EXECUTIVE SUMMARY–
Stage 1 of project PED 58/2025

Stage 1 of the project *"Design and Modeling of an Innovative RTO Strategy Dedicated to Power Management of a Multi-Source Propulsion System for a Fuel Cell Electric Vehicle (FCEV)"* had as its main objective the development and simulation-based validation of a power management strategy (Energy Management Strategy – EMS) of the RTO (Real-Time Optimization) type for a hybrid propulsion system with fuel cells, battery, and ultracapacitor.
The activities were carried out exclusively in a simulation environment, using the Matlab/Simulink and dSPACE Scalexio platforms, without physical implementation. The goal was to define the operating parameters, model the energy architecture, and verify the control algorithms under dynamic conditions representative of the WLTC (Worldwide Harmonised Light Vehicles Test Cycle) and EUDC (European Driving Cycle) driving cycles.

Within Activity 1.1, the operating parameters of the propulsion system and the system requirements for the EMS strategies were established. The optimal operating ranges of the two PEM fuel cells (25–35 kW) and the EMS control zones (Z0–Z6) were defined, and the software requirements and the ECU logical architecture were developed, including the specifications for deterministic execution and CAN/Ethernet communication.

In Activity 1.2, two real-time optimization strategies were developed and compared: an adaptive, rule-based strategy — RTO_1, and a strategy based on the GES (Global Extremum Seeking) algorithm — RTO_2.
The simulations showed superior results obtained with the RTO_1 strategy, namely an average reduction of 3–5% in specific hydrogen consumption and a DC (direct current) efficiency of up to 68%, while maintaining the battery state of charge (SoC) between 55–85%.

Activity 1.3 aimed at developing the software for the two RTO strategies and integrating them into a virtual control network compatible with the dSPACE Scalexio–ECU platform.
A complete model of the software architecture was developed, including the ECU_FC, ECU_BATT, ECU_UC, and ECU_MOT blocks, interconnected through virtual CAN/Ethernet communication.

The real-time simulations confirmed the stability of the 1 ms execution cycle, the perfect synchronization of the control signals, and the deterministic operation of the algorithms within the integrated software network.

The results obtained during this stage are consistent with those set out in the Project Implementation Plan and confirm the technical viability of the developed RTO strategies, as well as their compatibility with the real-time simulation and control platforms.

By completing this stage, the project achieved a complete foundation for the simulation phase, providing the models, algorithms, and software architecture required for progressing to the next stage, dedicated to the real-time experimental implementation and validation of the power management strategies on the dSPACE Scalexio platform and on the FCHEV demonstrator vehicle.

The obtained results dissemination was carried out through the publication of 7 scientific articles in ISI-indexed journals, as well as through participation with 3 papers at an international conference.