

Final report

1. Project details

Project title	Lubricant Oil Efficiency for Low Emission Cargo Shipping (Lu-bOilEfficiency)
File no.	
Name of the funding scheme	EUDP
Project managing company / institution	Smart-Marine ApS
CVR number (central business register)	39736721
Project partners	-
Submission date	01 May 2025

2. Summary

Project summary

Purpose of the project

The project addressed the challenge of reducing waste and energy consumption in the maritime sector by developing a system for onboard reuse of oil. The project developed, tested, and demonstrated an innovative circular technology that cleans and reinjects used oil, lowering emissions and operational costs.

Results

The project successfully developed and demonstrated the oil-reuse system, which was installed and tested onboard a vessel. The system effectively collected and cleaned used lubrication oil, enabling it to be reused in ship engines without compromising performance. This resulted in a significant reduction in the need for new lubricant oil, thereby lowering the energy consumption associated with refining, transporting, and handling fresh oil supplies, contributing to both cost savings and environmental benefits.

The system also contributed to operational improvements by optimizing fuel oil consumption and providing faster feedback on engine conditions, which improved engine tuning and reduced downtime. The strong interest from ship operators and sustainability departments exceeded expectations, opening additional commercial opportunities.

The system will now be scaled for broader market adoption. In a broader perspective, the project results may influence future developments in maritime sustainability practices and potentially shape new international regulations encouraging onboard waste recovery and oil reuse.

Projektresumé

Formål med projektet

Projektet adresserede udfordringen med at reducere affaldsprodukter og energiforbrug i den maritime sektor ved at udvikle et system til genbrug af olie ombord på skibe. Projektet udviklede, testede og demonstrerede en innovativ cirkulær teknologi, der renser brugt olie, hvilket reducerer både emissioner og driftsomkostninger.

Resultater

Projektet udviklede og demonstrerede med succes genbrugssystemet for olie, som blev installeret og testet ombord på et skib. Systemet opsamlede og rensede effektivt brugt smøreolie, hvilket gjorde det muligt at genanvende olien i skibsmotorer uden at gå på kompromis med performance. Dette førte til en markant reduktion i behovet for ny smøreolie og dermed et lavere energiforbrug forbundet med raffinering, transport og håndtering af frisk olie, hvilket bidrager til både økonomiske besparelser og miljømæssige gevinster.

Systemet bidrog også til driftsforbedringer ved at optimere forbruget af brændselsolie og muligheden for hurtigere feedback på motorens tilstand, hvilket forbedrede motortilstanden og reducerede nedetid.

Den store interesse fra rederier og bæredygtighedsafdelinger overgik forventningerne og åbnede for yderligere kommercielle muligheder. Systemet skal nu skaleres med henblik på bredere markedsadoption. I et bredere perspektiv kan projektets resultater få indflydelse på fremtidige udviklinger inden for den lovgivningsmæssige praksis i den maritime sektor og potentielt være med til at forme nye internationale regler, der fremmer genanvendelse af affald og olie ombord.

Project Objective

The primary goal of the project was to develop and validate a sustainable solution for the onboard reuse of lube oil in maritime vessels. The project was structured around three key objectives:

- 1. Concept design: Collect user-inputs from a range of end-users as well as engine manufacturers, develop detailed concept design, attain technical approvals, prepare documentation of the solution and its energy efficiency impact through reduction of the consumption of fossil based lubricant oil and fuel, determine market replication options*
- 2. Solution development: Iterative process with development of all necessary system elements for the LubOilEfficiency system concept by securing flow, fractionation and upgrading of excess lubricant oil from ship engines, including solutions for recovery, transport, filtering, cleaning, improvement, and reinjection of lubricant oil*
- 3. Test and demonstration: Iterative process with manufacturing and installation of mock-up prototype, operational prototypes and pilot series units.*

When re-using oil that is otherwise considered waste oil, several streams of energy savings are obtained:

Developed and Demonstrated Energy Technology

The project has developed and demonstrated a circular energy technology centered around the onboard reuse of lube oil. This innovation results in energy savings across multiple dimensions:

Reduced Refining Demand

Replacing new lube oil with reconditioned used oil significantly lowers the need for oil refining—a process that is highly energy-intensive.

Lower Transport Requirements

With reduced dependence on new oil supplies, the energy consumption associated with transporting refined oil to vessels is also minimized.

Reduced Waste Oil Handling

Reusing oil onboard reduces the energy required for transporting and processing waste oil—whether through onboard incineration or transfer to land-based reception facilities.

Fuel Oil Consumption Optimization

Full implementation of the developed solution has the potential to reduce fuel oil usage across the vessel's operational lifecycle by improving engine efficiency and reducing downtime due to imbalances.

Enhanced Engine Monitoring

Faster feedback on engine condition contributes to more efficient engine tuning and reduces both cylinder oil and fuel oil consumption.

This project contributes to the broader goal of reducing the maritime sector's environmental footprint by integrating energy-efficient circular economy practices into daily vessel operations.

3. Project implementation

Project implementation

The project evolved in a positive and largely predictable manner, closely following the planned objectives and milestones. While minor delays occurred, the overall flow of the project was maintained. The implementation phase was marked by successful pilot installations on large Maersk container ships, which confirmed the effectiveness of our system in cleaning and upgrading used lube oil onboard.

Risks and Challenges

Several risks were identified at the outset of the project. The most critical technical risk was the possibility that the system might fail to clean and upgrade the used lube oil to a satisfactory quality level. If the performance of the reused oil had proven inadequate, the entire project would have been compromised. Fortunately, this risk did not materialize. Results from pilot tests using our combined cleaning unit (LRS) demonstrated effective cleaning of the used oil. Furthermore, upgrading with traditional additive packages successfully restored key performance parameters. Reinjection and use of the refurbished oil onboard showed excellent anti-wear and cleaning performance in the engines.

Another significant risk was the potential loss of interest or engagement from the end users—namely, ship crews and shipping companies. Given that testing and demonstration occurred in real-world maritime environments, continuous engagement from the ship crews was vital. Our team could not be physically present during onboard operations, making us highly dependent on the motivation, diligence, and feedback from the crews.

This challenge was mitigated through strong personal relationships developed over years within the maritime industry. I, Thorbjørn Petersen, drew upon my 20+ years of experience and contacts within Maersk, which proved invaluable in securing ongoing commitment from both crew members and land-based personnel. The support, engagement, and feedback we received throughout the project were exemplary.

Another operational risk stemmed from the complexity of integrating the system into existing ship infrastructure without interfering with day-to-day vessel operations. However, through meticulous planning, close cooperation with ship technical managers, and on-site training modules, this risk was effectively controlled.

Milestones and Timeline

In general, the implementation followed the planned milestones. However, some minor schedule shifts occurred due to external factors, such as delays in ship availability, awaiting permissions for onboard installations, and extended timeframes for laboratory oil analysis. Despite these delays, the core project activities proceeded without major disruption.

Key milestones achieved included:

- Design finalization and prototyping of the LRS unit.
- Completion of factory acceptance testing.
- Successful pilot deployments on three Maersk vessels.
- Performance validation through onboard monitoring and lab testing.
- Finalization of the upgraded automated version of the system.

These milestones were not only achieved within the revised timelines but also provided critical feedback that fed directly into final product refinement.

Unexpected Issues

While the project unfolded largely as anticipated, we encountered several technical challenges along the way. One of the most notable lessons was the clear preference among users for a fully automated system over a manual solution. Initially, the project aimed to develop both manual and automated versions of the system. However, during the implementation phase, feedback from the industry consistently highlighted the need for high automation, simplicity, and fail-safe operation. As a result, the project shifted its focus toward developing a highly automated and user-friendly system, which ultimately aligned better with end-user expectations and operational realities.

Additionally, during the implementation, we identified unexpected wear on certain components within the early prototypes. This prompted a rapid review of material specifications and mechanical design, leading to minor but crucial hardware upgrades that improved system durability under shipboard operating conditions.

Lastly, although not foreseen, the increasing pressure on shipping companies to meet environmental and circular economy targets turned out to be an unexpected advantage. The project received more attention and positive momentum from corporate sustainability departments than initially expected, which opened the door to potential collaborations and commercial pathways beyond the original scope.

4. Project results

Project objectives

Objective 1 Concept Design: The initial concept was developed based on several discussions with end-users and subject matter experts in the field of oil processing. The technical documentation was used as a basis for further discussion with end-users and engine specialists. Through a few iterations, the documentation was modified to produce a concept ready for actual manufacturing of the prototype. Suppliers with expertise in the field of oil cleaning and preparation were consulted to establish the best options for the initial design. On this basis, the first prototypes were manufactured and assembled in workshop, and 2 prototypes were tested onboard, proving the functionality and concept for further development.

Objective 2 Solution Development: The first prototype was manufactured and various components tested with an oil sample collected from a vessel in service that resembles the expected conditions that the solution is developed for. Based on data collected from vessels in service the dimensioning and outline of the prototype was determined. Various configurations were considered and discussed again with experts and potential future end-users to design a feasible final solution, to be manufactured, tested and ultimately put in a vessel for onboard testing.

Objective 3 Test and demonstration: A prototype was developed and tested with oil collected from the vessel in service, and the concept was verified and proven together with well-reputed experts in the marine industry. During the initial testing period, several components were replaced with others, and various controlling strategies were tested both in workshop, and onboard a vessel in service.

Describe the obtained technological results

A prototype was designed based on the iterative feedback from end-users and engine and oil cleaning experts, clearly indicating that the design is viable, both in relation to fulfilling the task at hand, but also in relation to operability and need for maintenance. The entire system was improved to collect as much of the drained oil as possible, also increasing the potential for reducing the waste from the engine, and by utilizing the previously developed auger drain cleaners, the results meet the expectations outlined in the project objectives and will be developed further to optimize product cost and collect more data.

Obtained commercial results

The potential for recovering oil to be processed in the machine, is found to be quite significant. Oil that has until now been considered lost/wasted oil will be collected, cleaned, and repurposed. The impact for vessel operators will be significant, both in commercial terms and from a sustainability viewpoint. Also in the process, the tangible potential for re-use was investigated, to establish the potential for future users, and the impact on shipping. Here it was determined that over the lifespan of an engine, the potential for re-use will be significant. Also the efficiency of the cleaning process was determined, and clearly shows that the loss during the cleaning process is limited compared to the overall potential for repurposing drain oil.

Target group and added value for users

Since the pilot prototyping was done with Very Large Container Vessel, the target group will initially be container ship owners, third-party technical managers managing VLCC, and operators with VLCCs. Several stakeholders can be addressed, since there is both a financial and an environmental aspect of applying the cleaning machine. Prioritized from most important going down in priority will be container ship owners, owners of VLCC, that has similar engine types as VLCC, owners of the biggest ore- and bulk carriers with similar engines, and further down the chain 3rd party technical manager of same type of vessels will be addressed. It is clear that the bigger the engine, the bigger the commercial potential, so the aforementioned owners and operators will

be the main target during maturing process, however once concept is matured, and scaling possibilities further investigated, all 2-stroke engines operators could be included.

Where and how have the project results been disseminated? Specify which conferences, journals, etc. where the project has been disseminated.

- *SM has attended SMM in Hamburg, and Future Fuels conference in Hamburg.*

5. Utilisation of project results

Utilization of Technological Results

Smart-Marine's Lube Recovery System (LRS) has been developed to collect, clean, and reuse lubrication oil from the main engine of large vessels. Through extensive testing with a dedicated partner, the system has demonstrated strong performance, with our test partner providing highly positive written feedback.

The technological results obtained will be used as a foundation to introduce and market the system to new potential customers worldwide. Smart-Marine has identified key shipping companies where the LRS system will be highly relevant, and we anticipate widespread adoption across the global fleet.

Utilization of Commercial Results

Commercially, the results from the project will be utilized to scale production and expand market outreach. With a proven product, we are now engaging with leading shipping companies to introduce LRS as a cost-saving and environmentally beneficial solution.

To strengthen our market presence, we are investing in a professional new website to improve digital visibility and credibility. Additionally, we plan to exhibit at key maritime industry events and collaborate with well-connected agents to facilitate market entry. Our new website will also contribute to making us a more attractive workplace, sending a modern and dynamic signal to potential job applicants.

Impact on Turnover, Exports, Employment, and Investment

The project has already led to increased employment and investment. We have hired a production manager at our site in Kegnæs, Southern Denmark, and we are in the process of recruiting a service technician to assist with onboard installations. Furthermore, the increased demand for our technology has driven additional private investments into Smart-Marine.

We expect the project to further contribute to increased turnover, exports, and job creation as more shipping companies adopt the LRS system. With the positive results from initial testing, we foresee significant growth in international sales and additional private investments to support production scaling.

Competitive Situation and Market Entry

Smart-Marine has filed a patent application for the LRS system, securing a 'patent pending' status. To date, we have not identified direct competitors offering a similar technology for the collection, purification, and reuse of lubrication oil in the maritime sector.

The competitive challenge lies in convincing technical departments within shipping companies, particularly technical directors, to invest in our product over other operational or maintenance solutions. However, we hold a strong position due to our product's ability to:

- *Reduce costs (economic advantage)*
- *Lower CO2 and particulate emissions (environmental advantage)*
- *Improve engine condition (technical advantage)*
- *Eliminate labor-intensive, potentially hazardous manual tasks for crew members (safety and operational advantage)*

Market Competition and Entry Barriers

One of the key barriers to market entry is demonstrating that our product delivers significant savings without negatively impacting the main engine. We have addressed this by conducting trials with A.P. Møller-Maersk, which confirmed positive results. This collaboration serves as a 'stamp of approval' that will strengthen our credibility when approaching new customers.

The maritime industry tends to be conservative, as shipping companies have encountered suppliers who over-promise on performance. Therefore, securing real operational data from a trusted industry leader like Maersk is critical for overcoming skepticism and driving adoption.

Contribution to Energy Policy Objectives

By enabling the reuse of a significant portion of the lubrication oil collected from the main engine, the LRS system contributes directly to reducing CO2 and particulate emissions. This aligns with global energy policy objectives aimed at reducing environmental impact from shipping. Our product supports shipping companies in achieving compliance with stricter regulations and sustainability targets while maintaining cost efficiency.

Integration into Academic and Dissemination Activities

Although no Ph.D. candidates have been directly involved in this project, the results will be disseminated through industry conferences, technical papers, and training programs for engineers and technicians. As the technology gains traction, we anticipate closer collaborations with universities and maritime academies to integrate our findings into educational curricula and innovation initiatives within the maritime sector.

6. Project conclusion and perspective

Conclusions made

The project has successfully demonstrated the potential for significant reduction in oil waste and fuel consumption through the use of the developed Lube Recovery System (LRS). By efficiently collecting and reusing waste oil onboard ships, the technology not only improves operational efficiency but also contributes to more sustainable maritime practices.

Next steps

The next steps involve scaling the solution across fleets globally to maximize environmental and economic impact. Additionally, there are plans to develop a smaller version of the LRS, tailored for vessels with smaller engine types. This will enable broader adoption across a wider range of ship classes and further enhance sustainability within the global fleet. The technology also opens up opportunities to explore the recovery and reuse of other types of waste oil or by-products onboard, moving closer to a circular system where onboard waste is minimized and reused wherever possible.

Put into perspective how the project results may influence future development

In a broader perspective, the success of this project could influence future regulatory developments in the maritime industry, particularly within international bodies such as the International Maritime Organization (IMO). By setting a new standard for onboard waste recovery and oil reuse, the project demonstrates how innovative technologies can align with and support emerging environmental legislation, potentially shaping more sustainable practices industry-wide. This may eventually lead to legislation requiring more comprehensive onboard waste management practices as has been practiced for legislation of use of scrubbers for reducing emissions of particles from vessels.

7. Appendices

- Add link to relevant documents, publications, home pages etc.