*Zero waste Heat vessel towards relevant Energy savings also thanks to IT technologies*

# D 6.12 | ZHENIT policy positioning paper and Guidebook

## WP6 – Dissemination, communication and Exploitation

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Clean and competitive solutions for all transport modes - Innovative on-board energy saving solutions

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# Abbreviation and Acronyms

| Acronym | Description |
|---|---|
| WHR | Waste Heat Recovery |
| IMO | International Maritime Organization |
| EU | European Union |
| GHG | Greenhouse Gas |
| NZF | Net-Zero Framework |
| ETS | European Trading System |
| WtW | Well-to-Wake |
| MARPOL | Maritime Pollution Convention |
| MEPC | Marine Environment Protection Committee |
| ORC | Organic Rankine Cycle |



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# Executive Summary

The ZHENIT Project is an EU-funded project that aimes at accelerating the **decarbonization** of the maritime sector by delivering market-ready, retrofit-compatible energy efficiency solutions. In response to increasing regulatory pressure from the **International Maritime Organization** (IMO) and the **European Union** (EU), ZHENIT positions **Waste Heat Recovery** (WHR) and complementary retrofit technologies as practical, short- to medium-term solutions to reduce **greenhouse gas** (GHG) emissions from existing vessels.

Maritime transport, which carries approximately 90% of global trade, currently accounts for around 2–3% of global GHG emissions. With ambitious targets set by the IMO—net-zero emissions by 2050 and significant reductions by 2030 and 2040—as well as regional measures such as the FuelEU Maritime Regulation and the EU Emissions Trading System, the industry faces urgent pressure to adopt cleaner technologies and improve energy efficiency.

ZHENIT addresses this challenge through an integrated technological approach that combines advanced WHR systems, digital energy management tools, and retrofit solutions such as wind-assisted propulsion. Its WHR technologies—based on **Organic Rankine Cycle** systems for high-temperature heat and isobaric expansion engines for low-temperature heat—enable the recovery and reuse of energy that would otherwise be wasted. This approach can reduce vessel energy consumption by up to 25–35% without compromising operational performance or safety.

While challenges remain —such as onboard space constraints, integration complexity, regulatory certification, and upfront investment costs— ZHENIT demonstrates a strong potential as a scalable and cost-effective pathway to emissions reduction. By focusing on energy efficiency rather than fuel switching, it provides an immediately deployable solution that complements longer-term transitions to alternative fuels.

Overall, ZHENIT is positioned as a practical, policy-aligned solution that supports compliance with EU and IMO targets while enabling significant emissions reductions across the maritime sector in the critical decade leading up to 2030.

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# 1 Introduction

The ZHENIT Project ( *https://www.zhenit.eu/* ) is an EU-funded project designed to address the ship industry's decarbonization, which is a major concern regarding the all-around transport sector. ZHENIT aims to position a WHR and advanced retrofitting solutions as ready-to-implement technologies that will support achieving the 2030 IMO and the EU decarbonization targets. Through the development and validation of WHR systems within various temperature ranges, coupled with the integration of retrofitting measures, including wind-assisted propulsion and passive air lubrication, ZHENIT wants to highlight the ability to cut the vessel energy consumption by up to 25–35%, without compromising safety on aboard and maintaining fleet performance at its best.

Employee-driven technological innovation in the project creates a pathway for market-ready solutions within the EU shipping sector between 2027 and 2030.

# 2 Global Shipping in the Context of Environmental Considerations

The maritime transport industry is the fundamental pillar of the international trade. The volume of global trade that is accounted on the maritime sector is of approximately 90%. Keeping the economic relevance of the sector in mind, it can't be overlooked that GHG emissions are a significant contributor of the environmental degradation. It has been estimated by the IMO that the GHG global emissions which the maritime shipping is responsible for is approximately 2-3% annually. In response the IMO introduced the GHG Strategy from 2023 which sets out to achieve net-zero emissions by 2050. Including key targets, such as reducing emissions by at least 20% (striving for 30%) by 2030 and at least 70% (aiming for 80%) by 2040, these values compared to the 2008 levels.

A central and important component of the evolving regulatory framework is the development of the IMO's **Net-Zero Framework** (NZF), introducing the possibility of combining a global marine fuel standard and a market-based mechanism, this approach would effectively introduce carbon pricing on an international scale. This framework seeks to regulate the GHG intensity of marine fuels and encourage emissions reduction through economic incentives, supporting the current operational and technical strategies of the sector.

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The strategy that the IMO is trying to implement promotes the uptake of zero and near-zero emission fuels and also technologies, this to establish a target for their deployment, this to reach at least 5% (striving for 10%) of the total energy that is annually required in international shipping in 2030. The Framework therefore represents a critical step towards scaling alternative types of energy solutions such as ammonia, hydrogen when talking about fuels and technologies such as those evaluated in ZHENIT.

The IMO NZF will be added as Chapter 5 to Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL) once it is adoptned. Regrettably, during the extraordinary **Marine Environmental Protection Committee** (MEPC) session, that took place in October 2025 at the IMO, did not formally approve the NZF, during that session it was decided to give all IMO Member States an additional year to evaluate and framework and its implications for lifecycle GHG intensity limits and the potential of carbon pricing.

At the regional level, the **FuelEU Maritime Regulation** establishes increasingly stringent GHG intensity standards for fuels used by ships from 2025 through 2050, applying a “Well-to-Wake” (WtW) lifecycle approach. In addition, the **EU Emissions Trading System** (ETS), that has been in force since 2024, incorporates carbon pricing mechanisms for maritime operators, thereby strengthening the financial incentives to achieve emissions reductions. The shipping companies are required from the EU to surrender the allowances gradually. In 2025 shipping companies surrendered **40%** of their reported 2024 $CO_2$ emissions. In 2026 the emissions will increase at **60%** of the reported emissions in 2025. Effective from 2027 onward, they are obliged to surrender **100%** of the allowances.

The shipping industry is moving toward cleaner fuels and technologies, but this shift demands major operational and technological advances and significant investments from all parties.

## 2.1 Decarbonization and Regulatory Drivers in Maritime Transport

The Intergovernmental Panel on Climate Change highlights that to achieve a meaningful mitigation the worsening effects of climate change need to be a significant reduction in carbon dioxide emissions from all sectors, not only maritime, which as was pointed out before accounts from 2-3% of the overall emissions.

Some estimates, if the shipping sector is not mitigated, they could account for [FV3.1][GA3.2]up to 17% of the global $CO_2$ emissions by 2050. This scenario represents the worst-case based on the modelling

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that assumes that the shipping industry does not decarbonize at a fast enough pace as the other sectors. However, this study has attracted controversy, primarily because it implies that aggressive decarbonization is actually achieved in non-shipping sectors, while shipping industry is assumed to leg behind. This mainly due to some challenges that could be identified as technological limitations – mainly slower development – and regulatory hurdles, due to the complexity of the implementation of the global provisions and regional jurisdictions.

The transition to low- and zero-carbon is not only an environmental responsibility and a critical economic and social requirement. To be in line with the IMO 2050 targets the industry faces pressure to innovate, to adopt “cleaner” fuels, to implement energy-efficiency technologies and prepare for the new regulations.

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# 3 ZHENIT as a Key Decarbonization Solution for Maritime Transport

As mentioned above, ZHENiT project focuses on using innovative WHR systems to value onboard waste heat recovery, as an integrated technological approach on decarbonization. WHR will be tested on board of Teseo, a fishing vessel, during sea-trials on the coastline of Sicily as part of the validation campaign of the project. In addirion, ZHENIT is also focusing on a comprehensive approach, integrating various energy efficiency systems, digital optimization tools, and retrofit-oriented solutions.

During the project not only WHR system was analysed as specified in document[FV4.1][GA4.2], but also additional retrofitting options such as wind-assisted propulsion technology. Therefore, unlike single technology, ZHENIT takes a more complete approach, combining different energy recovery systems, digital optimization tools, and retrofit-oriented solutions. Due to the short to medium term decarbonisation targets set for 2030, the framework positions WHR as a key facilitator of the energy shift in the maritime industry, rather than just one of the many auxiliary efficiency measure.

The development and validation of the technology across different temperature ranges, that allows the recovery and reuse on board of thermal energy that would otherwise be lost, is of course the major assessment of the project. Once the temperature of the available waste heat is addressed, the main variable to be considered, the technological pathways can be identified. [FV5.1]In ZHENIT an Organic Rankine Cycle (ORC) equipment transforms the main engine jacket cooling water, with a temperature just below 100°C, into energy from heat that would otherwise be lost. By transforming exhaust heat into several energy forms, the demand on auxiliary or main engines is reduced, thereby improving the overall efficiency of the plant.

The research provides isobaric expansion engines that can transform low-grade thermal energy into mechanical work for low-temperature waste heat (below 100°C), which is usually wasted in traditional waste heat recovery systems. This solution helps achieving the overall goal of reducing onboard energy losses and increasing the usable energy range of waste heat recovery systems.

Thanks to the integration of the digital energy management systems, the energy flows onboard can be monitored, controlled and therefore optimized in real time, so that the recovered heat can be effectively used and maximised under a variety of operating circumstances. The performance of the system is intrinsically dependent on the dynamic load patterns and variability of operation, making the digitalization essential.

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As a project ZHENT prioritizes the retrofit compatibility for the installation of the system, to meet an urgent demand for decarbonizing the existing fleet. However, some obstacles are still limiting retrofitting possibilities, e.g. availability of space on board, weight increase with negative impact on ship stability, integration of components on existing ship systems, which also introduce technical complexity on the overall system. Moreover, the initial investment in capital (CAPEX) and fluctuations in fuel prices (OPEX), more and more frequent, have an impact on the cost-effectiveness and return of the investment of WHR systems. The adoption can also be delayed by regulatory factors, such as certification processes for new technologies, and the lack of “marinised” industry standards.

In conclusion, the ZHENIT’s project demonstrates that WHR can effectively deliver substantial improvements in energy efficiency on board, offering to the marine industry a viable and practical decarbonization route, both for new ships and the existing fleet, increasing the possibility of compliance with short-term climate goals, remaining also a key option for long-term goals.

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# 4 Positioning of ZHENIT

A significant strategy to increase the energy efficiency of a ship system is the recovery of residual heat, which immediately lowers fuel consumption and GHG emissions.

ZHENIT could be positioned as a practical short-term solution to help decarbonize, aligning with the objectives of the European Green Deal, the FuelEU Maritime Regulation and the IMO 2030 targets.

Long-term solutions, imply fuel-switching and substantial infrastructure, technological constraints, and an available fuel production chain, while ZENITH focuses on the energy efficiency through systematic recovery and reuse of onboard waste heat. This is the key to reduce fuel consumption and GHG emissions, while supporting the regulatory compliance during the transition to short-term and long-term solutions.

The design is modular and compatible with retrofitting, enabling the existing feet with suitable characteristics to adopt the system on board without disruptive modifications to the vessel, therefore addressing most of the fleet that will still be in operation by 2030.

Through the incorporation of the digital energy management system and supporting technologies such as wind assisted propulsion systems, ZHENIT boosts the overall energy efficiency of possibly the entire vessel and operational resilience, offering a scalable solution, and a policy-aligned pathway toward a more sustainable maritime operation.

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# 5 References


- Baldi, F., Ahlgren, F., Nguyen, T.-V., Thern, M. and Andersson, K. (2015) 'A review of waste heat recovery technologies for maritime applications', Energy Conversion and Management, 100, pp. 248–265.
- European Commission (2019) The European Green Deal. Brussels: European Commission.
- European Commission (2021) Fit for 55: Delivering the EU's 2030 Climate Target on the way to climate neutrality. Brussels: European Commission.
- European Union (2023) Regulation (EU) 2023/1805 of the European Parliament and of the Council on the use of renewable and low-carbon fuels in maritime transport (FuelEU Maritime). Official Journal of the European Union.
- International Energy Agency (2022) Energy Efficiency 2022. Paris: IEA.
- International Maritime Organization (2020) Fourth IMO Greenhouse Gas Study 2020. London: IMO.
- DNV (2023) Maritime Forecast to 2050. Høvik: DNV.
- European Maritime Safety Agency (2021) Study on the potential of energy efficiency technologies for ships. Lisbon: EMSA.
- Larsen, U., Pierobon, L., Haglind, F. and Gabrielii, C. (2014) 'Design and optimisation of organic Rankine cycles for waste heat recovery in marine engines using the principles of natural selection', Energy, 55, pp. 803–812.
- ZHENIT Project (2023) ZHENIT: Waste Heat Recovery Solutions for Maritime Decarbonisation. Available at: (insert website)


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