Clean Hydrogen Partnership

End-uses: Transport

On the road to zero emissions: Advancing MEA performance for fuel cell vehicles

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Heavy-duty road transport plays a vital role in Europe's logistics sector but also contributes disproportionately to greenhouse gas emissions. Meeting EU targets to cut CO_2 emissions from heavy-duty vehicles by 45% by 2030 depends, among others, on the rollout of durable, efficient and cost-effective fuel cell technologies. This means tackling one of the core technical challenges head-on: improving the performance and resilience of membrane electrode assemblies (MEAs).

Three complementary Clean Hydrogen Partnership-funded projects - IMMORTAL, DOLPHIN and FURTHER-FC - have made important advances in adapting MEAs for road transport. The projects have developed innovative fuel cell manufacturing processes and architectures to enhance proton-exchange membrane fuel cell (PEMFC) stack performance for automotive applications in terms of durability, weight and volume. Together, they are enhancing the performance of MEAs under real-world operating conditions, both in heavy-duty and light-duty fuel cell applications.

Re-engineering MEAs to meet real-world demands

While MEAs used in light-duty vehicles are optimised for stop-and-go urban driving, heavy-duty vehicles require MEAs tailored to sustained high-load operation and longer service lifetimes, typically up to 30,000 hours. IMMORTAL addressed this challenge by starting from low technology readiness levels and optimising MEA materials and design specifically for heavy-duty conditions, introducing innovative mitigation strategies to address specific degradation mechanisms directly into component design to increase durability.

"Advancing MEA technology is more than a technical achievement, it's a strategic step towards a zero-emission future for Europe's road transport."

Mirela Atanasiu, Head of Unit Operations and Communication, Clean Hydrogen Partnership

Meanwhile, DOLPHIN adopted novel manufacturing techniques such as gas diffusion layer (GDL) machining to improve fuel cell design. It focused on compact, lightweight stack design for light-duty vehicles, targeting higher power density at reduced cost through innovations in bipolar plate design, ink formulation and GDL processing, among others. Furthermore, FURTHER-FC is delving into the internal architecture of MEAs, applying advanced characterisation and modelling techniques to optimise catalyst-coated layers, where performance bottlenecks often arise.

Paving the Way for Commercial Deployment

Looking ahead, the projects are focused on scaling up and industrialising the membrane electrode assemblies and stack technologies developed so far. The goal is to validate these components at full system level, ensuring they meet the technical and operational requirements of commercial fuel cell truck platforms.

At the same time, further work is planned to refine the testing protocols introduced by the projects, to support regulatory harmonisation at European and global levels. In parallel, deeper techno-economic analyses will help map the real-world impacts of fuel cell efficiency, hydrogen pricing, and total cost of ownership, all of which are key to unlocking competitive, scalable zero-emission transport solutions.

The goal? To develop, produce and commercialise next-generation MEAs tailored to the performance, durability and efficiency demands of fuel-cell-powered heavy- and light-duty vehicles, supporting EU climate targets and industry competitiveness.

Key results? The three projects have demonstrated that with targeted material design, modelling and manufacturing improvements, fuel cell systems can meet the performance and lifetime expectations of heavy- and light-duty road transport, bringing the commercial rollout of zero-emission vehicles a step closer.

FIND OUT MORE

https://www.clean-hydrogen.europa.eu/projects-dashboard/projects-repository_en
https://www.immortal-fuelcell.eu/
https://www.dolphin-fc.eu/
https://further-fc.eu/

Clean Hydrogen Partnership
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KEY ACHIEVEMENTS

HEAVY DUTY MEAs
designed for 30,000 hours of operation with <10% power loss

CATALYST STABILITY
enhanced using nitrogen-functionalised carbon supports

STACK LIFETIME PREDICTION
models developed and validated under heavy duty load profiles

100% INCREASE
in cell-level area-specific power density, reaching up to 1.97 W/cm² at 3 A/cm²

20% IMPROVEMENT
in gravimetric and volumetric power densities, reaching over 4 kW/kg and 5 kW/litre at stack level

IMPACTS

FUEL CELL VIABILITY
demonstrated for heavy-duty long-haul applications

MATERIAL AND DESIGN INSIGHTS
enable improved durability and reduced maintenance

COST PATHWAYS
clarified through techno-economic analysis of total cost of ownership

TEST PROTOCOLS
will contribute to standardised fuel cell stack durability assessment

EUROPEAN INNOVATION CAPACITY
strengthened through collaboration between research and industry

SUPPLY CHAIN DEVELOPMENT
supported by fostering EU-based MEA know-how and production