CH2P

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

Project ID	735692
PRD 2022 Panel	4 – End use: Stationary applications
Call topic	FCH-02-4-2016: Cogeneration of hydrogen and electricity with high-temperature fuel cells
Project total costs	EUR 6 711 722.58
Clean H_2 max. contribution	EUR 3 999 896
Project period	1/2/2017 – 30/4/2022
Coordinator	Fondazione Bruno Kessler, Italy
Beneficiaries	HyGear Operations BV, HyGear Technology and Services BV, Vertech Group, SOLIDpower SpA, SOLIDpower SA, HyGear Fuel Cell Systems BV, HyGear BV, Shell Global Solutions International BV, École Polytechnique Fédérale de Lausanne, Deutsches Zentrum für Luft- und Raumfahrt EV

https://ch2p.eu

PROJECT AND OBJECTIVES

The CH2P project is designing, constructing and partially validating an innovative system prototype for hydrogen production. The system co-generates hydrogen, heat and electricity using solid oxide cell technology fuelled by carbon-lean natural gas (NG) or biomethane. The CH2P system operates in five modes, allowing flexibility in hydrogen and electricity supply. The prototype is placed in two 40-foot containers and it is modular to support future upscaling. CH2P has been designed as a transition technology for application at hydrogen-refuelling stations and has the ambition of producing hydrogen at < 4 €/kg.

NON-QUANTITATIVE OBJECTIVES

- CH2P targets 6 use cases.
- The project aims to co-generate hydrogen and electricity for hydrogen-refuelling stations. With a single technology, CH2P will deliver natural gas, hydrogen and power – the fuels of the EU directive on alternative fuels infrastructure.

PROGRESS AND MAIN ACHIEVEMENTS

- The large stack module has been built.
- CH2P created a pressure swing absorber.
- The project created a customised hot balance of plant.

FUTURE STEPS AND PLANS

- The CH2P system will run through the final testing phase, which is due to start shortly.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
AWP 2016	System size	kg of H_2/day	20	16	⚙
	Flexible cogeneration of H_2 and power	%	50 + 50	90	⚙
	System efficiency	%	65	80	✓

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COMSOS

COMMERCIAL-SCALE SOFC SYSTEMS

Project ID	779481
PRD 2022 Panel	4 – End use: Stationary applications
Call topic	FCH-02-11-2017: Validation and demonstration of commercial-scale fuel cell core systems within a power range of 10–100 kW for selected markets/applications
Project total costs	EUR 10 277 897.50
Clean H_2 max. contribution	EUR 7 486 954.75
Project period	1/1/2018 – 31/8/2022
Coordinator	Teknologian tutkimuskeskus VTT Oy, Finland
Beneficiaries	Energy Matters BV, Convion Oy, Sunfire GmbH, SOLIDpower SpA, SOLIDpower SA, Politecnico di Torino

http://www.comsos.eu/

PROJECT AND OBJECTIVES

The key objective of the ComSos project is to validate and demonstrate fuel-cell-based combined heat and power solutions in the mid-sized power ranges of 10–12 kW, 20–25 kW and 50–60 kW (referred to as Mini FC-CHP). The core of the project consortium consists of three SOFC system manufacturers aligned with individual strategies along the value chain: SOLIDpower, SunFire and Convion.

PROGRESS AND MAIN ACHIEVEMENTS

- All four Sunfire systems have been installed at customer sites.
- The first Convion unit has been installed at the customer site.
- SOLIDpower has contracted 14 BG-60 units and a further 12 units are close to being finalised.

FUTURE STEPS AND PLANS

- The second Convion unit will be installed at the customer site and start operation in 2022.
- The rest of the SOLIDpower units will be installed at customer sites and start operation in 2022.
- All four Sunfire units are expected to generate 1 000 hours of demonstration data in 2022.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
Project's own objective	SME participation	%	25	50	✓
MAWP Addendum (2018–2020)	NOx emission	mg/kWh	< 40	< 40	✓
	Electrical efficiency	%	> 50	> 50	✓

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E2P2

ECO EDGE PRIME POWER

Project ID	101007219
PRD 2022 Panel	4 – End use: Stationary applications
Call topic	FCH-02-9-2020: Fuel cell for prime power in data-centres
Project total costs	EUR 3 576 995.38
Clean H_2 max. contribution	EUR 2 499 715.50
Project period	1/1/2021 – 31/9/2024
Coordinator	Research Institutes of Sweden AB, Sweden
Beneficiaries	Vertiv Croatia DOO za trgovinu i usluge, Vertiv, InfraPrime GmbH, Equinix Netherlands BV, Snam SpA, TEC4FUELS, SOLIDpower SpA

http://www.e2p2.eu/

PROJECT AND OBJECTIVES

The main objectives of E2P2 are to define the fuel cell prime power concept for data centres and create an authoritative open standard for fuel cell adaptation to power data centres. E2P2 will demonstrate and validate a proof-of-concept fuel-cell-based prime power module for data centres, and evaluate the opportunities for improved energy efficiency and waste heat recovery. The project strongly anticipates opportunities for the European fuel cell suppliers to increase their uptake across multiple markets, with improved energy efficiency and cost-effectiveness.

PROGRESS AND MAIN ACHIEVEMENTS

The project started in 2021.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
MAWP (2014–2020)	Electrical efficiency	% LHV	42–62	N/A	
	Availability (% of plant's available power)	%	97		
	CAPEX	€/kW	3 500–6 500		

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EMPOWER

EUROPEAN METHANOL POWERED FUEL CELL CHP

Project ID	875081
PRD 2022 Panel	4 – End use: Stationary applications
Call topic	FCH-02-7-2019: Development of highly efficient and flexible mini CHP fuel cell system based on HTPEMFCs
Project total costs	EUR 1 499 876.25
Clean H_2 max. contribution	EUR 1 499 876.25
Project period	1/1/2020 – 31/12/2022
Coordinator	Teknologian tutkimuskeskus VTT Oy, Finland
Beneficiaries	Blue World Technologies ApS, THT Control Oy, Catator AB, Universidade do Porto

http://www.empower-euproject.eu/

PROJECT AND OBJECTIVES

The project will develop, manufacture and validate a methanol-fuelled 5 kWe combined heat and power (CHP) system based on high-temperature proton-exchange membrane fuel cell (HT-PEMFC) technology. The project will enhance the system's efficiency to target the mini-CHP market and provide a cost-competitive and low-carbon option. The developed CHP unit will be capable of fast start-up and fast dynamic response to help the integration of intermittent power production from renewable energy sources. Currently, the subsystems of the CHP are being finalised by project partners. The integration of the final CHP system has started.

NON-QUANTITATIVE OBJECTIVES

- EMPOWER aims to increase the visibility and awareness of the potential of renewable methanol. The project results are being openly communicated and disseminated, for example through public deliverables and scientific publications. The project has also arranged an international summer school on hydrogen technologies.
- The project aims to develop a business analysis for the use of renewable methanol in CHPs and other applications. Preliminary market analysis was performed in 2021, and this will be updated at the end of the project.
- EMPOWER aims to support knowledge exchange and production ramp-up through stakeholder searching, information and linkage. An industry webinar was arranged in January 2021, a workshop was arranged in Denmark in May 2022 and another is planned in Finland in December 2022.
- The main goal of the project is to produce affordable and secure electricity with a low carbon footprint. The carbon footprint will be analysed in 2022.

PROGRESS AND MAIN ACHIEVEMENTS

- The HT-PEMFC stack has been designed for pressurised operation.
- The CHP system enclosure and system balance-of-plant components have been finalised.
- The automated quality control methods for stack components have been developed.

FUTURE STEPS AND PLANS

- EMPOWER will demonstrate the project's 5 kW HT-PEMFC CHP system in the relevant end-user environment. The designed system will be demonstrated in autumn/winter 2022 in Finland to evaluate its performance and the project's key performance indicators.
- The HT-PEMFC subsystem will be integrated into the CHP system (planned for spring 2022).
- The system scale-up study (50–100 kW), carbon footprint analysis and business analysis will be performed in 2022.
- Scientific studies on aqueous-phase-reforming catalysts will be finalised during 2022.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
Project's own objectives	Rated stack electrical efficiency (LHV reformate gas)	%	55	N/A	⚙
	Fuel processing efficiency	%	85	> 85	✓
MAWP Addendum (2018–2020)	CHP electrical efficiency (LHV methanol)	%	37–67	N/A	⚙
	CAPEX	€/kWh	5 500	2 600	✓

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EVERYWH$_2$ERE

MAKING HYDROGEN AFFORDABLE TO SUSTAINABLY OPERATE EVERYWHERE IN EUROPEAN CITIES

Project ID	779606
PRD 2022 Panel	4 – End use: Stationary applications
Call topic	FCH-02-10-2017: Transportable FC gensets for temporary power supply in urban applications
Project total costs	EUR 6 770 248.74
Clean H_2 max. contribution	EUR 4 999 945.76
Project period	1/2/2018 – 31/10/2023
Coordinator	RINA Consulting SpA, Italy
Beneficiaries	FRIEM SpA, Linde Gas Italia SRL, Delta1 gUG (Haftungsbeschränkt), Swiss Hydrogen SA, Teknologian tutkimuskeskus VTT Oy, Mahytec SARL, Iren Smart Solutions SpA, Iren Energia SpA, Iren SpA, Genport SRL – spin off del Politecnico di Milano, THT Control Oy, PowerCell Sweden AB, Fundación para el Desarrollo de las Nuevas Tecnologías del Hidrógeno en Aragón, ICLEI Europasekretariat GmbH, Parco Scientifico Tecnologico per l'Ambiente Environment Park Torino SpA, Acciona Construccion SA

http://www.everywh2ere.eu/

PROJECT AND OBJECTIVES

The EVERYWH$_2$ERE project will integrate the previously demonstrated robust proton-exchange membrane fuel cell stacks and the low-weight, intrinsically safe pressurised-hydrogen technologies into easy-to-install, easy-to-transport, fuel-cell-based transportable gensets. Eight fuel cell 'plug and play' gensets fitted in containers will be realised and tested through a pan-European demonstration campaign in a demonstration-to-market approach. The prototypes will be tested at construction sites, music festivals and urban public events all around Europe, demonstrating their flexibility and their increased lifetimes.

NON-QUANTITATIVE OBJECTIVES

EVERYWH$_2$ERE aims to support the development of a regulatory framework for transportable hydrogen-fuelled systems.

PROGRESS AND MAIN ACHIEVEMENTS

- EVERYWH$_2$ERE organised a meeting with user communities. This involved interaction with rental companies and energy companies promoting use of fuel-cell-based gensets to their customers.
- The project undertook IPR activities to understand partners' exploitation intentions and potential common interests.
- EVERYWH$_2$ERE took steps towards standardisation. The assessment of the conformity of the 100 kW genset has been completed, whereas that of the 25 kW genset is ongoing.

FUTURE STEPS AND PLANS

- The project will finalise the commissioning of the first two prototypes and start demonstration (demonstration started on 1 June 2021). Prototypes are ready and validation is ongoing; this was being remotely supported owing to the travel ban for partners' staff due to COVID-19. The project will realise the other gensets. The finalisation of the commissioning is to be complete by the end of 2022.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SoA result achieved to date (by others)	Year of SoA target
Project's own objectives	Levelised cost of energy of the genset (identification of replication market with contractual costs ± 10 % of those of current power supply solutions)	€/kWh	1.1	N/A	⚙	1 €/kWh for diesel gensets according to rental market stakeholders According to LCC, the current €/kWh is very close to 1.10: this value has to be validated and evaluated for contractual/business purposes	2025
	Noise emission (of the full genset, not only the FC SuSy)	dB	< 65	60	✓	Diesel gensets insulated if very noisy (first tests guarantee operation at < 60 dB), mostly due to the fan of the FC thermal loop	2020
	Future manufacturing CAPEX (of the system)	€/kW	5 500	6 850	⚙	No FC-based gensets available today (according to stakeholders, 1 500–2 000 €/kW may be acceptable)	2025

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GRASSHOPPER

GRID ASSISTING MODULAR HYDROGEN PEM POWER PLANT

Project ID	779430
PRD 2022 Panel	4 – End use: Stationary applications
Call topic	FCH-02-7-2017: Development of flexible large fuel cell power plants for grid support
Project total costs	EUR 4 387 063.75
Clean H_2 max. contribution	EUR 4 387 063.75
Project period	1/1/2018 – 31/3/2022
Coordinator	Informatizacija Energetika Avtomatizacija DOO, Slovenia
Beneficiaries	Johnson Matthey Fuel Cells Limited, Zentrum für Brennstoffzellen-Technik GmbH, Abengoa Innovacion Sociedad Anonima, Nedstack Fuel Cell Technology BV, Politecnico di Milano

http://www.grasshopperproject.eu/

PROJECT AND OBJECTIVES

The GRASSHOPPER project aims to create a next-generation MW-sized fuel cell power plant that (FCPP) is more cost-effective and flexible in power output than current fuel cell power plants. The FCPP will be demonstrated in the field as a 100 kW submodule pilot plant, implementing newly developed balance-of-plant system components and stacks. A new stack design has been developed with increased power density, and short stack testing has been concluded. The pilot plant is undergoing factory acceptance testing on hydrogen. A dynamic simulation model of the pilot plant has been developed to support optimisation in the field and the scaling up of the design.

NON-QUANTITATIVE OBJECTIVES

The project aims to ensure operation flexibility and grid stabilisation capability via fast response. The operation strategy was defined considering the requirements in terms of response time for grid stabilisation.

PROGRESS AND MAIN ACHIEVEMENTS

- GRASSHOPPER has developed a new pilot power plant.
- It has developed a new fuel cell.
- The GRASSHOPPER membrane electrode assemblies (MEAs) show excellent durability in accelerated stress testing.

FUTURE STEPS AND PLANS

- The project will perform the testing, relocation and start-up of the pilot plant. Factory acceptance testing is ongoing. Once the site has been constructed, the plant will be relocated to the site.
- It will assemble the full stacks for the 100 kW plant. This will involve component optimisation on cell plates for the full stack.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Target achieved?	SoA result achieved to date (by others)	Year of SoA target
Project's own objectives	MEA cost reduction	%	65		MEA cost of electricity = 0.04 €/kWh	
	Stack efficiency	%	55		55	
MAWP Addendum (2018–2020)	System electrical efficiency	%	50	⚙	50	2018
	System CAPEX	€/kWe	1 500		3 000	
AWP 2017	Stack lifetime	hours	20 000		16 000	

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OXIGEN

NEXT-GENERATION SOLID OXIDE FUEL CELL STACK AND HOT BOX SOLUTION FOR SMALL STATIONARY APPLICATIONS

Project ID	779537
PRD 2022 Panel	4 – End use: Stationary applications
Call topic	FCH-02-9-2017: Development of next-generation SOFC stack for small stationary applications
Project total costs	EUR 2 996 873.75
Clean H_2 max. contribution	EUR 2 996 873.75
Project period	1/1/2018 – 30/6/2021
Coordinator	Société européenne des produits réfractaires, France
Beneficiaries	Sintef AS, Saint-Gobain Centre de Recherches et d'Etudes Europeen, Europäisches Institut Für Energieforschung EDF – KIT EWIV, ICI Caldaie SpA, Saint-Gobain Recherche SA, ENGIE, Stiftelsen Sintef, Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung EV, Commissariat à l'énergie atomique et aux énergies alternatives

http://oxigen-fch-project.eu/

PROJECT AND OBJECTIVES

OxiGEN aims to develop an innovative solid oxide fuel cell platform, including an all-ceramic stack design and a modular hot box, for small stationary micro-combined-heat-and-power (micro-CHP) applications. The objectives are to achieve a higher level of durability and a simpler design in micro-CHP units and other segments to fulfil customers' needs for long product lifetimes, high efficiency and low costs. Such a system will reduce the lifetime CO_2 emissions for a combined heating and electricity-generation system and reduce the financial burden for customers (individual property owners or small businesses).

NON-QUANTITATIVE OBJECTIVES

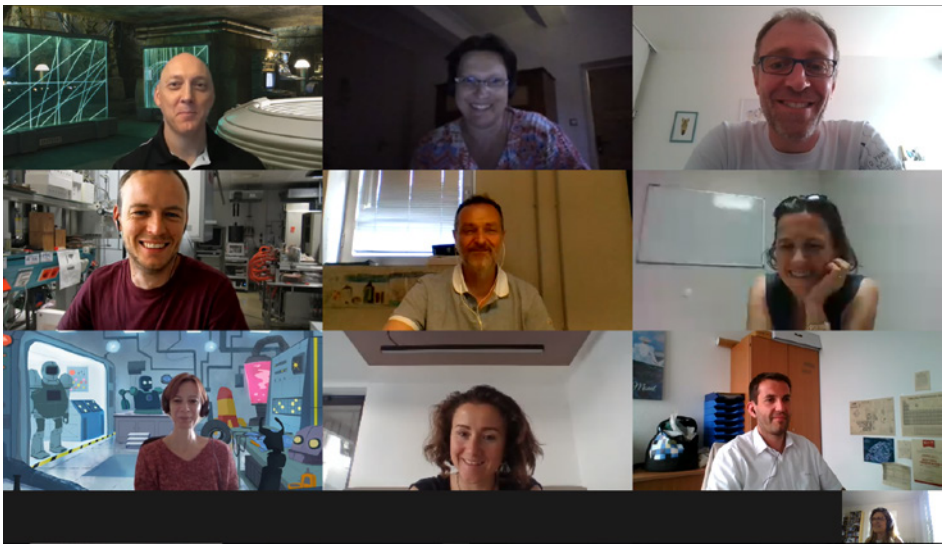
- OxiGEN aims to define market specifications for residential and small commercial applications, and the boundary limits of the hot box (completed).
- The project aims to produce a stack design (completed).
- It aims to produce a hot box design (completed).
- OxiGEN aims to produce the Gen3 short stack (in progress).

PROGRESS AND MAIN ACHIEVEMENTS

- OxiGEN has produced hot box specifications.
- It has produced a hot box for the Saint-Gobain stack.
- The project has developed a novel electrolyte composition with improved conductivity.

FUTURE STEPS AND PLANS

The project has finished.



PRD 2022 PANEL
H2 End Uses - Stationary

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PACE

PATHWAY TO A COMPETITIVE EUROPEAN FC MCHP MARKET

Project ID	700339
PRD 2022 Panel	4 – End use: Stationary applications
Call topic	FCH-02.9-2015: Large scale demonstration µCHP fuel cells
Project total costs	EUR 84 462 140.62
Clean H_2 max. contribution	EUR 33 932 752.75
Project period	1/6/2016 – 30/6/2022
Coordinator	European Association for the Promotion of Cogeneration VZW, Belgium
Beneficiaries	Element Energy, Remeha GmbH, Remeha NV, Viessmann Elektronik GmbH, Viessmann Werke Allendorf GmbH, BDR Thermea Group BV, SOLIDpower GmbH, Sunfire Fuel Cells GmbH, Remeha BV, Viessmann Werke GmbH & Co. KG, Sunfire GmbH, Baxi Innotech GmbH, Bosch Thermotechnik GmbH, SOLIDpower SpA, SenerTec Kraft-Wärme-Energiesysteme GmbH, EWE Aktiengesellschaft, Vaillant GmbH, Element Energy Limited, Hexis AG, Fachhochschule Zentralschweiz – Hochschule Luzern, Danmarks Tekniske Universitet

http://www.pace-energy.eu/

PROJECT AND OBJECTIVES

PACE is unlocking the large-scale European deployment of the state-of-the-art smart energy solution for private homes: fuel cell micro-cogeneration. PACE will see up to 2 800 households across Europe reaping the benefits of this home energy system. The project enables manufacturers to move towards product industrialisation and fosters market development at national level by working together with building professionals and the wider energy community. The project uses modern fuel cell technology to produce efficient heat and electricity at home, empowering consumers in their energy choices.

NON-QUANTITATIVE OBJECTIVES

- The project aims to achieve a system (excluding stack) lifetime of 10 years.
- It is planned that the need for stack replacement will be eliminated for all partners within the next 7 years.

PROGRESS AND MAIN ACHIEVEMENTS

- A total of 2 121 units have been commissioned to date.
- The project has increased the system lifetime to more than 15 years and improved the maintenance interval using new/improved components. The system (excluding stack) lifetime was 10 years at the start of project; this increased to a minimum of 15 years by the end of the project.
- By the end of the project, all partners will eliminate the need for stack replacement during a customer's 10-year service plan (the worst case is 7 years at the project's start).

FUTURE STEPS AND PLANS

- All of the 2 800 units to be deployed in the project will be installed.
- PACE will continue data collection and analysis to provide a fact-based understanding of the performance and benefits of technology.
- The project will identify ongoing regulatory barriers to the deployment of micro-combined-heat-and-power (micro-CHP) units across Europe, and collaborate with industry and policymakers to remove barriers.
- The project will develop use cases for fuel cell micro-CHP units relevant beyond the project finish point, including an assessment of the economic potential of fuel cell micro-CHP units.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
Project's own objectives	Number of units sold	pieces	2 800	2 909	✓
	Time before stack replacement	years	10 years' system lifetime with > 50 % reduction in stack replacement or no stack replacement during a 10-year service plan	15 years' system lifetime with > 50 % reduction in stack replacement or no stack replacement during a 10-year service plan	✓
	Manufacturing capacity (average production level)	pieces/ year	1 000	2 300	✓

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REMOTE

REMOTE AREA ENERGY SUPPLY WITH MULTIPLE OPTIONS FOR INTEGRATED HYDROGEN-BASED TECHNOLOGIES

Project ID	779541
PRD 2022 Panel	4 – End use: Stationary applications
Call topic	FCH-02-12-2017: Demonstration of fuel cell-based energy storage solutions for isolated micro-grid or off-grid remote areas
Project total costs	EUR 6 740 031.40
Clean H_2 max. contribution	EUR 4 995 950.25
Project period	1/1/2018 – 30/6/2023
Coordinator	Politecnico di Torino, Italy
Beneficiaries	Grupo Capisa Gestion y Servicios Sociedad Limitada, Sintef AS, Engie EPS Italia SRL, Trønderenergi AS, Orizwn Anonymh Techniki Etaireia, Powidian, IRIS SRL, Hydrogenics Europe NV, Instrumentación y Componentes SA, Enel Green Power SpA, Ballard Power Systems Europe AS, Ethniko Kentro Erevnas kai Technologikis Anaptyxis, Instituto Tecnológico De Canarias SA, Stiftelsen Sintef

http://www.remote-euproject.eu/

PROJECT AND OBJECTIVES

REMOTE is demonstrating the technical and economic feasibility of H_2-based energy storage solutions (integrated power-to-power (P2P) systems, non-integrated power-to-gas and gas-to-power systems (P2G+G2P), customised P2P systems) deployed in 3 demonstrations, based on renewable energy source (RES) inputs (solar, wind, hydro) in isolated microgrid or off-grid remote areas. In the 4 years of the project (up to December 2021), the design, procurement, installation, operation and analysis of 2 demonstrations (in Greece and Norway) have been assessed; the third demonstration (in Spain) is being finalised. The demonstration analysis is being carried out, and the exploitation plans are under development.

NON-QUANTITATIVE OBJECTIVES

- REMOTE aims to complete the demonstrations' design, installation and operation. REMOTE has created fundamental know-how for the next generation of P2Ps based on fuel cells and H_2 technologies adapted to the market and society's needs, making use of scientific advances in the management of off-grid and isolated microgrids.
- The project aimed to build experience throughout the value chain of P2P systems and validate real demonstration units in representative applications of isolated microgrid or off-grid areas. This enables suppliers, end users and general stakeholders to gain experience for the future deployment of these energy solutions.
- REMOTE aimed to gather technical data on the operation of H_2-based devices (PEMFC, electrolysers) in long-term real operation in P2P applications. The operation of the P2P systems (lasting more than a year) has generated learning experiences regarding the behaviour of technologies such as fuel cells and electrolysers in P2P applications. Companies now know what to improve.
- The project aimed to complete detailed life cycle analysis of RES-fed, H_2-based P2P systems in remote locations. The project allows for a detailed understanding of the complete life cycle analysis achieved by the RES-based P2P systems in remote areas, in terms of metrics such as global greenhouse gas reduction thanks to the adoption of H_2 at a local RES-storage system at seasonal range.

PROGRESS AND MAIN ACHIEVEMENTS

- REMOTE has achieved 1 year of experience of operation of the demonstration in Norway.
- It has achieved 1.5 years of experience of operation of the demonstration in Greece.
- The project has complete experience of the design, commissioning and operation of H_2-based P2P plants.

FUTURE STEPS AND PLANS

- The running and full analysis of the demonstration in Norway have been completed. The collected data are undergoing deep technical analysis.
- The running and full analysis of the demonstration in Greece have been completed. The collected data are undergoing deep technical analysis.
- REMOTE will finalise the installation of the new demonstration in Spain, and then put it in operation. The demonstration is under construction. The demonstration has been fully operational since July 2022, and is ready for data collection and analysis.
- Complete techno-economic analysis of the demonstration experience will be performed with real data, to develop an understanding of how to optimise P2P plants in the future, with improved efficiency and reduced costs.
- A business analysis of the H_2-based P2P plants for remote locations will be developed and presented to the market stakeholders.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SoA result achieved to date (by others)	Year of SoA target
MAWP Addendum (2018–2020)	Rated efficiency of the electrolyser (PEM)	kWh/kg	55 (2020) 52 (2024)	50	✓	50	2020
	Electrolyser footprint (PEM)	m^2/MW	100 (2020) 80 (2024)	273	⚙	10	2018–2020
	Rated efficiency of the fuel cell (PEM)	% LVH	42–62 (2024)	45–55	✓	51	2018
	Rated efficiency of the electrolyser (alkaline)	kWh/kg	50 (2020) 49 (2024)	55–60	⚙	55–60	2020

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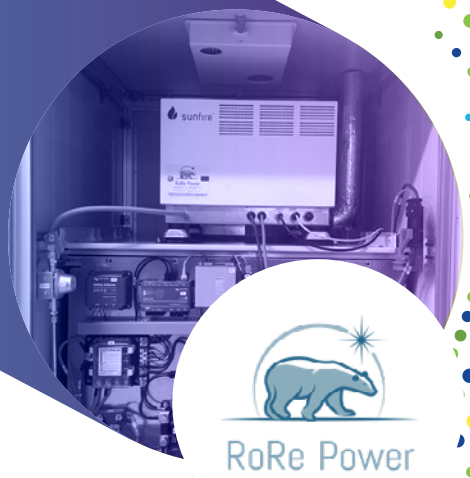
REPOWER

ROBUST AND REMOTE POWER SUPPLY



RoRe Power
ROBUST & REMOTE

Project ID	824953
PRD 2022 Panel	4 – End use: Stationary applications
Call topic	FCH-02-3-2018: Robust, efficient long term remote power supply
Project total costs	EUR 4 220 093.75
Clean H_2 max. contribution	EUR 2 999 190.26
Project period	1/1/2019 – 31/12/2023
Coordinator	Teknologian tutkimuskeskus VTT Oy, Finland
Beneficiaries	3E Energy Oy, Sunfire Fuel Cells GmbH, Sunfire GmbH, SOLIDpower SpA, European Fuel Cell Forum AG

https://rorepower.com

PROJECT AND OBJECTIVES

The overall objective of this project is to further develop and demonstrate solid oxide fuel cell (SOFC) systems for off-grid power generation in markets – such as the oil and gas infrastructure in remote regions – with harsh climate conditions (from – 40 °C to 50 °C), and the power supply of telecommunication towers, especially in emerging countries (e.g. telecommunication base stations or microwave transceivers). To date, 31 units have been installed at customer sites or are in the process of being installed. RoRePower is further strengthening and building the European value chain for fuel cell technologies.

PROGRESS AND MAIN ACHIEVEMENTS

- A total of 21 RoRePower units had been installed at the customer sites by the end of 2021.
- Harsh condition operation has been achieved: Sunfire Fuel Cells has operated at – 20 °C with natural gas and at – 35 °C with propane; SOLIDpower has operated at – 20 °C with natural gas.

FUTURE STEPS AND PLANS

- All RoRePower units will be installed at customer sites. In total, 31 customer contracts for demonstration sites have been signed; for 21 of these, units have already been installed.
- All RoRePower units have been demonstrated for a sufficiently long time. In total, 21 units will provide demonstration data in 2022.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
AWP 2019 annual work plan	Electrical efficiency	%	> 35	> 35	✓
	Operation in harsh conditions	°C	– 40	– 40 can be achieved with the project solutions	✓
	Maintenance frequency	months	15	13.7	✓
	Long-term desulphurisation	months	15	15	✓
	System start-up in harsh conditions	°C	– 40	– 40 can be achieved with the project solutions	✓

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RUBY

ROBUST AND RELIABLE GENERAL MANAGEMENT TOOL FOR PERFORMANCE AND DURABILITY IMPROVEMENT OF FUEL CELL STATIONARY UNITS

Project ID	875047
PRD 2022 Panel	4 – End use: Stationary applications
Call topic	FCH-02-8-2019: Enhancement of durability and reliability of stationary PEM and SOFC systems by implementation and integration of advanced diagnostic and control tools
Project total costs	EUR 2 999 715
Clean H_2 max. contribution	EUR 2 999 715
Project period	1/1/2020 – 31/12/2024
Coordinator	Universita degli Studi di Salerno, Italy
Beneficiaries	Communauté d'universités et d'établissements université Bourgogne-Franche-Comté, Sunfire Fuel Cells GmbH, Teknologian tutkimuskeskus VTT Oy, SOLIDpower SpA, Bitron SpA, Ballard Power Systems Europe AS, Europäisches Institut für Energieforschung EDF – KIT EWIV, Fondazione Bruno Kessler, Université De Franche-Comté, Institut 'Jožef Stefan', École Polytechnique Fédérale de Lausanne, Commissariat à l'énergie atomique et aux énergies alternatives

http://www.rubyproject.eu/

PROJECT AND OBJECTIVES

The RUBY project aims to exploit electrochemical impedance spectroscopy (EIS) for developing, integrating, engineering and testing a comprehensive and generalised monitoring, diagnostic, prognostic and control (MDPC) tool. Thanks to EIS features, RUBY will improve the efficiency, reliability and durability of solid oxide fuel cell (SOFC) and polymer electrolyte fuel cell (PEMFC) systems for stationary applications. The tool relies on advanced techniques and dedicated hardware, and will be embedded in the fuel cell systems for online validation in the relevant operational environment.

NON-QUANTITATIVE OBJECTIVES

The MDPC tool performs monitoring, diagnosis, prognosis control and mitigation of the stack and balance of plant (BoP) for PEMFC in back-up applications and for SOFC for micro-combined-heat-and-power (micro-CHP) applications.

PROGRESS AND MAIN ACHIEVEMENTS

- RUBY has developed the MDPC tool.
- It has produced the hardware configuration.

FUTURE STEPS AND PLANS

- The project will acquire conventional and advanced signals. The tool measures conventional signals from the balance of plant and stack (voltage, current, temperature, etc.) and the EIS for the stack.
- RUBY will advance the MDPC activities. The tool monitors the state of health of the stacks and the systems, detects faults at stack and balance-of-plant levels, estimates the stacks' lifetimes, applies advanced control actions and proposes mitigation strategies at system level.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?	SoA result achieved to date (by others)	Year of SoA target
Project's own objectives	Lifetime of micro-CHP applications (SOFC)	years	12	10		10	2020
		% of the appliance	99	97		97	
	Lifetime of back-up applications (PEMFC)	years	15	12		12	
		% of the appliance	99.999	99.99		99.99	

PRD 2022 PANEL
H2 End Uses - Stationary

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SO-FREE

SOLID OXIDE FUEL CELL COMBINED HEAT AND POWER: FUTURE-READY ENERGY

Project ID	101006667
PRD 2022 Panel	4 – End use: Stationary applications
Call topic	FCH-02-4-2020: Flexi-fuel stationary SOFC
Project total costs	EUR 3 045 355
Clean H_2 max. contribution	EUR 2 739 094
Project period	1/1/2021 – 31/8/2024
Coordinator	Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile, Italy
Beneficiaries	Kiwa Limited, Elcogen Oy, Kiwa Nederland BV, Università degli Studi Guglielmo Marconi – Telematica, PGE Polska Grupa Energetyczna SA, ICI Caldaie SpA, Instytut Energetyki, AVL List GmbH, Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung EV

http://www.so-free.eu/

PROJECT AND OBJECTIVES

The development and demonstration of a fully future-ready solid oxide fuel cell (SOFC)-based system for combined heat and power (CHP) generation allows for an operation window of 0–100 % of H_2 in natural gas, with additions of purified biogas. Furthermore, SO-FREE will endeavour to realise a standardised stack–system interface, allowing full interchangeability of SOFC stack types within a given SOFC CHP system.

NON-QUANTITATIVE OBJECTIVES

SO-FREE aims to realise a unique, standardised stack module–system interface for flexible system integration. The first alignment of two stack modules with a single interface has been proposed.

PROGRESS AND MAIN ACHIEVEMENTS

- The project has made two identical test stations for independent stack validation.
- SO-FREE has designed a unique stack module–system interface for flexible system integration.

FUTURE STEPS AND PLANS

- Stack validation and mapping is expected to start in August 2022.
- The final design of the system is due to be completed in August 2022.
- Stack production and delivery are expected to commence in March 2023.
- Two systems are ready for demonstration until June 2023.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Target achieved?	SoA result achieved to date (by others)
AWP 2020	Degradation rate	%	< 1		0.6
	Efficiency in H_2 consumption	%	48		47
	CAPEX	€/kW	8 000		10 000

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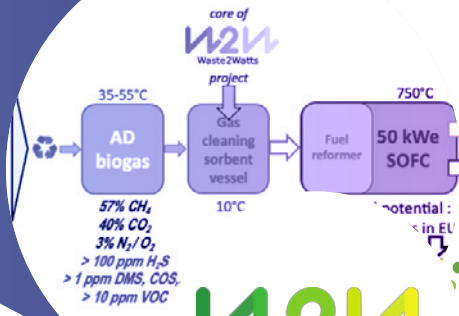
WASTE2WATTS

UNLOCKING UNUSED BIO-WASTE RESOURCES WITH LOW COST CLEANING AND THERMAL INTEGRATION WITH SOLID OXIDE FUEL CELLS



Project ID	826234
PRD 2022 Panel	4 – End use: Stationary applications
Call topic	FCH-02-7-2018: Efficient and cost-optimised biogas-based co-generation by high temperature fuel cells
Project total costs	EUR 1 681 602.50
Clean H_2 max. contribution	EUR 1 681 602.50
Project period	1/1/2019 – 31/3/2023
Coordinator	École Polytechnique Fédérale de Lausanne, Switzerland
Beneficiaries	Etudes et Applications d'Energies Renouvelables et d'Epuration Biokomp SRL, Arol Energy, Sunfire GmbH, SOLIDpower SpA, SOLIDpower SA, Politecnico di Torino, Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile, Commissariat à l'énergie atomique et aux énergies alternatives, Paul Scherrer Institut

https://waste2watts-project.net/

PROJECT AND OBJECTIVES

WASTE2WATTS is developing cleaning technologies for biogas to make the gas compatible with solid oxide fuel cells (SOFCs). It determines what needs to be cleaned from the gas and to which purity level to clean it. It also defines the proper scale for the best application of SOFCs with biogas, and the bioresources available at that scale. It assesses reformer catalysts and cells/stacks with biogas impurities and representative gas mixtures. A system layout proposes operating strategies without external water addition. A 6 kWe SOFC on agro-biogas has been prepared, and novel cryogenic cleaning of biogas at a scale of 100 m^3/h has been carried out.

NON-QUANTITATIVE OBJECTIVES

- There is a huge biogas resource in agriculture in Europe for use by small-scale SOFCs (50 kWe, 0.5 million units or 25 GWe; 1 500 PJ = 8 % of the EU's natural gas).
- The project aims to compile the sorbents database. Commercial sorbents have been sourced and characterised.
- It aims to analyse sorbents' real behaviour in relation to specific contaminants. The results of these tests are very different to what has been announced. COS is the most critical contaminant (< 1 g captured per kg of sorbent). It has a strong dependence on gas matrix (O_2, H_2O).
- WASTE2WATTS aims to analyse the behaviour of COS in SOFC cells. The outlet gases are H_2S and SO_2, alternating over time; the water–gas shift reaction is affected.
- The project aims to test new catalysts for biogas reforming (Ni_4Fe, Ru-doped SmCeCoOx). Ru-doped $CaZrO_3$ with dry reforming, mixed reforming and S-contaminants will be tested.
- WASTE2WATTS aims to perform multicontaminants testing. H_2S, COS, DMS and CH_4S are to be tested simultaneously on sorbents and cells to evaluate the matrix effect.

PROGRESS AND MAIN ACHIEVEMENTS

- Sorbents have been characterised specifically for biogas cleaning, allowing for the choice of an adapted cleaning solution.
- Reformer catalysts, cells and stacks characterised with specific sulphur compounds show resilience of up to 5 ppm of trace content.
- System cost analysis shows that biogas SOFC can achieve a levelised cost of electricity of < 15 ct€/kWhe, even at 20 kWe, for a 4-year stack life (stack cost 1 000€/kWe).

FUTURE STEPS AND PLANS

- WASTE2WATTS will install a cryogenic cleaning chain for biogas flow of 100 m^3/g on a real biogas site. This will involve ordering components, finalising the piping and instrumentation diagram, and calculations.
- The project will install the 6 kWe SOFC at the agro-biogas site, with adapted biogas cleaning based on project sorbent results. This will involve looking for co-financing, preparing analysis of the site's biogas and preparing a site visit for connections.
- Long-term testing of cells and stacks will be performed with 3–5 ppm of sulphur. All set-ups, gas analytics and detailed electrochemical characterisation methods have been established.
- The project will perform a total system cost calculation with updated input from project results, especially the cleaning (sorbents choice). The system model and cost calculation have been established.

QUANTITATIVE TARGETS AND STATUS

Target source	Parameter	Unit	Target	Achieved to date by the project	SoA result achieved to date (by others)	Year of SoA target
MAWP Addendum (2018–2020)	SOFC CAPEX	€/kWe	3 500–6 500 (2024)	2 000–4 000	2 000	2024
Project's own objectives	Pollutant balance	ppm	5	3	5	2021
	Pollutant nature and mix	S-compounds	Identification	Critical compounds identified	N/A	2008
	Biogas cleaning	€/kWe	< 1 000	< 1 000	1 000	2018
	LCOE	€/kWhe	< 15	0.09	0.11	2020

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