WINNER

WORLD CLASS INNOVATIVE NOVEL NANOSCALE OPTIMIZED ELECTRODES AND ELECTROLYTES FOR ELECTROCHEMICAL REACTIONS

Project ID	101007165
PRR 2025	Pillar 2 – H_2 storage and distribution
Call topic	FCH-03-1-2020
Project total cost	EUR 2 931 788.75
Clean H_2 JU max. contribution	EUR 2 931 788.75
Project period	01-01-2021 - 31-03-2024
Coordinator Beneficiary	SINTEF AS, NO
Beneficiaries	COORSTEK MEMBRANE SCIENCES AS, SHELL GLOBAL SOLUTIONS INTERNATIONAL BV, ALLEIMA TUBE AB, ENGIE, UNIVERSITETET I OSLO, DANMARKS TEKNISKE UNIVERSITET, AGENCIA ESTATAL CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS

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

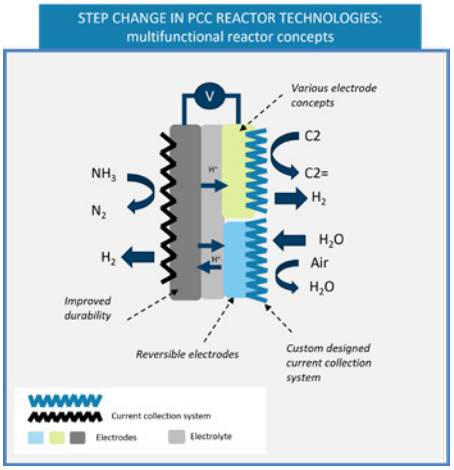
PROJECT AND GENERAL OBJECTIVES

WINNER contributes to the shift towards a more sustainable energy future by developing an efficient and durable technology platform based on electrochemical proton ceramic conducting (PCC) cells designed to unlock a path towards commercially viable production, extraction, purification and compression of hydrogen at small to medium scale through three process chains.

- Cracking of ammonia to produce pressurised hydrogen or power, where PCC reactors 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 PCC reactors open new sustainable pathways for electrically driven processes in the chemical industry.
- Reversible steam electrolysis (using reversible protonic ceramic electrochemical cells), where PCC reactors allow the shifting of 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 source.

NON-QUANTITATIVE OBJECTIVES

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



PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

SoA cells development:

- WINNER has developed novel tubular cells based on the production line established at CTMS. The half-tubular cells consist of Ni-BZCY72 electrode with BZCY81 dense electrolyte. Various electrode materials and architectures have been screened for the project's multiple applications.
- The following performance criteria were successfully met for the reversible electrolysis cells and ammonia to hydrogen cells: a cell area-specific resistance below 1 ohm.cm2 at 650C, a faradaic efficiency of 80-90%, and a degradation rate below 1.2% k/hour under reversible operation.

For the ammonia to hydrogen:

- WINNER has established an ammonia conversion above 99% with a hydrogen extraction above 98%.
- A tubular cell was successfully operating in reversible operation for more than 4 000 hours at 4 bar at 650 °C.

- Post-characterisation analysis showed some evolution of the cathode microstructure with the formation of Co-based nanoparticles, while no changes were observed in the other functional layers.

Engineering model:

- The partners initially created a communication platform to define common nomenclature, parameters and models and to establish a link between the different models and competences from atomistic scale to process scale.
- An engineering model has been defined for each of the WINNER applications, which is available in excel format and converted in an ASPEN file. The model is built based on the definition of the process flowsheet with necessary balance of plant and operating conditions, electrochemistry, kinetic and heat balance, etc.
- The tool is now functioning with multiple models integrated together (e.g. integrated atomistic + kinetics + electrochemistry models at cell levels, engineering tool + ASPEN models at cells, reactors and process levels, mechanical model).
- A computational fluid dynamics model has been initiated although its full integration into the engineering model is not completed.
- The outputs of the engineering tool are 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.).
- The tool has been integrated in ASPEN for the establishment of the integrated process flowsheet and setting up the techno-economic assessment of WINNER applications.
- Several deliverables and one master thesis report on the findings from this assessment which will be discussed in a public exploitation workshop.

Life cycle assessment:

- A life cycle assessment evaluation for three applications has been conducted with user cases and benchmark cases defined for all applications. The results show the benefits of proton ceramic-based technologies versus the benchmark cases.

Multi tube testing demonstration:

- A multi-tube testing unit has been prepared at Consejo Superior de Investigaciones Científicas.
- Extensive software and hardware upgrades have been implemented to ensure high operational safety and functionality.
- Operational protocols have been defined, and commissioning has been done.
- Cells needed for testing have been produced.

FUTURE STEPS AND PLANS

WINNER was finalised in March 2024 with the delivery of the techno-economic analysis and lifecycle analysis. An exploitation workshop was organised in March 2024 together with HYDROGNi.

Clean Hydrogen Partnership
Co-funded by the European Union