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Beyond Efficiency: Monetizing Economic and Environmental Impacts of an Innovative SOFC for Hydrogen Production

Sonia Sofi, Agatino Nicita, Gaetano Maggio, Gaetano Squadrito, Mauro Giorgianni
CNR ITAE, Messina, Italy

Extended Abstract

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Abstract Summary

This work explores the environmental, economic, and resource implications of substituting conventional materials in Solid Oxide Fuel Cells (SOFCs), focusing on replacing Yttria-Stabilized Zirconia (YSZ) with an innovative perovskite-based material (SCFA10) developed at CNR. The analysis is carried out at the eco-design stage to support informed design choices from the earliest phases of development. An integrated approach combining Life Cycle Assessment (LCA), environmental Life Cycle Costing (eLCC), and Critical Raw Materials (CRM) analysis is applied. The LCA is performed according to ISO 14040/44 standards using the ReCiPe 2016 Midpoint (H) method in SimaPro, adopting a cradle-to-gate perspective and a functional unit of 1 cm^2 of cell operating at target current density. A modular bottom-up modelling approach is used to isolate the contribution of each component. In parallel, the eLCC includes both direct production costs (CAPEX and OPEX) and monetized environmental externalities, while economic feasibility is assessed through a Net Present Value (NPV) approach. Results show that the SCFA10-based configuration leads to higher environmental impacts across all categories, mainly due to energy-intensive processing and upstream material production. This is reflected in the economic results, with a 21% increase in environmental costs and an overall production cost about 15% higher than the conventional NiO–YSZ configuration, along with a longer payback period (8 versus 5 years). From a resource perspective, the expected benefits are not fully achieved, as reduced nickel dependence is partially offset by other materials associated with supply risks or limited recycling potential. Overall, a clear trade-off emerges between environmental and economic performance and resource-related aspects. While the conventional solution remains more competitive under current conditions, the SCFA10-based configuration represents a promising option in the longer term, particularly for supply chain resilience, although further optimization and scaling are needed to improve its overall sustainability

Presenting Author Biography

Sonia Sofi is a Research Technologist at CNR ITAE since January 2025. Her work focuses on the Life Cycle Assessment of energy systems, with particular attention to hydrogen technologies such as SOFC, SOEC and PEM electrolyzers. She develops integrated sustainability analyses combining environmental, economic and resource aspects (LCA, LCC and Critical Raw Materials). She is actively involved in national and European research projects and contributes to the evaluation of advanced materials, components and systems. Her research activity is reflected in scientific publications and presentations at international conferences.