HYSELECT

EFFICIENT WATER SPLITTING VIA A FLEXIBLE SOLAR-POWERED HYBRID THERMOCHEMICAL-SULPHUR DIOXIDE DEPOLARISED ELECTROLYSIS CYCLE

Project ID	101101498
PRR 2024	Pillar 1 – Renewable hydrogen production
Call topic	HORIZON-JTI-CLEANH2-2022-01-06: Efficiency boost of solar thermochemical water splitting
Project total costs	EUR 3 982 105.00
Clean H_2 JU max. contribution	EUR 3 982 104.50
Project period	1.1.2023–31.12.2026
Coordinator	Deutsches Zentrum für Luft- und Raumfahrt EV, Germany
Beneficiaries	Aalto-korkeakoulusäätiö SR, Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile, Ethniko Kentro Erevnas Kai Technologikis Anaptyxis, FEN Research GmbH, Grillo-Werke AG, HelioHeat GmbH

https://www.hyselect.eu/

PROJECT AND GENERAL OBJECTIVES

Hyselect proposes a solution to boost the efficiency of solar thermal water splitting by introducing two innovative core devices for the steps of the hybrid sulphur cycle (HYS): (i) a sulphuric acid decomposition / sulphur-trioxide-splitting (SAD-STS) reactor that is spatially decoupled from the solar receiver and is allothermally heated using solid particles and (ii) a sulphur-dioxide-depolarised electrolyser (SDE) that does not use platinum group metals.

The ambition of Hyselect is to close the technical gaps and provide the missing links in the complete overall HYS technology concept, for a realistic overall evaluation of the technology and its scale-up. The innovations to be implemented will lead to highly efficient, long-term and cost-competitive concentrated-solar-technology-driven thermochemical hydrogen production.

Hyselect will demonstrate the production of H_2 by splitting water using concentrated solar technologies, with an attractive efficiency and cost, through the hybrid sulphur cycle. Hyselect will introduce, develop and operate under real conditions a complete H_2 production chain focusing on the SAD-STS reactor and the SDE. In the course of the work, non-critical materials and catalysts will be developed, qualified and integrated into the plant-scale prototype units for both the SAD-STS reactor and the SDE unit. Experimental work will be accompanied by component modelling and overall process simulation and culminate with a demonstration of the complete process, integrating its key units (a solar particle receiver, a hot particle storage system, a splitting reactor and an electrolyser) into a pilot plant. Testing for a period of at least 6 months in a large-scale solar tower, driven by smart operation and control strategies, will establish Hyselect's target efficiency and costs. Finally, an overall process evaluation will be carried out to assess the technical and economic prospects of the Hyselect technology, which are directly linked to the know-how and developments in the sulphuric acid and water electrolyser industries.

NON-QUANTITATIVE OBJECTIVES

- Successful pilot-scale HYS technology demonstration.
- Implementation of sulphuric acid decomposition and SDE devices under industry-compatible and -scalable conditions.
- New approach for transferring heat from a solar receiver to endothermic catalytic reactions.
- New catalytic ways to perform SO_3 splitting.
- New sulphur dioxide depolarised electrolysers.

PROGRESS AND MAIN ACHIEVEMENTS

The first flow chart of the Hyselect demo plant was drafted, including simulations for the mass and energy balances of the key blocks. This flow chart and the calculations serve as the basis for the design and dimensioning of the key blocks.

FUTURE STEPS AND PLANS

All key technology blocks will be designed, dimensioned and constructed. These blocks will be integrated into the demo plant to demonstrate the experimental operation of the Hyselect process.

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PROJECT TARGETS

Target source	Parameter	Unit	Target	Target achieved?
Project's own objectives	Development of structured SO_3-splitting catalysts with high activity and long-term stability	%	Loss of activity of < 10 % for at least 3 000 hours on stream exposure equivalent through accelerated tests	
	Development, construction and qualification of optimised SDE stack demonstrating stack cost reduction potential of two to three times that of known analogues without use of platinum group metals	hours	Operation of at least 100 hours	
	Scaled-up process plant layouts and techno-economic analysis demonstrating an optimised scenario	€/kg	Hydrogen production cost < 5€/kg	
	Demonstration of on-sun and off-sun solar tower testing campaigns with particle receiver prototype	°C	Temperature drop in hot storage tank less than 100 °C for 16 hours	
	Open access publications in scientific journals	number	> 20	
	Efficient prototype heat exchanger for gas streams SO_2, SO_3, O_2, H_2O	number	Design and construction	
	Experimental demonstration of HYS process scheme with key units (particle receiver, storage, splitting reactor, electrolyser) integrated into a pilot plant	%	Average daily solar-to-fuel energy conversion efficiency of > 10 % based on higher heating value and direct normal irradiance	
	Demonstration of on-sun and off-sun solar tower testing campaigns with particle receiver prototype	°C	Delivery of particles with temperatures of 900–1 000 °C	
	Gas separation system providing clean SO_2 to the SDE	number	Design and construction	
	Development of structured SO_3-splitting catalysts with high activity and long-term stability	%	SO_3 conversion ≥ 75 % of corresponding thermodynamic value	
	SDE cell and short-stack (five-cell) design incorporating Au catalytic materials to eliminate or minimise SO_2 carry-over from anode to cathode	hours	Demonstration of operation for < 50 hours	
	Presentations at international conferences	number	> 20	
	Upgrade and improved design of the existing particle-heated, high-efficiency, lab-scale prototype sulphuric-acid-splitting reactor	hours	Test operation for at least 100 hours	
	A particle-heated prototype reactor for sulphuric acid splitting	number	Design and construction	
SRIA (2021–2027)	Scaled-up process plant layouts and techno-economic analysis demonstrating an optimised scenario	k €/kg/day	Reduction of CAPEX from 15.19 k€/kg/dayin 2024 (design year) to 7.41 k€/kg/day by 2030	
	Experimental demonstration of the HYS process scheme with key units (particle receiver, storage, splitting reactor, electrolyser) integrated into a pilot plant	kg/day/m^2 receiver area	Average hydrogen production rates higher than 2.16 kg/day/m^2 receiver area	
	Scaled-up process plant layouts and techno-economic analysis demonstrating an optimised scenario	€/kg	Reduction of OPEX from 0.59€/kg in 2024 (design year) to 0.30 €/kg by 2030	

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