# Integration of an EGCS on methanol-fueled HT-PEM fuel cells for sustainable maritime shipping

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The increasing regulatory pressure on the maritime industry to adopt environmentally responsible technologies, emphasize the role of alternative fuels and innovative technologies and propulsion systems. Among these, the High-Temperature Proton Exchange Membrane (HT-PEM) fuel cells integrated with methanol reforming systems offer advantages such as high efficiency and ease of fuel storage providing a promising solution for sustainable maritime transportation, reducing environmental impact while maintaining operational efficiency. Methanol, as a molecular hydrogen carrier, is a viable fuel option that bypasses hydrogen storage and distribution challenges. However, while the steady-state operation of HT-PEM fuel cells results in negligible pollutant emissions, transient phases, particularly start-up, can lead to unintended emissions such as carbon monoxide, methanol, and formaldehyde. Addressing these concerns, this study which is part of research activities of the "Centro Nazionale per la Mobilità Sostenibile", presents preliminary findings on the development of an Exhaust Gas Cleaning System (EGCS) tailored for HT-PEM applications. Experimental data from a 5 kW HT-PEM module and numerical modelling provided preliminary insights into exhaust gas composition and pollutant mitigation strategies to adopt. In this application, gas adsorption emerges as a promising gas cleaning technique due to its passive operation, adaptability, and potential for sorbent regeneration to effectively mitigate emissions during transient operations. This approach ensures compliance with varying pollutant concentrations while maintaining minimal fuel penalties and backpressure (below 2 mbar).

Preliminary findings from process simulations indicate that fixed-bed adsorption using copper-loaded activated carbon or functionalized zeolites effectively reduces CO emissions. Design considerations, such as sorbent selection, bed depth, and adsorption kinetics, are crucial for optimizing performance. These advancements contribute to the broader transition toward sustainable maritime propulsion technologies. Future research will focus on refining adsorption-based EGCS designs and exploring regeneration techniques, such as thermal regeneration and non-thermal plasma methods.

**Keywords**: *Sustainable Shipping, HT-PEM fuel cells, Methanol, CO Adsorption process*

**Acknowledgements**: This research was developed within the "CN-MOST – Spoke 3 (Waterways)" research activity, funded under the National Recovery and Resilience Plan (PNRR) of the Italian Ministry of University and Research (MIUR); funded by the European Union – NextGenerationEU.