GAMER

GAMECHANGERINHIGHTEMPERATURESTEAM ELECTROLYSERS WITH NOVEL TUBULAR CELLS AND STACKS GEOMETRY FOR PRESSURIZED HYDROGEN PRODUCTION

Project ID:	779486
PRD 2023:	Panel 1 – H2 production
Call topic:	FCH-02-2-2017: Game changer high temperature steam electrolysers
Project total costs:	EUR 2 998 951.25
Clean H_2 JU max. contribution:	EUR 2 998 951.25
Project period:	1.1.2018–30.9.2022
Coordinator:	SINTEF AS, Norway
Beneficiaries:	MC2 Ingenieria y Sistemas SL, CRI EHF, CoorsTek Membrane Sciences AS, Shell Global Solutions International BV, Universitetet i Oslo, Stiftelsen SINTEF, Agencia Estatal Consejo Superior de Investigaciones Cientificas

https://www.sintef.no/projectweb/gamer/

PROJECT AND OBJECTIVES

GAMER is developing a novel cost-effective tubular proton ceramic electrolyser (PCE). The project focuses on a novel 'tube-in-shell' single engineering unit (SEU) design in which each tubular cell is placed in a steel shell, which has all necessary gas inlet/outlet connections. The steel shell also acts as a pressure containment vessel. The SEU stack technology is operational at 600 °C in pressurised operation. The main objectives of the project are to:

- design an innovative electrolysis system integrated in a renewable methanol plant with efficient thermal coupling of heat source (waste heat or heat from a renewable geothermal source);
- develop a high-volume cost-effective tubular SEU technology;
- assemble the novel SEUs and necessary balance-of-plant (BoP) equipment in a 10 kW prototype for pressurised operation;
- carry out techno-economic evaluation and life cycle analysis (LCA) of the integrated technology.

NON-QUANTITATIVE OBJECTIVES

The project has developed a novel design for a PCE stack in the form of tube-in-shell SEU operational at 600 °C and operated at up to 10 bar total pressure for more than 1 000 hours. It has also designed a 10 kW system, including assemblies of SEUs integrated in racks in a hot box, with BoP and power electronics developed for pressurised operation, delivering hydrogen with an output pressure of at least 30 bar. The containerised plant has been built and commissioned by Agencia Estatal Consejo Superior de Investigaciones Científicas. It has also been used to test two racks (each containing 16 SEUs) at a pressure of up to 7 bar. Due to some technical limitations and the project coming to an end, no more testing could be carried out. The plant will be exploited after project completion as part of the follow-up PROTOSTACK project, a new Clean Hydrogen JU project. The targeted production volume of the SEUs by CTMS was successfully achieved in the project, with reproducible results achieved when comparing the performance of the individual functional layers on both short segments (4–5 cm^2) and upscaled tubular cells (60 cm^2). The project demonstrates that PCE performance is improved by increasing the operational pressure from ambient pressure to at least 10 bar (in terms of both increasing the faradaic efficiency and reducing the cells' area-specific resistance).

PROGRESS AND MAIN ACHIEVEMENTS

Sixteen SEUs were tested in pressurised operation up to 10 bar at 600 °C. Good reproducibility was achieved after optimisation of the manufacturing process and steam electrode architectures. The stability of an SEU operating at 600 °C for more than 500 hours at 10 bar was successfully demonstrated in the project, while operated at a constant current density of 0.3 A/cm^2 (steam utilisation of 60 %).

The second rack of 16 SEUs was tested at atmospheric pressure at three different temperatures (600 °C, 575 °C, 550 °C). At 600 °C and atmospheric pressure, H_2 production of 0.47 Nl/min and a faradaic efficiency of 61 % were reached by applying a current of 100 A.

Techno-economic analysis and LCA have been conducted on this technology, integrated in various user cases (ammonia plant, refineries, geothermal plant). The results of this work show that a projected upscaled technology can reach a system cost below 8.8 M€/(t/d). Furthermore, a roadmap for further cost reduction below 2.7 M€/(t/d) post 2020, which relies on both the reduction of system cost and improved cell performance, has been set out.

FUTURE STEPS AND PLANS

- The finalisation of rack assembly and quality assurance is in progress.
- Integration of racks in the 10 kW testing unit and commissioning will take place. Testing will start with one rack, with the progressive integration of the other.
- The testing plant will be used in a new project named PROTOSTACK, funded by the Clean Hydrogen Joint Undertaking.

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	ASR of cell at 600 °C at 3 bar in electrolysis mode	ohm.cm^2	2	2.5	⚙	< 2	2022
	Faradaic efficiency of the SEU at 3 bar at 0.1 mA/cm^2 at 600 °C	%	> 85	95	✓	> 85	2020
	Degradation rate max. decrease of the voltage after 500 hours at 600 °C at 100 mA/cm^2	%/kh	1.2	< 5	⚙	N/A	2021
	System cost	M€	8.8	4.2–8.9	✓	N/A	N/A
	Hydrogen cost	€/kg	2.7	4.2–7.4	⚙	N/A	N/A

Clean Hydrogen Partnership
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