

GREEN MARINE: RETROFITTING TOWARDS CLIMATE NEUTRALITY

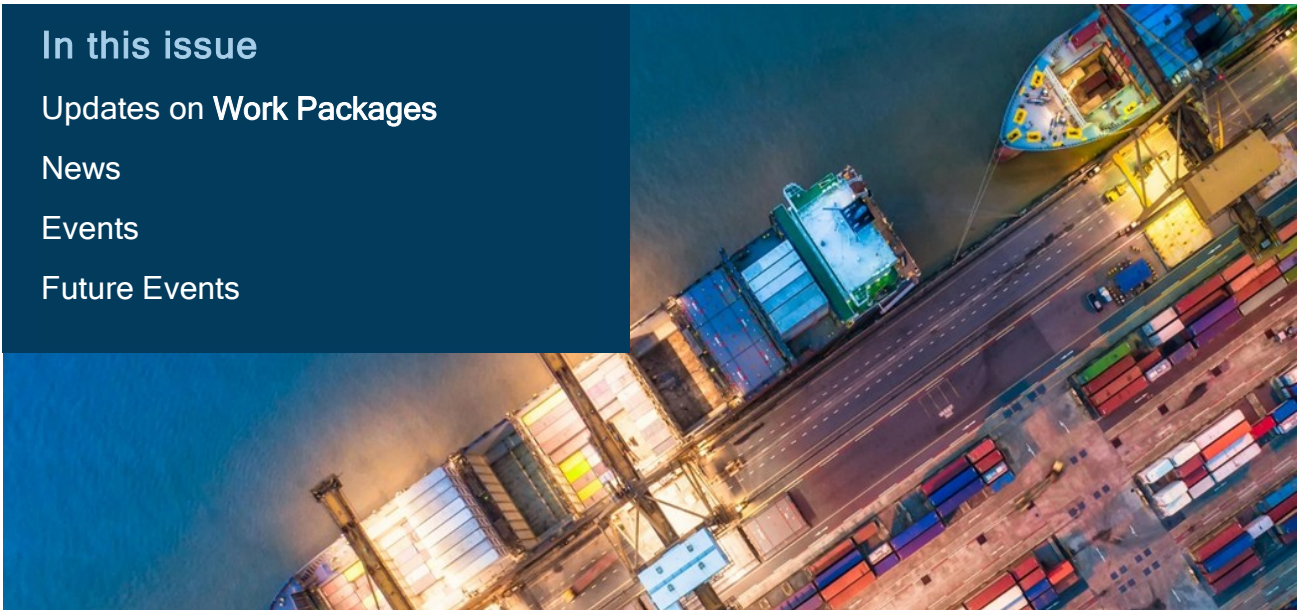
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RECENT ACTIVITIES

As we continue to work towards our goal of creating a sustainable and eco-friendly maritime industry, we are pleased to share the progress we have made over the past six months. In addition, the second Periodic Review (PR) meeting and the 7th consortium and General Assembly meeting of the project took place in March 2026, providing an overview of the project progress over the last few months while planning ahead for the way forward.

Demonstration of Retrofitting of Existing Fleets

Over the past six months, the project consortium has made significant progress in advancing retrofitting activities through WP1. The project partners received a Report on Approval in Principle (AiP) HAZID for CO₂ Abatement from Lloyd's Register (LR). The final report includes LR's review and approval of the comments submitted by University of Strathclyde (UoS) and project partners. This report consolidates the findings into a number of recommendations (consistent with those initially prepared by UoS to guide the work) and provides clearer explanations with a safeguard checklist for verification. A number of them have been addressed collaboratively by partners, following a series of internal workshops and technical meetings. The remaining ones are formally consolidated with agreed safeguards and verification requirements and are to be addressed by all relevant partners in the coming weeks.

A Cause & Effect (C&E) Matrix has been prepared by UoS to address a specific LR recommendation. Additionally, the creation of a Failure Mode, Effects, and Criticality Analysis (FMECA) table has been initiated and is currently being updated based on the latest Process Flow Diagram (PFD) of the Green Marine Integrated System (GMIS). A list of required tasks for the installation of the GMIS was prepared with input from all partners based on LR/UK MCA's recommendations and provisional costs/values and timelines were received. These updates strengthen engineering readiness and support certification progress for upcoming retrofit phases.

Furthermore, in addition to the 3D drawings that have been previously developed considering two initial options for onboard installation of the Integrated Green Marine System, two new configuration options were developed by UoS to optimize space utilization. Discussions are ongoing to select the most suitable configuration.

Land-based Testing and Integration of Solutions

Significant progress was made in regard to land-based testing in the past six months. In WP3, all the technology providers, upscaled, commissioned, risk assess their technologies and shipped them in Cyprus in preparation for the land-based campaigns in Cyprus.



Figure 1: Shipping from Norway of the membrane pilot unit.

A key milestone of the project has been the land-based testing campaign, which was conducted in January 2026 in Cyprus. During the land-based testing technologies that constitute the Green Marine Integrated System (GMIS) were evaluated under realistic marine engine conditions:

- A membrane-based carbon capture technology to separate CO₂ from flue gas.
- The Carbon Capture Machine, which converts captured CO₂ into mineralised products.
- A Thermo-Electric Element, which converts waste heat from the exhaust gases into electricity.
- The SepaRaptor particle treatment technology, designed to improve the efficiency and durability of membrane-based carbon capture systems by removing fine particles from the exhaust gases.

The GMIS technologies were connected to the maritime diesel engine through a bypass and tested under realistic and representative marine engine operating conditions at different motor loadings leading to several diesel exhaust compositions, temperatures and flow rates for a total of 5 working days. Membrane CO₂ separation was tested for an aggregate of 17 hours achieving CO₂ enrichment factors of 3-4 under the achieved operating envelope. The CCM was tested for an aggregate 10 hours at several engine operating conditions ranging from idle to 100 kW and flue gas rates ranging from 5 to 75 m³/h. The maximum CO₂ capture rate recorded was 4 kg/s, with approximately 35 kg of CO₂ being captured across all tests. Furthermore, the production of carbonate products from synthetic brine and the captured CO₂ was demonstrated and samples were taken for further testing and analysis.



Figure 2: Pilot testing in Cyprus.

A series of HAZID workshops was conducted prior to the land-based testing by project partners in collaboration with key maritime stakeholders including Lloyd’s Register (LR) and the UK Maritime and Coastguard Agency (MCA) to ensure all technologies met maritime safety standards and regulatory requirements.

KPIs, Integration, TEA, SEA, LCA, Risk, Safety

This work package continues to drive technical validation, recently finalizing retrofitting system requirements and KPIs following critical design internal reviews with inputs from Lloyd’s Register and the UK MCA. On the safety front, Task 4.2 transitioned into active land-based testing at PML facilities, where rigorous QHSE protocols—including CO monitoring, exhaust extensions, and engine room modifications—ensured personnel safety during pilot operations. Environmental modeling via Task 4.3 yielded updated Life Cycle Assessments for the SepaRaptor, TEE, and Carbon Capture Machine (CCM), and SINTEF pilot, also refining inventory data for membrane production to reflect the latest manufacturing tweaks. On the techno-economic side, the Techno-Economic Assessment (TEA) successfully validated a 0D ICE model against experimental results, showing a close match between simulated and real-world engine performance. A new FastAPI-based microservice now integrates these technical inputs—such as membrane area impact and power demand—

directly into the Green Marine software platform via a graph-based execution engine (DAG). Social readiness remains a priority, with BX completing an on-site fieldwork campaign on the Oban-Craignure ferry route to collect passenger data on the public acceptance of sustainable marine tech. Looking ahead to mid-2026, the team is initiating the subcontracting process for deacidification mineral assessments and refining licensing-based business models to secure long-term exploitation pathways, as well as continuing to refine the TEA models and deepen the environmental analysis with usage phases.

Software Tool Catalogue for GHG-Reduction

Over the past six months, WP5 has made significant progress in developing the Software Tool Catalogue for GHG-emission reduction solutions. Key activities focused on advancing modular software components, platform integration, and analytical tools. The techno-economic assessment (TEA) tool has been designed as a flexible, high-performance platform, enabling future evaluation of different carbon capture technologies once validation data becomes available. In parallel, data collection for health, safety, risk, and environmental aspects has continued to support tool development. The core software infrastructure has been strengthened through API development and integration within a centralised platform, alongside a chatbot interface to facilitate user interaction. Progress was also achieved in digital mimic development, with initial models for carbon capture systems created using simulation and machine learning techniques. Engineering analyses, including CFD studies for airflow and exhaust systems, supported optimal onboard integration concepts. Additionally, a social engagement module and retrofit catalogue activities have progressed, preparing for upcoming demonstration and integration phases.

Exploitation and dissemination

By participating in various domestic and international dissemination activities, the project team successfully presented project outcomes, shared best practices, and exchanged knowledge with experts and stakeholders. Key achievements and methodologies developed during project activities were highlighted through oral presentations, workshops, and panel discussions. Participation in dissemination events also facilitated networking and the establishment of new collaborations for future research and implementation. Overall, these dissemination efforts significantly enhanced the project's visibility and contributed to the broader impact of its findings.

Project Management

The project second Periodic Review (PR) meeting and the 7th Consortium and General Assembly meeting of the project was successfully conducted on 11-13 March 2026, in-person in Hengelo, the Netherlands, and with online participation. During the PR meeting, the Green Marine consortium shared the latest project developments with the EU Project Officer and external expert and received valuable feedback and suggestions. During the General Assembly meeting, partners reviewed key project milestones, discussed impending issues, and collaboratively defined decisions, directions, and actionable plans to ensure smooth progress. The meeting provided an important forum for aligning on objectives, addressing challenges, and strengthening coordination among consortium members, reinforcing our commitment to advancing climate-neutral retrofitting solutions for the maritime sector.



Figure 3: 7th Consortium and General Assembly Meeting.



Figure 4: Green Marine banner at the 7th Consortium and General Assembly meeting.

NEWS

Decarbonising UK Shipping Workshop

UoS hosted the “Decarbonising UK Shipping: Industry Engagement and Onboard Carbon Capture” workshop, which was held at the University of Strathclyde, in Glasgow, U.K., on September 10, 2025. UoS, CMMI, and PDM all participated and presented at the workshop. Overall, 8 presentations took place and more than 80 participants attended the workshop either in-person or online.

Block your calendar!
September 10, 2025

Decarbonising UK Shipping: Industry Engagement on Onboard Carbon Capture (OCC) workshop

AGENDA

- POLICY AND STRATEGIC CONTEXT
- TECHNICAL AND OPERATIONAL LESSONS FROM OCC DEPLOYMENT
- INDUSTRY PERSPECTIVES & APPLIED TRANSITION
- TECHNOLOGY INTEGRATION IN PILOT PROJECTS
- CLASSIFICATION, REGULATION & RISK
- NETWORKING AND KNOWLEDGE EXCHANGE

WHAT? A HYBRID, COLLABORATIVE WORKSHOP FOCUSED ON ACCELERATING THE DEVELOPMENT AND DEPLOYMENT OF ONBOARD CARBON CAPTURE (OCC) SOLUTIONS IN UK SHIPPING.

WHY? TO RAISE AWARENESS AND FOSTER COLLABORATION BETWEEN INDUSTRY, ACADEMIA, AND REGULATORS, TACKLING BARRIERS AND SHAPING THE FUTURE OF MARITIME DECARBONISATION THROUGH OCC.

WHERE? ROOM 105, STENHOUSE WING, STRATHCLYDE BUSINESS SCHOOL, GLASGOW G4 0QU (ALSO AVAILABLE ONLINE)

For any enquiries please contact: y.ahmed@strath.ac.uk

THIS WORKSHOP IS SUPPORTED BY EPSRC: IAA SMALL GRANT

Registration is free!

What are you waiting for?

Decarbonising UK Shipping Industry Engagement on Onboard Carbon Capture (OCC)

Net-Zero-Emission CI Workshop

CMMI participated in the “Net-Zero-Emission-CI Workshop: Cold-ironing challenges – The Cyprus case”, which was held in Larnaca, Cyprus, on October 19, 2025.

Green Marine x RETROFIT55 collaborative workshop #4 & #5

Representatives from Green Marine and RETROFIT55 engaged in further collaborative brainstorming to advance the development of an integrated software catalogue platform on November 6 and December 12, 2025.

Alliance4XR Workshop

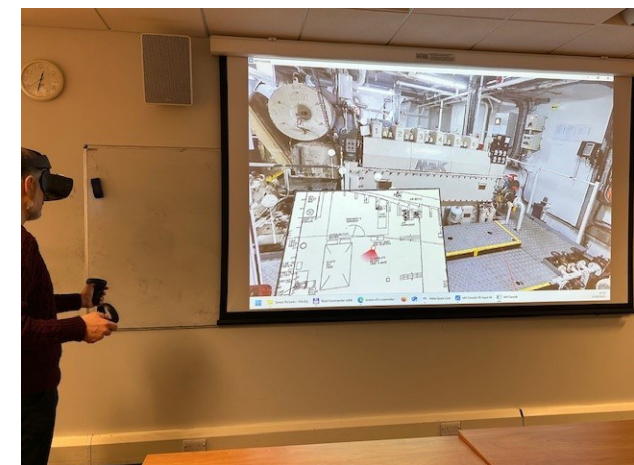
CMMI participated in the Alliance4XR workshop demonstration “XR Horizons: Building Skills for Tomorrow”, at the University College Dublin, in Dublin, Ireland on December 2, 2025, where they demonstrated the project’s vision and progress.



Onboard VR Demonstrations

UoS presented the in-house developed Virtual Reality application showcasing the environment onboard the CalMac vessel to-be-retrofit on several separate occasions.

During the Strath Open Days, which took place on September 2 and October 4, 2025, at the University of Strathclyde, Glasgow, U.K., the application was demonstrated to approximately 100 pupils each day, totaling 200 pupils.



The application was also presented in three additional occasions during relevant lectures at the University of Strathclyde, Glasgow, U.K, to 40 2nd-year students, 30 5th-year students, and 50 2nd-year students, on November 5, 2025, December 3, 2025, and February 17, 2026, respectively.

CAPE-OPEN Annual Conference

UoS presented the advances of the project along with the internal use of the CAPE-OPEN standard in the CAPE-OPEN Annual Conference, which took place in Ghent, Belgium, on October 29-31, 2025.



H.I.M.T. (EL.I.N.T.) Annual Conference

UoS presented the advances of the project along with the development of the VR application at the H.I.M.T. Annual Conference which took place in Paleo Faliro, Greece, on December 9-10, 2025.



SNAME WES Symposium 2025

UoS presented recent project advances at the SNAME WES Symposium 2025, which was organized by the SNAME Student Section of the University of Strathclyde and took place in Glasgow, U.K., on February 11, 2026.

SAFETY4SEA Limassol Forum 2026

CMMI participated in the SAFETY4SEA Limassol Forum 2026 held on 18 March 2026 in Limassol, Cyprus, joining industry experts to discuss the future of sustainable shipping.

During the Sustainable Shipping panel, insights shared from the Green Marine project were shared, focusing on how retrofit solutions can help reduce emissions from the existing fleet.



WHO WE ARE

Given its knowledge, experience and innovative techniques, methods, and tools, the Green Marine consortium will develop and implement real-world solutions for retrofitting vessels in an effort to mitigate climate change.

Coordinator:



Partners:



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the European Union

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