ALKAMMONIA
Ammonia-fuelled alkaline fuel cells for remote power applications

Panel 3 — Technology validation in stationary applications

Acronym:	**ALKAMMONIA**
Project ID:	325343
Title:	Ammonia-fuelled alkaline fuel cells for remote power applications
Call Topic:	SP1-JTI-FCH.2012.3.5
Project total costs (€):	€ 2,9 million
FCH JU maximum contribution (€):	€ 2,0 million
Project start/end:	01 May 2013 - 30 Apr 2017
Coordinator:	AFC Energy, United Kingdom
Beneficiaries:	Acta, Fast - Federazione delle Associazioni Scientifiche e Tecniche, Uni. Duisburg-Essen, UPS Systems, Zentrum Fur Brennstoffzellen-Technik, Paul Scherrer Inst.
Website:	http://alkammonia.eu/

Project and objectives

Project ALKAMMONIA focused on the design, manufacture and testing of a prototype integrated small-scale power system designed for remote applications. The prototype integrates two main components: a fuel delivery system that passes ammonia through a cracker to produce hydrogen and an alkaline fuel cell system which utilises the hydrogen produced. A control system for the fuel cell component should be extended to manage the whole integrated system. The main development are underpinned by computational modelling and a programme of project controls running throughout the project duration.

Major project achievements

- 11.4 kWe in a 101-cell stack achieved (original target 10 kWe). Partly populated stacks in 2.5 kW range also successfully tested.
- NH3 cracker designed, built and being validated in ZBT laboratories.
- A high-level integrated system design has been produced

Future steps

- NH3 cracker HAZOP close out and validation of performance in ZBT laboratory
- BoP and cracker installation, integration and commissioning
- Operation of the integrated system for minimum 1,000 h
- Sustainability & Total System Cost Analysis plus LCA to be produced
- Dissemination and communication of project results

Non-quantitative objectives and status

- Achieve CE certification
  CE certification requirement may be reviewed, based on scenario of ownership and operation responsibility for future commercial applications
- Assessment of system impact
  Life Cycle Analysis (LCA) and Sustainability & Total System Cost Analysis pending

Relevant to FCH JU overarching objectives

- Increase the electrical efficiency and the durability of the different fuel cells used for power production to levels which can compete with conventional technologies, while reducing costs
- Reduce the use of the EU defined 'Critical raw materials', for instance through low-platinum or platinum-free resources and through recycling or reducing or avoiding the use of rare earth elements.

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
Project's own	Cracker durability	h	500	2,000			Not achieved	Validation required
Project's own	Cracker efficiency (LHV)	% (< & >)	80	80	90	90	Not achieved	Validation required
Project's own	Projected cracker costs	€	2,000	1,000	2,000		Not achieved	Pending
Project's own	Efficiency	%	50	50	55	60	Achieved	Stack operating voltage 700-800mV average cell voltage. Based on LHV of H_2 and taking the midpoint this achieves 60%LHV efficiency.
Project's own	Stack weight	kg	200	150	120	120	Achieved	Achieved using 2.5kW stack
Project's own	Stack durability	h	1,400	3,000	1,400		Not achieved	Routine testing up to 1000 h +forecasting thereafter. Coupon testing degradation rate <30 µV/h. Needs validating when cracker arrives
Project's own	Leakage losses	%	10	1			Not addressed	Subject to future design review (outside of project timeline, but future focus of company).
Project's own	High AFC BoP efficency	% (< & >)	80	90	80		Not achieved	
Project's own	Decrease BoP system costs	€	6,000	3,000	6,000		Not achieved	
select	Decrease start-up time	min(> & <)	30.00	10	30.00		Not achieved	

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AutoRE
AUTomotive deRivative Energy system

Panel 3 — Technology validation in stationary applications

Acronym:	**AutoRE**
Project ID:	671396
Title:	AUTomotive deRivative Energy system
Call Topic:	FCH-02.5-2014
Project total costs (€):	€ 4,5 million
FCH JU maximum contribution (€):	€ 3,5 million
Project start/end:	01 Aug 2015 - 31 Jul 2018
Coordinator:	Alstom Power Ltd, United Kingdom
Beneficiaries:	Nucellsys, General Electric (Switzerland), Uni. Tuscia, ELVIO Anonymi Etaireia Systimaton Paragogis Ydrogonou Kai Energeias, Sveuciliste U Splitu, Daimler, Stiftelsen Sintef
Website:	http://www.autore-fch.com/

Project and objectives

The main objective is to create the foundations to commercialise an automotive derivative fuel cell system in the 50-100 kWe range for CHP in commercial and industrial buildings. The project is in its second year and is progressing largely to schedule. The fuel cell CHP prototype site has been prepared and the automotive derivative PEM fuel cell installed. Lab-scale testing of component enhancements to the prototype system, to reduce its cost of electricity/foot-print and increase its performance are underway. Extensive modelling of the CHP system has been carried out.

Major project achievements

- The prototype CHP site has been prepared and the fuel cell system installed, with the H_2 production system undergoing final factory acceptance tests
- Testing of selective H_2 separation membranes is underway. Relative to the baseline, cooling/dehydration of reformed natural gas feed is not required
- Modelling of the system shows that reformer thermal integration improves performance and that selective membranes should be in integrated with WGS

Future steps

- Factory acceptance test of completed H_2 production system prior to delivery to prototype test site
- Complete prototype system build and undertake 3000h duration test programme
- Complete system modelling activities including RAMS, durability and performance modelling
- Complete lab-scale testing of selective hydrogen separation membrane and compact heat exchangers
- Prepare business case for commercial system and disseminate project findings to key stakeholders

Non-quantitative objectives and status

- Support development of codes and standards for new technologies Learnings from site application to build prototype system in the UK to be made available as 'public' deliverable
- Contribute to decarbonisation of building and power generation sector Successful commercial exploitation of mid-sized auto-derivative fuel-cell based CHP systems will contribute to CO_2 reduction targets in the EU

Relevant to FCH JU overarching objectives

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

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
MAWP 2014-2020	CAPEX	€/kW	10,000	3,000		3,000	Due later	Target for grid parity on LCOE (for the 50kWe sized CHP system @ mass production)
MAWP 2014-2020	Durability	years	2	2		2	Due later	>2y life expected based on 30kh stack life; Leverage results from other EU projects (eg Giantleap/Sapphire/ Healthcode)
MAWP 2014-2020	Availability (plant)	%	97	97		9797.00	Due later	
MAWP 2014-2020	Electrical Efficiency	% LHV	40	40		40	Due later	Target for 50kWe prototype. 45-47% to be demonstrated with improved components through modelling.
MAWP 2014-2020	Thermal Efficiency	% LHV	40	45		45	Due later	Show 90% combined electrical + thermal efficiency is possible
MAWP 2014-2020	LCOE	€cent/kWh	60	20		20	Due later	i.e. move from 3*grid parity to 1*grid
	Emissions	mg/kWh	40	40		40	Due later	Low emission through low temperature catalytic combustor approach in H_2 production system

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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

Panel 3 — Technology validation in stationary applications

Acronym:	**CLEARGEN DEMO**
Project ID:	303458
Title:	The Integration and demonstration of Large Stationary Fuel Cell Systems for Distributed Generation
Call Topic:	SP1-JTI-FCH.2011.3.6
Project total costs (€):	€ 8,6 million
FCH JU maximum contribution (€):	€ 4,6 million
Project start/end:	01 May 2012 - 30 Jun 2020
Coordinator:	Dantherm Power, Denmark
Beneficiaries:	Aquipac, Jema Energy, Budapesti Muszaki Es Gazdasagtudomanyi Egyetem, Centre National de la Recherche Scientifique CNRS, Hydrogene de France, Linde Gas Magyarorszag Zartkoruen Mukodo Reszvenytarsasag, Logan Energy Ltd
Website:	www.cleargen.eu

Project and objectives

The CLEARgen Demo proposal aims to address this need for a large-scale stationary fuel cell demonstration.

The objectives of the CLEARgen Demo Project are:

1) Development and construction of a fuel cell system, purpose-built for the European market,
2) Validation of the technical and economic readiness of the fuel cell system at the megawatt scale, and
3) Field demonstration of a megawatt scale system at a European chemical production plant.

The site for the ClearGen system was found and is placed at SARA Group on Martinique, France. The preparation of the installation has started.

Major project achievements

- The final site location was established and the investors for AQUIPAC was found
- The preparation of the site and installation are progressing and the applications for the necessary permits have been sent
- The first 500 kW power bank is in commissioning and the production of the second 500 kW power bank is ready to start

Future steps

- The final location of the ClearGen system has been found and the preparation of the site was finished (September 2017)
- The two 500 kW power banks are installed, commissioned and in operation (beginning of 2018)
- The first data set from the operation is collected and analyzed (October 2018)
- The midterm conference was hold (beginning of 2018)

Non-quantitative objectives and status

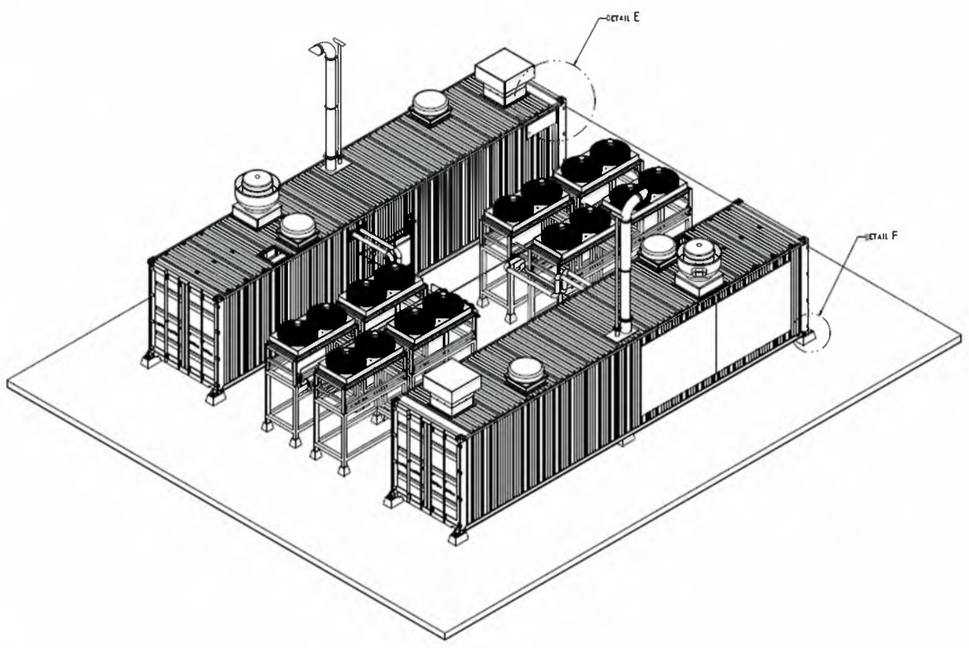
- Evaluate the entire lifecycle costs of the ClearGen installation
  To be done
- Conduct a thorough techno-economic analysis, to show transferability
  To be done
- Demonstrate the commercial viability of FC in distributed power generator
  To be done
- Facilitate EU objectives in environmental sustainability
  To be done

Relevant to FCH JU overarching objectives

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

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
AIP 2011	Demonstration size	MW	1	1	0.50	1	Due later	1st 500 kW power bank in commissioning - delivery in Sept. 2017. 2nd power bank to be delivered in Dec. 2017
MAIP 2008-2013	Stack lifetime	Hours	20,000	20,000		20,000	Due later	Expect to be exceeded after the project end
AIP 2011	Electrical Efficiency	%	50	43	48	43	Due later	Reduction of parasitic losses is important for high system efficiency
AIP 2011	System lifetime	Hours	20,000	20,000		20,000	Due later	System will be installed in the second part of 2017



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PROGRAMME REVIEW DAYS 2017

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

D2Service
Design of 2 technologies and applications to service

Panel 3 — Technology validation in stationary applications

Acronym:	**D2Service**
Project ID:	671473
Title:	Design of 2 technologies and applications to service
Call Topic:	FCH-02.9-2014
Project total costs (€):	€ 3,6 million
FCH JU maximum contribution (€):	€ 2,9 million
Project start/end:	01 Sep 2015 - 31 Aug 2018
Coordinator:	EWE Forschungszentrum für Energietechnologie, Germany
Beneficiaries: Energy Partners, British Gas Trading Ltd, Solidpower, Zentrum fur Brennstoffzellen-Technik, Bosal Emission Control Systems, Ballard Power Systems Europe	
Website:	www.project-D2Service.eu

Project and objectives

The D2Service project aims at improving serviceability of residential and commercial fuel cell systems. Installation and maintenance procedures of SOFC and PEM fuel cell-based units are analysed and optimised to reduce service times and costs, and to avoid mistakes during installation and service. Design and the components of the units are optimised towards simplified exchangeability, increased longevity and standardisation, thus decreasing service intervals and durations. The project has reached mid-term. First laboratory tests of improved units and components have been conducted.

Major project achievements

- Improved design of SOFC and PEM µ-CHP units with respect to efficiency, serviceability, durability and cost reduction
- Suitable catalyst and adsorber materials identified for 60000h lifetime of hydrodesulphurisation component
- Identification and preparation of sites for field trial of improved units

Future steps

- Finalisation of PEM and SOFC µ-CHP unit improvements
- Installation of units on field trial sites
- Laboratory evaluation of improved µ-CHP units
- Development of guidelines for easy-to-understand graphical manuals
- Development of simplified service procedures

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Quantitative targets and status

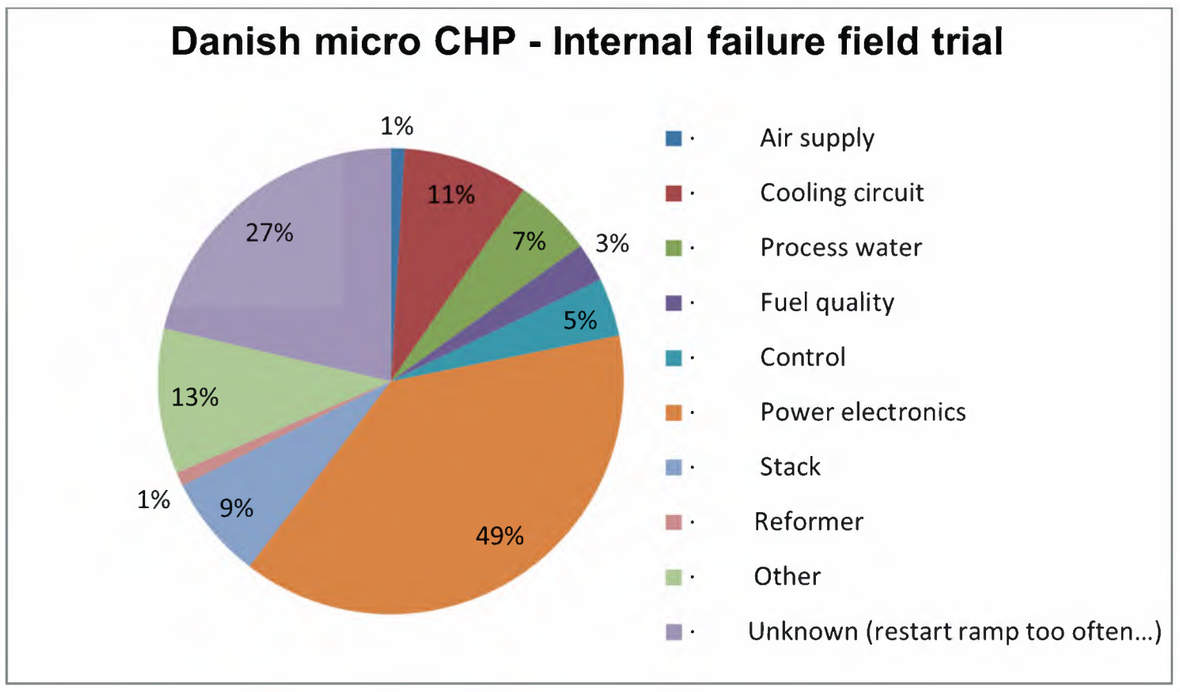
Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
AIP 2014	Presence/Service time – presence time of maintenance technician	h	8	<4	<8	<4	Due later	Redesign of system architecture +_ hot / cold components for easier maintenance / exchange
AIP 2014	Total down-time of equipment for service (PEM)	h		<48	48	24	Achieved	As above
AIP 2014	Total down-time of equipment for service (SOFC)	h	120	<48	96	0/48/72	Due later	Down-time for single service. 0 for service for components except forHotBox; 48h for periodical service; 72h for stack replacement (ca. every 3y)
AIP 2014	Increased service interval time	nr/a	4	<1	1	≤ 1	Due later	Via increased components' durability & lifetime
AIP 2014	Service cost	Euro/kW/year	11.500	<600	1.500	<600	Due later	Exact costs of redesigned components are not fixed yet

Non-quantitative objectives and status

- Elaboration of guidelines for easily understandable service manuals
  Current state-of-the-art is identified; graphical illustrations with minimal text is aimed at.
- Life-time desulphurisation (type HDS)
  Suitable catalyst and adsorber materials identified for 60000h. Necessary recirculation stream and type of recirculation device elaborated
- Water treatment optimisation
  Better material identified leading to extended service intervals

Relevant to FCH JU overarching objectives

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



DEMCOPEM-2MW

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

Panel 3 — Technology validation in stationary applications

Acronym:	**DEMCOPEM-2MW**
Project ID:	621256
Title:	Demonstration of a combined heat and power 2 MWe PEM fuel cell generator and integration into an existing chlorine production plant
Call Topic:	SP1-JTI-FCH.2013.3.5
Project total costs (€):	€ 10,5 million
FCH JU maximum contribution (€):	€ 5,5 million
Project start/end:	01 Jan 2015 - 31 Dec 2018
Coordinator:	Akzo Nobel Industrial Chemicals B.V., The Netherlands
Beneficiaries:	Politec. Milano, Johnson Matthey Fuel Cells Ltd, Mtsa Technopower, Nedstack Fuel Cell Technology
Website:	http://www.demcopem-2mw.eu

Project and objectives

The aim of the project is 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 third year and the PEM system has been installed in September 2016 at the chlor-alkali plant in Yingkou, China.

The initial capacity reached 1,7 MW (due to some technical limitations); from January 2017 - when technical items were solved - the installation is capable to function on full capacity of 2MW.

Major project achievements

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

Future steps

- Remote Monitoring of system/stacks performances
- Application and optimisation validation model developed for the project
- Optimise cost
- Supply and testing of improved stacks containing improved MEA's

Non-quantitative objectives and status

- High net conversion efficiency, i.e. > 50% electric energy on system
  Possible/achieved (even if not implemented by end-user)
- Over 2 years (16,000 hrs) for fuel cell stacks
  Data collection ongoing.
- Fully automated way of operation and remote control
  Achieved

Relevant to FCH JU overarching objectives

- Reduce the production cost of fuel cell systems to be used in transport applications, while increasing their lifetime to levels which can compete with conventional technologies
- Increase the electrical efficiency and the durability of the different fuel cells used for power production to levels which can compete with conventional technologies, while reducing costs
- Demonstrate on a large scale the feasibility of using hydrogen to support integration of renewable energy sources into the energy systems, including through its use as a competitive energy storage medium for electricity produced from renewable energy sources

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
MAIP 2008-2013	Installed capacity	MW	1	2	2	2	Achieved	+ prove potential for 20 more similar-sized PEM power plants
MAIP 2008-2013	Cost	€/kW		2500			Due later	In the remaining one and half year of the project further data will be analised for cost reduction
MAIP 2008-2013	Durability	hours		16,000			Due later	
Project's own	electrical efficiency	%		50			Achieved	
Project's own	heat+power efficiency	%		85			Not yet addressed	

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DEMOSOFC
Demonstration of large SOFC system fed with biogas from WWTP

Panel 3 — Technology validation in stationary applications

Acronym:	**DEMOSOFC**
Project ID:	671470
Title:	Demonstration of large SOFC system fed with biogas from WWTP
Call Topic:	FCH-02.11-2014
Project total costs (€):	€ 5,9 million
FCH JU maximum contribution (€):	€ 4,5 million
Project start/end:	01 Sep 2015 - 31 Aug 2020
Coordinator:	Politec. Torino, Italy
Beneficiaries:	Risorse Idriche, VTT, Società Metropolitana Acque Torino, Imperial College Science Technol. and Medicine, Convion
Website:	www.demosofc.eu
Linkedin:	DEMOSOFC (Linkedin group)
Twitter:	@Steps_Polito

Project and objectives

DEMOSOFC is a 5-year project with an aim of demonstrating a medium-scale distributed CHP system (electric power of 175 kW and thermal recovery of 90 kW) based on SOFC and fed with locally available biogas produced in a waste water treatment plant.

Status at June 2017:

1) detailed engineering, including safety analysis and permitting procedures: completed
2) site preparation (biogas recovery and cleaning, electrical connections, thermal recovery) by mid July 2017
3) installation of the first (up to 3) SOFC module by end of July 2017
4) start up October 2017
5) business analysis (on going)

Major project achievements

- Complete experience of detailed engineering for the installation and operation of a biogas-fed SOFC CHP system at industrial scale, all included
- Complete experience of installation of a biogas-fed SOFC CHP system in an existing industrial context (waste water treatment plant)
- Design and construction of the biogas clean-up module for SOFC targets (material selection, engineering, control)

Future steps

- Complete of the DEMO installation and start-up of the operation
- Monitoring of the operation of the DEMO: Analysis of the electric
- Monitoring of the operation of the DEMO (electricity, thermal recovery, emissions)
- Analysis of the business opportunities of biogas-fed SOFC CHP systems
- Dissemination: newsletters, papers, but especially public workshops (2 in the period)

Quantitative targets and status

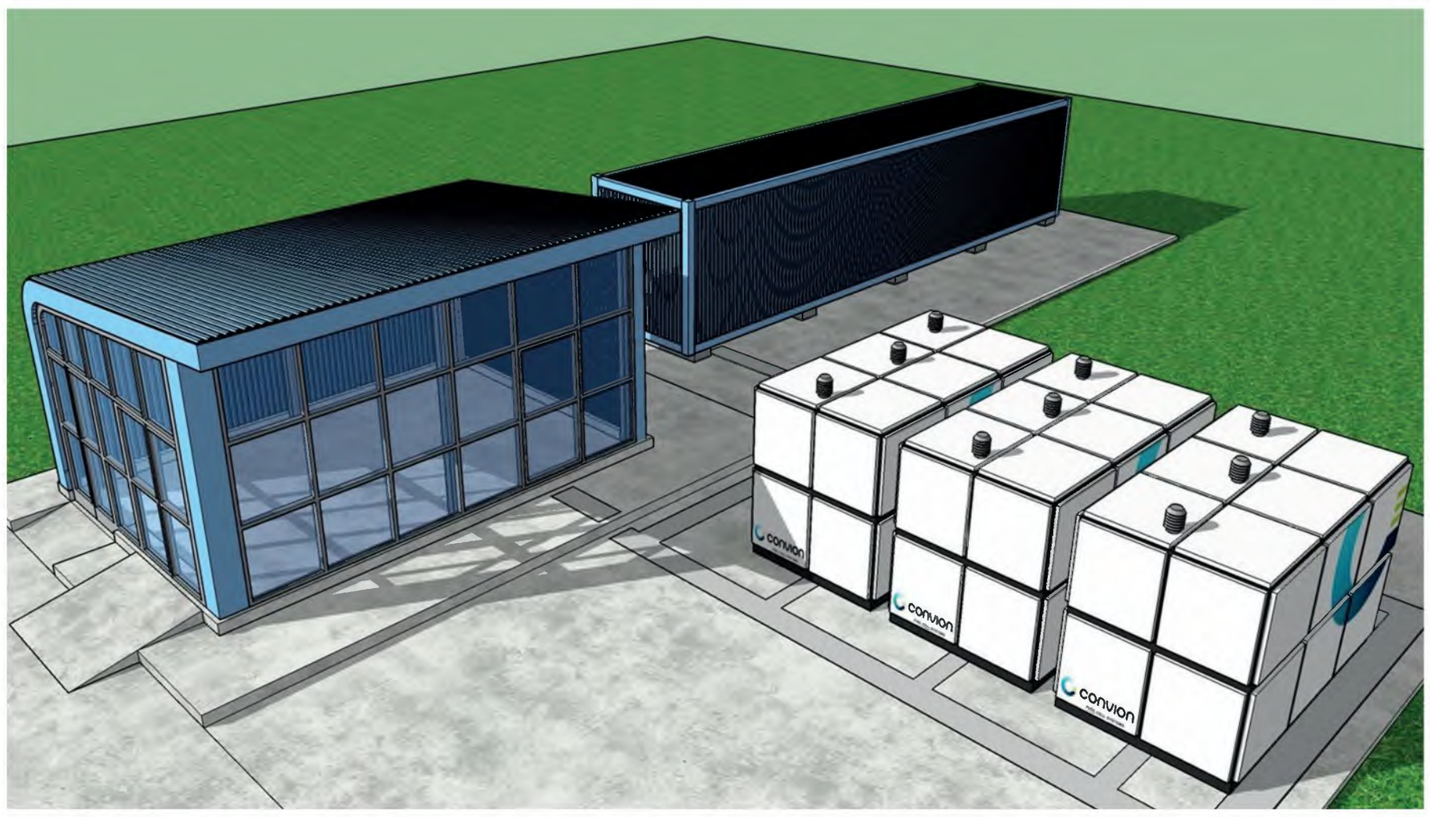
Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
AIP 2014	CAPEX of SOFC systems	€/kW	15,669	7,000		7,000	Due later	Install the third module (by Autumn 2017) with improved performances and lower unit costs
AIP 2014	Emissions of CO_2 and other contaminants	g/kWh NG	422	422	422	422	Not yet addressed	CO_2 emissions will be neutral (biogas fuel); also 27% lower vs ICE. The other contaminants (CO, PM, VOC) are absent
MAWP 2014-2020	Increase FC system electrical efficiency	%	53	58	53	58	Due later	Electrical efficiency of a complete biogas-fed SOFC system, from biogas to AC power
MAWP 2014-2020	Heat recovery	%	30	40	30	40	Due later	To organise the FC system to ensure a complete heat recovery
MAWP 2014-2020	Fuel clean-up before FC	ppm	1	0.2	0.2	0.2	Achieved	Removal of micro-contaminants in the biogas (sulphur compounds, siloxanes)

Non-quantitative objectives and status

- DEMO of a SOFC-based distributed CHP system fed by a biogenous fuel
  Installation ongoing, to be completed by July 2017 (and last SOFC module in autumn 2017). First industrial size SOFC-based system in EU so far
- Build technical knowledge, customer confidence, investor confidence
  Detailed engineering done, lessons learned for replication. Installation on-going, to be completed by July 2017 (last SOFC module in Autumn 2017)
- Demonstrate high efficiency of SOFC-based CHP systems fed by biogas
  We foresee an electrical efficiency of 53-55%, and an overall efficiency of 90%. Third SOFC module is expected to reach 58% electric efficiency
- Strong dissemination for public awareness
  Dissemination started using press release, social media (Facebook, Twitter, etc.) and website. Next actions centred on workshops after DEMO start-up

Relevant to FCH JU overarching objectives

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



FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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ENE.FIELD
European-wide field trials for residential fuel cell micro-CHP

Panel 3 — Technology validation in stationary applications

Acronym:	**ENE.FIELD**
Project ID:	303462
Title:	European-wide field trials for residential fuel cell micro-CHP
Call Topic:	SP1-JTI-FCH.2011.3.7
Project total costs (€):	€ 52,5 million
FCH JU maximum contribution (€):	€ 25,9 million
Project start/end:	01 Sep 2012 - 31 Aug 2017
Coordinator:	COGEN, the European Association for the Promotion of Cogeneration, Belgium
Beneficiaries:	Hexis, Baxi Innotech, Bosch Thermotechnik, Danmarks Tek. Uni., Ballard Power Systems Europe, Dbi - Gastechnologisches Inst. G Freiberg, Dolomiti Energia, Dong Energy Oil & Gas, Dong Energy Wind Power Holding, Elcore, British Gas Trading Ltd, Ceres Power Ltd, Imperial College Science Technol. and Medicine, Eifer Europaisches Inst. fur Energieforschung, Parco Scientifico e Tecnol. Per l'Ambiente - Environment Park, Politec. Torino, Element Energy Ltd, Riesaer Brennstoffzellentechnik, Senertec Kraft-Warme Energiesysteme, Solidpower, The Energy Saving Trust Ltd by Guarantee, Vaillant, Viessmann Werke, ENGIE, Gaswarme-Inst. Essen, Hydrogen, Fuel Cells and Electro-mobility in European Regions HYER, Itho Daalderop Group, Razvojni Center Za Vodikove Tehnologije
Website:	http://enefield.eu/

Project and objectives

The ene.field project has placed over 950 fuel cell µ-CHPs into homes across 12 European countries by June 2017 and has commitments to place a total of 1051 units by the end of the project on 31/08/2017. The project consortium comprises 26 partners from across research, heating industry, utility and association communities and will have received around €26 million EU funding over its duration. It is Europe's largest deployment of this modern FC µ-CHP technology to date and has allowed manufacturers to begin to reduce costs and build market.

Major project achievements

- Almost 1000 units have been installed to date out of the updated plan of 1051 units representing a 5% increase on the original plan
- Report on the non-economic barriers to large-scale market uptake of fuel cell based micro-CHP technology
- National events have been organised in several countries where installations take place to promote the technology

Future steps

- Deployment will continue until 1051 units are installed. A report will be prepared based on the inputs from manufacturers on deployment
- The report on technical performance of all µ-CHP units in the trial will be finalised
- Non-economic barriers Report, Lifecycle cost assessments, and Environmental life cycle assessments reports will be completed
- The report on macro-economic and macro-environmental impact will become available
- The final dissemination event will be held 11 October 2017 in Brussels which, at the same time, will be a launch event for PACE ("follow-up" project)

Quantitative targets and status

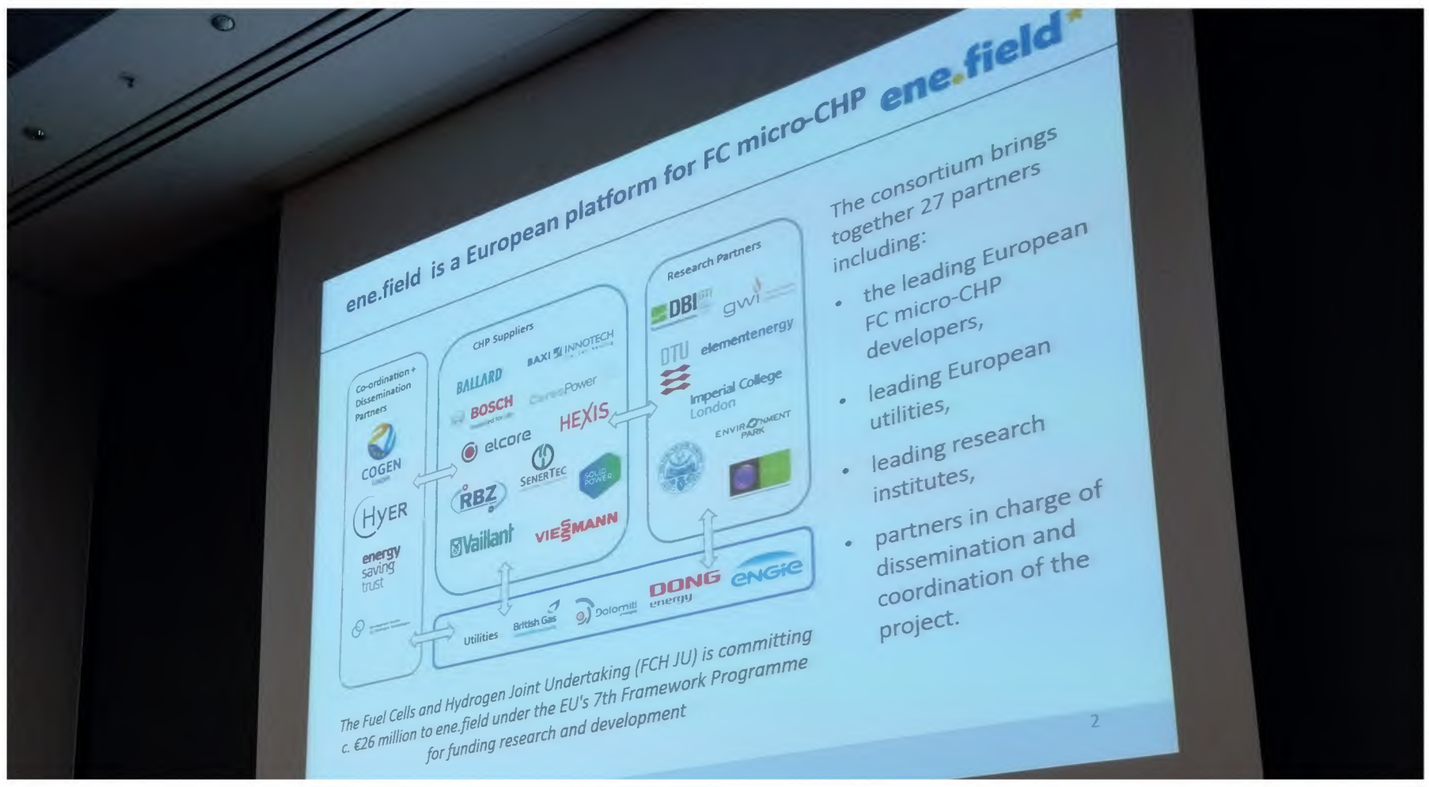
Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
MAIP 2008-2013	Nr of units installed		500	1000	1046	1046	Achieved	> 1000 units by Q4 2017
MAIP 2008-2013	Nr of countries with units installed		1	11	10	10	Achieved	
MAIP 2008-2013	Nr of µ-CHP suppliers		5	9	10	10	Achieved	10 suppliers and 11 products trialled
MAIP 2008-2013	Electrical efficiency	%	30	35	35	35	Achieved	Field trials real-life data have shown electrical efficiencies in range 30 – 60%
MAIP 2008-2013	Overall efficiency >85% (LHV)	%	70	8	85	85	Achieved	Field trials real-life data have shown overall efficiencies as high as 85-95%
project's own	Availability	%	90	95	96	96	Achieved	96 to 99%

Non-quantitative objectives and status

- Increase the operational experience
  Diverse set of installations representing housing sector market throughout Europe.
  Operation in three climatic regions
- Estimate full life cycle costs and environmental sustainability asses
  A full life cycle cost (LCC) and life cycle environmental assessment (LCA) have been delivered
- Identify barriers and risks to full implementation
  Full record of issues encountered during manufacture, installation and operation, to inform practical barriers to implementation
- Disseminate to a wider audience incl. potential customers and industry
  Active dissemination was conducted throughout the project

Relevant to FCH JU overarching objectives

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



HEATSTACK
Production Ready Heat Exchangers and Fuel Cell Stacks for Fuel Cell mCHP

Panel 3 — Technology validation in stationary applications

Acronym:	**HEATSTACK**
Project ID:	700564
Title:	Production Ready Heat Exchangers and Fuel Cell Stacks for Fuel Cell mCHP
Call Topic:	FCH-02.6-2015
Project total costs (€):	€ 2,9 million
FCH JU maximum contribution (€):	€ 2,9 million
Project start/end:	01 Apr 2016 - 31 Mar 2019
Coordinator:	Senior UK, United Kingdom
Beneficiaries: Sunfire, Vaillant, ICI Caldaie, Uni. Birmingham, Senior Flexonics, PNO Consultants Ltd	
Website:	http://www.heatstack.eu/news-and-events/heatstack-production-ready-heat-exchangers-fuel-cell-stacks-fuel-cell-mchp/
Linkedin:	HEATSTACK Project
Twitter:	@HEATSTACK_EU

Project and objectives

HEATSTACK is an industrially focussed project aiming at cost reduction of the two most expensive components of micro-combined heat and power (μ-CHP) with a primary focus on working towards sufficient cost reductions to enable mass market adoption in domestic properties. This objective will be realised through the improved design, manufacturing process and automation of the cathode air preheater and stack, with a goal of reducing cost per unit by 50% once annual production of 10.000 units is realised by a target date of 2020.

Major project achievements

- Senior have fully developed the tooling and equipment, and process methodology, to be in a position to manufacture CAPHs reliably and efficiently
- The CAPH has been redesigned to give it higher stability and durability for extended usage
- Birmingham University's tests have provided positive and valuable data on the performance of the AluChrom 318, proving its utility in this application

Future steps

- None reported

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Quantitative targets and status

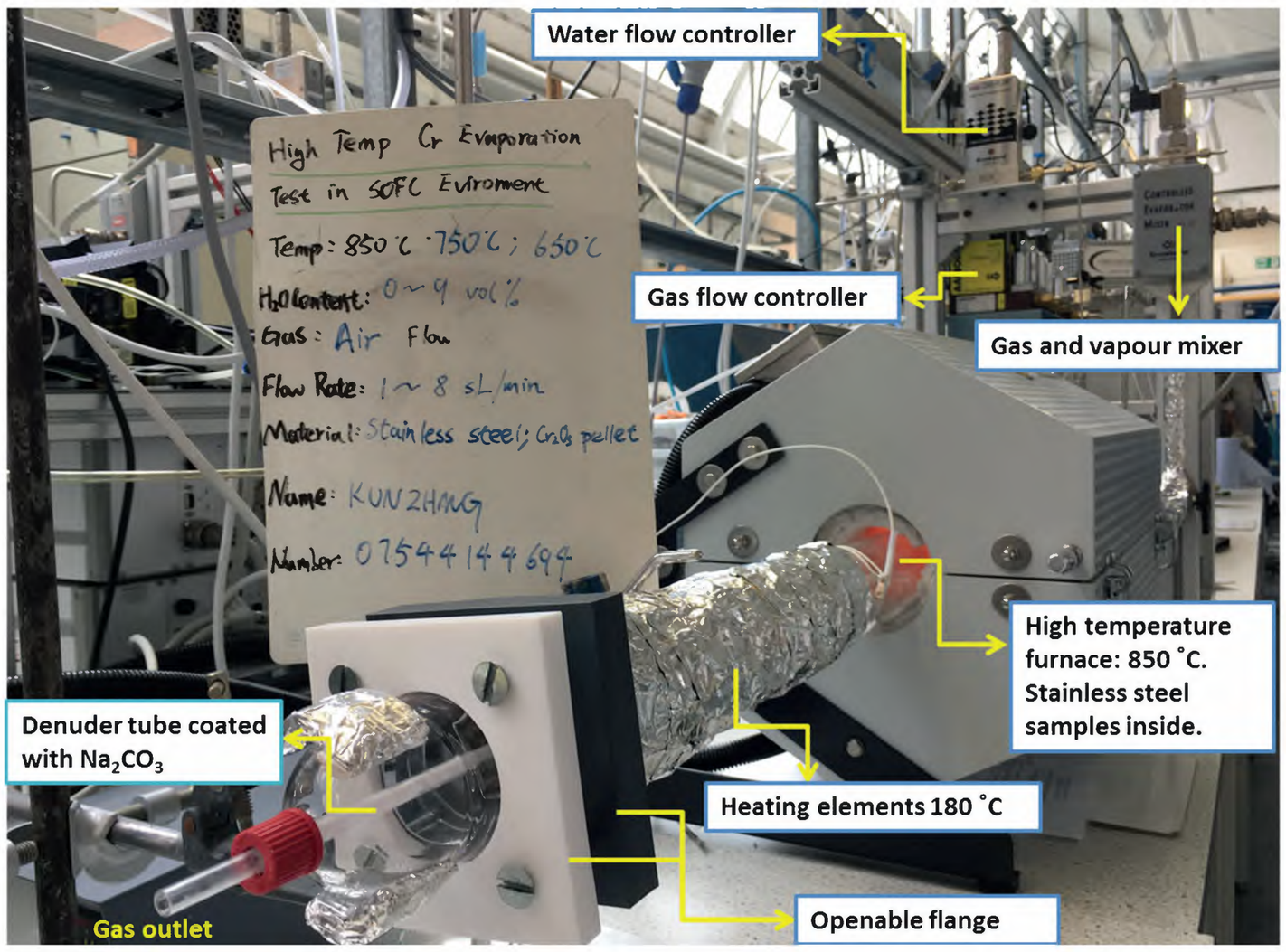
Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
Project's own	Unit cost reduction of CAPH reduced by 50%	£	600	300	500	500	Due later	Further cost reductions can only be achieved through mass manufacture and hence eocnomies of scale which was forecast for 2020
Project's own	Sealing time	min	200	100	200	100	Due later	Reduce sealing time of fuel cells by 50% - In the design phase - will be implemented in the coming year
Project's own	Nr cells per CAPH	units	28	14	14	14	Achieved	Through successful changes to CAPH design
Project's own	CAPH manufacture cycle time	h	8.83	1.35			Due later	

Non-quantitative objectives and status

- Develop novel tooling for welding process
  Successfully completed
- Establish method to repair leads to reduce scrap
  The system has been procured and has proven to be able to repair previously difficult leaks, attaining the planned objective successfully
- Material testing for understanding of corrosion & performance of AluChro
  This work is well underway and has generated positive results so far which will be used in marketing material, testing continues
- Increase production volume potential
  Vaillant's withdrawal from the fuel cell sector has made this a challenge- need applications for the CAPH and new end users are being explored

Relevant to FCH JU overarching objectives

- None reported



INNO-SOFC
Development of innovative 50 kW SOFC system and related value chain

Panel 3 — Technology validation in stationary applications

Acronym:	**INNO-SOFC**
Project ID:	671403
Title:	Development of innovative 50 kW SOFC system and related value chain
Call Topic:	FCH-02.5-2014
Project total costs (€):	€ 4,0 million
FCH JU maximum contribution (€):	€ 4,0 million
Project start/end:	01 Sep 2015 - 28 Feb 2018
Coordinator:	VTT, Finland
Beneficiaries:	Forschungszentrum Julich, Energy Matters, Convion, Elcogen, Elringklinger, Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile
Website:	http://www.innosofc.eu/

Project and objectives

The INNO-SOFC project is focusing on development of an innovative 50 kW SOFC system and related value chain from interconnects and stacks to end-users and application analysis. The main objective of this project is to design, assemble and demonstrate a novel 50 kW SOFC power plant with significant cost reductions, improved efficiency and longer lifetime compared to current state of the art SOFC systems (60% electrical and 85% total efficiency). In general, the project is progressing according to the plan, except some months delay in system design and manufacturing.

Major project achievements

- Optimization of interconnect plate for manufacturing and delivery of these plates for INNO-SOFC stacks
- Identification of most promising end-users and applications.
- Stacks assembled using project's interconnect plates and characterization started (long-term and performance)

Future steps

- Application analysis with different future scenarios
- Finalising detail design of the system
- Stack delivery to Convion
- System start-up
- Continuation of stack validation

Non-quantitative objectives and status

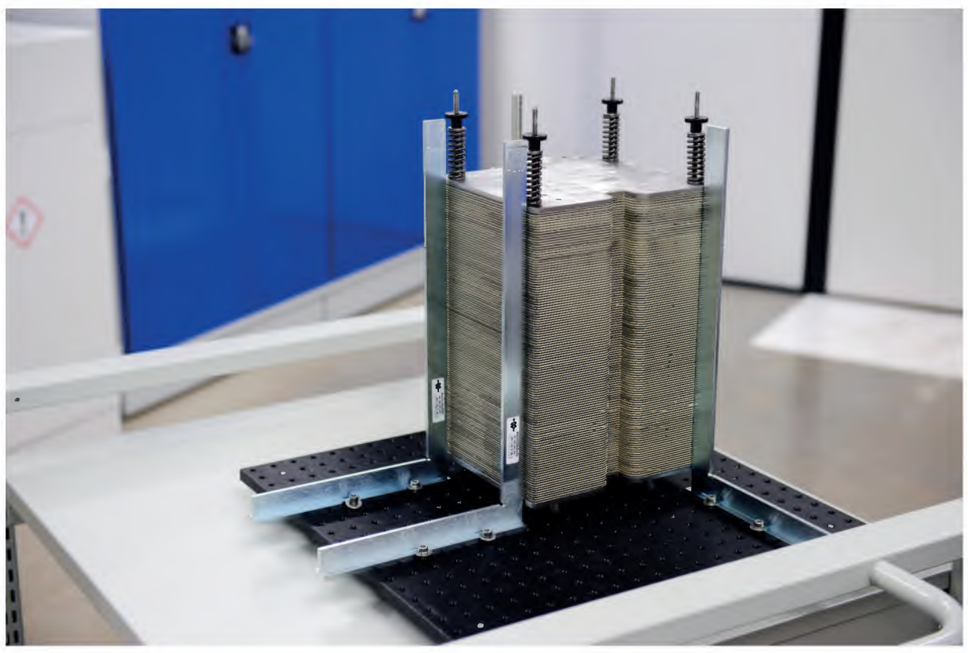
- Identify most promising end users and customers
  Most promising end-users and application have been analysed, identified, and reported

Relevant to FCH JU overarching objectives

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

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
AIP 2014	Operating time	hrs		30,000		30,000	Due later	Through system design and components
AIP 2014	System cost	€/kW		4,000		4,000	Due later	
AIP 2014	Electrical efficiency	%		60		60	Due later	
AIP 2014	Total efficiency	%		85		85	Due later	
AIP 2014	Stack cost	€/kW		2,000		2,000	Due later	Elcogen stack at 5-10 MW/year production level is to be analysed to meet project target.



FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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

Panel 3 — Technology validation in stationary applications

Acronym:	**ONSITE**
Project ID:	325325
Title:	Operation of a novel SOFC-battery integrated hybrid for telecommunication energy systems
Call Topic:	SP1-JTI-FCH.2012.3.4 &SP1-JTI-FCH.2012.3.5
Project total costs (€):	€ 5,5 million
FCH JU maximum contribution (€):	€ 3 million
Project start/end:	01 Jul 2013 - 30 Sep 2017
Coordinator:	Consiglio Nazionale delle Ricerche CNR, Italy
Beneficiaries:	Bonfiglioli Vectron, Fiamm Energy Storage Solutions, Erdle Erich Konrad, Htceramix, Ericsson Telecomunicazioni, Haute Ecole Specialisé de Suisse Occidentale, Instytut Energetyki
Website:	http://www.onsite-project.eu/

Project and objectives

The overall objective of ONSITE is the construction and operation of a sheltered system, based on SOFC/sodium nickel chloride battery hybrid system generating 10 kW at high efficiency and economically competitive costs, i.e. a rigorous proof of concept. The demonstration of the system shall take place on a real site of an existing telecom station. Starting from SOFC previous research results, commercially available power electronics and sodium nickel chloride batteries will improve next generation SOFC systems and adapt them to the specific requirements for medium size telecom stations.

Major project achievements

- Telecom Operator engagement and arrangement of the real site for the PoC test
- Realization of a sheltered PoC able to be installed in a Telecom Operator site
- Realization of a integrated CCHP (Combined Heat Cold and Power) prototype for the ICT sector

Future steps

- Test of the sheltered 5 kW SOFC/SNC hybrid system (Telecom load at test facility)
- Installation and test of the 5 kW SOFC/SNC hybrid system at Telecom Operator site

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017
Project's own	FC system efficiency	%	30	40	40	40	Achieved
AIP 2012	Development of Proof-of-concept combining advanced components int	none					Achieved
AIP 2012	Assessment of the fuel cell system's ability to compete with existing						Due later
Project's own	Prototype ability to exchange power with the grid						Due later
Project's own	Continuos operating hours	hours		3000	600	600	Achieved
AIP 2012	Novel system architectures						Achieved
AIP 2012	The PoC system will be required to comply with all relevant CE regul.						Achieved
Project's own	Integration with an adsorption chiller in order to produce cold						Due later
Project's own	Output power	kW		10	10	10	Achieved

Non-quantitative objectives and status

- Training of young student
  The involvement of HAUTE ECOLE SPECIALISEE DE SUISSE OCCIDENTALE has allowed the training of young students

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PACE
Pathway to a Competitive European FC mCHP market

Pathway to a competitive European Fuel Cell micro-CHP Market

Panel 3 — Technology validation in stationary applications

Acronym:	**PACE**
Project ID:	700339
Title:	Pathway to a Competitive European FC mCHP market
Call Topic:	FCH-02.9-2015
Project total costs (€):	€ 90,3 million
FCH JU maximum contribution (€):	€ 33,9 million
Project start/end:	01 Jun 2016 - 28 Feb 2021
Coordinator:	COGEN, the European Association for the Promotion of Cogeneration, Belgium
Beneficiaries:	Solidpower, Viessmann Werke, Bosch Thermotechnik, Solidpower, Vaillant, Danmarks Tek. Uni., BDR Thermea Group, Ewe, Element Energy
Website:	http://www.pace-energy.eu

Project and objectives

PACE is a major initiative aimed at ensuring the European µ-CHP sector makes the next move to mass market commercialisation. The project will deploy a total of 2,650 new fuel cell µ-CHP units with real customers and monitor them for an extended period.

This will:

- Enable fuel cell µ-CHP manufacturers to scale up production, using new series techniques, and increased automation
- Allow the deployment of new innovations in fuel cell µ-CHP products, which reduce unit cost by over 30%, increase stack lifetime to over 10 years

Major project achievements

- Deployment of units have started.
- Communications activities of the project are supported by a professional communications agency.
- Professional communications materials have been developed (website, brochure, presentation etc.)

Future steps

- The number of units deployed under PACE will significantly increase
- PACE launch event 11 October, 2017 in Brussels with units on display
- Report on the lessons learned in setting up the servicing and after sales support
- Summary results on policy scenario analysis

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
MAWP 2014-2020	Total efficiency	%	85	95	95	95	Due later	Next gen product designs with > 90% overall efficiency and/or >50% electrical efficiency
MAWP 2014-2020	Improved durability	Years	10	15	10	15	Due later	
MAWP 2014-2020	Relative CAPEX reduction-individual systems	%	100	70		70	Due later	≥500 units/manufacturer, enhanced automation/scale-up
MAWP 2014-2020	CAPEX- overall average system cost	EUR	20000	10000		10000	Due later	<10,000 EUR/system - or <10,000 EUR/kWe for systems over 1kWe by end of project
MAWP 2014-2020	Stack replacement	%	100	50		50	Due later	
MAWP 2014-2020	Manufacturing capacity	Units/year	50	1000		1000	Due later	

Non-quantitative objectives and status

- Field support- cross cutting working group on training & certification
  The aim is to exchange information on training technicians and installers and to discuss options for developing more standard standardised training
- Customer feedback survey
  The aim is to collect qualitative and quantitative data on the satisfaction of customers with their units, positive and negative experiences
- Dissemination objective
  Promote Fuel Cell µ-CHP towards industry and policy-makers to facilitate the transition to mass market commercialisation
- Working with policy makers
  Identify the supportive Member State narratives and policy vehicles for introducing the favourable approaches

Relevant to FCH JU overarching objectives

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

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PROGRAMME REVIEW DAYS 2017

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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

Panel 3 — Technology validation in stationary applications

Acronym:	**PEMBEYOND**
Project ID:	621218
Title:	PEMFC system and low-grade bioethanol processor unit development for back-up and off-grid power applications
Call Topic:	SP1-JTI-FCH.2013.4.4
Project total costs (€):	€ 4,6 million
FCH JU maximum contribution (€):	€ 2,3 million
Project start/end:	01 May 2014 - 31 Oct 2017
Coordinator:	VTT, Finland
Beneficiaries:	Genport - Spin-off from Politecnico Milano, Powercell Sweden, Uni. Porto, Fraunhofer Gesellschaft zur Foerderung der Angewandten Forschung
Website:	http://pembeyond.eu/

Project and objectives

The PEMBeyond project aims to develop a bio-ethanol 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 are ready and tested, with the integrated system commissioning tests ongoing and the 1000 h field trial about to start. The goal is to eventually introduce the bio-ethanol based systems to market, allowing the direct use of easily transported and stored, locally and affordably produced low emission fuel in power generation.

Major project achievements

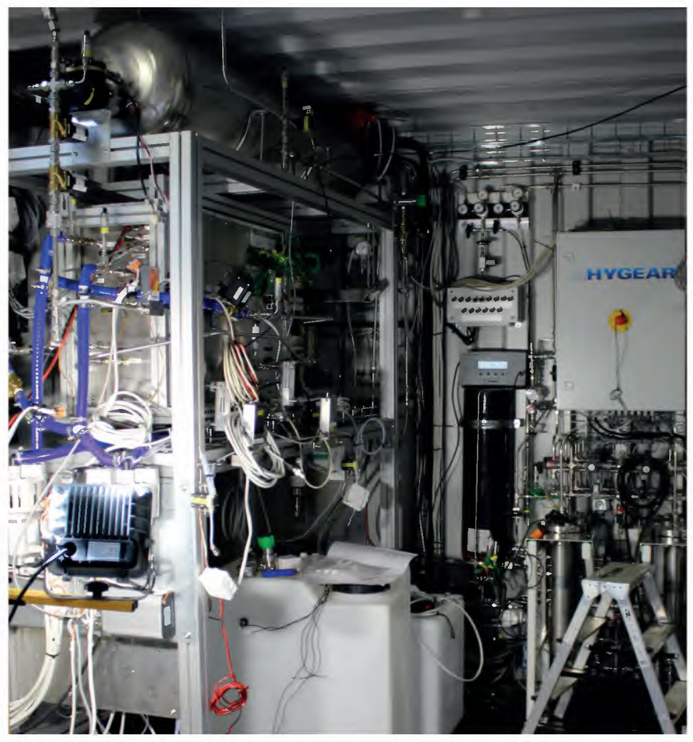
- A system operated on crude bioethanol designed and manufactured and the initial testing of the subsystems completed
- Development of superior PSA adsorbent able to purify syngas with 1 % of CO down to the automotive grade of 0.2 ppm in product gas
- Stable steam reforming catalyst for crude bioethanol developed, together with non-noble metal based LT-WGS catalyst surpassing any commercial products

Future steps

- The system commissioning tests will be completed and reported
- The field trial of 1000 hours will be completed and reported
- The LCA study will be completed and reported
- The roadmap to volume production and advanced concept study will be completed and reported

Non-quantitative objectives and status

- Developing the reformed ethanol fuel cell technology for market entry
  Based on the manufactured systems, the concept is very attractive for commercialization.
  Within 2 years, a limited production could commence

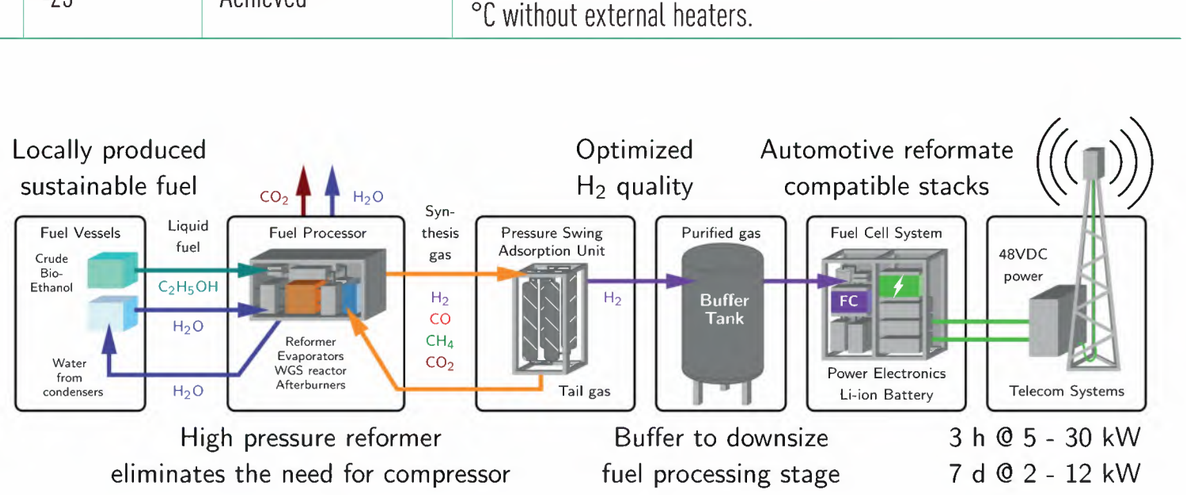


Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
AIP 2013	5 kW FC and H_2 system cost @ 500 units/yr	€/kW	9000	3300	3757	3500	Due later	Only small cost reductions are foreseen, but TCO is already competitive with diesel gensets.
AIP 2013	25 kW FC and H_2 system cost @ 500 units/yr	€/kW	9000	2500		2500	Due later	
AIP 2013	FC system efficiency %	%		45	48	48	Achieved	Including power electronics losses. Otherwise efficiency 53 %.
AIP 2013	System efficiency with an integrated hydrogen generator	%		30	11	20	Due later	Based on initial tests with un-optimised operation parameters. 20% may be reached with the prototype, with redesign 30 % is no problem.
AIP 2013	System life-time	h		20,000		1000	Due later	Long-term durability testing not included in project, but conclusions can be made based on the 1000-h field trial.
Project's own	Steam reforming catalyst stability with crude bioethanol	h		1000	1060	1060	Achieved	Catalyst stable with un-purified ethanol from barley feedstock.
Project's own	PSA product hydrogen CO level	ppm	100	25	20	14	Achieved	Adsorbent developed in project shows superior performance, and allows further cost reductions & higher efficiency of a 2nd generation system.
Project's own	System operating temperature	°C	0	-25	-25	-25	Achieved	700 W 10-cell reformate S2 stack successfully cold started from -25 °C without external heaters.

Relevant to FCH JU overarching objectives

- Increase the electrical efficiency and the durability of the different fuel cells used for power production to levels which can compete with conventional technologies, while reducing costs
- Increase the energy efficiency of production of hydrogen mainly from water electrolysis and renewable sources while reducing operating and capital costs, so that the combined system of the hydrogen production and the conversion using the fuel cell system can compete with the alternatives for electricity production available on the market



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POWER-UP
Demonstration of 500 kWe alkaline fuel cell system with heat capture

Panel 3 — Technology validation in stationary applications

Acronym:	**POWER-UP**
Project ID:	325356
Title:	Demonstration of 500 kWe alkaline fuel cell system with heat capture
Call Topic:	SP1-JTI-FCH.2012.3.7
Project total costs (€):	€ 13,6 million
FCH JU maximum contribution (€):	€ 6,1 million
Project start/end:	01 Apr 2013 - 30 Jun 2017
Coordinator:	AFC Energy, United Kingdom
Beneficiaries:	Air Products, Fast - Federazione delle Associazioni Scientifiche e Tecniche, G.B. Innomech Ltd, Zentrum fur Brennstoffzellen-Technik, Paul Scherrer Inst.
Website:	http://project-power-up.eu/

Project and objectives

Project POWER-UP was established to manufacture, install and operate an industrial-scale alkaline fuel cell plant in an industrial environment. The infrastructure was designed and built to German standards, while the KORE system has been installed and operated with the produced electricity exported to the grid. The introduction of automation and modern manufacturing techniques has enabled the scale-up of fuel cell production whilst maintaining high quality. The system's technical and environmental performance, total cost of ownership, social and environmental impacts have also been determined.

Major project achievements

- Electricity fed and sold into the local grid
- Fuel cell manufacturing facility upgraded and automated, resulting in an increase in fuel cell quality, reproducibility and performance
- Alkaline fuel cell plant built, installed and operated according to local regulations

Future steps

- LCA and socioeconomic analysis

Non-quantitative objectives and status

- Clear understanding of external impacts
  Life Cycle Assessment report completed and agreed

Relevant to FCH JU overarching objectives

- Increase the electrical efficiency and the durability of the different fuel cells used for power production to levels which can compete with conventional technologies, while reducing costs
- Reduce the use of the EU defined 'Critical raw materials', for instance through low-platinum or platinum-free resources and through recycling or reducing or avoiding the use of rare earth elements

Quantitative targets and status

Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
Project's own	Reduction in fuel cells rejected for defects	%	10	<3	15		Not achieved	Increased due to increased volume throughput. Lean tools being employed to reduce it
Project's own	Increase in cells manufactured per hour	% increase	20	20	220	220	Achieved	starting point = 16 electrodes/day
Project's own	Power output	kWe	4	500	204	240	Achieved	Qualified success in January 2016. Target revised to plant commissioning result and decision to only install 1 KORE BoP of 240kW nameplate.
Project's own	Re-use of stack components	% reused	0	70	88	80	Achieved	% by mass. The % achieved will go back down because the relative mass of the components will change as evolved technology comes online.
Project's own	Total performance loss	% (	10	3	40		Not achieved	Change of catalyst system with broader operating range
Project's own	Reduced manpower required to install fuel cell system	Person-Mth	1	0.25	1	1	Not achieved	Due to multiple site changes a system housed in a building has been used. Time quoted refers to fuel cell BoP installation only.
Project's own	Recovery of catalyst materials	%	90	97	99	99	Achieved	All waste catalyst material is recovered during manufacturing and post operation. 99% is the recovery rate from the reprocessor used.
MAIP 2008-2013	Stack electrical efficiency	%	52	58	57	57	Achieved	based on LHV

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STAGE-SOFC
Innovative SOFC system layout for stationary power and CHP applications

Panel 3 — Technology validation in stationary applications

Acronym:	**STAGE-SOFC**
Project ID:	621213
Title:	Innovative SOFC system layout for stationary power and CHP applications
Call Topic:	SP1-JTI-FCH.2013.3.4
Project total costs (€):	€ 4,0 million
FCH JU maximum contribution (€):	€ 2,2 million
Project start/end:	01 Apr 2014 - 31 Oct 2017
Coordinator:	VTT, Finland
Beneficiaries:	Lappeenrannan Teknillinen Yliopisto, Sunfire, ICI Caldaie, Zachodniopomorski Uni. Technol. W Szczecinie
Website:	http://www.stage-sofc-project.eu/

Project and objectives

The aim of the STAGE-SOFC project is to develop a Proof-of-Concept (PoC) prototype of a new solid oxide fuel cell (SOFC) concept with a serial connection of one exothermal catalytic partial oxidation (CPOX) stage with one or a multiple of endothermic steam reforming stages. The system will combine the benefits of the simple and robust CPOX layout with the high efficiencies obtained by the steam reforming process. The first prototype achieved the set targets on electrical power >5 kW (AC) and electrical efficiency >45%. The PoC prototype has been designed, constructed, and commissioned and is currently being tested.

Major project achievements

- The PoC system has been designed, constructed and commissioned
- Extensive knowledge on hotbox design gained by experimental work and simulation
- Active dissemination of project results including conferences, exhibitions and scientific papers

Future steps

- Continue and complete the extended test runs with the PoC system
- Finalise all remaining work in WPs
- Report the work in the project

Quantitative targets and status

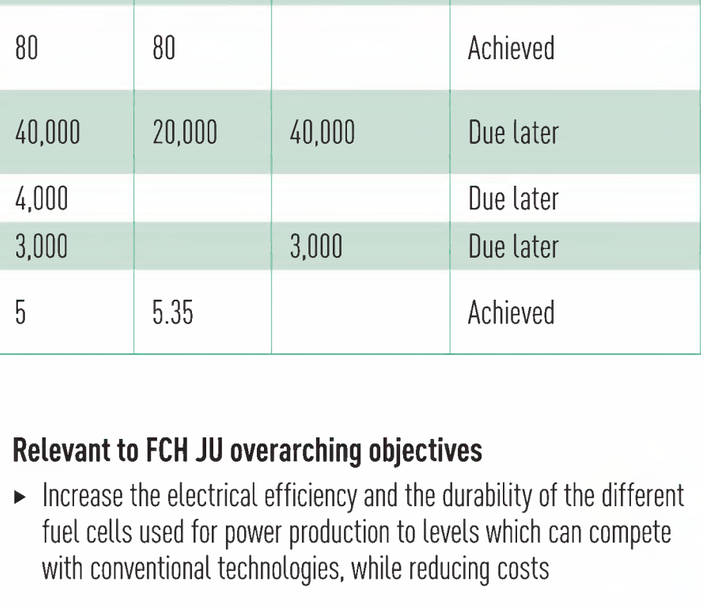
Target Source	Parameter	Unit	Starting point	Target for project	Achieved to date in project	Best est. of final project result	Target: status on May 1st 2017	Description
MAIP 2008-2013	System electrical efficiency (AC, LHV)	%		45	45		Achieved	Prototype PT1: Verified by system simulations and experimentally
MAIP 2008-2013	System total efficiency (LHV)	%		80	80		Achieved	Verified by system simulation
MAIP 2008-2013	Stack lifetime	h		40,000	20,000	40,000	Due later	Long-term stack investigations [in parallel to project] by Vaillant - in system
MAIP 2008-2013	Unit cost @ 5 kW	€/kW		4,000			Due later	Only achievable by mass-production
Project's own	Prototype running time	h		3,000		3,000	Due later	Long-term testing not started yet
Project's own	Prototype electrical power	kW		5	5.35		Achieved	Power target achieved in PT 1

Non-quantitative objectives and status

- Step change improvements over existing technology
  Design and successful evaluation of an innovative fuel cell system that achieves high electrical efficiencies without laborious water handling
- Development of PoC prototypes that form an integrated system
  Complete 5 kW prototype built and tested. The system consists of hotbox, coldbox and will be coupled to a heating system
- Novel system architectures, including new fuel processing units
  The PoC prototype will be based on an innovative hotbox for which a customised pre-reformer needs to be developed amongst other elements

Relevant to FCH JU overarching objectives

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



FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

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