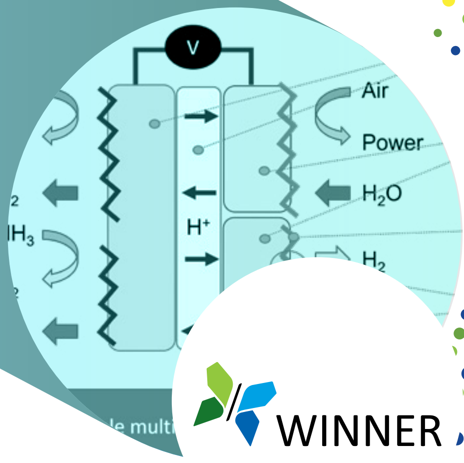

WINNER

WORLD-CLASS INNOVATIVE NOVEL NANOSCALE OPTIMISED ELECTRODES AND ELECTROLYTES FOR ELECTROCHEMICAL REACTION

Project ID:	101007165
PRD 2023:	Panel 2 – H2 storage and distribution
Call topic:	FCH-03-1-2020: HT proton conducting ceramic materials for highly efficient and flexible operation
Project total costs:	EUR 2 931 788.75
Clean H_2 JU max. contribution:	EUR 2 931 788.75
Project period:	1.1.2021–31.12.2023
Coordinator:	Sintef AS, Norway
Beneficiaries:	Agencia Estatal Consejo Superior de Investigaciones Cientificas, Alleima, CoorsTek Membrane Sciences AS, Danmarks Tekniske Universitet, Engie, Shell Global Solutions International BV, Universitetet i Oslo

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

PROJECT AND OBJECTIVES

WINNER is contributing to the shift towards a more sustainable energy future by developing an efficient and durable technology platform based on electrochemical proton-conducting ceramic cells designed to unlock a path towards commercially viable production, extraction, purification and compression of hydrogen, at small or medium scale, using three process chains:

- cracking of ammonia to produce pressurised hydrogen or power, where proton-conducting ceramic reactors (PCCRs) provide an innovative solution for flexible, secure and profitable storage and utilisation of energy in the form of green ammonia;
- dehydrogenation of ethane to produce ethylene and pressurised hydrogen, where PCCRs open new sustainable pathways for electrically driven processes in the chemical industry;
- reversible steam electrolysis, where PCCRs allow for a shift from electric power generation to hydrogen production, enabling grid balancing, improved matching of the demand and supply of electricity and more efficient use of renewable energy.

NON-QUANTITATIVE OBJECTIVES

WINNER is developing a multiscale multiphysics modelling platform integrating all disciplines (atomistic, electrochemical, mechanical, fluid flow, reactor engineering, electric, heat) with the goal of establishing rate-determining steps at meso scale in the electrochemical cell, and the most efficient dimensioning and arrangement of the cells in the multitube reactor design. The work is supported by relevant experimental data and enhanced experimentation methodologies applied in the project.

PROGRESS AND MAIN ACHIEVEMENTS

State-of-the-art (SoA) cell development. The project has developed novel tubular cells based on the production line established using the software CTMS. The half-tubular cells consist of a Ni-BZCY72 electrode with a BZCY81 dense electrolyte. Various electrode materials and architectures have been screened for the multiple applications of the project. The following performance criteria were successfully met for the reversible electrolysis cells and ammonia-to-hydrogen cells: cell area-specific resistance of below 1 Ωcm^2 at 650 °C, faradaic efficiency of 80–90 % and a degradation rate below 1.2 % per 1 000 hours under reversible operation. For the conversion of ammonia to hydrogen, the NH_3 conversion is above 99 % with H_2 extraction of > 98 %. Current work on dehydrogenation application is focusing on materials/electrode research. Results will be presented in the next period.

A tubular cell was successfully operating in reversible operation for more than 4 000 hours at 4 bar at 650 °C. The cell shows high faradaic efficiency at the end of the testing period (above 80 %). Post-characterisation analysis is currently being performed.

Engineering model. The results of these research and development activities are reported in several public deliverables (31–34). The partners initially worked on establishing a communication platform (i.e. defining common nomenclature, parameters and models) to put in place a link between the different models and competences developed from the atomistic scale to the process scale. An engineering model has been defined for each of the WINNER applications; these models are available in Excel format and in converted Aspen files. The models are built based on the definition of the process flowsheet with necessary balance of plant, operating conditions, electrochemistry, kinetic and heat balance, etc. The tool is now functioning with multiple integrated models (e.g. integrated atomistic + kinetics + electrochemistry models at the cell level; CFD + engineering tool + Aspen models at the cell, reactor and process levels; mechanical model to be integrated with CFD). The outputs of this tool include the energy demand per balance of plant and for the overall process for the selected input parameters (temperature, selectivity, conversion efficiency, cell voltage, faradaic efficiency, etc.).

Life cycle assessment. Life cycle assessment evaluation of the three applications is currently in progress, with user cases and benchmark cases defined for all applications.

FUTURE STEPS AND PLANS

WINNER is currently preparing for the multitube module demonstration, which will focus on reversible electrolysis operating at 600 °C with pressure ranging from 4 bar to 20 bar. Twelve cells will be tested in parallel. The production for this cell has started, as have all activities around the test unit (plant and analytic coupling, hazard and operability analysis, definition of operational protocols, commissioning).

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 and MAWP addendum (2018–2020)	Levelised cost of the produced hydrogen	€/kg	5	N/A	⚙	> 6 based on GAMER technology with several scaling-up assumptions	2022
Project's own objectives	ASR of the cell	Ωcm^2 at 650 °C	< 1	< 1	✓	2.5	
	Round-trip efficiency of reversible steam electrolysis	% at 650 °C	> 75	N/A	⚙	N/A	2019
	Faradaic efficiency	%	> 95	> 90	⚙	> 90	2021
	Durability test	hours	3 000	> 4 000	✓	< 1 000	

Clean Hydrogen Partnership
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