HYSELECT

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

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PRR 2025	Pillar 1 - H_2 Production
Call Topic	HORIZON-JTI-CLEANH$_2$-2022-01-06
Project Total Costs	3 982 105.00
Clean H_2 JU Max. Contribution	3 982 104.50
Project Period	01-01-2023 - 31-12-2026
Coordinator Beneficiary	DEUTSCHES ZENTRUM FUR LUFT - UND RAUMFAHRT EV, DE
Beneficiaries	GRILLO-WERKE AG, FEN RESEARCH GMBH, HELIOHEAT GMBH, AALTO KORKEAKOULUSAATIO SR, ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS, AGENZIA NAZIONALE PER LE NUOVE TECNOLOGIE, L'ENERGIA E LO SVILUPPO ECONOMICO SOSTENIBILE

https://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 splitting 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 overall, complete HYS cycle 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 hydrogen production.

HySelect will:

- Demonstrate the production of hydrogen by splitting water using concentrated solar technologies (CST) with an attractive efficiency and cost, through the hybrid sulphur cycle (HyS).
- Introduce, develop and operate, under real conditions, a complete H_2 production chain focusing on the SAD-STS reactor and an SDE.
- Develop and qualify non-critical materials and catalysts, for integration into plant scale prototype units for both the acid splitting reactor and the SDE unit.
- Combine experimental work with component modelling and overall process simulation culminating in a demonstration integrating HySelect's key units of a solar particle receiver, a hot particles storage system, a splitting reactor and an electrolyser into a pilot plant.
- Establish the HySelect targeted efficiency and costs through testing in a large-scale solar tower, driven with smart operation and control strategies.
- Carry out an overall process evaluation to assess the technical and economic prospects of the HySelect technology, directly linked to the know-how and developments of the sulphuric acid and water electrolysers industries.

NON-QUANTITATIVE OBJECTIVES

- Successful pilot-scale HYS technology demonstration.
- Implementation of sulphuric acid decomposition and SDE devices under industry-compatible and industry-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, MAIN ACHIEVEMENTS AND RESULTS

- Design of flow chart of the HySelect demonstration plant with process simulation results and the main design of all relevant technology blocks is in place.
- Selection of best-performing catalytic formulations for sulphuric acid splitting (SAS), focusing on the technology blocks.
- Design of a modular pilot scale SAS Reactor.
- Investigation of the interface of the SAS reactor with the harvesting of the solar power.
- Commissioning of the solar centrifugal particle receiver.
- Demonstration of an optimised SDE cell and short stack for 50 hours, driving the design of the pilot scale electrolyser.
- Identification and assessment of technical solutions for achieving the target heat recovery. A series of heat exchangers and columns are chosen as the best commercially available technique. A critical element here is the projected cost of all the equipment; an intensive market-search based estimation identifies the essential equipment.

FUTURE STEPS AND PLANS

- Finalisation of the key elements.
- Purchasing, assembly and integration of the technology blocks.
- Conducting experimental campaigns.

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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 <10% for at least 3 000 h on stream exposure equivalent via accelerated tests.	
	Development, construction and qualification of optimised SDE stack demonstrating stack costs reduction potential of 2-3 times vs. known analogues without use of platinum group metals.	hours	Operation of at least 100 hours.	
	Scaled-up process plant layouts and techno-economic analysis (TEA) demonstrating an optimised scenario.	€/kg	Hydrogen production cost <5 €/kg.	
	Scaled-up process plant layouts and techno-economic analysis (TEA) demonstrating an optimised scenario.	€k/(kg/day)	Reduction of CAPEX starting from 15.19 in 2024 (design year) to 7.41 k€/kg/day by 2030.	
	Demonstration of on-sun and off sun solar tower testing campaigns with particle receiver prototype.	°C	Temperature drop in hot storage tank < 100 °C for 16 hours.	
	Open access publications in scientific journals.	-	>20	
	Efficient prototype heat exchanger for gas streams SO_2, SO_3, O_2, H_2O.	-	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 (HHV) and direct normal irradiance (DNI).	⚙
	Experimental demonstration of 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 (TEA) demonstrating an optimised scenario.	€/kg	Reduction of OPEX from 0.59 in 2024 (design year) to 0.30 €/kg by 2030.	
	Demonstration of on-sun and off sun solar tower testing campaigns with particle receiver prototype.	°C	Deliver particles of temperature 900 – 1 000.	
	Gas separation system providing clean SO_2 to the SDE.	-	Design and construction.	
	Presentations at international conferences.	-	> 20	
	Upgrade and improved design of the existing particles-heated, high-efficiency lab-scale prototype sulphuric acid splitting reactor.	hours	Test operation for at least 100 hours.	
	A particles-heated prototype reactor for sulphuric acid splitting.	-	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 (5 cells) design incorporating Au catalytic materials to eliminate or minimise SO_2 carry-over from anode to cathode.	hours	Demonstration of operation <50h.	✓

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