European Institute
for Energy Research
by EDF and KIT

GrInHy

Green Industrial Hydrogen via Reversible High-temperature Electrolysis

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Key Facts

Funding Agency
JTI-FCH-JU

Project Call
FCH-02.3-2015

Duration
03/2016 – 02/2019

Coordinator
SZMF – Salzgitter Mannesmann Forschung GmbH

Partners
- Salzgitter Flachstahl GmbH
- Boeing Research and Technology Europe
- Sunfire GmbH
- VTT Technical Research Centre of Finland
- Institute of Physics of Materials, Brno
- Politecnico di Torino

Website
https://www.green-industrial-hydrogen.com/

This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (JU) under grant agreement No 826350.

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

Project Objectives

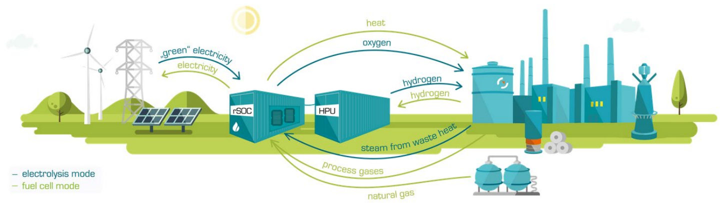
The GrInHy project aims to activate significant cost-cutting potential of high temperature electrolysers. Additional value will be created if the electrolyser system is able to work in a reversible mode using a reversible Solid Oxide Cell (rSOC). The project will be integrated and operated at the iron and steel works from Salzgitter Flachstahl.

Technical objectives:

- Increase the power of a single stack up to 120 kW while automatizing the production process at the manufacturer
- Increase the lifetime of stacks by reaching a degradation rate <1%/1000 h during 10,000 h of operation.
- Control the purity of the produced hydrogen during 7000 h of operation

Economic objective:

- Reach a milestone of the technology roadmap with regard to size/cost of the system and including reversibility.



EIFER's Contribution

From cells to modules (stack + hotbox) tests.

Lab technical objectives:

- Electrical and electrochemical impedance spectroscopy measurements for performance and durability analysis
- Influence od operation parameters (current, temperature, gas compositions, steam-to-hydrogen conversion rate.

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Work performed and main results achieved

Over the project duration of 36 months, all project’s objectives and milestones were reached with only minor deviations. A flexible and dynamically applicable prototype was successfully designed and manufactured with a nominal electrolyser capacity of 150 kWAC,EC (40 Nm^{3}H2/h) and a maximal power of 200 kWAC,EC (50 Nm^3/h). The prototype system was set-up in June 2017 and connected to a hydrogen processing unit in order to meet the integrated iron-and-steel-works requirements in terms of H2 purity and pressure. An efficiency of the HTE of 78 %LHV,EC (without drying and compression) was measured. This was related to the 88 % bi-directional power electronics efficiency, compared to 94% as specified, which would result in an HTE efficiency of 84 %LHV,EC.

Additionally, the fuel cell (FC) operation showed the system’s fuel adaptability: Operated with natural gas in fuel cell mode, the system reached the nominal power of 25 kWAC,NG-FC and a maximum AC efficiency of 52 %LHV,NG-FC at 80 % load (20 kWAC,NG-FC). With hydrogen, the nominal power was 30 kWAC,H2-FC and a maximum AC efficiency 48 %LHV,H2-FC. The reversible HTE was tested for typical dynamic cycles derived from load management and grid balancing.

The prototype was operated for approximately 10,000 h in electrolysis, fuel cell or hot-standby mode. Several optimizations on hardware and software level were performed, both for the reversible HTE and the hydrogen processing unit. In total, about 90,000 Nm^3 of hydrogen were produced during electrolysis operation of which more than 41,000 Nm^3 with a quality of 3.8 at 10 bar(g) were used for annealing processes at Salzgitter’s integrated iron-and-steel works.

Cells and stacks were optimized and tested e.g. for degradation and mechanical properties on cell and stack level resulting in material improvements and optimized stack integration. Due to contaminations and failures of the test bench, the foreseen 10,000 h continued stack testing was aborted after 8,300 h. Another stack under optimized test conditions reached degradation rates well below the project target of <1 %/kh for more than 5,000 h. More than 80,000 ultra-fast load cycles (direct on/off-switching of current) on cell level and more than 16,000 cycles at stack level were performed without increased impact on the degradation rate.
The technology’s cost structure, potential business cases and environmental performance were assessed in accompanying studies. Based on all results, a comprehensive exploitation roadmap was elaborated laying the foundation for the HTE towards a marketable product.

GrInHy achieved a high-level of public awareness during scientific conferences, international fairs and dedicated hydrogen technology workshops. The project reached numerous political decision makers, researchers and possible costumers while exchanging results with other FCH2-JU projects. Due to its results, GrInHy was nominated for the FCH JU Awards 2018 “Best Project Innovation”.

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