
- Successful testing of the ammonia cracker and fuel delivery system
- Successful integration of sub-systems into the ALKAMMONIA system

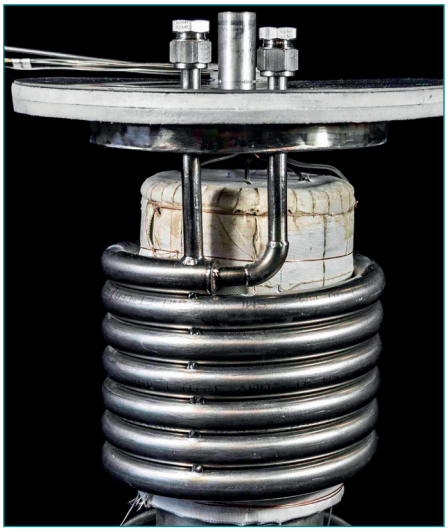
FUTURE STEPS & PLANS

- Complete longevity testing for integrated ALKAMMONIA system, this involves a 1,000h test plus data analysis and forecasting.
- Life Cycle Analysis of integrated system and comparison with competing technologies for specific target applications.
- Close out the project, which includes documenting achievements per Consortium knowledge management guidelines and finalizing project report

RELEVANCE TO FCH JU OVERARCHING OBJECTIVES

Increase the electrical efficiency and the durability of the different fuel cells

Stack development as part of this project has addressed both increased electrical efficiency and durability of alkaline fuel cells.



QUANTITATIVE TARGETS AND STATUS

State of the Art (SoA)*

PARAMETER	UNIT	RESULT ACHIEVED TO DATE	SoA result achieved to date by other group/ project (SoA Year)	SoA Source
Cracker efficiency (based on LHV)	%	90 % (thermal efficiency) (by feeding the cracker with gaseous ammonia and firing the system burner with LPG)	No comparable information about burner fired crackers is available.	The only available information in literature belongs to electrical heated small scale micro ammonia crackers, which are not applicable here.
Maintain high efficiency of current AFC stack	%	62%, based on electrochemical efficiency calculation, measured against the lower heating value (LHV) of hydrogen, using a technical grade H2 fuel supply for testing.	59%	After our literature survey, the only applicable SoA is based on POWER- UP, also utilising AFC Energy technology and based on a technical grade H2 fuel supply
Reduced AFC stack weight	kg	70kg, this is the stack weight, i.e. excluding the enclosure, based on a 2.5kWe stack BOM.	200kg, based on a 5kWe stack.	After our literature survey, the only applicable SoA is based on AFC Energy's State of the Art at the ALKAMMONIA project start.
Increased AFC stack durability	hours	≥6,300h, extrapolated from 2,000h of actual operation, using technical grade H2 fuel supply	N/A	After our literature survey, the only competing alkaline fuel cell manufacturer for this success criterion to AFC Energy are GENCELL, who have made no relevant information public, with inferences of perhaps 500h, not explicitly stated.
Reduced AFC stack leakage losses	%	<1%	<10%	After our literature survey, the only applicable SoA is based on AFC Energy's State of the Art at the ALKAMMONIA project start.

* Available data provided by the Project

AutoRE
AUTOMOTIVE DERIVATIVE ENERGY SYSTEM

Project ID:	**671396**
Call topic:	**FCH-02.5-2014** - Innovative fuel cell systems at intermediate power range for distributed combined heat and power generation
Project total costs:	**€ 4,464,447.25**
FCH JU max. Contribution:	**€ 3,496,947.00**
Project start - end:	01/08/2015 - 30/04/2019
Coordinator:	**ALSTOM POWER LTD, UKE**
Website:	**www.autore-fch.com**

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

PROJECT AND OBJECTIVES

The main objective is to create the foundations to commercialize a 50-100kWe automotive derivative fuel cell CHP system. The project is in its 3rd year, with key achievements including: automotive fuel cell is installed/ commissioned, gas reformer is built and factory tested, significant modelling of the cycle has been completed, together with laboratory scale testing of fuel cell stack on reformate and the membrane to separate H2. Next steps are to deliver the reformer to the UK test site, complete site installation and carry-out the 3000h test programme.

NON QUANTITATIVE OBJECTIVES

- Support development of codes and standards for new technologies
- Constribute to decarburization of building/power sectors

PROGRESS & MAIN ACHIEVEMENTS

- The prototype CHP site has been prepared, fuel system installed and commissioned and gas reformer built and factory tested
- Testing of fuel cell short-stacks completed on reformate, together with testing of hydrogen separation membranes
- Modelling of the system has been completed showing reformer thermal integration improves overall performance

FUTURE STEPS & PLANS

- Deliver natural gas reformer to prototype site and complete system build and commissioning
- Complete 3000h system endurance test
- Complete system modelling activities including RAMS study
- Prepare business case for commercial system and disseminate project findings to key stakeholders

RELEVANCE TO FCH JU OVERARCHING OBJECTIVES

Increase the electrical efficiency and the durability of the different fuel cells

- Test of novel components e.g. hydrogen membrane to increase efficiency
- 3000h demonstration test to determine durability issues
- Cycle performance modelling to define optimum configuration

QUANTITATIVE TARGETS AND STATUS

FCH JU Programme Targets*

PARAMETER	UNIT	RESULT ACHIEVED TO DATE	TARGET	TARGET ACHIEVED?	SoA result achieved to date by other group/project (SoA Year)
Rated system electrical efficiency (LHV)	%		42-60	✗	52%
Rated system thermal efficiency (LHV)	%		24-42	✓	N/A
Lifetime of the fuel cell system	years		8 - 20	✓	N/A
Stack durability	hours		50,000	✗	21,900
Reliability	hours		30,000	✗	N/A
Hydrogen tolerance	% (volume)		100	✗	N/A
CAPEX	EUR/kWe		4,500 - 7,500	✓	2,400
Land use / footprint	m2/kW	0.02	0.08	✓	N/A

*As identified in MAWP Addendum 2018-2020, Target year 2020

CH2P

COGENERATION OF HYDROGEN AND POWER USING SOLID OXIDE BASED SYSTEM FED BY METHANE RICH GAS

Project ID:	**735692**
Call topic:	**FCH-02-4-2016** - Co-generation of Hydrogen and Electricity with High-Temperature Fuel Cells (>50 kW) generation
Project total costs:	**€ 6,868,158.75**
FCH JU max. Contribution:	**€ 3,999,896**
Project start - end:	01/02/2017- 31/07/2020
Coordinator:	**FUNDACIO INSTITUT DE RECERCA DE L'ENERGIA DE CATALUNYA, ES**
Website:	**www.ch2p.eu**

BENEFICIARIES: DEUTSCHES ZENTRUM FUER LUFT - UND RAUMFAHRT EV, ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE, HTceramix SA, HYGEAR BV, HyGear Fuel Cell Systems B.V., HYGEAR TECHNOLOGY AND SERVICES BV, SHELL GLOBAL SOLUTIONS INTERNATIONAL BV, SOLIDPOWER SPA, VERTECH GROUP

PROJECT AND OBJECTIVES

CH2P is a project focused on flexible cogeneration of hydrogen and power for the distributed production on hydrogen refuelling stations. It aims at reaching high conversion efficiency (up to 75%), low cost of hydrogen (<4.5 €/kg), production of hydrogen compliant with the use on onboard PEMFC considering hydrogen purity. The project will have pilot testing of 100 kg/day system in real environment. At the present, the project in the component validation phase, after full design, system modelling and definition of a final P & Id layout.

NON QUANTITATIVE OBJECTIVES

- Dynamic and flexible generation of hydrogen and power
- Use of low carbon gas mixtures
- LCA to assess for carbon emissions using different methane rich mixtures
- High Educational Vocational Training course on Energy and Environment

PROGRESS & MAIN ACHIEVEMENTS

- Finalized the PFD - process flow diagram. Finalized the engineering in a P&ID. This consolidation has been achieved through system modelling
- Finalized the technology application scenarios: technology scenarios has been consolidated considering six main use cases of the HRS
- Finalized the definition of the system requirements

FUTURE STEPS & PLANS

- Complete the validation of components: stack, stacks-tower, large stack (4 stacks for 25 kW), PSA, steam reformer burner, heat exchangers, compressor
- Final engineering of the gas upgrading system, of the downstream purification and compression, of the fuel conditioning and filtering
- Realization of a 20 kg/day prototype system and controls including testing and validation
- Realization of a 100 kg/day system with validation and pilot testing in real environment
- Design of a 200 or 400 kg/day system for real scale HRS

RELEVANCE TO FCH JU OVERARCHING OBJECTIVES

Reduce the production cost of fuel cell systems to be used in transport applications

CH2P, by its innovative cost model, will realize a considerable reduction of hydrogen cost compared with the SoA, down to 4,5 €/kg.

Increase the electrical efficiency and the durability of the different fuel cells

Electric efficiency is expected to be up to 75% and average of 65%. The durability of the fuel cell is expected to be 5 years.

QUANTITATIVE TARGETS AND STATUS

FCH JU Programme Targets*

PARAMETER	UNIT	RESULT ACHIEVED TO DATE	TARGET	TARGET ACHIEVED?	DESCRIPTION
Hours of operation - cumulative	hours	3500	1000	✓	The cumulative hours of operation for the stack development and testing for the period exceed 3500 h.
Purity required for the fuel	%	99.999	99.9	✓	5N purity level, compliant with the use in the transport sector, for onboard PEMFC
Rated system lifetime	years	10	8 - 20	✓	Hydrogen production research (excl. electrolysis)
Rated stack durability	hours	40,000	50,000	✗	Fuel cells research at system level

*As identified in AWP 2016 and MAWP Addendum 2018-2020, Target years 2019-2020

D2Service

DESIGN OF 2 TECHNOLOGIES AND APPLICATIONS TO SERVICE

Project ID:	**671473**
Call topic:	**FCH-02.9-2014** - Significant improvement of installation and service for fuel cell systems by Design-to-Service
Project total costs:	**€ 3,636,797.5**
FCH JU max. Contribution:	**€ 2,953,790.75**
Project start - end:	01/09/2015 - 30/11/2019
Coordinator:	**DLR-INSTITUT FUR VERNETZTE ENERGIESYSTEME EV, DE**
Website:	**www.project-D2Service.eu**

BENEFICIARIES: BALLARD POWER SYSTEMS EUROPE AS, BOSAL EMISSION CONTROL SYSTEMS NV, BRITISH GAS TRADING LIMITED, ENERGY PARTNER SRL, SOLIDPOWER SPA, ZENTRUM FUR BRENNSTOFFZELLEN-TECHNIK GMBH

PROJECT AND OBJECTIVES

The D2Service project aims at improving the service ability and maintainability of fuel cell-based m-CHP and backup power systems. The relatively high complexity of these systems currently still requires specialized service personnel and non-standard components when the systems are maintained in regular intervals or repaired due to failures. Two different fuel cell technologies, LT-PEMFC and SOFC, are investigated. Improvements are developed on system design and component levels, as well as guidelines for easier service procedures and manuals are designed.

NON QUANTITATIVE OBJECTIVES

- Elaboration of guidelines for development of guidelines for easily understandable service manuals
- Life-time desulphurisation (type HDS)
- Water treatment optimization

PROGRESS & MAIN ACHIEVEMENTS

- Improved design of SOFC and PEM m-CHP units with respect to efficiency, serviceability, durability and cost reduction
- Suitable catalyst and absorber materials identified for 60,000h lifetime of hydrodesulphurisation component
- Identification and preparation of sites for field trial of improved units

FUTURE STEPS & PLANS

- Installation of units on field trial sites
- Laboratory evaluation of SOFC m-CHP unit
- Development and verification of guidelines for easy-to-understand graphical manuals

RELEVANCE TO FCH JU OVERARCHING OBJECTIVES

Increase the electrical efficiency and the durability of the different fuel cells

Development of more durable and standardized components, such as desulphurisation, water treatment and connections.

QUANTITATIVE TARGETS AND STATUS

FCH JU Programme Targets*

PARAMETER	UNIT	RESULT ACHIEVED TO DATE	TARGET	TARGET ACHIEVED?
Rated stack durability	hours	40,000	50,000	✗ SoA 2017 achieved
Stack durability	hours	40,000	50,000	✗ SoA 2017 achieved
FC system CAPEX	EUR/kW	28,376	10,000	✗
Est. FC system CAPEX @ mass production	EUR/kW	8,890	10,000	✓ projection achieved
Degradation rate in %/kh	%/kh	0.304	<0.25	✗
System availability	%	75	97	✗

*As identified in AWP 2016, 2017 and MAWP Addendum 2018-2020, Target years 2019-2020

DEMCOPEM-2MW

DEMONSTRATION OF A COMBINED HEAT AND POWER 2 MWE PEM FUEL CELL GENERATOR AND INTEGRATION INTO AN EXISTING CHLORINE PRODUCTION PLANT

Project ID:	**621256**
Call topic:	**SP1-JTI-FCH.2013.3.5** - Field demonstration of large scale stationary power and CHP fuel cell systems
Project total costs:	**€ 10,524,200.4**
FCH JU max. Contribution:	**€ 5,466,525**
Project start - end:	01/01/2015- 31/12/2018
Coordinator:	**AKZO NOBEL INDUSTRIAL CHEMICALS B.V., NL**
Website:	**www.demcopem-2mw.eu**

BENEFICIARIES: JOHNSON MATTHEY FUEL CELLS LIMITED, MTSA TECHNOPOWER BV, NEDSTACK FUEL CELL TECHNOLOGY BV, POLITECNICO DI MILANO

PROJECT AND OBJECTIVES

The aim of the project was to design, construct and demonstrate an economical combined heat and power PEM fuel cell power plant and integration into a chlor-alkali production plant. The project is currently in its last year (a total of 48 months are foreseen), the PEM system has been installed since September 2016 at the chlor-alkali plant in Yingkou, China. The planned capacity of 2MW has been already reached, even if some technical problems (related to air and hydrogen quality) have been encountered.

NON QUANTITATIVE OBJECTIVES

Trainings of system operators

PROGRESS & MAIN ACHIEVEMENTS

- 2MW system operative (heat recovery available)
- Modelling/Monitoring and operation possible in remote
- Reduce/minimize hydrogen waste in the chlor-alkali factory

FUTURE STEPS & PLANS

- Solving some of the technical issues registered (due to local conditions) such as stack decay (both reversible and irreversible)
- Ongoing analysis on how to reduce costs and contribute to the design of the second generation PEM plant
- Further the analysis of the operational hours and data is been carrying on

QUANTITATIVE TARGETS AND STATUS

FCH JU Programme Targets*

PARAMETER	UNIT	RESULT ACHIEVED TO DATE	TARGET	TARGET ACHIEVED?
Rated system electrical efficiency (LHV)	%	50	45	✓
Rated system thermal efficiency (LHV)	%	35	22-40	✓
Lifetime of the fuel cell system	years	10	25	✗ SoA 2017 Achieved
Stack durability	hours	16,000	20,000-60,000	✗
Reliability	hours	8,500	25,000	✗
Availability	%	95	98	✗
Operation of the System**	MW	2 MW	2 MW system operation	✓

*As identified in MAWP Addendum 2018-2020, Target year 2020
** Project's own objective

DEMOSOFC

DEMONSTRATION OF LARGE SOFC SYSTEM FED WITH BIOGAS FROM WWTP

DEMOSOFC
FCH2-JU PROJECT

Project ID:	**671470**
Call topic:	**FCH-02.11-2014** - Large scale fuel cell power plant demonstration in industrial/ commercial market segments
Project total costs:	**€ 5,905,336.25**
FCH JU max. Contribution:	**€ 4,492,561**
Project start - end:	01/09/2015 - 31/08/2020
Coordinator:	**POLITECNICO DI TORINO, IT**
Website:	**www.demosofc.eu**

BENEFICIARIES: CONVION OY, IMPERIAL COLLEGE OF SCIENCE TECHNOLOGY AND MEDICINE, RISORSE IDRICHE S.P.A., Società Metropolitana Acque Torino S.p.A., Teknologian tutkimuskeskus VTT Oy

PROJECT AND OBJECTIVES

DEMOSOFC operates the largest industrial-size Soli Oxide Fuel Cell (SOFC) biogas-fed FC plant in Europe, in Torino (IT). Key advantages of the DEMOSOFC concept, compared to traditional engines, are very high electrical efficiency (50-55% vs 35-40%), zero emissions and modularity. The first of the 3 SOFC modules started its operation on October 30, 2017 and has now reached more than 2500 hours. Results confirmed the efficiency of the SOFC module (always higher than 50%, with peaks at 55-56%) and the zero emissions (NOx and SO2 below detection limits). The next 2 SOFC modules are expected to enter in operation within 2018.

NON QUANTITATIVE OBJECTIVES

- Build technical knowledge, customer confidence, investor confidence
- Demonstrate high efficiency of SOFC-based CHP systems fed by biogas
- Compete FMEA of the DEMO
- Dissemination for public awareness

PROGRESS & MAIN ACHIEVEMENTS

- More than 2500 hours of operation, with efficiency of the SOFC module always higher than 50% (with peaks at 55-56%) and zero emissions to atmosphere
- Complete experience of detailed engineering, installation and management of a biogas-fed SOFC CHP system in an existing industrial context
- Complete experience of design, construction and management of the biogas clean-up module for SOFC targets (material selection, engineering, control)

FUTURE STEPS & PLANS

- WP3: Tests of automatic regulation of the complete DEMO (e.g. reduction in biogas production, island mode operation because of a grid failure, etc.)
- WP4: Maintenance during the DEMO operation (including stack replacement in first module); analysis of degradation processes in the whole plant
- WP5: monitoring and analysis of technical KPIs (related to energy and emissions); guidelines for the replication of safety analysis
- WP6: monitoring and analysis of economic KPIs; re-engineering of the complete balance of plant hosting the SOFC (for minimization of plant costs)
- WP7: increase of activities with EU-level associations/ groups e.g. European Biogas Association (EBA), Municipal Waste Europe, Association of cities

RELEVANCE TO FCH JU OVERARCHING OBJECTIVES

Increase the electrical efficiency and the durability of the different fuel cells

Through the in-field test, monitoring and analysis of a SOFC module, allowing to understand where and how to improve the overall performance of the plant. Then, through a demonstration of the high achievements of the technology, increasing the interest of end users and the quantity of orders per year.

QUANTITATIVE TARGETS AND STATUS

FCH JU Programme Targets*

PARAMETER	UNIT	RESULT ACHIEVED TO DATE	TARGET	TARGET ACHIEVED?	SoA result achieved to date by other group/project (SoA year)	DESCRIPTION
Electrical efficiency	%	52	42-60	✓	41-55 (2020)	We do not have evidence of data from other similar plants if any (biogas-fed SOFC at industrial size) at the international level/ SoA based on MAW Addendum for medium sized applications
Thermal efficiency	%	30	24-42	✓	24-41 (2020)	

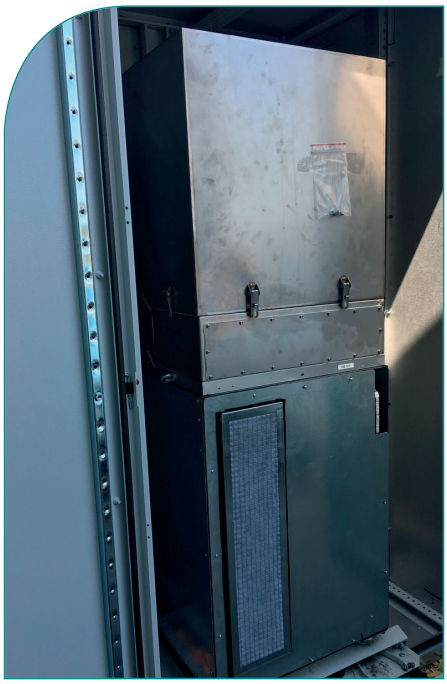
*** As identified in MAWP Addendum 2018-2020, Target year 2020**

ONSITE

OPERATION OF A NOVEL SOFC-BATTERY INTEGRATED HYBRID FOR TELECOMMUNICATION ENERGY SYSTEMS

Project ID:	325325
Call topic:	SP1-JTI-FCH.2012.3.4 - Component and sub-system cost and reliability improvement for critical path items in stationary power and CHP fuel cell systems
Project total costs:	€ 5,571,479.44
FCH JU max. Contribution:	€ 3,012,038
Project start - end:	01/07/2013- 30/09/2017
Coordinator:	CONSIGLIO NAZIONALE DELLE RICERCHE, IT
Website:	www.onsite-project.eu

BENEFICIARIES: BONFIGLIOLI VECTRON GMBH, ERDLE ERICH KONRAD, ERICSSON TELECOMUNICAZIONI, FIAMM ENERGY STORAGE SOLUTIONS SRL, HAUTE ECOLE SPECIALISEE DE SUISSE OCCIDENTALE, HTceramix SA, INSTYTUT ENERGETYKI



PROJECT AND OBJECTIVES

The ONSITE project aimed at developing a hybrid system using two innovative technologies: Solid Oxide. Fuel Cells (SOFC) and Sodium Nickel Chloride (SNC) batteries, capable of connecting production and storage devices on the one hand, and of managing and controlling the energy and its exchange with the power grid on the other hand. Two prototypes of SOFC/SNC hybrid system have been realized and tested combining a 2.5 kW SOFC system, two SNC batteries and a bidirectional Power Conversion System showing a good electrical and thermal efficiency, 40% and 45% respectively.

PROGRESS & MAIN ACHIEVEMENTS

- SOFC systems, fed by natural gas, showing a good electrical and thermal efficiency, 40% and 45% respectively
- A prototype combining a 2.5 kW SOFC system, two SNC batteries and a bidirectional Power Conversion System able to generate both AC and DC micro grid
- Field test at a real Telecom Operator site

FUTURE STEPS & PLANS

Project is finished.

RELEVANCE TO FCH JU OVERARCHING OBJECTIVES

Increase the electrical efficiency and the durability of the different fuel cells

The project aimed at developing a hybrid FC system for stationary application. The developed SOFC generator reached 85% of total efficiency (40% electrical and 45% thermal).

QUANTITATIVE TARGETS AND STATUS

FCH JU Programme Targets*

PARAMETER	UNIT	RESULT ACHIEVED TO DATE	TARGET	TARGET ACHIEVED?	SoA result achieved to date by other group/project (SoA year)	DESCRIPTION
Rated Lifetime of the fuel cell system	years	10	8 - 20	✓	N/A	Stationary FC
FC system efficiency	%	40	42-60	✗	52 (2017)	System
Land use / footprint	m2/kW	0.72	0.08	✗	N/A	Stationary FC

* As identified in MAWP Addendum 2018-2020, Target year 2020

PACE

PATHWAY TO A COMPETITIVE EUROPEAN FC M-CHP MARKET

Project ID:	**700339**
Call topic:	**FCH-02.9-2015** - Large scale demonstration µCHP fuel cells
Project total costs:	**€ 83,765,010.07**
FCH JU max. Contribution:	**€ 33,932,752.75**
Project start - end:	01/06/2016 - 31/08/2021
Coordinator:	**THE EUROPEAN ASSOCIATION FOR THE PROMOTION OF COGENERATION VZW, BE**
Website:	**www.pace-energy.eu**

PROJECT AND OBJECTIVES

PACE is a major initiative aimed at ensuring the European m-CHP sector makes the next move to mass market commercialisation. The project will deploy a total of 2,800 new fuel cell m-CHP units with real customers and monitor them for an extended period. This will: Enable fuel cell m-CHP manufacturers to scale up production, using new series techniques, and increased automation. By 2020, five leading European manufacturers (Bosch, SOLIDpower, Viessmann, BDR Thermea and Sunfire) are expected to have installed capacity for production of over 1,000 units/year.

NON QUANTITATIVE OBJECTIVES

- Demonstrate in the field in the range of 2800 units
- Test and demonstration of remote control models with regards to grid stability support of Virtual Fuel Cell Power Plants as part of Europe's future renewable energy system
- Verification of heat and power contracting business models for applicable markets by the manufacturers present in the project
- Establish the basis and further develop, if possible, marketing and sales strategies of European m-CHP manufacturers

PROGRESS & MAIN ACHIEVEMENTS

- Fuel Cell micro-Cogeneration: Generating Sustainable Heat and Power for your Home - PACE kick-off event, 11 October 2017
- 942 units sold, 152 installed as of end May 2018
- Snapshot from PACE target markets - insights from Belgium, Italy, the Netherlands, and the United Kingdom available on project website

FUTURE STEPS & PLANS

- The majority of the 2800 units to be deployed in the project will be installed
- Solid and growing basis of operational data from m-CHP units with analysis and dissemination of project results
- EU & national political agendas - Put FC m-CHP on the EU agenda for new Commission (FC Declaration),
- EU Advocacy (2030 Framework) - Provide input on ongoing discussions (SRI, Electricity Market Design). Fix Energy Labelling methodology
- PACE technical workshop for policy-makers will be held on 09th October 2018, Brussels

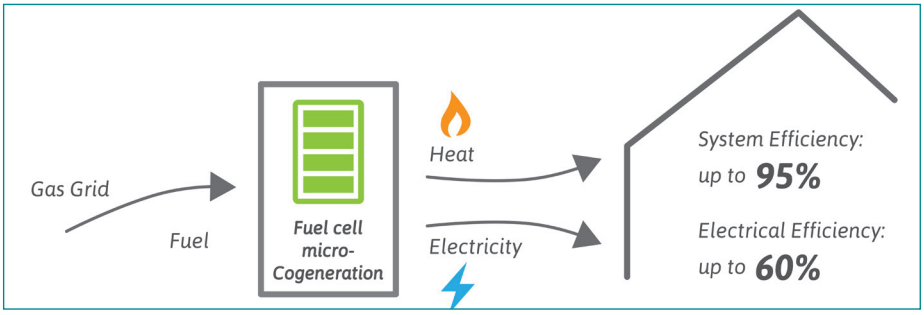
RELEVANCE TO FCH JU OVERARCHING OBJECTIVES

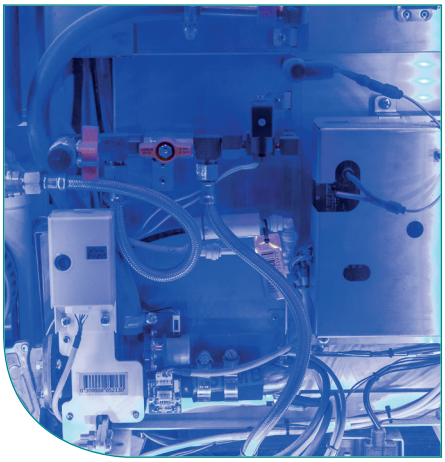
Increase the electrical efficiency and the durability of the different fuel cells

All manufacturers will develop next generation product designs with improved overall efficiencies (>90%) and/or electrical efficiencies (>50%), as well as aiming for 50% reduction in stack replacement or elimination of the need for stack replacement during a 10 year service plan.

Demonstrate on a large scale the feasibility of using hydrogen to support integration of renewable energy sources into the energy systems

The project will demonstrate the potential for FC m-CHP to offer real-world benefits to the grid through a large-scale demonstration involving virtual control of 25 units.



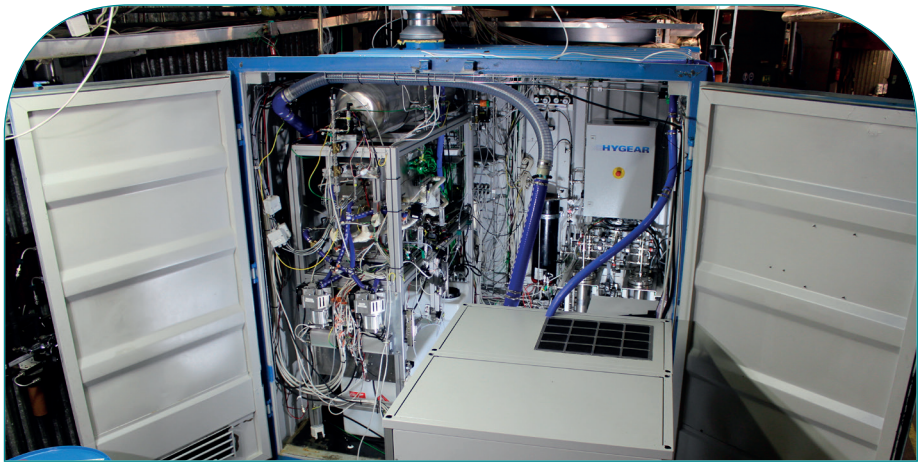


PEMBeyond

PEMBeyond

PEMFC SYSTEM AND LOW-GRADE BIOETHANOL PROCESSOR UNIT DEVELOPMENT FOR BACK-UP AND OFF-GRID POWER APPLICATIONS

Project ID:	**621218**
Call topic:	**SP1-JTI-FCH.2013.4.4** - Development of 1-30kW fuel cell systems and hydrogen supply for early market applications
Project total costs:	**€ 4,586,324.9**
FCH JU max. Contribution:	**€ 2,315,539**
Project start - end:	01/05/2014 - 31/12/2017
Coordinator:	**TEKNOLOGIAN TUTKIMUSKESKUS VTT OY, FI**
Website:	**www.pembeyond.eu**



BENEFICIARIES: FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V, GENPORT SRL - SPIN OFF DEL POLITECNICO DI MILANO, Powercell Sweden AB, TEKNOLOGIAN TUTKIMUSKESKUS VTT, UNIVERSIDADE DO PORTO

PROJECT AND OBJECTIVES

PEMBeyond project aims to develop a bioethanol fuelled integrated PEMFC based power system for back-up and off-grid applications. The work started from catalyst and adsorbent material development and continued in the design and manufacturing of subsystems. The subsystems were tested individually and then integrated together for a field trial. The system could not be fully demonstrated due to third party related Sulphur contamination in fuel processor, but the hydrogen produced from the bioethanol was shown to function well with the fuel cell system.

PROGRESS & MAIN ACHIEVEMENTS

- Steam reforming catalyst stability with crude bioethanol demonstrated with 1000 h laboratory run
- PSA product hydrogen CO level < 20 ppm reached with demo unit and < 0.2 in lab unit
- The in project developed S2 stack demonstrated for cold start-up capability from -25 °C

FUTURE STEPS & PLANS

Project is finished

RELEVANCE TO FCH JU OVERARCHING OBJECTIVES

Increase the energy efficiency of production of hydrogen mainly from water electrolysis and renewable sources into while reducing operating and capital costs

The project demonstrated H2 production from crude bioethanol. Furthermore, a very effective PSA purification method was demonstrated, being capable of producing automotive grade fuels from very low quality synthesis gas streams.

Demonstrate on a large scale the feasibility of using hydrogen to support integration of renewable energy sources into the energy systems

The reformed ethanol fuel cell system was partially aimed for telecom and micro grid application, replacing existing diesel gensets, often combined with renewables.

QUANTITATIVE TARGETS AND STATUS

FCH JU Programme Targets*

PARAMETER	UNIT	RESULT ACHIEVED TO DATE	TARGET	TARGET ACHIEVED?	DESCRIPTION
Hydrogen tolerance of the Stationary Unit	%	100	100	✓	N/A
Rated system electrical efficiency (LHV)	%	48	45	✓	At 3 kW net operation point.
Lifetime of the fuel cell system	years	20	8 - 20	✓	Some of the blowers/pumps may need replacement depending on operating hours.
CAPEX	EUR/kW	3800	4,500 - 7,500 [or 2,500 (including H2 generator) (@ >500 units)]	✗	N/A
Land use / footprint	m2/kW	0.1	0.08	✗	N/A

* As identified in AIP 2013, MAWP Addendum 2018-2020, Target years 2017- 2020

POWER-UP
DEMONSTRATION OF 500 KWE ALKALINE FUEL CELL SYSTEM

Project ID:	**325356**
Call topic:	**SP1-JTI-FCH.2012.3.7** - Field demonstration of large scale stationary power and CHP fuel cell systems
Project total costs:	**€ 13,654,855.67**
FCH JU max. Contribution:	**€ 6,137,565**
Project start - end:	01/04/2013 - 30/06/2017
Coordinator:	**AFC ENERGY PLC, UK**
Website:	**www.project-power-up.eu**

BENEFICIARIES: AIR PRODUCTS PLC, FAST - FEDERAZIONE DELLE ASSOCIAZIONI SCIENTIFICHE E TECNICHE, G.B. INNOMECH LIMITED, PAUL SCHERRER INSTITUT, ZENTRUM FUR BRENNSTOFFZELLEN-TECHNIK GMBH

PROJECT AND OBJECTIVES

In project POWER-UP, AFC Energy and the Consortium partners worked towards the demonstration of an alkaline fuel cell (AFC) system at Air Products industrial gas plant at Stade, Lower Saxony, Germany. This project is the world's first demonstration of a large-scale alkaline fuel cell system, intended to prove within four years that this laboratory-based prototype technology could be scaled up to a 240kWe industrial fuel cell system running on hydrogen available as a by-product of the chlor-alkali process.

NON QUANTITATIVE OBJECTIVES

Clear understanding of external impacts

PROGRESS & MAIN ACHIEVEMENTS

- The 240 kWe alkaline fuel cell demonstration plant in Germany has been constructed and commissioned successfully by AFC, a global first at this scale
- AFC Energy's fuel cell component manufacturing has been scaled up significantly, with 1.375% capacity improvement after yield
- Environmental 'footprint' and relevant socio-economic factors of the fuel cell system have been analyses and quantified by project partner PSI

FUTURE STEPS & PLANS

- Project is finished
- The Stade plant is still actively used as a demonstration facility for new alkaline fuel cell stack designs and balance of plant upgrades

RELEVANCE TO FCH JU OVERARCHING OBJECTIVES

Increase the electrical efficiency and the durability of the different fuel cells

For alkaline fuel cell technology, both the Balance of Plant and Stack efficiency and durability have increased remarkably during the project.

QUANTITATIVE TARGETS AND STATUS

FCH JU Programme Targets*

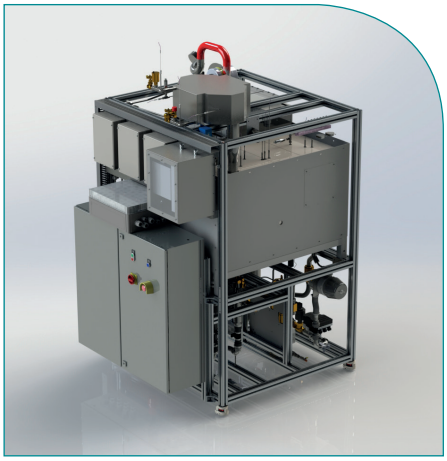
PARAMETER	UNIT	RESULT ACHIEVED TO DATE	TARGET	TARGET ACHIEVED?	SoA result achieved to date by other group/project (SoA year)	DESCRIPTION
Lifetime of the fuel cell system	years	25	8-20	✓	N/A	Alkaline fuel cells allow cost-effective material and component selection with significant lifespan, due to the relatively low operating temperature and pressure
Conversion efficiency	%	62%, based on electrochemical efficiency calculation, measured against the lower heating value (LHV) of hydrogen	>85%	✗	59% (2016)	N/A
Availability	%	>95% for specific runs'	97	✓ for specific runs'	90% (2013)	N/A

* As identified in MAWP Addendum 2018-2020, Target year 2020

STAGE-SOFC

INNOVATIVE SOFC SYSTEM LAYOUT FOR STATIONARY POWER

Project ID:	621213
Call topic:	**SP1-JTI-FCH.2013.3.4** - Proof of concept and validation of whole fuel cell systems for stationary power and CHP applications at a representative scale
Project total costs:	**€ 3,921,223.1**
FCH JU max. Contribution:	**€ 2,165,724.6**
Project start - end:	01/04/2014 - 30/04/2018
Coordinator:	**TEKNOLOGIAN TUTKIMUSKESKUS VTT OY, FI**
Website:	**www.stage-sofc-project.eu**



BENEFICIARIES: ICI CALDAIE SPA, LAPPEENRANNAN TEKNILLINEN YLIOPISTO, SUNFIRE GMBH, TEKNOLOGIAN TUTKIMUSKESKUS VTT, ZACHODNIOPOMORSKI UNIWERSYTET TECHNOLOGICZNY W SZCZECINIE

PROJECT AND OBJECTIVES

This project introduced a new SOFC-concept featuring the serial connection of an exothermal CPOx stage with an endothermic steam reforming stage. The project aimed at developing a proof-of-concept (PoC) system that achieves an electrical efficiency of at least 45 % and a thermal efficiency of over 85 %. The development of the PoC prototype consisted of two successive steps including the design and construction of two prototypes. Finally, the 2nd prototype was subjected to long-term testing.

PROGRESS & MAIN ACHIEVEMENTS

- The overall feasibility of the staged concept was verified
- Using an optimised system, AC net efficiency of 45 to 50 % can be achieved
- Through LCA studies verified that the concept provides a high CO2 emission reduction potential

FUTURE STEPS & PLANS

- Project is finished
- The problems encountered in the long term system will be corrected and the product developed to a commercial maturity

RELEVANCE TO FCH JU OVERARCHING OBJECTIVES

Increase the electrical efficiency and the durability of the different fuel cells

This target was one of the key issues of the project and it was clearly achieved.

QUANTITATIVE TARGETS AND STATUS

FCH JU Programme Targets*

PARAMETER	UNIT	RESULT ACHIEVED TO DATE	TARGET	TARGET ACHIEVED?
Availability	%	99	97	✓
Rated system electrical efficiency (LHV)	%	45	42-60	✓
Rated system thermal efficiency (LHV)	%	40	24-42	✓
Lifetime of the fuel cell system	years	10	8 - 20	✓
Stack durability	khrs	20,000	50,000	✗
Hydrogen tolerance	% (volume)	20	100	✗
Land use / footprint	m2/kW	0.3	0.08	✗

*** As identified in MAWP Addendum 2018-2020, Target year 2020**

CLEARgen Demo

THE INTEGRATION AND DEMONSTRATION OF LARGE STATIONARY FUEL CELL SYSTEMS FOR DISTRIBUTED GENERATION

Project ID:	**303458**
Call topic:	**SP1-JTI-FCH.2011.3.6** - Field demonstration of large stationary fuel cell systems for distributed generation and other relevant commercial or industrial applications
Project total costs:	**€ 10,343,142.6**
FCH JU max. Contribution:	**€ 4,590,095**
Project start - end:	01/05/2012- 30/09/2020
Coordinator:	**BALLARD POWER SYSTEMS EUROPE AS, DK**
Website:	**www.cleargen.eu**

BENEFICIARIES: AQUIPAC SAS, BUDAPESTI MUSZAKI ES GAZDASAGTUDOMANYI EGYETEM, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS, HYDROGENE DE France, JEMA ENERGY SA, LINDE GAS MAGYARORSZAG ZARTKORUEN MUKODO RESZVENYTARSASAG, LOGAN ENERGY LIMITED

PROJECT AND OBJECTIVES

- The development and construction of a large scale fuel cell system for conversion of by-product hydrogen, purpose-built for the European market
- The validation of the technical and economic readiness of the fuel cell system power generation at the megawatt scale
- The field demonstration and deployment of fuel cell megawatt scale power system at a European chemical production plant. The project is in the phase of finalizing the host site preparation for installation and commissioning.

NON QUANTITATIVE OBJECTIVES

- Safety improvement
- Training

PROGRESS & MAIN ACHIEVEMENTS

- The planned studies (implementation, process, safety, civil work, steel structure, pipeline, instrumentation) were finalized
- The construction of the two 500 kW CLEARgen units and completion of FAT test were finalized
- The host site preparation is in progress

FUTURE STEPS & PLANS

- Installation and Commissioning: The preparation of installation phase is not yet advanced. Nevertheless, first discussions occur to plan the commission
- System Operation and Maintenance: This work package will begin together with the start of the fuel cell. System Monitoring Assessment and Knowledge Transfer: performance reports for 12,000 hours of operation from 2019 to 2020
- Midterm review, planned for October 2018
- Midterm conference, planned for March 2018

RELEVANCE TO FCH JU OVERARCHING OBJECTIVES

Increase the electrical efficiency and the durability of the different fuel cells

One of the objectives is to Demonstrate the commercial viability of fuel cells for use in distributed power generation and the benefits associated to the modularity that this technology and product offers.

QUANTITATIVE TARGETS AND STATUS

FCH JU Programme Targets*

PARAMETER	UNIT	RESULT ACHIEVED TO DATE	TARGET	TARGET ACHIEVED?	DESCRIPTION
Rated system electrical efficiency (LHV)	%	46.6	42-60	✓	The efficiency of the system is the average of 2 power banks. Efficiency of each power banks are respectively 46.4% and 46.8%.
Lifetime of the fuel cell system	years	15	8-20	✓	The PPA is planned on 15 years operation
Stack durability	hours	20,000	50,000	✗	the aim is to reach 40 000 h of operation for a stack
Land use / footprint	m2/kW	0.278	0.08	✗	The fuel cell system occupy 15.35m x 18.1m of land excluding purification system for hydrogen and transformer unit.

*** As identified in MAWP Addendum 2018-2020, Target year 2020**

ene.field

EUROPEAN-WIDE FIELD TRIALS FOR RESIDENTIAL FUEL CELL M-CHP

Project ID:	**303462**
Call topic:	**SP1-JTI-FCH.2011.3.7** - Field demonstration of small stationary fuel cell systems for residential and commercial applications
Project total costs:	**€ 54,542,494.38**
FCH JU max. Contribution:	**€ 25,907,168.77**
Project start - end:	01/09/2012 - 31/10/2017
Coordinator:	**THE EUROPEAN ASSOCIATION FOR THE PROMOTION OF COGENERATION VZW, BE**
Website:	**www.enefield.eu**

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

PROJECT AND OBJECTIVES

Ene.field is the largest European demonstration of the latest home energy solution for private homes, fuel cell m-CHP. The project ran from 2012 to 2017 and during these five years it installed 1,046 Fuel Cell m-CHP systems across 10 key European countries and demonstrated more than 5.5 million hours of operation and 4.5 GWh of power produced. Outputs of the project include: detailed performance data, lifecycle cost and environmental assessments, market analysis, commercialization strategy.

NON QUANTITATIVE OBJECTIVES

- Provide an overview of the current regulations, codes and standards in Europe and at national level
- Carry out a comprehensive life cycle assessment (LCA)
- Determine a future commercialization strategy for the technology by reviewing cost and volume projections with the manufacturers and by exploring different routes to market assess the requirements for future policy or financial incentives

PROGRESS & MAIN ACHIEVEMENTS

- 1046 units have been installed FC m-CHP units have been installed under ene.field, which exceeds the original target of 1000
- A number of public reports (or reports with a public summary) have been produced with the findings of the project that are available on the website: enefield.eu
- FC m-CHP is ready for a large market penetration. In the best 6-month period, availability of the units to the end-user has been above 99%

FUTURE STEPS & PLANS

Project is finished.

RELEVANCE TO FCH JU OVERARCHING OBJECTIVES

Increase the electrical efficiency and the durability of the different fuel cells

Real-life data from the field trial has shown electrical efficiencies in between 30 – 60%.

QUANTITATIVE TARGETS AND STATUS

FCH JU Programme Targets*

PARAMETER	UNIT	RESULT ACHIEVED TO DATE	TARGET	TARGET ACHIEVED?
Availability	%	Up to 100	97	✓
Operational and maintenance costs (OPEX)	EUR/kWh	Less than 0.02	0.05	✓
Lifetime of the m-CHP unit	years	10-15	13	✓
stack durability	hours	30,000- 80,000	50,000	✓
Hydrogen tolerance	%	Up to 100	100	✓

*** As identified in MAWP Addendum 2018-2020, Target year 2020**