

IMMORTAL

IMPROVED LIFETIME STACKS FOR HEAVY DUTY TRUCKS THROUGH ULTRA-DURABLE COMPONENTS

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Project ID	101006641
PRR 2025	Pillar 3 - H ₂ End Uses - Transport
Call Topic	FCH-01-2-2020
Project Total Costs	3 825 927.50
Clean H ₂ JU Max. Contribution	3 825 927.50
Project Period	01-01-2021 - 31-03-2024
Coordinator Beneficiary	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS, FR
Beneficiaries	UNIVERSITE DE MONTPELLIER, UNIVERSITE DE MONTPELLIER, FPT MOTORENFORSCHUNG AG, FPT INDUSTRIAL SPA, JOHNSON MATTHEY HYDROGEN TECHNOLOGIES LIMITED, PRETEXO, ALBERT-LUDWIGS-UNIVERSITAET FREIBURG, ROBERT BOSCH GMBH, JOHNSON MATTHEY PLC, AVL LIST GMBH

<http://www.immortal-fuelcell.eu>

PROJECT AND GENERAL OBJECTIVES

IMMORTAL aimed to develop high-performance and high-durability membrane electrode assemblies (MEAs), and their components, specifically designed for use in heavy-duty (HD) truck applications. The project intended to develop load profile tests specific to HD truck application, and apply these tests, and accelerated stress tests, to MEAs at both sub-scale and short stack levels. The results of load profile testing have also been used to validate a novel lifetime prediction method, and the method used to predict the lifetime of project MEAs. The project assessed the results through a technoeconomic evaluation and provided HD fuel cell powertrain validation and system recommendations.

NON-QUANTITATIVE OBJECTIVES

IMMORTAL contributed to activities in Mission Innovation's hydrogen innovation challenge through cooperation with the US Department of Energy's Million Mile Fuel Cell Truck Consortium. Several workshops were held with the consortium and Japan's fuel cell platform. These included discussions on, inter alia, heavy-duty stressors, the second-generation Toyota Mirai and advanced characterisation techniques.

PROGRESS, MAIN ACHIEVEMENTS AND RESULTS

- Developed a nanofiber-reinforced membrane with exceptional durability in an MEA in accelerated stress testing at 90 C, comprising 120 000 wet/dry cycles at open-circuit voltage corresponding to 2 200 hours in an accelerated stress test, without rupture.
- Developed MEAs comprising project mate-

rials that reached the 2024 SRIA target for heavy-duty vehicles of 1.2 W/cm² at 0.65 V, and came within 5% of the AWP target of 1.2 W/cm² at 0.675 V (for generation 2 MEAs), giving a Pt loading of 0.32 g Pt/kW.

- Developed a regression model for fuel cell degradation forecasting with emphasis on the prediction confidence interval (uncertainty).
- Developed a method for creating accelerated durability tests for fuel cells, based on Markov chains.
- Established a lifetime prediction method and validated it using 1 500 hours of load profile testing.
- Obtained a predicted power loss of 10% after 30 000 hours (baseline MEAs), which corresponds to the AWP target.
- Identified the principal contributor to power loss during load profile testing as the loss of electrochemically active surface area from the cathode catalyst.
- Developed a modal load profile test from actual truck mission profiles.
- Achieved more than 7 500 hours of load profile testing on short stacks without catastrophic failure.

FUTURE STEPS AND PLANS

IMMORTAL finished in March 2024. Future plans include carrying forward the learning and most prospective materials from IMMORTAL to future heavy-duty MEA development projects, in particular in 'High performing ultra-durable membrane electrode assemblies for trucks' (HIGHLANDER).

PROJECT TARGETS

Target source	Parameter	Unit	Target	Achieved to date by the project	Target achieved?
Project's own objectives	Catalyst surface area and mass activity	cm ² /g Pt and A/mg Pt	Exceeds the performance of reference Pt and demonstrates better retention after accelerated degradation cycles than reference Pt/C.	2 catalyst designs achieve this objective	✓
	Membrane durability in MEA AST cycles	cycles	50 000	110 000	